

INHIBITORS OF HEPATITIS C VIRUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 119(e) to U.S.

- 5 Provisional Application Serial Number 61/667,806, filed on July 3, 2012, and U.S. Provisional Application Serial Number 61/798,524, filed on March 15, 2013. The entirety of both applications is incorporated herein by reference.

FIELD

- Novel small molecule inhibitors of viral replication are disclosed,
10 compositions containing such compounds, and therapeutic methods comprising the administration of such compounds are also disclosed.

BACKGROUND

- The hepatitis C virus (HCV), a member of the hepacivirus genera within
15 the *Flaviviridae* family, is the leading cause of chronic liver disease worldwide (Boyer, N. et al. *J Hepatol.* 2000, 32, 98-112). Consequently, a significant focus of current antiviral research is directed toward the development of improved methods for the treatment of chronic HCV infections in humans (Ciesek, S., von Hahn T., and Manns, MP., *Clin. Liver Dis.*, 2011, 15, 597-609; Soriano, V. et al,
20 *J. Antimicrob. Chemother.*, 2011, 66, 1573-1686; Brody, H., *Nature Outlook*, 2011, 474, S1-S7; Gordon, C. P., et al., *J. Med. Chem.* 2005, 48, 1-20; Maradpour, D., et al., *Nat. Rev. Micro.* 2007, 5, 453-463).

- Virologic cures of patients with chronic HCV infection are difficult to achieve because of the prodigious amount of daily virus production in chronically
25 infected patients and the high spontaneous mutability of HCV (Neumann, et al., *Science* 1998, 282, 103-7; Fukimoto, et al., *Hepatology*, 1996, 24, 1351-4; Domingo, et al., *Gene* 1985, 40, 1-8; Martell, et al., *J. Virol.* 1992, 66, 3225-9). HCV treatment is further complicated by the fact that HCV is genetically diverse and expressed as several different genotypes and numerous subtypes. For
30 example, HCV is currently classified into six major genotypes (designated 1-6),

many subtypes (designated a, b, c, and so on), and about 100 different strains (numbered 1, 2, 3, and so on).

HCV is distributed worldwide with genotypes 1, 2, and 3 predominate within the United States, Europe, Australia, and East Asia (Japan, Taiwan, Thailand, and China). Genotype 4 is largely found in the Middle East, Egypt and central Africa while genotype 5 and 6 are found predominantly in South Africa and South East Asia respectively (Simmonds, P. et al. *J Virol.* 84: 4597-4610, 2010).

The combination of ribavirin, a nucleoside analog, and interferon-alpha (α) (IFN), is utilized for the treatment of multiple genotypes of chronic HCV infections in humans. However, the variable clinical response observed within patients and the toxicity of this regimen have limited its usefulness. Addition of a HCV protease inhibitor (telaprevir or boceprevir) to the ribavirin and IFN regimen improves 12-week post-treatment virological response (SVR12) rates substantially. However, the regimen is currently only approved for genotype 1 patients and toxicity and other side effects remain.

The use of directing acting antivirals to treat multiple genotypes of HCV infection has proven challenging due to the variable activity of antivirals against the different genotypes. HCV protease inhibitors frequently have compromised *in vitro* activity against HCV genotypes 2 and 3 compared to genotype 1 (See, e.g., Table 1 of Summa, V. et al., *Antimicrobial Agents and Chemotherapy*, 2012, 56, 4161-4167; Gottwein, J. et al, *Gastroenterology*, 2011, 141, 1067-1079).

Correspondingly, clinical efficacy has also proven highly variable across HCV genotypes. For example, therapies that are highly effective against HCV genotype 1 and 2 may have limited or no clinical efficacy against genotype 3. (Moreno, C. et al., Poster 895, 61st AASLD Meeting, Boston, MA, USA, Oct. 29 – Nov. 2, 2010; Graham, F., et al, *Gastroenterology*, 2011, 141, 881-889; Foster, G.R. et al., EASL 45th Annual Meeting, April 14-18, 2010, Vienna, Austria.) In some cases, antiviral agents have good clinical efficacy against genotype 1, but lower and more variable against genotypes 2 and 3. (Reiser, M. et al., *Hepatology*, 2005, 41,832-835.) To overcome the reduced efficacy in genotype 3

patients, substantially higher doses of antiviral agents may be required to achieve substantial viral load reductions (Fraser, IP *et al.*, Abstract #48, HEP DART 2011, Koloa, HI, December 2011.)

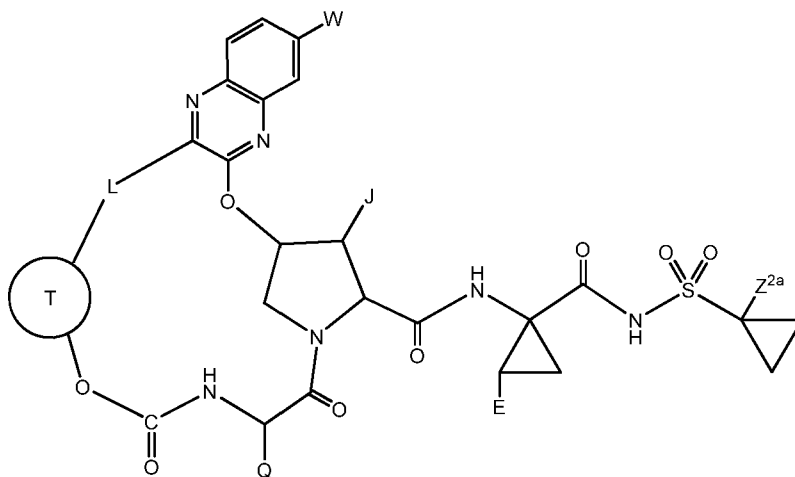
Antiviral agents that are less susceptible to viral resistance are also needed. For example, resistance mutations at positions 155 and 168 in the HCV protease frequently cause a substantial decrease in antiviral efficacy of HCV protease inhibitors (Mani, N. *Ann Forum Collab HIV Res.*, 2012, 14, 1-8; Romano, KP *et al*, *PNAS*, 2010, 107, 20986-20991; Lenz O, *Antimicrobial agents and chemotherapy*, 2010, 54,1878–1887.)

In view of the limitations of current HCV therapy, there is a need to develop more effective anti-HCV therapies. It would also be useful to provide therapies that are effective against multiple HCV genotypes and subtypes.

SUMMARY

Novel compounds that inhibit the hepatitis C virus (HCV) NS3 protease are disclosed. In certain embodiments, the compounds disclosed inhibit multiple genotypes of the hepatitis C virus. These compounds are useful for the treatment of HCV infection and the related symptoms.

In one embodiment, a compound of Formula (IV):



(IV),

or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, is provided, wherein:

J is C₁-C₄ alkyl or C₃-C₆ carbocyclyl, wherein C₁-C₄ alkyl or C₃-C₆ carbocyclyl is optionally substituted with halogen, -OH, aryl or cyano;

5 $\textcircled{\text{T}}$ is C₃-C₅ carbocyclylene that is attached to L and to the remainder of the compound through two adjacent carbons, wherein said C₃-C₆ carbocyclylene is optionally substituted with C₁-C₄ alkyl, C₁-C₃ haloalkyl, halogen, -OH, or cyano, or $\textcircled{\text{T}}$ is C₅-C₈ bicyclic carbocyclylene that is attached to L and to the remainder of the compound through two adjacent carbons;

10 L is C₃-C₆ alkylene, C₃-C₆ alkenylene or -(CH₂)₃-cyclopropyl-, optionally substituted with 1-4 halogen, -OH, or cyano;

Q is C₂-C₄ alkyl or C₃-C₆ carbocyclyl optionally substituted with C₁-C₃ alkyl, halogen, -OH, or cyano;

15 E is C₁-C₃ alkyl or C₂-C₃ alkenyl, optionally substituted with C₁-C₃ alkyl, halogen, -OH, or cyano;

W is H, -OH, -O(C₁-C₃)alkyl, -O(C₁-C₃)haloalkyl, halogen or cyano; and Z^{2a} is H or C₁-C₃ alkyl, halogen, -OH, or cyano.

20 In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons, wherein said C₃-C₆ carbocyclylene is optionally substituted with C₁-C₄ alkyl or C₁-C₃ haloalkyl.

25 In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons, wherein the C₃-C₆ carbocyclylene is optionally substituted with methyl, ethyl or trifluoromethyl.

In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is cyclopropylene.

In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₆-C₈ bridged bicyclic carbocyclylene or C₆-C₈ fused bicyclic carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons.

In a further embodiment of Formula (IV), L is C₃-C₆ alkylene, substituted with 1-4 halogens. In another embodiment of Formula (IV), L is C₅ alkylene, substituted with two halogens. In some embodiments, the halogens are each fluoro.

In a further embodiment of Formula (IV), L is C₃-C₆ alkylene.

In a further embodiment of Formula (IV), L is C₅ alkylene.

In a further embodiment of Formula (IV), Q is t-butyl or C₅-C₆ carbocyclyl.

In a further embodiment of Formula (IV), Q is t-butyl.

In a further embodiment of Formula (IV), E is C₁-C₃ alkyl optionally substituted with 1-3 halogen atoms.

In a further embodiment of Formula (IV), E is difluoromethyl.

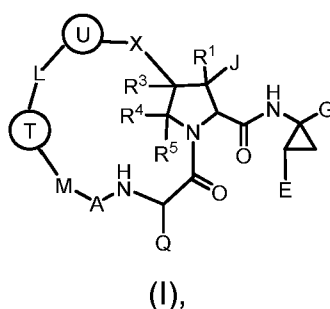
In a further embodiment of Formula (IV), W is hydrogen, -O(C₁-C₃)alkyl, halogen or cyano.

In a further embodiment of Formula (IV), W is methoxy.

In a further embodiment of Formula (IV), Z^{2a} is hydrogen or methyl.

In a further embodiment of Formula (IV), Z^{2a} is methyl.

In one embodiment, a compound of Formula (I):



or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, is provided, wherein:

J is J¹, J², J³, J⁴, J⁵, J⁶, J⁷, J⁸ or J⁹;

$\textcircled{\text{T}}$ is T¹, T², T³, T⁴, T⁵, T⁶, T⁷, T⁸, T⁹, T¹⁰, T¹¹, T¹², T¹³ or T¹⁴;

L is L¹, L², L³, L⁴, L⁵, L⁶, L⁷, L⁸, L⁹ or L¹⁰;

X is -O-, -CH₂-, -OC(O)-, -C(O)O-, -C(O)-, -SO₂-, -S(O)-, -N(R¹⁶)-, -S-, =N-O- or a bond;

A is -C(O)-, -S(O)₂-, a 6-10 membered arylene, 5-10 membered heteroarylene, or 4-10 membered heterocyclene, wherein any of said arylene, heterocyclene, or heteroarylene is optionally substituted with 1-4 Z¹ groups;

M is a bond, C₁-C₆ alkylene, -O-, or -N(R¹⁶)-;

R¹ is H or F;

R³, R⁴, and R⁵ are each independently selected from H or Z¹;

Q is Q¹, Q², Q³, Q⁴, Q⁵, Q⁶ or Q⁷;

E is E¹, E², E³, E⁴, E⁵, or E⁶;

G is -CO₂H, -CONHSO₂Z², tetrazolyl, -CONHP(O)(R¹⁶)₂, -P(O)(OH)(R¹⁶), and -P(O)(R¹⁶)₂;

Ⓢ is U¹, U², U³, U⁴, U⁵, U⁶ or U⁷;

J¹ is halogen;

J² is -OH and R¹ is H;

J³ is -NR¹⁷R¹⁸ and R¹ is H;

J⁴ is C₁-C₈ alkyl;

J⁵ is C₁-C₈ alkyl substituted with 1-4 Z³ groups;

J⁶ is C₃-C₈ carbocyclyl optionally substituted with 1-4 Z³ groups;

J⁷ is C₆-C₁₀ aryl, 5-10 membered heteroaryl, or 4-10 membered heterocyclyl optionally substituted with 1-4 Z³ groups;

J⁸ is C₁-C₈ alkoxy optionally substituted with 1-4 Z³ groups and R¹ is H;

J⁹ is C₃-C₈ carbocyclyleoxy optionally substituted with 1-4 Z³ groups and R¹ is H;

T¹ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons;

T² is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with 1-4 C₁-C₈ alkyl groups;

T³ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with 1-4 halogen atoms and said carbocyclylene is optionally substituted with 1-4 C₁-C₆ alkyl groups;

5 T⁴ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is optionally substituted with a C₁-C₈ alkyl group, wherein said alkyl group is optionally substituted with 1-4 Z³ groups;

10 T⁵ is 4-10 membered heterocyclene that is attached to L and M through two adjacent carbons;

T⁶ is 4-10 membered heterocyclene that is attached to L through a carbon atom and attached to M through an N atom, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

15 T⁷ is 4-10 membered heterocyclene that is attached to M through a carbon atom and attached to L through an N atom, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T⁸ is 4-10 membered heterocyclene that is attached to L and M through two adjacent carbons, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

20 T⁹ is C₅-C₁₂ spiro bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said spiro bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

25 T¹⁰ is C₅-C₁₂ fused bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said fused bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

T¹¹ is C₅-C₁₂ bridged bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said bridged bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

30 T¹² is C₄-C₈ carbocyclylene that is attached to L and M through two non-adjacent carbons, wherein said carbocyclylene is optionally substituted with 1-4 Z¹ groups;

T¹³ is a 5-8 membered fused, bridged, or spiro bicyclic heterocyclene that is attached to L and M through two adjacent atoms, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T¹⁴ is C₃-C₈ carbocyclene that is attached to L and M through two adjacent carbons, wherein said carbocyclene is optionally substituted with 1-4 Z⁴ groups;

L¹ is C₁-C₈ alkylene or C₂-C₈ alkenylene;

L² is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene is substituted with 1-4 halogens or said C₂-C₈ alkenylene is substituted with 1-4 halogens;

L³ is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene is substituted with 1-4 Z⁴ groups or said C₂-C₈ alkenylene is substituted with 1-4 Z⁴ groups and wherein each is optionally substituted with 1-4 halogens;

L⁴ is C₁-C₈ alkylene or C₂-C₈ alkenylene substituted with two geminal C₁-C₄ alkyl groups that come together to form a spiro C₃-C₈ carbocyclyl group, wherein L⁴ is optionally substituted with 1-4 Z¹ groups;

L⁵ is 2-8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\textcircled{\text{T}}$ by an O, S or N atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z³ groups;

L⁶ is 2-8 membered heteroalkylene or 5-8 membered heteroalkenylene that is connected to $\textcircled{\text{T}}$ by a carbon atom and said heteroalkylene or heteroalkenylene is substituted with 1-4 halogen atoms and is optionally substituted with 1-4 Z⁴ groups;

L⁷ is 2-8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\textcircled{\text{T}}$ by a carbon atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z⁴ groups;

L⁸ is L^{8A}-L^{8B}-L^{8C} wherein L^{8A} and L^{8C} are each independently selected from C₁-C₆ alkylene, C₁-C₆ heteroalkylene, C₂-C₆ alkenylene or a bond and L^{8B} is a 3- to 6- membered saturated or unsaturated ring

containing 0 to 3 heteroatoms selected from N, O, or S, wherein L^{8A} and L^{8C} connect to L^{8B} at two different ring atoms and L^{8B} is optionally substituted with 1-4 Z^1 groups;

L^9 is C_2 - C_8 alkynylene optionally substituted with 1-4 Z^1 groups;

5 L^{10} is C_1 - C_8 alkylene or C_3 - C_8 alkenylene substituted with two geminal Z^1 groups that come together to form a spiro 4-8 membered heterocyclyl group, wherein L^{10} is optionally substituted with 1-4 Z^1 groups;

U^1 is C_6 - C_{14} membered arylene optionally substituted with 1-4 W groups;

10 U^2 is C_3 - C_8 membered carbocyclylene optionally substituted with 1-4 W groups;

U^3 is 4-14 membered heterocyclene optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

15 U^4 is 5 or 6 membered monocyclic heteroarylene containing 1, 2 or 3 heteroatoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

20 U^5 is 8, 9 or 10 membered fused bicyclic heteroarylene containing 1, 2 or 3 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

25 U^6 is 11-14 membered fused tricyclic heteroarylene containing 1, 2, 3 or 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

30 U^7 is 8-10 membered fused bicyclic heteroarylene containing 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroaryl is optionally substituted with 1-2 W groups that are located on one or more ring atoms selected from C or N;

W is independently W^1 , W^2 , W^3 , W^4 , W^5 , W^6 or W^7 ;

W^1 is oxo, halogen, $-OR^6$, C_1-C_6 alkyl, $-CN$, $-CF_3$, $-SR^6$, $-C(O)_2R^6$,
 $-C(O)N(R^6)_2$, $-C(O)R^6$, $-N(R^6)C(O)R^6$, $-SO_2(C_1-C_6 \text{ alkyl})$,
 $-S(O)(C_1-C_6 \text{ alkyl})$, C_3-C_8 carbocyclyl, C_3-C_8 cycloalkoxy, C_1-C_6
5 haloalkyl, $-N(R^6)_2$, $-NR^6(C_1-C_6 \text{ alkyl})O(C_1-C_6 \text{ alkyl})$, halo(C_1-C_6
alkoxy), $-NR^6SO_2R^6$, $-SO_2N(R^6)_2$, $-NHCOOR^6$, $-NHCONHR^6$, C_6-C_{10}
aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl
or $-O(4-10 \text{ membered heterocyclyl})$, wherein said W^1 alkyl,
carbocyclyl, cycloalkoxy, haloalkyl, haloalkoxy, aryl, heteroaryl, or
10 heterocyclyl is optionally substituted with 1-4 Z^{1c} groups;

each R^6 is independently selected from H, C_6-C_{10} aryl or C_1-C_6 alkyl,
wherein said aryl or alkyl is optionally substituted with 1 to 4
substituents independently selected from halogen atoms, C_1-C_6
alkyl, C_6-C_{10} aryl, C_3-C_8 carbocyclyl, 5-14 membered heteroaryl, 4-
15 10 membered heterocyclyl, halo(C_1-C_6 alkoxy), $-OH$, $-O(C_1-C_6$
alkyl), $-SH$, $-S(C_1-C_6 \text{ alkyl})$, $-NH_2$, $-NH(C_1-C_6 \text{ alkyl})$, $-N(C_1-C_6 \text{ alkyl})_2$,
 $-C(O)(C_1-C_6 \text{ alkyl})$, $-SO_2N(C_1-C_6 \text{ alkyl})_2$, $-NHCOO(C_1-C_6 \text{ alkyl})$,
 $-NHCO(C_1-C_6 \text{ alkyl})$, $-NHCONH(C_1-C_6 \text{ alkyl})$, $-CO_2(C_1-C_6 \text{ alkyl})$, or
 $-C(O)N(C_1-C_6 \text{ alkyl})_2$;

W^2 is C_1-C_6 alkoxy substituted with a 5-14 membered heteroaryl or C_6-C_{10}
aryl; wherein said heteroaryl or aryl is substituted with 1-4 Z^1
groups;

W^3 is C_2-C_6 alkynyl substituted with an C_6-C_{10} aryl, C_3-C_8 carbocyclyl,
 C_1-C_8 alkyl, C_1-C_6 haloalkyl, 4-10 membered heterocyclyl, or 5-14
25 membered heteroaryl; wherein said aryl, carbocyclyl, alkyl,
haloalkyl, heterocyclyl, or heteroaryl is optionally substituted with
1-4 Z^1 groups;

W^4 is $-SF_5$;

W^5 is $-O(C_2-C_6 \text{ alkyl})OR^{22}$ wherein R^{22} is an C_6-C_{10} aryl, 5-14 membered
30 heteroaryl or 4-10 membered heterocyclyl optionally substituted
with 1-4 Z^1 groups;

W⁶ is -O(C₂-C₆ alkyl)NR¹⁶R²² wherein R²² is an C₆-C₁₀ aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl optionally substituted with 1-4 Z¹ groups;

W⁷ is -O(5-14 membered heteroaryl); wherein said -O(5-14 membered heteroaryl) is optionally substituted with 1-4 Z¹ groups;

E¹ is C₂-C₆ alkenyl;

E² is C₁-C₆ alkyl;

E³ is C₁-C₆ haloalkyl;

E⁴ is C₂-C₆ haloalkenyl;

E⁵ is C₃-C₆ carbocyclyl;

E⁶ is C₁-C₆ alkyl substituted with -OCH₃, -OCD₃, -OCF₃, or -OCF₂H;

Q¹ is H, C₁-C₈ alkyl, C₃-C₈ carbocyclyl, C₆-C₁₀ aryl, 5-6 membered heteroaryl, or 5-6 membered heterocyclyl, wherein when Q¹ is not H, said Q¹ is optionally substituted with 1-3 substituents independently selected from halogen, -OR⁶, -SR⁶, -N(R⁶)₂, C₆-C₁₀ aryl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ haloalkoxy, -CN, -CF₃, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), -NR⁶SO₂Z², -SO₂NR¹⁷R¹⁸, -NHCOOR¹⁶, -NHCOZ², -NHCONHR¹⁶, -CO₂R⁶, -C(O)R⁶, or -CON(R⁶)₂;

Q² is C₅-C₁₀ spiro bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

Q³ is C₅-C₁₀ fused bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

Q⁴ is C₅-C₁₀ bridged bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

Q⁵ is 4-membered heterocyclyl having 1 heteroatom selected from N, O or S wherein Q⁵ is optionally substituted with 1-4 Z³ groups;

Q⁶ is C₁-C₈ alkyl, C₃-C₈ carbocyclyl, C₆-C₁₀ aryl, 5-6 membered heteroaryl, or 5-6 membered heterocyclyl, wherein Q⁶ is substituted with 1 oxo group and with 0 to 3 substituents independently selected from halogen, -OR⁶, -SR⁶, -N(R⁶)₂, C₆-C₁₀ aryl, C₁-C₆ alkyl, C₁-C₆

haloalkyl, C₁-C₆ haloalkoxy, -NO₂, -CN, -CF₃, -SO₂(C₁-C₆ alkyl),
 -S(O)(C₁-C₆ alkyl), -NR⁶SO₂Z², -SO₂NR¹⁷R¹⁸, -NHCOOR¹⁶,
 -NHCOZ², -NHCONHR¹⁶, -CO₂R⁶, -C(O)R⁶, or -CON(R⁶)₂;

Q⁷ is C₃-C₈ carbocyclyl, wherein Q⁷ is substituted with 4-8 F atoms and
 each carbon of Q⁷ is substituted with 0-2 F atoms;

each Z¹ is independently oxo, halogen, C₁-C₈ alkyl, C₂-C₈ alkenyl, C₂-C₈
 alkynyl, C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₁-C₈
 haloalkyl, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered
 heterocyclyl, -CN, -C(O)R¹⁶, -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸,
 -NR¹⁶C(O)R¹⁶, -NR¹⁶C(O)NR¹⁷R¹⁸, -NR¹⁶S(O)₂R¹⁶,
 -NR¹⁶S(O)₂NR¹⁷R¹⁸, -NR¹⁶S(O)₂OR¹⁶, -OR¹⁶, -OC(O)R¹⁶,
 -OC(O)NR¹⁷R¹⁸, -SR¹⁶, -S(O)R¹⁶, -S(O)₂R¹⁶ or -S(O)₂NR¹⁷R¹⁸
 wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or
 heterocyclyl of Z¹ is optionally substituted with 1-4 Z^{1a} groups;

each Z^{1a} is independently oxo, halogen, C₂-C₈ alkenyl, C₂-C₈ alkynyl, C₃-C₈
 carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₁-C₈ haloalkyl, C₆-C₁₀
 aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl,
 -CN, -C(O)R¹⁶, -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸,
 -NR¹⁶C(O)R¹⁶, -NR¹⁶C(O)OR¹⁶, -NR¹⁶C(O)NR¹⁷R¹⁸, -NR¹⁶S(O)₂R¹⁶,
 -NR¹⁶S(O)₂NR¹⁷R¹⁸, -NR¹⁶S(O)₂OR¹⁶, -OR¹⁶, -OC(O)R¹⁶, -OC(O)N
 R¹⁷R¹⁸, -SR¹⁶, -S(O)R¹⁶, -S(O)₂R¹⁶ or -S(O)₂NR¹⁷R¹⁸ wherein any
 alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of Z^{1a} is
 optionally substituted with 1-4 Z^{1c} groups;

each R¹⁶ is independently H, C₁-C₈ alkyl, C₂-C₈ alkenyl, C₂-C₈ alkynyl,
 C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₆-C₁₀ aryl, 5-14
 membered heteroaryl or 4-10 membered heterocyclyl, wherein any
 alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of
 R¹⁶ is optionally substituted with 1-4 Z^{1c} groups;

each Z^{1c} is independently oxo, halogen, C₁-C₈ alkyl, C₃-C₈ carbocyclyl,
 C₅-C₁₀ bicyclic carbocyclyl, C₁-C₈ haloalkyl, C₆-C₁₀ aryl, 5-14
 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O)(C₁-

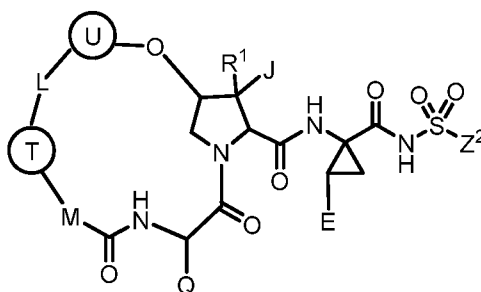
C₈ alkyl), -C(O)O(C₁-C₈ alkyl), -C(O)N(C₁-C₈ alkyl)₂, -NH₂, -NH(C₁-C₈ alkyl), -N(C₁-C₈ alkyl)₂, -NHC(O)O(C₁-C₈ alkyl), -NHC(O)(C₁-C₈ alkyl), -NHC(O)NH(C₁-C₈ alkyl), -OH, -O(C₁-C₈ alkyl), C₃-C₈ cycloalkoxy, C₅-C₁₀ bicyclic carbocyclyloxy, -S(C₁-C₈ alkyl) or
 5 -S(O)₂N(C₁-C₈ alkyl)₂ wherein any alkyl, carbocyclyl, aryl, heteroaryl, heterocyclyl or cycloalkoxy portion of Z^{1c} is optionally substituted with 1-4 halogen atoms or C₁-C₆ alkoxy groups;
 R¹⁷ and R¹⁸ are each independently H, C₁-C₈ alkyl, C₂-C₈ alkenyl, C₂-C₈ alkynyl, C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, -C(O)R¹⁶,
 10 -C(O)OR¹⁶, C₆-C₁₀ aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl, wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of R¹⁷ or R¹⁸ is optionally substituted with 1-4 Z^{1c} groups, or R¹⁷ and R¹⁸ together with the nitrogen to which they are attached form a 4-7 membered
 15 heterocyclyl group, wherein said 4-7 membered heterocyclyl group is optionally substituted with 1-4 Z^{1c} groups;
 each Z² is independently C₁-C₈ alkyl, C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -NR¹⁷R¹⁸ or -OR¹⁶ wherein any alkyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portion of Z² is
 20 optionally substituted with 1-4 Z^{2a} groups;
 each Z^{2a} is independently oxo, halogen, C₁-C₈ alkyl, C₂-C₈ alkynyl, C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₁-C₈ haloalkyl, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -(C₂-C₈ alkynyl)aryl, -(C₂-C₈ alkynyl)heteroaryl, -CN, -C(O)(C₁-C₆ alkyl),
 25 -C(O)O(C₁-C₆ alkyl), -C(O)N(C₁-C₆ alkyl)₂, -NH₂, -NH(C₁-C₆ alkyl), -N(C₁-C₆ alkyl)₂, -NHC(O)O(C₁-C₆ alkyl), -NHC(O)(C₁-C₆ alkyl), -NHC(O)NH(C₁-C₆ alkyl), -OH, -O(C₁-C₆ alkyl), halo(C₁-C₆ alkoxy), C₃-C₈ cycloalkoxy, -S(C₁-C₆ alkyl), or -SO₂N(C₁-C₆ alkyl)₂; wherein
 30 any alkyl, alkynyl, carbocyclyl, cycloalkoxy, aryl, heteroaryl or

heterocyclyl portions of Z^{2a} is optionally substituted with 1-4 halogen or C_1 - C_6 alkoxy groups;

each Z^3 is independently oxo, halogen, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸, -NR¹⁶C(O)NR¹⁷R¹⁸, -OR¹⁶, -SR¹⁶ or -SO₂R¹⁶; wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z^3 is optionally substituted with 1-4 halogen; and

each Z^4 is independently oxo, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸, -NR¹⁶C(O)NR¹⁷R¹⁸, -OR¹⁶, -SR¹⁶ or -SO₂R¹⁶, wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z^4 is optionally substituted with 1-4 halogen.

In another embodiment, a compound of Formula (II):



(II),

or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, is provided, wherein:

M is -O-;

J is J¹, J², J³, J⁴, J⁵, J⁶, J⁷, J⁸ or J⁹;

$\textcircled{T}$ is T¹, T², T³, T⁴, T⁵, T⁷, T⁸, T⁹, T¹⁰, T¹¹, T¹², T¹³ or T¹⁴;

L is L¹, L², L³, L⁴, L⁵, L⁶, L⁷, L⁸, L⁹ or L¹⁰;

R¹ is H or F;

Q is Q¹, Q², Q³, Q⁴, Q⁵, Q⁶ or Q⁷;

E is E¹, E², E³, E⁴, E⁵, or E⁶;

Ⓢ is U¹, U², U³, U⁴, U⁵, U⁶ or U⁷;

J¹ is halogen;

5 J² is -OH and R¹ is H;

J³ is -NR¹⁷R¹⁸ and R¹ is H;

J⁴ is C₁-C₈ alkyl;

J⁵ is C₁-C₈ alkyl optionally substituted with 1-4 Z³ groups;

J⁶ is C₃-C₈ carbocyclyl optionally substituted with 1-4 Z³ groups;

10 J⁷ is C₆-C₁₀ aryl, 5-14 membered heteroaryl, or 4-10 membered heterocyclyl, any of which are optionally substituted with 1-4 Z³ groups;

J⁸ is C₁-C₈ alkoxy optionally substituted with 1-4 Z³ groups and R¹ is H;

15 J⁹ is C₃-C₈ carbocycloxy optionally substituted with 1-4 Z³ groups and R¹ is H;

T¹ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons;

20 T² is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is optionally substituted with 1-4 C₁-C₈ alkyl groups;

T³ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is optionally substituted with 1-4 halogen atoms and said carbocyclylene is optionally substituted with 1-4 C₁-C₆ alkyl groups;

25 T⁴ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is optionally substituted with a C₁-C₈ alkyl group, wherein said alkyl group is optionally substituted with 1-4 Z³ groups;

30 T⁵ is 4-10 membered heterocyclene that is attached to L and M through two adjacent carbons;

T⁷ is 4-10 membered heterocyclene that is attached to M through a carbon atom and attached to L through a N atom, wherein said

heterocyclene is optionally substituted with 1-4 Z¹ groups;

T⁸ is 4-10 membered heterocyclene that is attached to L and M through

5 two adjacent carbons, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T⁹ is C₅-C₁₂ spiro bicyclic carbocyclene that is attached to L and M

through two adjacent carbons, wherein said spiro bicyclic carbocyclene is optionally substituted with 1-4 Z¹ groups;

10 T¹⁰ is C₅-C₁₂ fused bicyclic carbocyclene that is attached to L and M

through two adjacent carbons, wherein said fused bicyclic carbocyclene is optionally substituted with 1-4 Z¹ groups;

T¹¹ is C₅-C₁₂ bridged bicyclic carbocyclene that is attached to L and M

15 through two adjacent carbons, wherein said bridged bicyclic carbocyclene is optionally substituted with 1-4 Z¹ groups;

T¹² is C₄-C₈ carbocyclene that is attached to L and M through two non-adjacent carbons, wherein said carbocyclene is optionally substituted with 1-4 Z¹ groups;

T¹³ is a 5-8 membered fused, bridged, or spiro bicyclic heterocyclene that

20 is attached to L and M through two adjacent atoms, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T¹⁴ is C₃-C₈ carbocyclene that is attached to L and M through two

adjacent carbons, wherein said carbocyclene is optionally substituted with 1-4 Z⁴ groups;

25 L¹ is C₁-C₈ alkylene or C₂-C₈ alkenylene;

L² is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene is substituted with 1-4 halogens or said C₂-C₈ alkenylene is substituted with 1-4 halogens;

L³ is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene is

30 substituted with 1-4 Z⁴ groups or said C₂-C₈ alkenylene is substituted

with 1-4 Z^4 groups and wherein each is optionally substituted with 1-4 halogens;

L^4 is C_1 - C_8 alkylene or C_2 - C_8 alkenylene substituted with two geminal C_1 - C_4 alkyl groups that come together to form a spiro C_3 - C_8 carbocyclyl group, wherein L^4 is optionally substituted with 1-4 Z^1 groups;

L^5 is 2-8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\textcircled{T}$ by an O, S or N atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z^3 groups;

L^6 is 2-8 membered heteroalkylene or 5-8 membered heteroalkenylene that is connected to $\textcircled{T}$ by a carbon atom and said heteroalkylene or heteroalkenylene is substituted with 1-4 halogen atoms and is optionally substituted with 1-4 Z^4 groups;

L^7 is 2-8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\textcircled{T}$ by a carbon atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z^4 groups;

L^8 is L^{8A} - L^{8B} - L^{8C} wherein L^{8A} and L^{8C} are each independently selected from C_1 - C_6 alkylene, C_1 - C_6 heteroalkylene, C_2 - C_6 alkenylene or a bond and L^{8B} is a 3- to 6- membered saturated or unsaturated ring containing 0 to 3 heteroatoms selected from N, O, or S, wherein L^{8A} and L^{8C} connect to L^{8B} at two different ring atoms and L^{8B} is optionally substituted with 1-4 Z^1 groups;

L^9 is C_2 - C_8 alkynylene optionally substituted with 1-4 Z^1 groups;

L^{10} is C_1 - C_8 alkylene or C_3 - C_8 alkenylene substituted with two geminal Z^1 groups that come together to form a spiro 4-8 membered heterocyclyl group, wherein L^{10} is optionally substituted with 1-4 Z^1 groups;

U^1 is C_6 - C_{14} membered arylene optionally substituted with 1-4 W groups; each U^2 is C_3 - C_8 membered carbocyclylene optionally substituted 1-4 W groups;

each U³ is 4-14 membered heterocyclene optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁴ is 5 or 6 membered monocyclic heteroarylene containing 1, 2 or 3 heteroatoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁵ is 8, 9 or 10 membered fused bicyclic heteroarylene containing 1, 2 or 3 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁶ is 11-14 membered fused tricyclic heteroarylene containing 1, 2, 3 or 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁷ is 8-10 membered fused bicyclic heteroarylene containing 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroaryl is optionally substituted with 1-2 W groups that are located on one or more ring atoms selected from C or N;

each W is independently W¹, W², W³, W⁴, W⁵, W⁶ or W⁷;

each W¹ is oxo, halogen, -OR⁶, C₁-C₆ alkyl, -CN, -CF₃, -SR⁶, -C(O)₂R⁶, -C(O)N(R⁶)₂, -C(O)R⁶, -N(R⁶)C(O)R⁶, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), C₃-C₈ carbocyclyl, C₃-C₈ cycloalkoxy, C₁-C₆ haloalkyl, -N(R⁶)₂, -NR⁶(C₁-C₆ alkyl)O(C₁-C₆ alkyl), halo(C₁-C₆ alkoxy), -NR⁶SO₂R⁶, -SO₂N(R⁶)₂, -NHCOOR⁶, -NHCONHR⁶, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl or -O(4-10 membered heterocyclyl), wherein said W¹ alkyl, carbocyclyl, cycloalkoxy, haloalkyl, haloalkoxy, aryl, heteroaryl, or heterocyclyl is optionally substituted with 1-4 Z^{1c} groups;

each R^6 is independently selected from H, C_6-C_{10} aryl or C_1-C_6 alkyl,
 wherein said aryl or alkyl is optionally substituted with 1 to 4
 substituents independently selected from halogen atoms, C_1-C_6
 alkyl, C_6-C_{10} aryl, C_3-C_8 carbocyclyl, 5-14 membered heteroaryl,
 4-10 membered heterocyclyl, halo(C_1-C_6 alkoxy), -OH, -O(C_1-C_6
 5 alkyl), -SH, -S(C_1-C_6 alkyl), -NH₂, -NH(C_1-C_6 alkyl), -N(C_1-C_6 alkyl)₂,
 -C(O)(C_1-C_6 alkyl), -SO₂N(C_1-C_6 alkyl)₂, -NHCOO(C_1-C_6 alkyl),
 -NHCO(C_1-C_6 alkyl), -NHCONH(C_1-C_6 alkyl), -CO₂(C_1-C_6 alkyl), or
 -C(O)N(C_1-C_6 alkyl)₂;

10 each W^2 is C_1-C_6 alkoxy substituted with a 5-14 membered heteroaryl or
 C_6-C_{10} aryl; wherein said heteroaryl or aryl is substituted with 1-4
 Z^{1c} groups;

each W^3 is C_2-C_6 alkynyl substituted with an C_6-C_{10} aryl, C_3-C_8
 carbocyclyl, C_1-C_8 alkyl, C_1-C_6 haloalkyl, 4-10 membered
 15 heterocyclyl, or 5-14 membered heteroaryl; wherein said aryl,
 carbocyclyl, alkyl, haloalkyl, heterocyclyl, or heteroaryl is optionally
 substituted with 1-4 Z^1 groups;

each W^4 is -SF₅;

each W^5 is -O(C_2-C_6 alkyl)OR²² wherein R²² is an C_6-C_{10} aryl, 5-14
 20 membered heteroaryl or 4-10 membered heterocyclyl optionally
 substituted with 1-4 Z^1 groups;

each W^6 is -O(C_2-C_6 alkyl)NR¹⁶R²² wherein R²² is an C_6-C_{10} aryl, 5-14
 membered heteroaryl or 4-10 membered heterocyclyl optionally
 substituted with 1-4 Z^1 groups;

25 each W^7 is -O(5-14 membered heteroaryl); wherein said -O(5-14
 membered heteroaryl) is optionally substituted with 1-4 Z^1 groups
 and 2 adjacent substituents of said -O(5-14 membered heteroaryl)
 may be taken together to form a 3- to 6-membered cyclic ring
 containing 0 to 3 heteroatoms independently selected from N, O, or
 30 S;

E^1 is C_2-C_6 alkenyl;

E² is C₁-C₆ alkyl;

E³ is C₁-C₆ haloalkyl;

E⁴ is C₂-C₆ haloalkenyl;

E⁵ is C₃-C₆ carbocyclyl;

5 E⁶ is C₁-C₆ alkyl optionally substituted with -OCH₃, -OCD₃, -OCF₃, or -OCF₂H;

Q¹ is selected from H, C₁-C₈ alkyl, C₃-C₈ carbocyclyl, C₆-C₁₀ aryl, 5-6 membered heteroaryl, or 5-6 membered heterocyclyl groups, wherein when Q¹ is not H, said Q¹ is optionally substituted with 1-4 substituents independently selected from halogen, -

10 OR⁶, -SR⁶, -N(R⁶)₂, C₆-C₁₀ aryl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ haloalkoxy, -NO₂, -CN, -CF₃, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), -NR⁶SO₂Z², -SO₂NR¹⁷R¹⁸, -NHCOOR¹⁶, -NHCOZ², -NHCONHR¹⁶, -CO₂R⁶, -C(O)R⁶, and -CON(R⁶)₂;

15 Q² is C₅-C₁₀ spiro bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

Q³ is C₅-C₁₀ fused bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

20 Q⁴ is C₅-C₁₀ bridged bicyclic carbocyclyl optionally substituted with 1-4 Z¹ groups;

Q⁵ is 4-membered heterocyclyl having 1 heteroatom selected from N, O or S wherein Q⁵ is optionally substituted with 1-4 Z³ groups;

25 Q⁶ is C₁-C₈ alkyl, C₃-C₈ carbocyclyl, C₆-C₁₀ aryl, 5-6 membered heteroaryl, or 5-6 membered heterocyclyl, wherein Q⁶ is substituted with 1 oxo group and with 0 to 3 substituents independently selected from halogen, -OR⁶, -SR⁶, -N(R⁶)₂, C₆-C₁₀ aryl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ haloalkoxy, -NO₂, -CN, -CF₃, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), -NR⁶SO₂Z², -SO₂NR¹⁷R¹⁸, -NHCOOR¹⁶, -NHCOZ², -NHCONHR¹⁶, -CO₂R⁶, -C(O)R⁶, or -CON(R⁶)₂;

30 Q⁷ is C₃-C₈ carbocyclyl, wherein Q⁷ is substituted with 4-8 F atoms and each carbon of Q⁷ is substituted with 0-2 F atoms;

each Z^1 is independently oxo, halogen, C_1 - C_8 alkyl, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O) R^{16} , -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸,
 5 -NR¹⁷R¹⁸, -NR¹⁶C(O) R^{16} , -NR¹⁶C(O)NR¹⁷R¹⁸, -NR¹⁶S(O)₂R¹⁶,
 -NR¹⁶S(O)₂NR¹⁷R¹⁸, -NR¹⁶S(O)₂OR¹⁶, -OR¹⁶, -OC(O) R^{16} ,
 -OC(O)NR¹⁷R¹⁸, -SR¹⁶, -S(O) R^{16} , -S(O)₂R¹⁶ or -S(O)₂NR¹⁷R¹⁸
 wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or
 heterocyclyl of Z^1 is optionally substituted with 1-4 Z^{1a} groups;

10 each Z^{1a} is independently oxo, halogen, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8
 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10}
 aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl,
 -CN, -C(O) R^{16} , -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸,
 -NR¹⁶C(O) R^{16} , -NR¹⁶C(O)OR¹⁶, -NR¹⁶C(O)NR¹⁷R¹⁸, -NR¹⁶S(O)₂R¹⁶,
 15 -NR¹⁶S(O)₂NR¹⁷R¹⁸, -NR¹⁶S(O)₂OR¹⁶, -OR¹⁶, -OC(O) R^{16} , -OC(O)N
 R^{17} R¹⁸, -SR¹⁶, -S(O) R^{16} , -S(O)₂R¹⁶ or -S(O)₂NR¹⁷R¹⁸ wherein any
 alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of Z^{1a} is
 optionally substituted with 1-4 Z^{1c} groups;

each R^{16} is independently H, C_1 - C_8 alkyl, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl,
 20 C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_6 - C_{10} aryl, 5-14
 membered heteroaryl or 4-10 membered heterocyclyl, wherein any
 alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of
 R^{16} is optionally substituted with 1-4 Z^{1c} groups;

each Z^{1c} is independently oxo, halogen, C_1 - C_8 alkyl, C_3 - C_8 carbocyclyl,
 25 C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14
 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O)(C_1 -
 C_8 alkyl), -C(O)O(C_1 - C_8 alkyl), -C(O)N(C_1 - C_8 alkyl)₂, -NH₂, -NH(C_1 -
 C_8 alkyl), -N(C_1 - C_8 alkyl)₂, -NHC(O)O(C_1 - C_8 alkyl), -NHC(O)(C_1 - C_8
 alkyl), -NHC(O)NH(C_1 - C_8 alkyl), -OH, -O(C_1 - C_8 alkyl), C_3 - C_8
 30 cycloalkoxy, C_5 - C_{10} bicyclic carbocyclyloxy, -S(C_1 - C_8 alkyl) or
 -S(O)₂N(C_1 - C_8 alkyl)₂ wherein any alkyl, carbocyclyl, aryl,

heteroaryl, heterocyclyl or cycloalkoxy portion of Z^{1c} is optionally substituted with 1-4 halogen atoms or C_1 - C_6 alkoxy groups;

R^{17} and R^{18} are each independently H, C_1 - C_8 alkyl, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, $-C(O)R^{16}$, $-C(O)OR^{16}$, C_6 - C_{10} aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl, wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of R^{17} or R^{18} is optionally substituted with 1-4 Z^{1c} groups, or R^{17} and R^{18} together with the nitrogen to which they are attached form a 4-7 membered heterocyclyl group, wherein said 4-7 membered heterocyclyl group is optionally substituted with 1-4 Z^{1c} groups;

each Z^2 is independently C_1 - C_8 alkyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-NR^{17}R^{18}$ or $-OR^{16}$ wherein any alkyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portion of Z^2 is optionally substituted with 1-4 Z^{2a} groups;

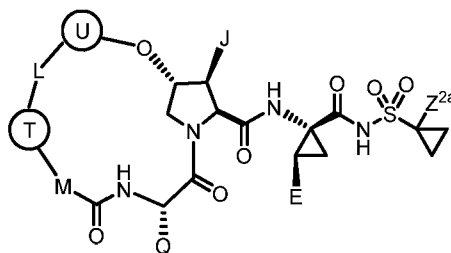
each Z^{2a} is independently oxo, halogen, C_1 - C_8 alkyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-(C_2-C_8 \text{ alkynyl})\text{aryl}$, $-(C_2-C_8 \text{ alkynyl})\text{heteroaryl}$, $-CN$, $-C(O)(C_1-C_6 \text{ alkyl})$, $-C(O)O(C_1-C_6 \text{ alkyl})$, $-C(O)N(C_1-C_6 \text{ alkyl})_2$, $-NH_2$, $-NH(C_1-C_6 \text{ alkyl})$, $-N(C_1-C_6 \text{ alkyl})_2$, $-NHC(O)O(C_1-C_6 \text{ alkyl})$, $-NHC(O)(C_1-C_6 \text{ alkyl})$, $-NHC(O)NH(C_1-C_6 \text{ alkyl})$, $-OH$, $-O(C_1-C_6 \text{ alkyl})$, halo(C_1-C_6 alkoxy), C_3 - C_8 cycloalkoxy, $-S(C_1-C_6 \text{ alkyl})$, or $-SO_2N(C_1-C_6 \text{ alkyl})_2$; wherein any alkyl, alkynyl, carbocyclyl, cycloalkoxy, aryl, heteroaryl or heterocyclyl portions of Z^{2a} is optionally substituted with 1-4 halogen or C_1 - C_6 alkoxy groups;

each Z^3 is independently oxo, halogen, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-CN$, $-C(O)OR^{16}$, $-C(O)NR^{17}R^{18}$, $-NR^{17}R^{18}$, $-NR^{16}C(O)NR^{17}R^{18}$,

-OR¹⁶, -SR¹⁶ or -SO₂R¹⁶; wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z³ is optionally substituted with 1-4 halogen; and

each Z⁴ is independently oxo, C₂-C₈ alkenyl, C₂-C₈ alkynyl, C₃-C₈ carbocyclyl, C₅-C₁₀ bicyclic carbocyclyl, C₁-C₈ haloalkyl, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, -CN, -C(O)OR¹⁶, -C(O)NR¹⁷R¹⁸, -NR¹⁷R¹⁸, -NR¹⁶C(O)NR¹⁷R¹⁸, -OR¹⁶, -SR¹⁶ or -SO₂R¹⁶, wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z⁴ is optionally substituted with 1-4 halogen.

In a further embodiment a compound of Formula (III):



(III),

or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, is provided, wherein:

M is -O-;

J is J¹, J², J³, J⁴, J⁵, J⁶, J⁷, J⁸ or J⁹;

Ⓣ is T¹, T², T³, T⁴, T⁵, T⁷, T⁸, T⁹, T¹⁰, T¹¹, T¹², T¹³ or T¹⁴;

L is L¹, L², L³, L⁴, L⁵, L⁶, L⁷, L⁸, L⁹ or L¹⁰;

Q is Q¹, Q², Q³, Q⁴, Q⁵ or Q⁷;

E is E¹, E², E³, or E⁴;

Ⓢ is selected from U¹, U³, U⁴, U⁵, U⁶ or U⁷;

J¹ is halogen;

J² is -OH;

J³ is -NR¹⁷R¹⁸;

J⁴ is C₁-C₈ alkyl;

J⁵ is C₁-C₈ alkyl substituted with 1-4 Z³ groups;

J⁶ is C₃-C₈ carbocyclyl optionally substituted with 1-4 Z³ groups;

J⁷ is C₆-C₁₀ aryl, 5-14 membered heteroaryl, or 4-10 membered

5 heterocyclyl any of which groups are optionally substituted with 1-4 Z³ groups;

J⁸ is C₁-C₈ alkoxy optionally substituted with 1-4 Z³ groups;

J⁹ is C₃-C₈ carbocycloxy optionally substituted with 1-4 Z³ groups;

10 T¹ is C₃-C₈ carbocyclylene attached to L and M through two adjacent carbons;

T² is C₃-C₈ carbocyclylene attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with 1-4 C₁-C₈ alkyl groups;

15 T³ is C₃-C₈ carbocyclylene attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with 1-4 halogen atoms and said carbocyclylene is optionally substituted with 1-4 C₁-C₆ alkyl groups;

20 T⁴ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with a C₁-C₈ alkyl group, wherein said alkyl group is substituted with 1-4 Z³ groups;

T⁵ is 4-10 membered heterocyclene that is attached to L and M through two adjacent carbons;

25 T⁷ is 4-10 membered heterocyclene that is attached to M through a carbon atom and attached to L through a N atom, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T⁸ is 4-10 membered heterocyclene that is attached to L and M through two adjacent carbons, wherein said heterocyclene is substituted with 1-4 Z¹ groups;

T⁹ is C₅-C₁₂ spiro bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said spiro bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

5 T¹⁰ is C₅-C₁₂ fused bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said fused bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

T¹¹ is C₅-C₁₂ bridged bicyclic carbocyclylene that is attached to L and M through two adjacent carbons, wherein said bridged bicyclic carbocyclylene is optionally substituted with 1-4 Z¹ groups;

10 T¹² is C₄-C₈ carbocyclylene that is attached to L and M through two non-adjacent carbons, wherein said carbocyclylene is optionally substituted with 1-4 Z¹ groups;

15 T¹³ is a 5-8 membered fused, bridged, or spiro bicyclic heterocyclene that is attached to L and M through two adjacent atoms, wherein said heterocyclene is optionally substituted with 1-4 Z¹ groups;

T¹⁴ is C₃-C₈ carbocyclylene that is attached to L and M through two adjacent carbons, wherein said carbocyclylene is substituted with 1-4 Z⁴ groups;

L¹ is C₁-C₈ alkylene or C₂-C₈ alkenylene;

20 L² is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene or said C₂-C₈ alkenylene is substituted with 1-4 halogens;

L³ is C₁-C₈ alkylene or C₂-C₈ alkenylene wherein said C₁-C₈ alkylene or said C₂-C₈ alkenylene and wherein said C₁-C₈ alkylene or said C₂-C₈ alkenylene is optionally substituted with 1-4 halogens;

25 L⁴ is C₁-C₈ alkylene or C₂-C₈ alkenylene substituted with two geminal C₁-C₄ alkyl groups that come together to form a spiro C₃-C₈ carbocyclyl group, wherein L⁴ is optionally substituted with 1-4 Z¹ groups;

30 L⁵ is 2-8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\bigcirc^{\text{T}}$ by an O, S or N atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z³ groups;

L⁶ is 2–8 membered heteroalkylene or 5-8 membered heteroalkenylene that is connected to $\textcircled{\text{T}}$ by a carbon atom and said heteroalkylene or heteroalkenylene is substituted with 1-4 halogen atoms and is optionally substituted with 1-4 Z⁴ groups;

5 L⁷ is 2–8 membered heteroalkylene or 4-8 membered heteroalkenylene that is connected to $\textcircled{\text{T}}$ by a carbon atom and said heteroalkylene or heteroalkenylene is optionally substituted with 1-4 Z⁴ groups;

10 L⁸ is L^{8A}-L^{8B}-L^{8C} wherein L^{8A} and L^{8C} are each independently C₁-C₆ alkylene, C₁-C₆ heteroalkylene, C₂-C₆ alkenylene or a bond and L^{8B} is a 3- to 6- membered saturated or unsaturated ring containing 0 to 3 heteroatoms selected from N, O, or S, wherein L^{8A} and L^{8C} connect to L^{8B} at two different ring atoms and L^{8B} is optionally substituted with 1-4 Z¹ groups;

L⁹ is C₂-C₈ alkynylene optionally substituted with 1-4 Z¹ groups;

15 L¹⁰ is C₁-C₈ alkylene or C₃-C₈ alkenylene substituted with two geminal Z¹ groups that come together to form a spiro 4-8 membered heterocyclyl group, wherein L¹⁰ is optionally substituted with 1-4 Z¹ groups;

U¹ is a C₆-C₁₄ membered arylene optionally substituted with 1-4 W groups;

20 U³ is a 4-14 membered heterocyclene optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

25 U⁴ is a 5 or 6 membered monocyclic heteroarylene containing 1, 2 or 3 heteroatoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

30 U⁵ is a 8, 9 or 10 membered fused bicyclic heteroarylene containing 1, 2 or 3 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁶ is a 11-14 membered fused tricyclic heteroarylene containing 1, 2, 3 or 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroarylene is optionally substituted with 1-4 W groups that are located on one or more ring atoms selected from C or N;

U⁷ is a 8-10 membered fused bicyclic heteroarylene containing 4 heteroatom ring atoms independently selected from N, O, or S, wherein said heteroaryl is optionally substituted with 1-2 W groups that are located on one or more ring atoms selected from C or N;

each W is independently W¹, W², W³, W⁴, W⁵, W⁶ or W⁷;

each W¹ is independently oxo, halogen, -OR⁶, C₁-C₆ alkyl, -CN, -CF₃, -SR⁶, -C(O)₂R⁶, -C(O)N(R⁶)₂, -C(O)R⁶, -N(R⁶)C(O)R⁶, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), C₃-C₈ carbocyclyl, C₃-C₈ cycloalkoxy, C₁-C₆ haloalkyl, -N(R⁶)₂, -NR⁶(C₁-C₆ alkyl)O(C₁-C₆ alkyl), halo(C₁-C₆ alkoxy), -NR⁶SO₂R⁶, -SO₂N(R⁶)₂, -NHCOOR⁶, -NHCONHR⁶, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl or -O(4-10 membered heterocyclyl), wherein said W¹ alkyl, carbocyclyl, cycloalkoxy, haloalkyl, haloalkoxy, aryl, heteroaryl, or heterocyclyl is optionally substituted with 1-4 Z^{1c} groups;

each R⁶ is independently H, C₆-C₁₀ aryl or C₁-C₆ alkyl, wherein said aryl or alkyl is optionally substituted with 1 to 4 substituents independently selected from halogen atoms, C₁-C₆ alkyl, C₆-C₁₀ aryl, C₃-C₈ carbocyclyl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, halo(C₁-C₆ alkoxy), -OH, -O(C₁-C₆ alkyl), -SH, -S(C₁-C₆ alkyl), -NH₂, -NH(C₁-C₆ alkyl), -N(C₁-C₆ alkyl)₂, -C(O)(C₁-C₆ alkyl), -SO₂N(C₁-C₆ alkyl)₂, -NHCOO(C₁-C₆ alkyl), -NHCO(C₁-C₆ alkyl), -NHCONH(C₁-C₆ alkyl), -CO₂(C₁-C₆ alkyl), or -C(O)N(C₁-C₆ alkyl)₂;

each W² is C₁-C₆ alkoxy substituted with a 5-14 membered heteroaryl or C₆-C₁₀ aryl; wherein said heteroaryl or aryl is substituted with 1-4 Z¹ groups;

each W^3 is C_2 - C_6 alkynyl group substituted with a C_6 - C_{10} aryl, C_3 - C_8 carbocyclyl, C_1 - C_8 alkyl, C_1 - C_6 haloalkyl, 4-10 membered heterocyclyl, or 5-14 membered heteroaryl group; wherein said aryl, carbocyclyl, alkyl, haloalkyl, heterocyclyl, or heteroaryl group is optionally substituted with 1-4 Z^1 groups;

each W^4 is $-SF_5$;

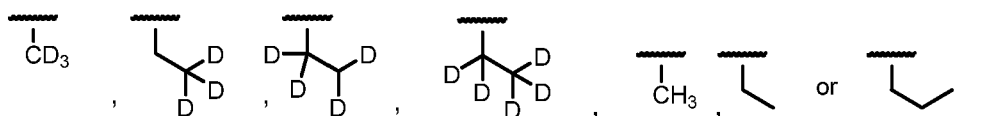
each W^5 is $-O(C_2-C_6 \text{ alkyl})OR^{22}$ wherein R^{22} is a C_6 - C_{10} aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl group optionally substituted with 1-4 Z^1 groups;

each W^6 is $-O(C_2-C_6 \text{ alkyl})NR^{16}R^{22}$ wherein R^{22} is an aryl, heteroaryl or heterocyclyl group optionally substituted with 1-4 Z^1 groups;

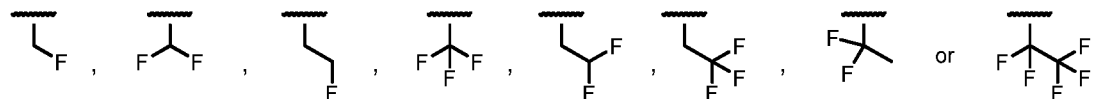
each W^7 is $-O(5-14 \text{ membered heteroaryl})$; wherein said $-O(5-14 \text{ membered heteroaryl})$ is optionally substituted with 1-4 Z^1 groups and 2 adjacent substituents of said $-O(5-14 \text{ membered heteroaryl})$ may be taken together to form a 3- to 6-membered cyclic ring containing 0 to 3 heteroatoms independently selected from N, O, or S;

E^1 is ;

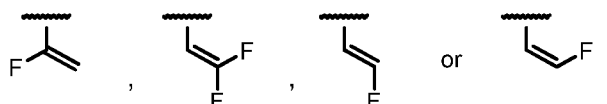
E^2 is



E^3 is



E^4 is



Q^1 is H, C_1 - C_8 alkyl, C_3 - C_8 carbocyclyl, C_6 - C_{10} aryl, 5-6 membered heteroaryl, or 5-6 membered heterocyclyl groups, wherein when Q^1

is not H, said Q^1 is optionally substituted with 1-4 substituents independently selected from halogen, $-OR^6$, $-SR^6$, $-N(R^6)_2$, C_6-C_{10} aryl, C_1-C_6 alkyl, C_1-C_6 haloalkyl, C_1-C_6 haloalkoxy, $-CN$, $-CF_3$, $-SO_2(C_1-C_6 \text{ alkyl})$, $-S(O)(C_1-C_6 \text{ alkyl})$, $-NR^6SO_2Z^2$, $-SO_2NR^{17}R^{18}$, $-NHCOOR^{16}$, $-NHCOZ^2$, $-NHCONHR^{16}$, $-CO_2R^6$, $-C(O)R^6$ or $-CON(R^6)_2$;

Q^2 is C_5-C_{10} spiro bicyclic carbocyclyl optionally substituted with 1-4 Z^1 groups;

Q^3 is C_5-C_{10} fused bicyclic carbocyclyl optionally substituted with 1-4 Z^1 groups;

Q^4 is C_5-C_{10} bridged bicyclic carbocyclyl optionally substituted with 1-4 Z^1 groups;

Q^5 is 4-membered heterocyclyl having 1 heteroatom selected from N, O or S wherein Q^5 is optionally substituted with 1-4 Z^3 groups;

Q^7 is C_3-C_8 carbocyclyl substituted with 4-8 F atoms and each carbon of Q^7 is substituted with 0-2 F atoms;

each Z^1 is independently oxo, halogen, C_1-C_8 alkyl, C_2-C_8 alkenyl, C_2-C_8 alkynyl, C_3-C_8 carbocyclyl, C_5-C_{10} bicyclic carbocyclyl, C_1-C_8 haloalkyl, C_6-C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-CN$, $-C(O)R^{16}$, $-C(O)OR^{16}$, $-C(O)NR^{17}R^{18}$, $-NR^{17}R^{18}$, $-NR^{16}C(O)R^{16}$, $-NR^{16}C(O)NR^{17}R^{18}$, $-NR^{16}S(O)_2R^{16}$, $-NR^{16}S(O)_2NR^{17}R^{18}$, $-NR^{16}S(O)_2OR^{16}$, $-OR^{16}$, $-OC(O)R^{16}$, $-OC(O)NR^{17}R^{18}$, $-SR^{16}$, $-S(O)R^{16}$, $-S(O)_2R^{16}$ or $-S(O)_2NR^{17}R^{18}$

wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of Z^1 is optionally substituted with 1-4 Z^{1a} groups;

each Z^{1a} is independently oxo, halogen, C_2-C_8 alkenyl, C_2-C_8 alkynyl, C_3-C_8 carbocyclyl, C_5-C_{10} bicyclic carbocyclyl, C_1-C_8 haloalkyl, C_6-C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-CN$, $-C(O)R^{16}$, $-C(O)OR^{16}$, $-C(O)NR^{17}R^{18}$, $-NR^{17}R^{18}$, $-NR^{16}C(O)R^{16}$, $-NR^{16}C(O)OR^{16}$, $-NR^{16}C(O)NR^{17}R^{18}$, $-NR^{16}S(O)_2R^{16}$, $-NR^{16}S(O)_2NR^{17}R^{18}$, $-NR^{16}S(O)_2OR^{16}$, $-OR^{16}$, $-OC(O)R^{16}$,

$-\text{OC}(\text{O})\text{NR}^{17}\text{R}^{18}$, $-\text{SR}^{16}$, $-\text{S}(\text{O})\text{R}^{16}$, $-\text{S}(\text{O})_2\text{R}^{16}$ or $-\text{S}(\text{O})_2\text{NR}^{17}\text{R}^{18}$

wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of Z^{1a} is optionally substituted with 1-4 Z^{1c} groups;

each R^{16} is independently H, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, $\text{C}_3\text{-C}_8$ carbocyclyl, $\text{C}_5\text{-C}_{10}$ bicyclic carbocyclyl, $\text{C}_6\text{-C}_{10}$ aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl, wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of R^{16} is optionally substituted with 1-4 Z^{1c} groups;

each Z^{1c} is independently oxo, halogen, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_3\text{-C}_8$ carbocyclyl, $\text{C}_5\text{-C}_{10}$ bicyclic carbocyclyl, $\text{C}_1\text{-C}_8$ haloalkyl, $\text{C}_6\text{-C}_{10}$ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-\text{CN}$, $-\text{C}(\text{O})(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{C}(\text{O})\text{O}(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{C}(\text{O})\text{N}(\text{C}_1\text{-C}_8 \text{ alkyl})_2$, $-\text{NH}_2$, $-\text{NH}(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{N}(\text{C}_1\text{-C}_8 \text{ alkyl})_2$, $-\text{NHC}(\text{O})\text{O}(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{NHC}(\text{O})(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{NHC}(\text{O})\text{NH}(\text{C}_1\text{-C}_8 \text{ alkyl})$, $-\text{OH}$, $-\text{O}(\text{C}_1\text{-C}_8 \text{ alkyl})$, $\text{C}_3\text{-C}_8$ cycloalkoxy, $\text{C}_5\text{-C}_{10}$ bicyclic carbocycloxy, $-\text{S}(\text{C}_1\text{-C}_8 \text{ alkyl})$ or $-\text{S}(\text{O})_2\text{N}(\text{C}_1\text{-C}_8 \text{ alkyl})_2$ wherein any alkyl, carbocyclyl, aryl, heteroaryl, heterocyclyl or cycloalkoxy portion of Z^{1c} is optionally substituted with 1-4 halogen atoms or $\text{C}_1\text{-C}_6$ alkoxy groups;

R^{17} and R^{18} are each independently H, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, $\text{C}_3\text{-C}_8$ carbocyclyl, $\text{C}_5\text{-C}_{10}$ bicyclic carbocyclyl, $-\text{C}(\text{O})\text{R}^{16}$, $-\text{C}(\text{O})\text{OR}^{16}$, $\text{C}_6\text{-C}_{10}$ aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl, wherein any alkyl, alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl of R^{17} or R^{18} is optionally substituted with 1-4 Z^{1c} groups, or R^{17} and R^{18} together with the nitrogen to which they are attached form a 4-7 membered heterocyclyl group, wherein said 4-7 membered heterocyclyl group is optionally substituted with 1-4 Z^{1c} groups;

each Z^2 is independently $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_3\text{-C}_8$ carbocyclyl, $\text{C}_5\text{-C}_{10}$ bicyclic carbocyclyl, $\text{C}_6\text{-C}_{10}$ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-\text{NR}^{17}\text{R}^{18}$ or $-\text{OR}^{16}$ wherein any alkyl,

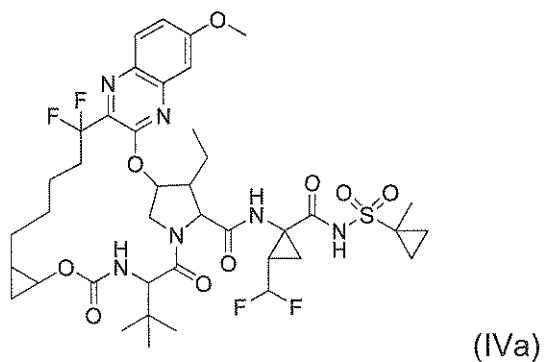
carbocyclyl, aryl, heteroaryl or heterocyclyl portion of Z^2 is optionally substituted with 1-4 Z^{2a} groups;

each Z^{2a} is independently oxo, halogen, C_1 - C_8 alkyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-(C_2-C_8 \text{ alkynyl})\text{aryl}$, $-(C_2-C_8 \text{ alkynyl})\text{heteroaryl}$, $-\text{CN}$, $-\text{C}(\text{O})(C_1-C_6 \text{ alkyl})$, $-\text{C}(\text{O})\text{O}(C_1-C_6 \text{ alkyl})$, $-\text{C}(\text{O})\text{N}(C_1-C_6 \text{ alkyl})_2$, $-\text{NH}_2$, $-\text{NH}(C_1-C_6 \text{ alkyl})$, $-\text{N}(C_1-C_6 \text{ alkyl})_2$, $-\text{NHC}(\text{O})\text{O}(C_1-C_6 \text{ alkyl})$, $-\text{NHC}(\text{O})(C_1-C_6 \text{ alkyl})$, $-\text{NHC}(\text{O})\text{NH}(C_1-C_6 \text{ alkyl})$, $-\text{OH}$, $-\text{O}(C_1-C_6 \text{ alkyl})$, halo(C_1-C_6 alkoxy), C_3 - C_8 cycloalkoxy, $-\text{S}(C_1-C_6 \text{ alkyl})$, or $-\text{SO}_2\text{N}(C_1-C_6 \text{ alkyl})_2$; wherein any alkyl, alkynyl, carbocyclyl, cycloalkoxy, aryl, heteroaryl or heterocyclyl portions of Z^{2a} is optionally substituted with 1-4 halogen or C_1 - C_6 alkoxy groups;

each Z^3 is independently oxo, halogen, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-\text{CN}$, $-\text{C}(\text{O})\text{OR}^{16}$, $-\text{C}(\text{O})\text{NR}^{17}\text{R}^{18}$, $-\text{NR}^{17}\text{R}^{18}$, $-\text{NR}^{16}\text{C}(\text{O})\text{NR}^{17}\text{R}^{18}$, $-\text{OR}^{16}$, $-\text{SR}^{16}$ or $-\text{SO}_2\text{R}^{16}$; wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z^3 is optionally substituted with 1-4 halogen; and

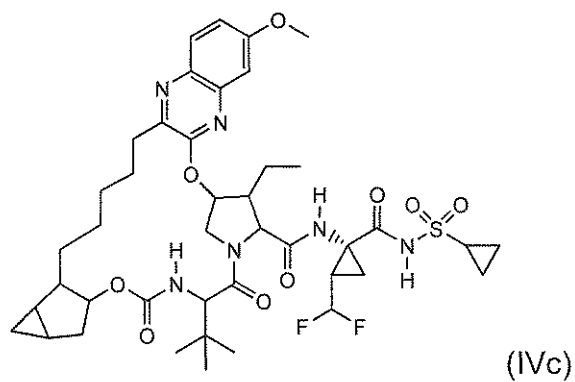
each Z^4 is independently oxo, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, C_3 - C_8 carbocyclyl, C_5 - C_{10} bicyclic carbocyclyl, C_1 - C_8 haloalkyl, C_6 - C_{10} aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, $-\text{CN}$, $-\text{C}(\text{O})\text{OR}^{16}$, $-\text{C}(\text{O})\text{NR}^{17}\text{R}^{18}$, $-\text{NR}^{17}\text{R}^{18}$, $-\text{NR}^{16}\text{C}(\text{O})\text{NR}^{17}\text{R}^{18}$, $-\text{OR}^{16}$, $-\text{SR}^{16}$ or $-\text{SO}_2\text{R}^{16}$, wherein any alkenyl, alkynyl, carbocyclyl, aryl, heteroaryl or heterocyclyl portions of Z^4 is optionally substituted with 1-4 halogen.

In one aspect, there is provided a compound of Formula IVa:



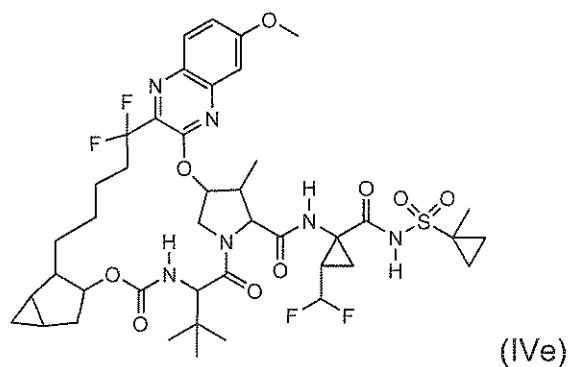
or a pharmaceutically acceptable salt thereof.

In one aspect, there is provided a compound of Formula IVc:



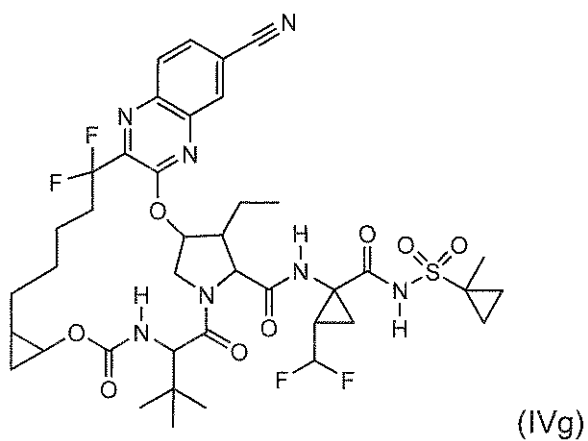
or a pharmaceutically acceptable salt thereof.

In one aspect, there is provided a compound of Formula IVe:



or a pharmaceutically acceptable salt thereof.

In one aspect, there is provided a compound of Formula IVg:



or a pharmaceutically acceptable salt thereof.

One embodiment provides a pharmaceutical composition comprising a compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a

stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier.

5 In one aspect, there is provided a pharmaceutical composition comprising a compound as described herein, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable excipient.

In one aspect, there is provided a pharmaceutical composition as described herein for use in treating hepatitis C virus infection.

10 One embodiment provides a method for treating a *Flaviviridae* viral infection (e.g., an HCV viral infection) in a patient in need thereof (e.g., mammal such as a human). The method includes administering a compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

15 One embodiment provides a method for inhibiting the proliferation of the HCV virus, treating HCV or delaying the onset of HCV symptoms in a patient in need thereof (e.g., mammal such as a human). The method includes administering a compound of Formula I, II, III, or IV (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

20 One embodiment provides a compound of Formula I, II, III, or IV (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof for use in medical therapy (e.g., for use in treating a *Flaviviridae* viral infection such as an HCV viral infection or in treating the proliferation of the HCV virus or delaying the onset of HCV symptoms in a patient in need thereof (e.g., mammal such as a human)).

25 In one aspect, there is provided a compound as described herein or a pharmaceutically acceptable salt thereof for use in medical therapy.

30 One embodiment provides a compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof for use in the manufacture of a medicament for treating a *Flaviviridae* viral infection (e.g., an HCV viral infection) or the proliferation of the HCV virus or delaying the onset of HCV symptoms in a patient in need thereof (e.g., mammal such as a human).

35 One embodiment provides a compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of the proliferation of a *Flaviviridae* virus, an HCV virus or for use in the therapeutic treatment of delaying the onset of HCV symptoms.

One embodiment provides a compound of Formula I, II, III, or IV (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of a *Flaviviridae* virus infection (e.g., an HCV virus infection).

In one aspect, there is provided a compound as described herein, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of a hepatitis C virus infection.

One embodiment provides the use of a compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for a *Flaviviridae* virus infection (e.g., an HCV virus infection) in a patient in need thereof (e.g., mammal such as a human).

One embodiment provides processes and intermediates disclosed herein that are useful for preparing compounds of Formula I, II, III, or IV (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or salts thereof.

Other embodiments, objects, features and advantages will be set forth in the detailed description of the embodiments that follows, and in part will be apparent from the description, or may be learned by practice, of the claimed invention. These objects and advantages will be realized and attained by the processes and compositions particularly pointed out in the written description and claims hereof. The foregoing Summary has been made with the understanding that it is to be considered as a brief and general synopsis of some of the embodiments disclosed herein, is provided solely for the benefit and convenience of the reader, and is not intended to limit in any manner the scope, or range of equivalents, to which the appended claims are lawfully entitled.

DETAILED DESCRIPTION

While the present invention is capable of being embodied in various forms, the description below of several embodiments is made with the understanding that the present disclosure is to be considered as an exemplification of the claimed subject matter, and is not intended to limit the appended claims to the specific embodiments illustrated. The headings used throughout this disclosure are provided for convenience only and are not to be construed to limit the claims

in any way. Embodiments illustrated under any heading may be combined with embodiments illustrated under any other heading.

Abbreviations

- 5 The following abbreviations are used throughout the specification, and have the following meanings:
- °C = degrees Celsius
- Å = Angstrom
- Ac = acetyl
- 10 AcOH = acetic acid
- aq = aqueous
- Ar = argon
- atm = atmosphere
- BEP = 2-bromo-1-ethyl pyridinium tetrafluoroborate
- 15 Bis(diphenylphosphino)ferrocene)palladium(II) dichloride
- Bn = benzyl
- Boc = *tert*-butoxy carbonyl
- Boc₂O = di-*tert*-butyl dicarbonate
- bp = boiling point
- 20 Bs = 4-bromophenylsulfonyl
- Bu = butyl
- calcd = calculated
- CBS = Corey-Bakshi-Shibata
- CBZ = Cbz = carboxybenzyl
- 25 CDI = 1,1'-carbonyldiimidazole
- cm = centimeter
- COMU = (1-cyano-2-ethoxy-2-oxoethylidenaminoxy)dimethylamino-morpholino-carbenium hexafluorophosphate
- DABCO = 1,4-diazabicyclo[2.2.2]octane
- 30 DBU = 1,8-diazabicycloundec-7-ene
- DCE = 1,2-dichloroethane

DCM = dichloromethane

DDQ = 2,3-dichloro-5,6-dicyanobenzoquinone

DIAD = diisopropyl azodicarboxylate

dioxane = 1,4-dioxane

5 DIPEA = *N,N*-diisopropyl-*N*-ethylamine

DMF = *N,N*-dimethylformamide

DMAP = 4-dimethylaminopyridine

DMPU = 1,3-dimethyl-3,4,5,6-tetrahydro-2(1H)-pyrimidinone

DMSO = dimethylsulfoxide

10 dppf = 1,1'-bis(diphenylphosphino)ferrocene

DSC = *N,N'*-disuccinimidyl carbonate

EA = EtOAc = ethyl acetate

EC₅₀ = half maximal effective concentration

EDC = 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide

15 Et = ethyl

Et₂O = diethyl ether

EtOAc = ethyl acetate

EtOH = ethanol

equiv = equivalent

20 F-NMR = fluorine nuclear magnetic resonance spectroscopy

g = gram

h = hr = hour

HATU = *O*-(7-azabenzotriazol-1-yl)-*N,N,N',N'*-tetramethyluronium
Hexafluorophosphate

25 HCV = hepatitis C virus

HEPES = hydroxyethyl piperazineethanesulfonic acid

Hex = hex = hexanes

HMDS = hexamethyldisilazane(azide)

HMPA = hexamethylphosphoramide

30 ¹H-NMR = proton nuclear magnetic resonance spectroscopy

HOAc = acetic acid

HOBT = hydroxybenzotriazole

HPLC = high pressure liquid chromatography

Hz = Hertz

IPA = isopropyl alcohol

5 i = iso

J = coupling constant

KHMDS = potassium bis(trimethylsilyl)amide

L = liter

LCMS-ESI⁺ = liquid chromatography mass spectrometer (electrospray ionization)

10 LiHMDS = lithium bis(trimethylsilyl)amide

M = molar concentration (mol/L)

*m*CPBA = *meta*-chloroperoxybenzoic acid

Me = methyl

MeCN = ACN = acetonitrile

15 MeOH = methanol

MeTHF = 2-methyltetrahydrofuran

mg = milligram

MHz = mega Hertz

mL = milliliter

20 mmol = millimole

min = minute

MTBE = methyl tert-butylether

Ms = methanesulfonyl

MsCl = methanesulfonyl chloride

25 MS = molecular sieves

MSA = methanesulfonic acid

n = normal

N = normal concentration

NCS = N-chlorosuccinimide

30 NMM = N-methylmorpholine

NMO = *N*-methylmorpholine-*N*-oxide

NMP = *N*-methylpyrrolidinone

o/n = overnight

PCR = polymerase chain reaction

Pf = 9-phenyl-9H-fluoren-9-yl

5 PG = protecting group

PE = petroleum ether

Ph = phenyl

PhMe = toluene

pM = picomolar

10 PMB = 4-methoxybenzyl

Pr = propyl

$\text{Pd(dppf)Cl}_2 = \text{PdCl}_2(\text{dppf}) = \text{PdCl}_2\text{dppf} = (1,1'$
bis(diphenylphosphino)ferrocene)dichloropalladium(II)

PPh_3 = triphenylphosphine

15 RetTime = retention time

rt = room temperature

sat = sat. = saturated

sec = secondary

$\text{S}_{\text{N}}1$ = nucleophilic substitution unimolecular

20 $\text{S}_{\text{N}}2$ = nucleophilic substitution bimolecular

$\text{S}_{\text{N}}\text{Ar}$ = nucleophilic substitution aromatic

t = tert = tertiary

TBAF = tetra-*n*-butylammonium fluoride

TBS = TBDMS = *tert*-Butyldimethylsilyl

25 TBTU = O-(benzotriazol-1-yl)-N,N,N',N'-tetramethyluronium tetrafluoroborate

TEA = triethylamine

temp = temperature

TEMPO = (2,2,6,6-Tetramethylpiperidin-1-yl)oxyl

Tf = trifluoromethanesulfonyl

30 TFA = trifluoroacetic acid

THF = tetrahydrofuran

TIPS = triisopropylsilyl

TLC = thin layer chromatography

TMS = trimethylsilyl

TMSOTf = trimethylsilyl trifluoromethanesulfonate

5 TPAP = tetrapropylammonium perruthenate

Tr = triphenylmethyl

Ts = *para*-toluenesulfonyl

wt = weight

w/w = weight/weight ratio

10

Definitions

Unless stated otherwise, the following terms and phrases as used herein are intended to have the following meanings:

15 When a cyclic group (*e.g.* cycloalkyl, carbocyclyl, bicyclic carbocyclyl, heteroaryl, heterocyclyl) is limited by a number or range of numbers, the number or numbers refer to the number of atoms making up the cyclic group, including any heteroatoms. Therefore, for example, a 4-8 membered heterocyclyl group has 4, 5, 6, 7 or 8 ring atoms.

20 "Alkenyl" refers to a straight or branched chain hydrocarbyl with at least one site of unsaturation, *e.g.*, a (sp^2)carbon-(sp^2)carbon double bond. For example, an alkenyl group can have 2 to 8 carbon atoms (*i.e.*, C₂-C₈ alkenyl), or 2 to 6 carbon atoms (*i.e.*, C₂-C₆ alkenyl). Examples of suitable alkenyl groups include, but are not limited to, ethylene or vinyl (-CH=CH₂) and allyl (-CH₂CH=CH₂).

25 "Alkenylene" refers to an alkene having two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different carbon atoms of a parent alkene. Exemplary alkenylene radicals include, but are not limited to, 1,2-ethenylene (-CH=CH-) or prop-1-enylene (-CH₂CH=CH-).

30 "Alkoxy" is RO- where R is alkyl, as defined herein. Non-limiting examples of alkoxy groups include methoxy, ethoxy and propoxy.

“Alkyl” refers to a saturated, straight or branched chain hydrocarbyl radical. For example, an alkyl group can have 1 to 8 carbon atoms (*i.e.*, (C₁-C₈) alkyl) or 1 to 6 carbon atoms (*i.e.*, (C₁-C₆ alkyl) or 1 to 4 carbon atoms. Examples of alkyl groups include, but are not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *t*-butyl, pentyl, hexyl, heptyl, octyl, nonyl and decyl.

“Alkylene” refers to an alkyl having two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different carbon atoms of a parent alkane. Examples of alkylene radicals include, but are not limited to, methylene (-CH₂-), ethylene (-CH₂CH₂-), propylene (-CH₂CH₂CH₂-) and butylene (-CH₂CH₂CH₂CH₂-).

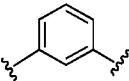
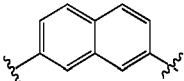
“Alkynyl” refers to a straight or branched chain hydrocarbon with at least one site of unsaturation, e.g., a (*sp*)carbon-(*sp*)carbon triple bond. For example, an alkynyl group can have 2 to 8 carbon atoms (C₂-C₈ alkyne) or 2 to 6 carbon atoms (C₂-C₆ alkynyl). Examples of alkynyl groups include, but are not limited to, acetylenyl (-C≡CH) and propargyl (-CH₂C≡CH) groups.

“Alkynylene” refers to an alkynyl having two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different carbon atoms of a parent alkyne. Typical alkynylene radicals include, but are not limited to, acetylene (-C≡C-), propargylene (-CH₂C≡C-), and 1-pentynylene (-CH₂CH₂CH₂C≡C-).

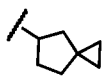
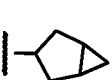
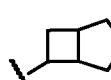
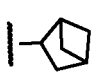
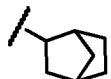
“Aryl” refers to a single all carbon aromatic ring or a multiple condensed all carbon ring system (e.g., a fused multicyclic ring system) wherein at least one of the rings is aromatic. For example, an aryl group can have 6 to 20 carbon atoms, 6 to 14 carbon atoms, or 6 to 12 carbon atoms. It is to be understood that the point of attachment of a multiple condensed ring system, as defined above, can be at any position of the ring system including an aromatic or a carbocyclyl portion of the ring. Examples of aryl groups include, but are not limited to, phenyl, naphthyl, tetrahydronaphthyl and indanyl.

“Arylene” refers to an aryl as defined herein having two monovalent radical centers derived by the removal of two hydrogen atoms from two different carbon

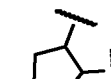
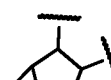
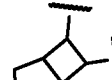
atoms of a parent aryl. Typical arylene radicals include, but are not limited to,

phenylene, e.g., , and naphthylene, e.g., .

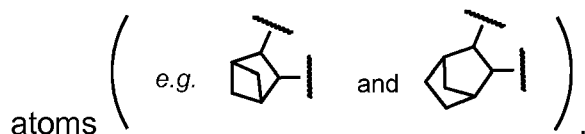
“Bicyclic carbocyclyl” refers to a 5-14 membered saturated or partially unsaturated bicyclic fused, bridged, or spiro ring hydrocarbon attached via a ring carbon. In a spiro bicyclic carbocyclyl, the two rings share a single common carbon atom. In a fused bicyclic carbocyclyl, the two rings share two common and adjacent carbon atoms. In a bridged bicyclic carbocyclyl, the two rings share three or more common, non-adjacent carbon atoms. Examples of bicyclic carbocyclyl groups include, but are not limited to spiro bicyclic carbocyclyl groups wherein two carbocyclyl rings share one common atom

(e.g.  and ), fused bicyclic carbocyclyl groups wherein two carbocyclyl rings share two common atoms (e.g.  and , and bridged bicyclic carbocyclyl groups wherein two carbocyclyl rings share three or more (such as 3, 4, 5 or 6) common atoms (e.g.  and .

“Bicyclic carbocyclylene” refers to a bicyclic carbocyclyl, as defined above, having two monovalent radical centers derived from the removal of two hydrogen atoms from the same or two different carbon atom of a parent bicyclic carbocyclyl. Examples of bicyclic carbocyclylene groups include, but are not limited to, spiro bicyclic carbocyclylene groups wherein two carbocyclyl rings

(e.g.  and , fused bicyclic carbocyclylene groups wherein two carbocyclyl rings share two common atoms (e.g.  and , and bridged bicyclic carbocyclylene groups

wherein two carbocyclyl rings share three or more (such as 3, 4, 5 or 6) common



“Carbocyclyloxy” is RO- where R is carbocyclyl, as defined herein.

5 “Bicyclic carbocyclyloxy” is RO- where R is bicyclic carbocyclyl, as defined herein.

“Carbocyclyl”, and “carbocycle” refers to a hydrocarbyl group containing one saturated or partially unsaturated ring structure, attached via a ring carbon.

In various embodiments, carbocyclyl refers to a saturated or a partially
10 unsaturated C₃-C₁₂ cyclic moiety, examples of which include cyclopropyl, cyclobutyl, cyclopentyl, cyclopentenyl, cyclohexyl, cyclohexenyl, cycloheptyl and cyclooctyl.

“Carbocyclylene” (as well as “carbocyclene”) refers to a carbocyclyl, as defined herein, having two monovalent radical centers derived by the removal of
15 two hydrogen atoms from the same or two different carbon atoms of a parent carbocyclyl. Examples of carbocyclylene include, but are not limited to, cyclopropylene, cyclobutylene, cyclopentylene and cyclohexylene.

“Carbocyclylalkyl” refers to a hydrocarbyl group containing one saturated or partially unsaturated ring structure attached to an alkyl group, attached via a ring
20 carbon or an alkyl carbon. In various embodiments, carbocyclylalkyl refers to a saturated or a partially unsaturated C₇-C₁₂ carbocyclylalkyl moiety, examples of which include cyclopropylalkyl, cyclobutylalkyl, cyclopropylethyl, and cyclopropylpropyl.

“Carbocyclylalkylene” refers to a carbocyclylalkyl, as defined herein, having
25 two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different carbon atoms of a parent cycloalkylalkyl. Examples of cycloalkylene include, but are not limited to, cyclopropylmethylene and cyclopropylmethylene.

“Cycloalkyl” refers to a hydrocarbyl group containing one saturated ring structure, attached via a ring carbon. In various embodiments, cycloalkyl refers to a saturated C₃-C₁₂ cyclic moiety, examples of which include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl and cyclooctyl.

5 “Cycloalkoxy” is RO- where R is cycloalkyl, as defined herein.

“Direct bond” refers a covalent bond between two atoms.

“Halo” or “halogen” refers to chloro (-Cl), bromo (-Br), fluoro (-F) or iodo (-I).

10 “Haloalkenyl” refers to alkenyl group, as defined herein, substituted with one or more halogen atoms.

“Haloalkoxy” refers to alkoxy, as defined herein, substituted with one or more halogen atoms.

15 “Haloalkyl” refers to an alkyl group, in which one or more hydrogen atoms of the alkyl group is replaced with a halogen atom. Examples of haloalkyl groups include, but are not limited to, -CF₃, -CHF₂, -CFH₂ and -CH₂CF₃.

“Haloalkylene” refers to alkylene group, as defined herein, substituted with one or more halogen atoms.

“Heteroalkyl” refers to an alkyl group, as defined herein, in which one or more carbon atoms is replaced with an oxygen, sulfur, or nitrogen atom.

20 “Heteroalkylene” refers to an alkylene group, as defined herein, in which one or more carbon atoms is replaced with an oxygen, sulfur, or nitrogen atom.

“Heteroalkenyl” refers to an alkenyl group, as defined herein, in which one or more carbon atoms is replaced with an oxygen, sulfur, or nitrogen atom.

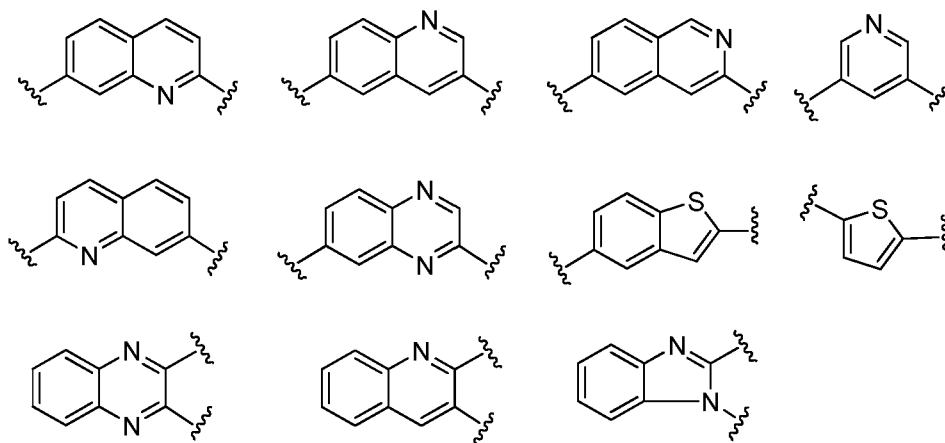
25 “Heteroalkenylene” refers to heteroalkenyl group, as defined above, having two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different atoms of a parent heteroalkenyl group.

30 “Heteroaryl” refers to a single aromatic ring that has at least one atom other than carbon in the ring, wherein the atom is selected from the group consisting of oxygen, nitrogen and sulfur; the term also includes multiple condensed ring systems that have at least one such aromatic ring. For example, heteroaryl includes monocyclic, bicyclic or tricyclic ring having up to 6 atoms in

each ring, wherein at least one ring is aromatic and contains from 1 to 4 heteroatoms in the ring selected from the group consisting of oxygen, nitrogen and sulfur. The rings of the multiple condensed ring system can be connected to each other via fused, spiro and bridged bonds when allowed by valency

5 requirements. Non-limiting examples of heteroaryl include pyridyl, thienyl, furanyl, pyrimidyl, imidazolyl, pyranyl, pyrazolyl, thiazolyl, thiadiazolyl, isothiazolyl, oxazolyl, isoxazolyl, pyrrolyl, pyridazinyl, pyrazinyl, quinoliny, isoquinoliny, quinoxaliny, benzofuranyl, dibenzofuranyl, dibenzothiophenyl, benzothienyl, indolyl, benzothiazolyl, benzooxazolyl, benzimidazolyl, isoindolyl,
10 benzotriazolyl, purinyl, thianaphthenyl and pyrazinyl. Attachment of heteroaryl can occur via an aromatic ring, or, if heteroaryl is bicyclic or tricyclic and one of the rings is not aromatic or contains no heteroatoms, through a non-aromatic ring or a ring containing no heteroatoms. "Heteroaryl" is also understood to include the N-oxide derivative of any nitrogen containing heteroaryl.

15 "Heteroarylene" refers to a heteroaryl, as defined above, having two monovalent radical centers derived by the removal of two hydrogen atoms from the same or two different carbon atoms or the removal of a hydrogen from one carbon atom and the removal of a hydrogen atom from one nitrogen atom of a parent heteroaryl group. Non-limiting examples of heteroarylene groups are:



20

"Heterocyclyl" refers to a saturated or partially unsaturated monocyclic, bicyclic or tricyclic group of 2 to 14 ring-carbon atoms and, in addition to ring-carbon atoms, 1 to 4 heteroatoms selected from nitrogen, oxygen and sulfur. Bi- or tricyclic heterocyclyl groups may have fused, bridged, or spiro ring

connectivity. In various embodiments the heterocyclic group is attached to another moiety through carbon or through a heteroatom. Examples of heterocyclyl include without limitation azetidiny, oxazoliny, isoxazoliny, oxetany, tetrahydropyrany, tetrahydrothiopyrany, tetrahydroisoquinoliny, 1,4-dioxany, pyrrolidiny, morpholiny, thiomorpholiny, dihydrobenzoimidazolyl, dihydrobenzofurany, dihydrobenzothiophenyl, dihydrobenzoxazolyl, dihydrofuranly, dihydroimidazolyl, dihydroindolyl, dihydroisooxazolyl, dihydroisothiazolyl, dihydrooxadiazolyl, dihydrooxazolyl, dihydropyrazinyl, dihydropyrazolyl, dihydropyridiny, dihydropyrimidiny, dihydropyrroly, dihydroquinoliny, dihydrotetrazolyl, dihydrothiadiazolyl, dihydrothiazolyl, dihydrothienyl, dihydrotriazolyl, dihydroazetidiny, methylenedioxybenzoyl, chromany, dihydropyranoquinoxaliny, tetrahydroquinoxaliny, tetrahydroquinoliny, dihydropyranoquinoliny and tetrahydrothienyl and N-oxides thereof. A spiro bicyclic heterocyclyl group refers to a bicyclic heterocyclyl group wherein the two rings of the bicyclic heterocyclyl group share one common atom. A fused bicyclic heterocyclyl group refers to a bicyclic heterocyclyl group wherein the two rings of the bicyclic heterocyclyl group share two common atoms. A bridged bicyclic heterocyclyl group refers to a bicyclic heterocyclyl group wherein the two rings of the bicyclic heterocyclyl group share three or more (such as 3, 4, 5 or 6) common atoms.

“Heterocyclene” refers to a heterocyclyl, as defined herein, having two monovalent radical centers derived from the removal of two hydrogen atoms from the same or two different carbon atoms, through a carbon and a heteroatom, or through two heteroatoms of a parent heterocycle.

“Prodrug” refers to any compound that when administered to a biological system generates the drug substance, or active ingredient, as a result of spontaneous chemical reaction(s), enzyme catalyzed chemical reaction(s), photolysis, and/or metabolic chemical reaction(s). A prodrug is thus a covalently modified analog or latent form of a therapeutically active compound. Non-limiting examples of prodrugs include ester moieties, quaternary ammonium moieties, glycol moieties, and the like.

The term “optionally substituted” refers to a moiety wherein all substituents are hydrogen or wherein one or more of the hydrogens of the moiety are replaced by non-hydrogen substituents; that is to say the moiety that is optionally substituted is either substituted or unsubstituted.

5 “Leaving group” (LG) refers to a moiety of a compound that is active towards displacement or substitution in a chemical reaction. Examples of in which such as displacement or substitution occur include, but are not limited to, nucleophilic substitution bimolecular (S_N2), nucleophilic substitution unimolecular (S_N1), nucleophilic aromatic substitution (S_NAr), and transition metal catalyzed
10 cross-couplings. Examples of leaving groups include, but are not limited to, a halogen atom (e.g. -Cl, -Br, -I) and sulfonates (e.g. mesylate (-OMs), tosylate (-OTs) or triflate (-OTf)). The skilled artisan will be aware of various chemical leaving groups and strategies for activation and will appreciate the appropriate moiety that will act as leaving groups, based on the particular chemical reaction,
15 the functionality that the group is attached to, and the chemical reagents used to affect the displacement or substitution reaction. As a non-limiting example, in some situations, a halogen atom (e.g. -Cl, -Br, or -I) serves as a leaving group in a reaction catalyzed by a transition metal (e.g. Pd catalyzed Suzuki coupling between an aryl halide and aryl boronic acid) and another reagents such as a
20 base.

Stereoisomers

Stereochemical definitions and conventions used herein generally follow S. P. Parker, Ed., *McGraw-Hill Dictionary of Chemical Terms* (1984) McGraw-Hill Book Company, New York; and Eliel, E. and Wilen, S., *Stereochemistry of*
25 *Organic Compounds* (1994) John Wiley & Sons, Inc., New York.

The term “chiral” refers to molecules which have the property of non-superimposability of the mirror image partner, while the term “achiral” refers to molecules which are superimposable on their mirror image partner.

“Isomers” are different compounds that have the same molecular formula.
30 Isomers include stereoisomers, enantiomers and diastereomers.

“Diastereoisomers” are stereoisomers that have at least two asymmetric atoms, but which are not mirror-images of each other.

“Enantiomers” are a pair of stereoisomers that are non-superimposable mirror images of each other. A 1:1 mixture of a pair of enantiomers is a “racemic” mixture. The term “(±)” is used to designate a racemic mixture where appropriate.

The term “stereoisomers” refers to compounds which have identical chemical constitution, but differ with regard to the arrangement of the atoms or groups in space.

The compounds disclosed herein may have chiral centers, e.g., chiral carbon atoms. Such compounds thus include racemic mixtures of all stereoisomers, including enantiomers, diastereomers, and atropisomers. In addition, the compounds disclosed herein include enriched or resolved optical isomers at any or all asymmetric, chiral atoms. In other words, the chiral centers apparent from the depictions are provided as the chiral isomers or racemic mixtures. Both racemic and diastereomeric mixtures, as well as the individual optical isomers isolated or synthesized, substantially free of their enantiomeric or diastereomeric partners, are all within the scope of the invention. The racemic mixtures can be separated into their individual, substantially optically pure isomers through well-known techniques such as, for example, the separation of diastereomeric salts formed with optically active adjuncts, e.g., acids or bases followed by conversion back to the optically active substances. The desired optical isomer can also be synthesized by means of stereospecific reactions, beginning with the appropriate stereoisomer of the desired starting material.

It is to be understood that for compounds disclosed herein when a bond is drawn in a non-stereochemical manner (e.g., flat) the atom to which the bond is attached includes all stereochemical possibilities. It is also to be understood that when a bond is drawn in a stereochemical manner (e.g., bold, bold-wedge, dashed or dashed-wedge) the atom to which the stereochemical bond is attached has the stereochemistry as shown unless otherwise noted.

Accordingly, in one embodiment, a compound disclosed herein is greater than 50% a single enantiomer. In another embodiment, a compound disclosed herein

is at least 80% a single enantiomer. In another embodiment, a compound disclosed herein is at least 90% a single enantiomer. In another embodiment, a compound disclosed herein is at least 98% a single enantiomer. In another embodiment, a compound disclosed herein is at least 99% a single enantiomer.

- 5 In another embodiment, a compound disclosed herein is greater than 50% a single diastereomer. In another embodiment, a compound disclosed herein is at least 80% a single diastereomer. In another embodiment, a compound disclosed herein is at least 90% a single diastereomer. In another embodiment, a compound disclosed herein is at least 98% a single diastereomer. In another embodiment, a compound disclosed herein is at least 99% a single diastereomer.
- 10

Tautomers

- The compounds disclosed herein can also exist as tautomeric isomers in certain cases. Although only one delocalized resonance structure may be depicted, all such forms are contemplated within the scope of the invention. For example, ene-amine tautomers can exist for purine, pyrimidine, imidazole, guanidine, amidine, and tetrazole systems and all their possible tautomeric forms are within the scope of the invention.
- 15

Isotopes

- It is understood by one skilled in the art that this invention also includes any compound claimed that may be enriched at any or all atoms above naturally occurring isotopic ratios with one or more isotopes such as, but not limited to, deuterium (^2H or D). As a non-limiting example, a $-\text{CH}_3$ group may be replaced by $-\text{CD}_3$.
- 20

- Specific values listed below for radicals, substituents, and ranges are for illustration only; they do not exclude other defined values or other values within defined ranges for the radicals and substituents.
- 25

Protecting Groups

In certain embodiments, protecting groups include prodrug moieties and chemical protecting groups. Protecting groups may be represented by the

abbreviation "PG."

"Protecting group" ("PG") refers to a moiety of a compound that masks or alters the properties of a functional group or the properties of the compound as a whole. Chemical protecting groups and strategies for protection/deprotection are well known in the art. See e.g. Peter G. M. Wuts and Theodora W. Greene, *Protective Groups in Organic Synthesis*, 4th edition; John Wiley & Sons, Inc.: New Jersey, 2007. See also Kocienski, P.J. *Protecting Groups*, 3rd edition; Georg Thieme Verlag Stuttgart: New York, 2005, in particular Chapter 1, Protecting Groups: An Overview, pages 1-48, Chapter 2, Carbonyl Protecting Groups, pages 49-118, Chapter 3, Diol Protecting Groups, pages 119-186, Chapter 4, Hydroxyl Protecting Groups, pages 187-364, Chapter 5, Thiol Protecting Groups, pages 365-392. Protecting groups are often utilized to mask the reactivity of certain functional groups, to assist in the efficiency of desired chemical reactions, e.g., making and breaking chemical bonds in an ordered and planned fashion.

Protection of functional groups of a compound alters other physical properties besides the reactivity of the protected functional group, such as the polarity, lipophilicity (hydrophobicity), and other properties which can be measured by common analytical tools. Chemically protected intermediates may themselves be biologically active or inactive.

In certain embodiments, protecting groups are optionally employed to prevent side reactions with the protected group during synthetic procedures. Selection of the appropriate groups to protect, when to do so, and the nature of the chemical protecting group "PG" is dependent upon the chemistry of the reaction to be protected against (e.g., acidic, basic, oxidative, reductive or other conditions) and the intended direction of the synthesis. PGs do not need to be, and generally are not, the same if the compound is substituted with multiple PG. In general, PG will be used to protect functional groups such as carboxyl, hydroxyl, thio, or amino groups and to thus prevent side reactions or to otherwise facilitate the synthetic efficiency. The order of deprotection to yield free deprotected groups is dependent upon the intended direction of the synthesis

and the reaction conditions to be encountered, and may occur in any order as determined by the artisan.

Salts and Hydrates

Examples of pharmaceutically acceptable salts of the compounds

5 disclosed herein include salts derived from an appropriate base, such as an alkali metal (for example, sodium), an alkaline earth metal (for example, magnesium), ammonium and NX_4^+ (wherein X is C_1 – C_4 alkyl). Pharmaceutically acceptable salts of a nitrogen atom or an amino group include for example salts of organic carboxylic acids such as acetic, benzoic, lactic, fumaric, tartaric, maleic, malonic, 10 malic, isethionic, lactobionic and succinic acids; organic sulfonic acids, such as methanesulfonic, ethanesulfonic, benzenesulfonic and p-toluenesulfonic acids; and inorganic acids, such as hydrochloric, hydrobromic, sulfuric, phosphoric and sulfamic acids. Pharmaceutically acceptable salts of a compound of a hydroxy group include the anion of said compound in combination with a suitable cation 15 such as Na^+ and NX_4^+ (wherein each X is independently selected from H or a C_1 – C_4 alkyl group).

For therapeutic use, salts of active ingredients of the compounds disclosed herein will typically be pharmaceutically acceptable, i.e., they will be salts derived from a physiologically acceptable acid or base. However, salts of 20 acids or bases which are not pharmaceutically acceptable may also find use, for example, in the preparation or purification of a compound of Formula I, II, III or IV, (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or another compound disclosed herein. All salts, whether or not derived from a physiologically acceptable acid or base, are within the scope of 25 the present invention.

Metal salts typically are prepared by reacting the metal hydroxide with a compound disclosed herein. Examples of metal salts which are prepared in this way are salts containing Li^+ , Na^+ , and K^+ . A less soluble metal salt can be precipitated from the solution of a more soluble salt by addition of the suitable 30 metal compound.

In addition, salts may be formed from acid addition of certain organic and inorganic acids, e.g., HCl, HBr, H₂SO₄, H₃PO₄ or organic sulfonic acids, to basic centers, such as amines. Finally, it is to be understood that the compositions herein comprise compounds disclosed herein in their un-ionized, as well as zwitterionic form, and combinations with stoichiometric amounts of water as in hydrates.

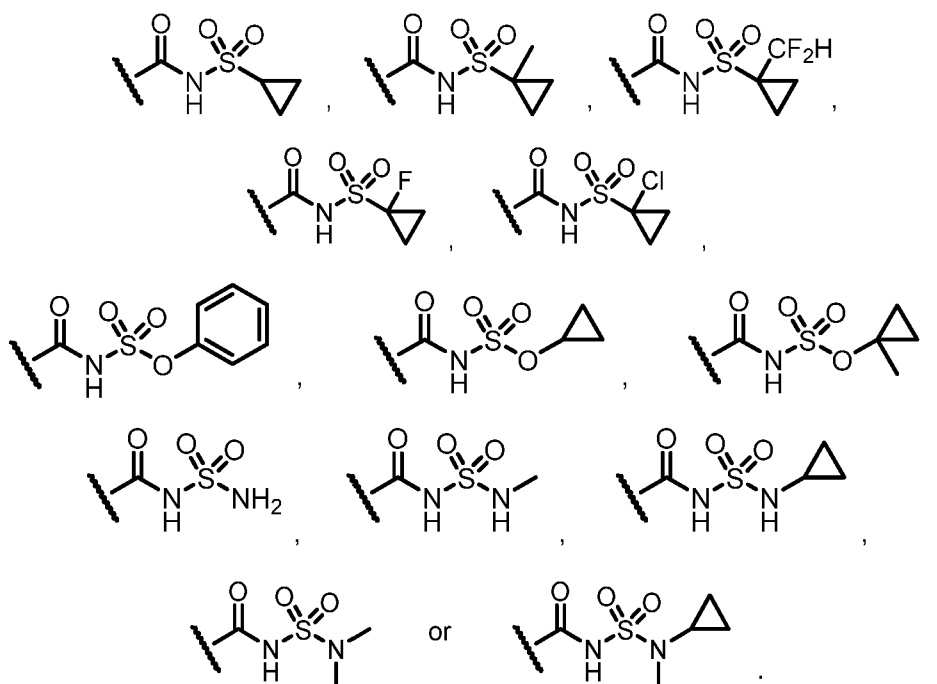
Embodiments

In certain embodiments, A is -C(O)-, 6-10 membered arylene, or 5-6 membered heteroarylene group, wherein said arylene or heteroarylene is optionally substituted with 1-4 halogens or haloalkyl groups. In some embodiments, A is -C(O)-.

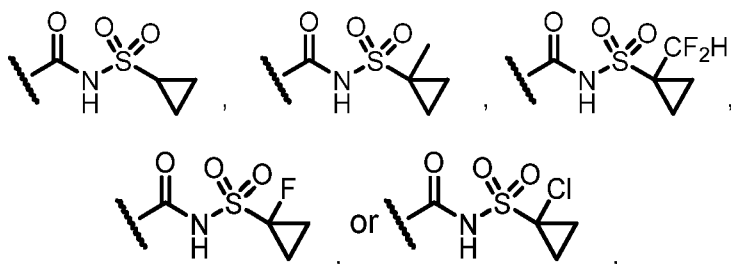
In certain embodiments, M is -O- or a bond. In some embodiments, M is -O-.

In certain embodiments, G is -CO₂H or -CONHSO₂Z². In some embodiments, G is -CONHSO₂Z². In some embodiments, G is -CONHSO₂Z² and Z² is cyclopropyl optionally substituted with methyl.

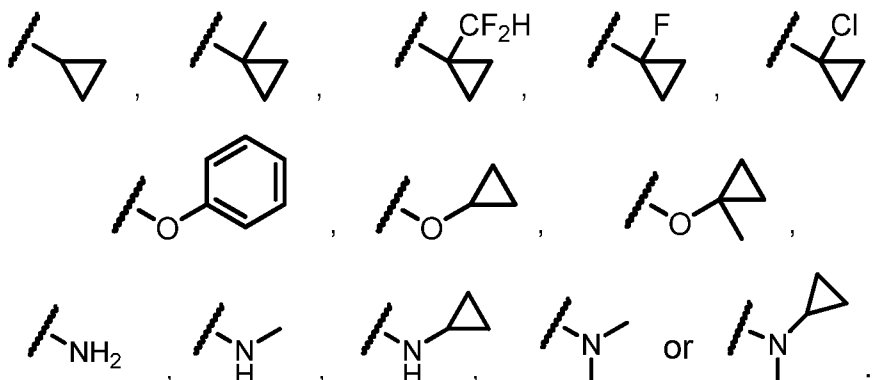
In certain embodiments, G is:



In some embodiments, G is:



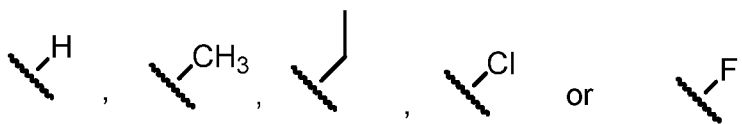
In certain embodiments, Z^2 is:

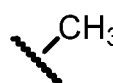


In certain embodiments, Z^2 is:



10 In certain embodiments, Z^{2a} is hydrogen, halogen or methyl. In some embodiments, Z^{2a} is:



In other embodiments, Z^{2a} is  or  (i.e., hydrogen or methyl).

In other embodiments, Z^{2a} is .

15 In still more embodiments, Z^{2a} is  (i.e., methyl).

In certain embodiments, one of R^3 , R^4 , and R^5 is Z^1 and the other two are H. In some embodiments, R^3 , R^4 and R^5 are each H.

In certain embodiments, X is -OC(O)-, -O-, or a direct bond. In some embodiments, X is -O-.

In certain embodiments, X is -OC(O)-, -O-, or a direct bond. In certain other embodiments, X is -O-.

5 In certain embodiments, $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as IVa-IVh) through two adjacent carbons, wherein said C₃-C₅ carbocyclylene is optionally substituted with C₁-C₄ alkyl or C₁-C₃ haloalkyl.

10 In certain embodiments, $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons, wherein the C₃-C₅ carbocyclylene is optionally substituted with methyl, ethyl or trifluoromethyl. In some embodiments, $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons.

15 In certain embodiments, $\textcircled{\text{T}}$ is C₃-C₆ cycloalkyl that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons, wherein the C₃-C₅ cycloalkyl is optionally substituted with methyl, ethyl or trifluoromethyl. In some embodiments, $\textcircled{\text{T}}$ is C₃-C₆ cycloalkyl that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons.

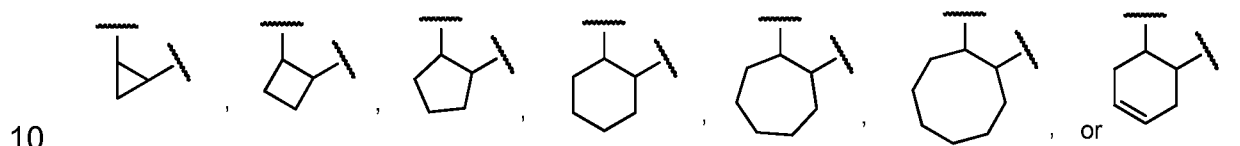
In certain embodiments, $\textcircled{\text{T}}$ is cyclopropyl optionally substituted with methyl or trifluoromethyl.

25 In certain embodiments, $\textcircled{\text{T}}$ is C₆-C₈ bridged bicyclic carbocyclylene or C₆-C₈ bridged fused carbocyclylene that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons.

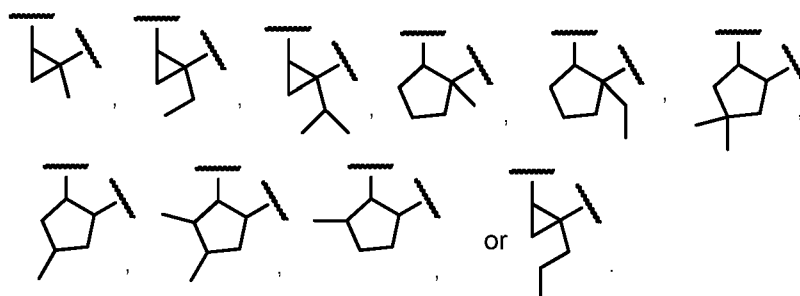
In certain embodiments, $\textcircled{\text{T}}$ is C₆-C₈ bridged bicyclic cycloalkyl or C₆-C₈ bridged fused cycloalkyl that is attached to L and to the remainder of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh) through two adjacent carbons.

- 5 In some embodiments, $\textcircled{\text{T}}$ is T¹, T², T³, T⁴, T⁵, T⁸, T⁹, T¹⁰, T¹¹, or T¹². In certain embodiments, $\textcircled{\text{T}}$ is T¹, T², T³, T⁴, T⁹, T¹⁰, T¹¹ or T¹⁴. In some embodiments, $\textcircled{\text{T}}$ is T¹, T², or T³, optionally substituted with 1-4 Z¹ groups which are the same or different.

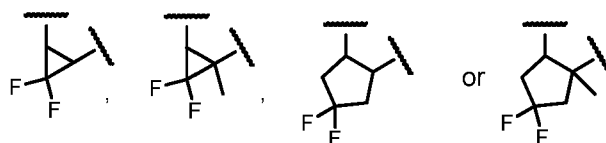
In some embodiments, T¹ is



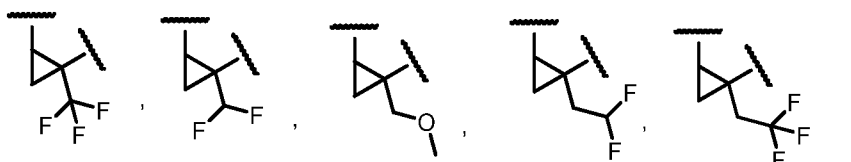
In some embodiments, T² is

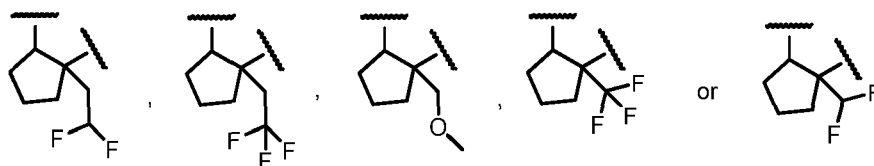


In some embodiments, T³ is

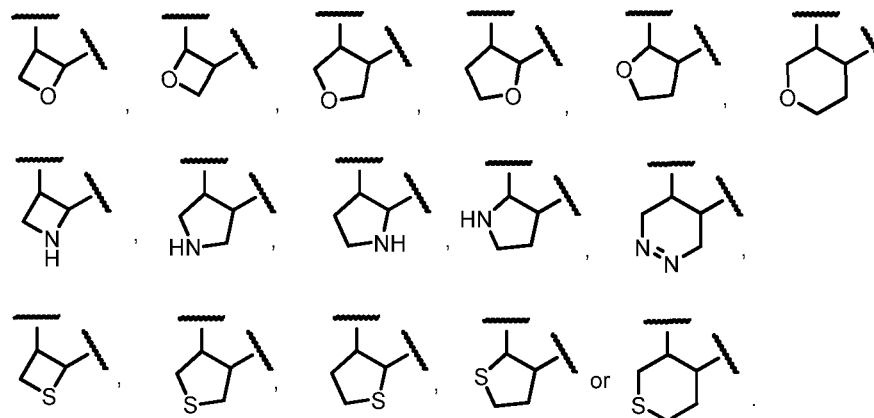


- 15 In some embodiments, T⁴ is

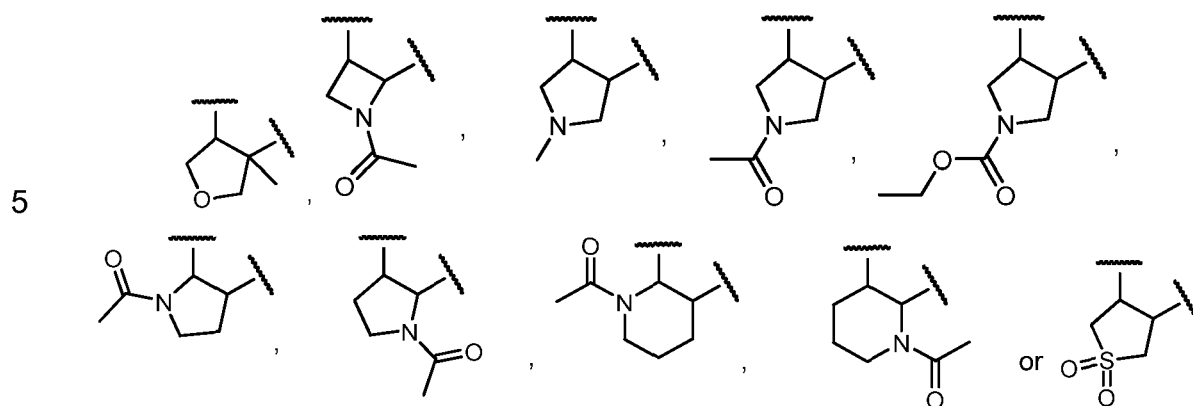




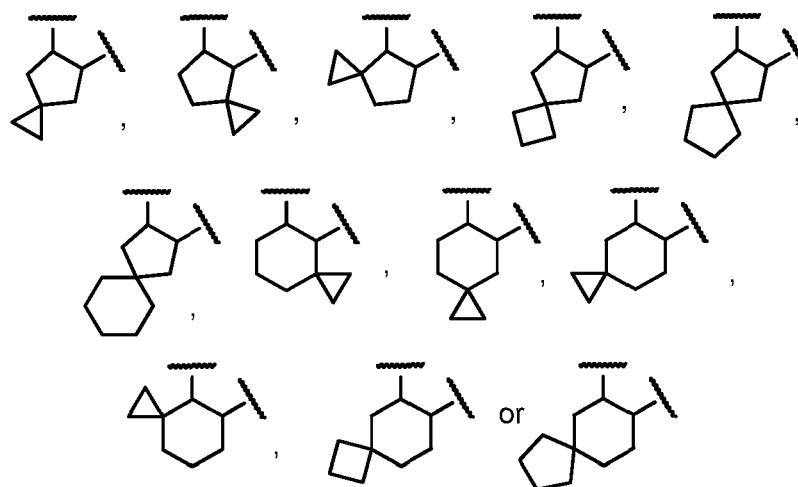
In some embodiments, T⁵ is



In some embodiments, T⁸ is

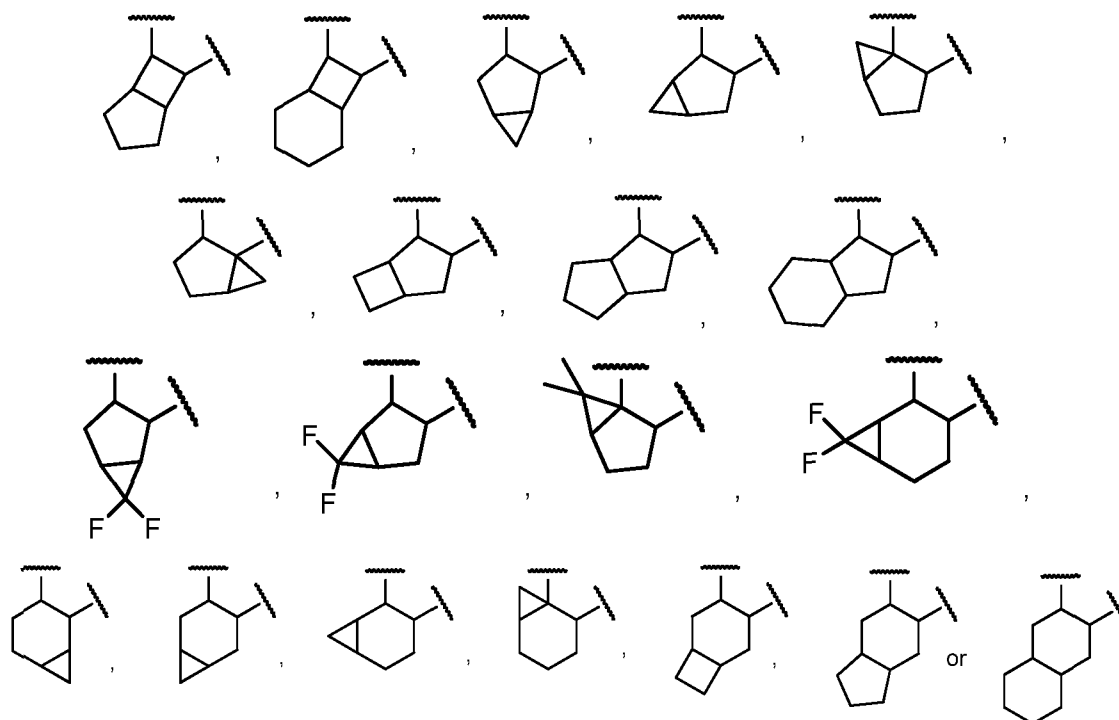


In some embodiments, T⁹ is



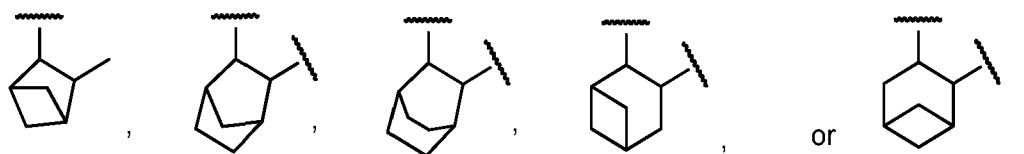
10

In some embodiments, T¹⁰ is

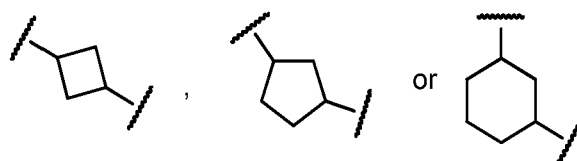


5

In some embodiments, T¹¹ is

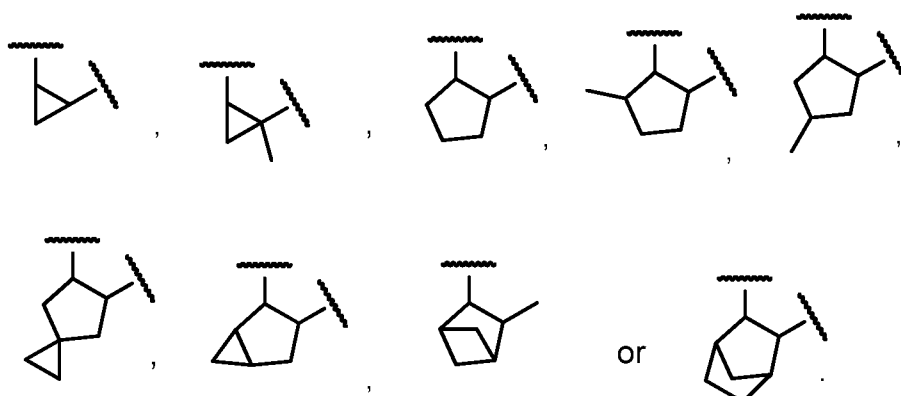


In some embodiments, T¹² is

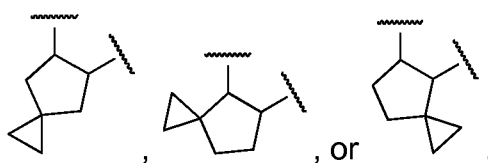


10

In other embodiments, $\textcircled{\text{T}}$ is

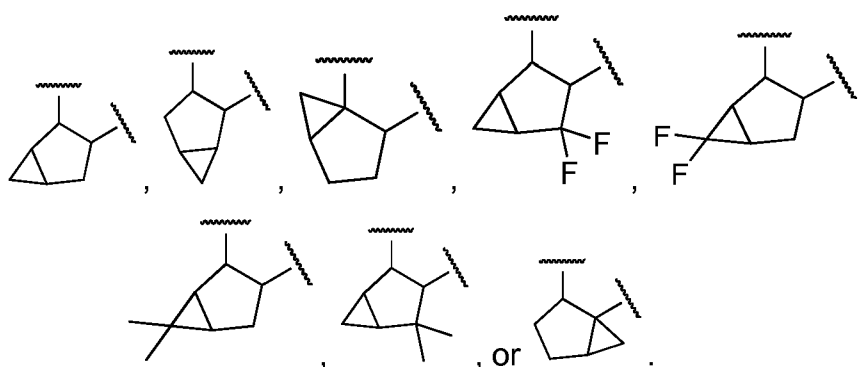


In certain embodiments, T^1 is:

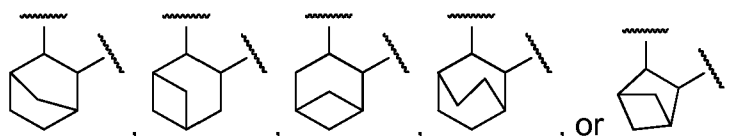


5

In certain embodiments, T^2 is:



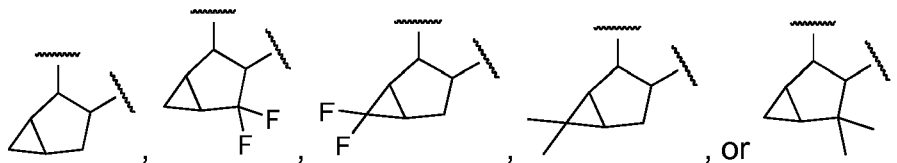
In certain embodiments, T^3 is:



10

In certain embodiments, $\textcircled{\text{T}}$ is T^2 , which is optionally substituted with 1-4 Z^1 groups, which are the same or different.

In certain embodiments, T^2 is:



In certain embodiments, $\textcircled{T}$ is , , , or .

In other embodiments, $\textcircled{T}$ is .

5

In other embodiments, $\textcircled{T}$ is .

In other embodiments, $\textcircled{T}$ is .

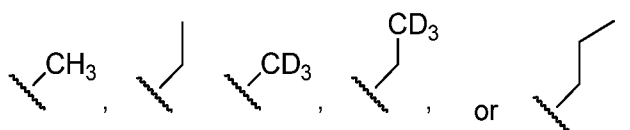
In certain embodiments, T^2 is: .

In certain embodiments, T^2 is: .

10 In certain embodiments, T^2 is: (a stereoisomer of bicyclo[3.1.0]hexanylene).

In certain embodiments, J is J^1 , J^4 , J^5 or J^8 . In other embodiments, J is J^4 .
In certain embodiments, J is J^5 .

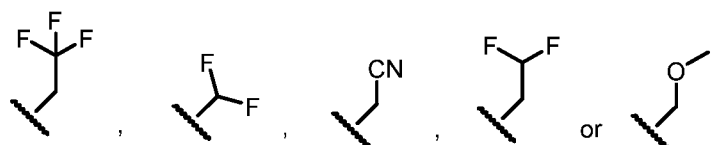
In further embodiments, J^4 is



In other embodiments, J is .

In other embodiments, J is .

In other embodiments, J⁵ is



5

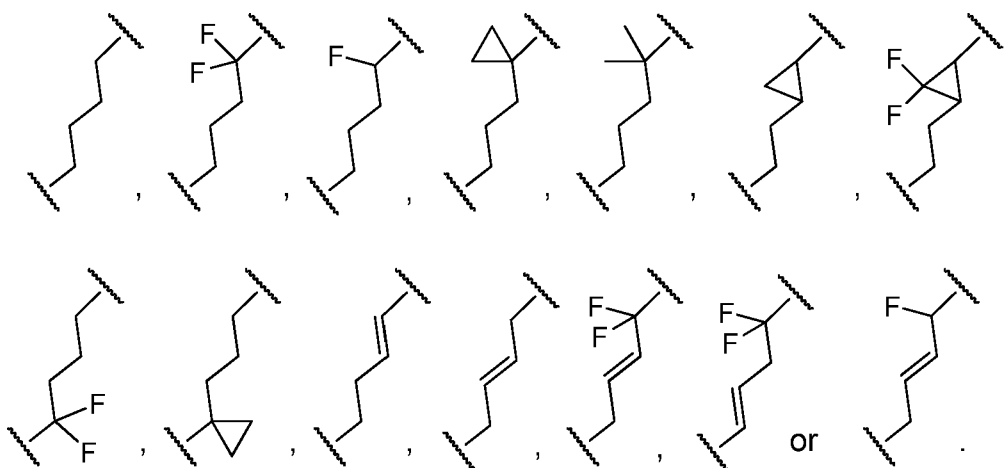
In certain embodiments, J is C₁-C₃ alkyl. In certain embodiments, J is methyl or ethyl. In further other embodiments, J is -CH₂-CH₃.

In some embodiments, L is L¹, L², L³, L⁴, L⁵, L⁶, L⁷, L⁸ or L⁹. In one
10 embodiment, L is L¹, L², L³, L⁴, L⁵ or L⁶. In certain embodiments, L is L¹ or L².

In some embodiments, L is C₃-C₆ alkylene, substituted with 1-4 halogens.

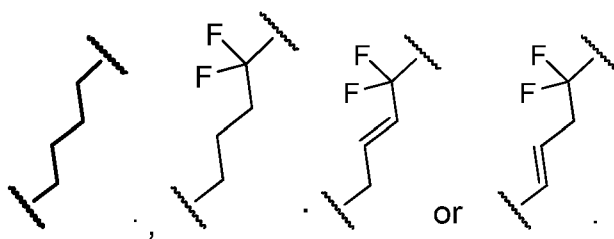
In some embodiments, L is C₅ alkylene, substituted with two halogens. In some embodiments, the halogens of L are each fluoro.

In certain embodiments, L is:

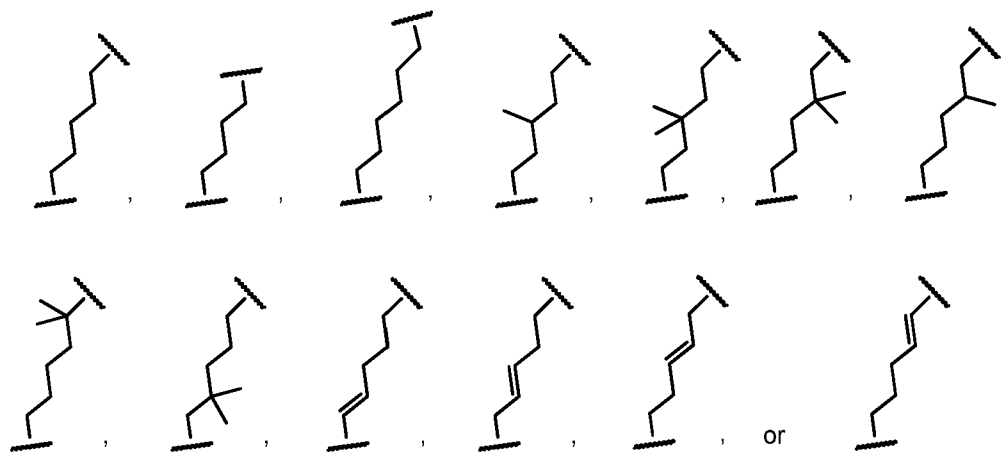


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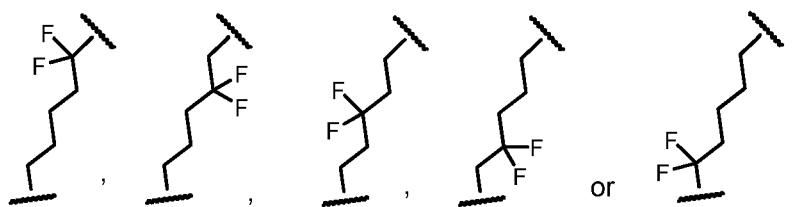
In certain other embodiments, L is



In some embodiments, L^1 is:

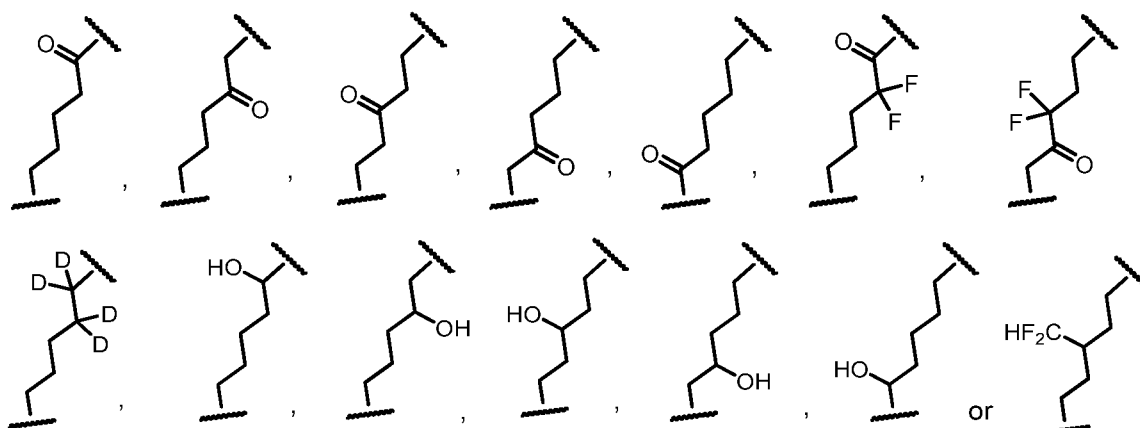


In some embodiments, L^2 is:

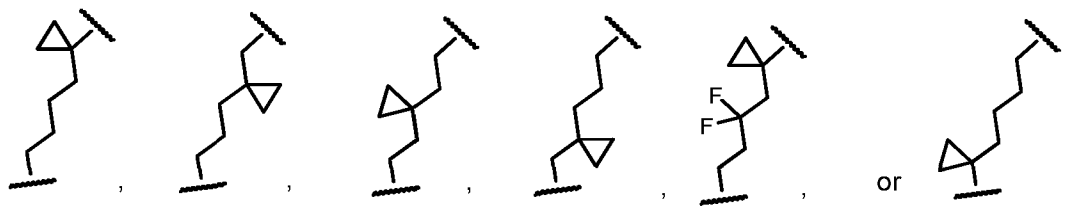


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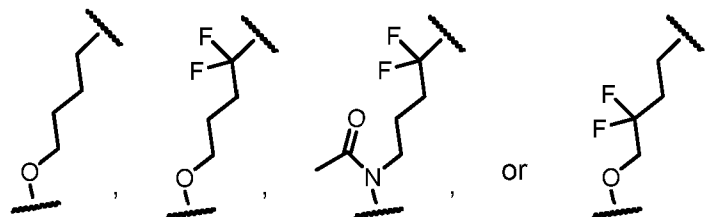
In some embodiments, L^3 is



In some embodiments, L⁴ is

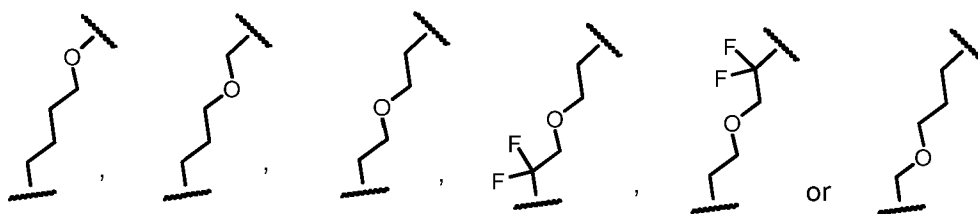


In some embodiments, L⁵ is

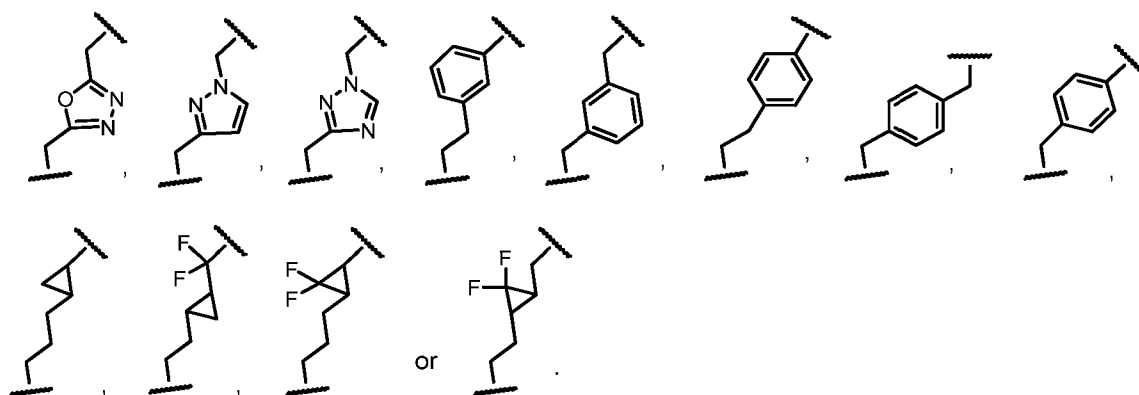


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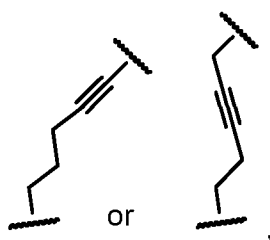
In some embodiments, L⁶ is



In some embodiments, L⁷ is

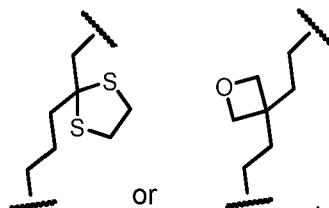


In some embodiments, L⁸ is



10

In some embodiments, L⁹ is

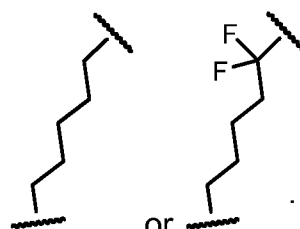


In other embodiments, L is



5

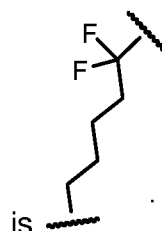
In further embodiments, L is



In further embodiments, L is



In still more embodiments, L is



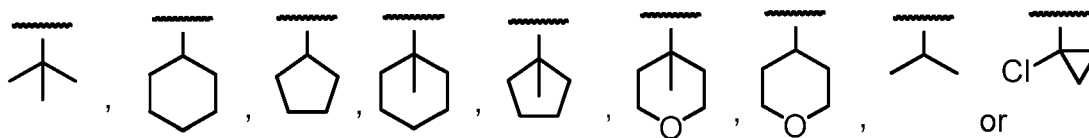
In other embodiments, L is



10

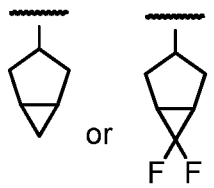
In some embodiments, Q is Q¹, Q², Q³, Q⁴, Q⁵ or Q⁷

In some embodiments, Q¹ is

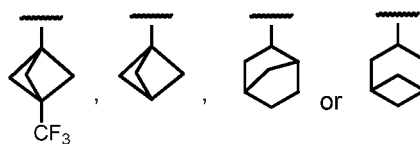


In some embodiments, Q^2 is

In some embodiments, Q^3 is

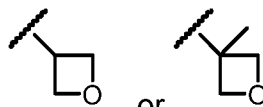


In some embodiments, Q^4 is

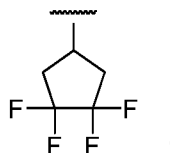


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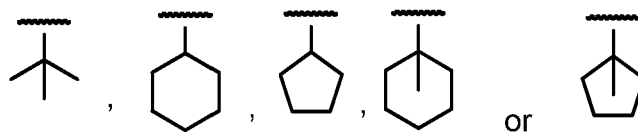
In some embodiments, Q^5 is



In some embodiments, Q^7 is



In other embodiments, Q is



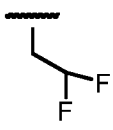
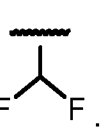
10

In certain embodiments, Q is Q^1 . In certain other embodiments, Q is C_1 - C_4

alkyl or C_3 - C_6 carbocyclyl. In further embodiments, Q is (i.e., t-butyl). In some embodiments, Q is t-butyl or C_5 - C_6 cycloalkyl.

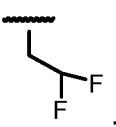
In certain embodiments, E is E^1 , E^2 , E^3 , or E^4 . In certain embodiments, E is E^3 .

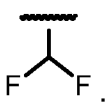
In certain embodiments, E is C₁-C₃ alkyl optionally substituted with 1-3 halogen atoms. In certain embodiments, E is difluoromethyl.

In certain other embodiments, E is  or .

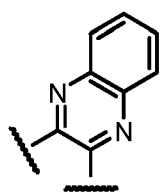
In some embodiments, E is .

5 In other embodiments, E is .

In other embodiments, E is .

In other embodiments, E is .

In certain embodiments, $\textcircled{\text{U}}$ is bicyclic heteroaryl, optionally substituted with 1-4 W groups which are the same or different.

10 In certain other embodiments, $\textcircled{\text{U}}$ is  optionally substituted with 1-4 W groups, which are the same or different.

In certain embodiments, $\textcircled{\text{U}}$ is substituted with one W group.

15 In some embodiments, $\textcircled{\text{U}}$ is U¹, U³, U⁴, U⁵ or U⁶, wherein each U¹, U³, U⁴, U⁵ or U⁶ is optionally substituted with 1-3 W at any substitutable position, and each W is independently W¹, W², W³, W⁴, W⁵, W⁶ or W⁷.

In certain embodiments, W¹ is oxo, halogen, -OR⁶, C₁-C₆ alkyl, -CN, -CF₃, -SR⁶, -C(O)₂R⁶, -C(O)N(R⁶)₂, -C(O)R⁶, -N(R⁶)C(O)R⁶, -SO₂(C₁-C₆ alkyl), -S(O)(C₁-C₆ alkyl), C₃-C₈ carbocyclyl, C₃-C₈ cycloalkoxy, C₁-C₆ haloalkyl, -N(R⁶)₂, -NR⁶(C₁-C₆ alkyl)O(C₁-C₆ alkyl), halo(C₁-C₆ alkoxy), -NR⁶SO₂R⁶, -SO₂N(R⁶)₂,

-NHCOOR⁶, -NHCONHR⁶, C₆-C₁₀ aryl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl or -O(4-10 membered heterocyclyl), wherein said W¹ alkyl, carbocyclyl, cycloalkoxy, haloalkyl, haloalkoxy, aryl, heteroaryl, or heterocyclyl is optionally substituted with 1-4 Z^{1c} groups.

5 In certain embodiments, each R⁶ is independently H, C₆-C₁₀ aryl or C₁-C₆ alkyl, wherein said aryl or alkyl is optionally substituted with 1 to 4 substituents independently selected from halogen atoms, C₁-C₆ alkyl, C₆-C₁₀ aryl, C₃-C₈ carbocyclyl, 5-14 membered heteroaryl, 4-10 membered heterocyclyl, halo(C₁-C₆ alkoxy), -OH, -O(C₁-C₆ alkyl), -SH, -S(C₁-C₆ alkyl), -NH₂, -NH(C₁-C₆ alkyl), -N(C₁-
10 C₆ alkyl)₂, -C(O)(C₁-C₆ alkyl), -SO₂N(C₁-C₆ alkyl)₂, -NHCOO(C₁-C₆ alkyl), -NHCO(C₁-C₆ alkyl), -NHCONH(C₁-C₆ alkyl), -CO₂(C₁-C₆ alkyl), or -C(O)N(C₁-C₆ alkyl)₂.

In certain embodiments, W² is C₁-C₆ alkoxy substituted with a 5-14 membered heteroaryl or C₆-C₁₀ aryl; wherein said heteroaryl or aryl is substituted
15 with 1-4 Z^{1c} groups.

In certain embodiments, W³ is a C₂-C₈ alkynyl group substituted with a C₆-C₁₀ aryl, C₃-C₈ carbocyclyl, C₁-C₈ alkyl, C₁-C₆ haloalkyl, 4-10 membered heterocyclyl, or 5-14 membered heteroaryl group; wherein said aryl, carbocyclyl, alkyl, haloalkyl, heterocyclyl, or heteroaryl group is optionally substituted with 1-4
20 Z^{1c} groups.

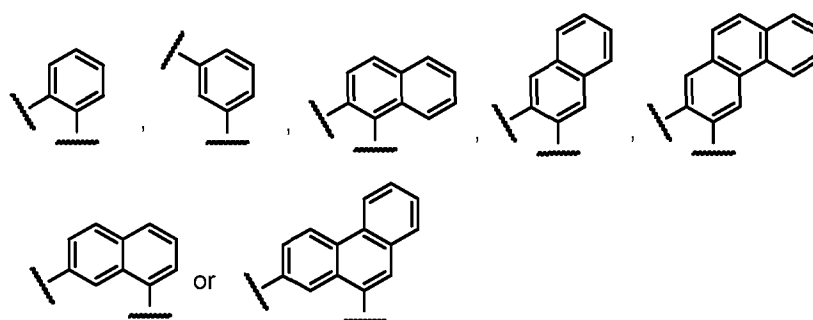
In some embodiments, W⁴ is -SF₅.

In some embodiments, W⁵ is -O(C₂-C₆ alkyl)OR²² wherein R²² is a C₆-C₁₀ aryl, 5-14 membered heteroaryl or 4-10 membered heterocyclyl group that is optionally substituted with 1-4 Z^{1c} groups.

25 In certain embodiments, W is hydrogen, -O(C₁-C₃)alkyl, halogen or cyano.

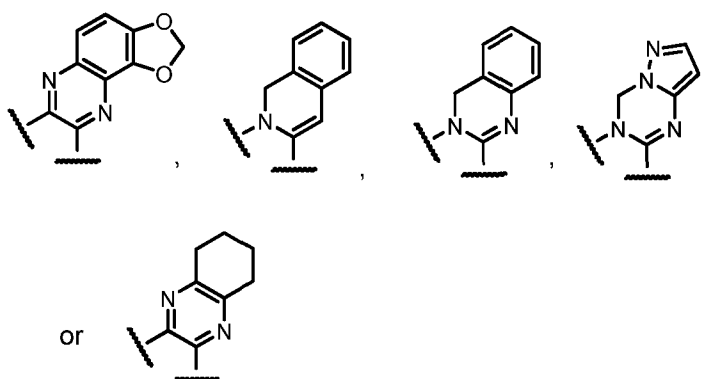
In certain embodiments, W is methoxy.

In some embodiments, U¹ is



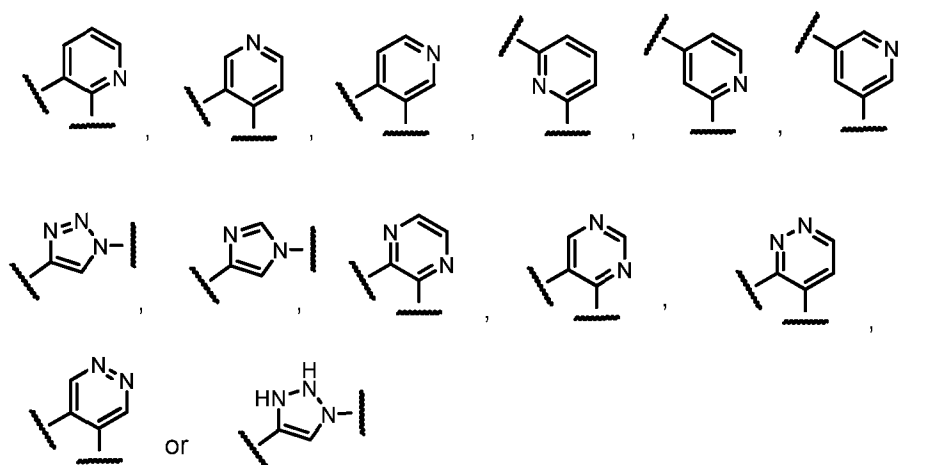
wherein each U^1 is optionally substituted with 1-2 Z^1 groups.

In some embodiments, U^3 is



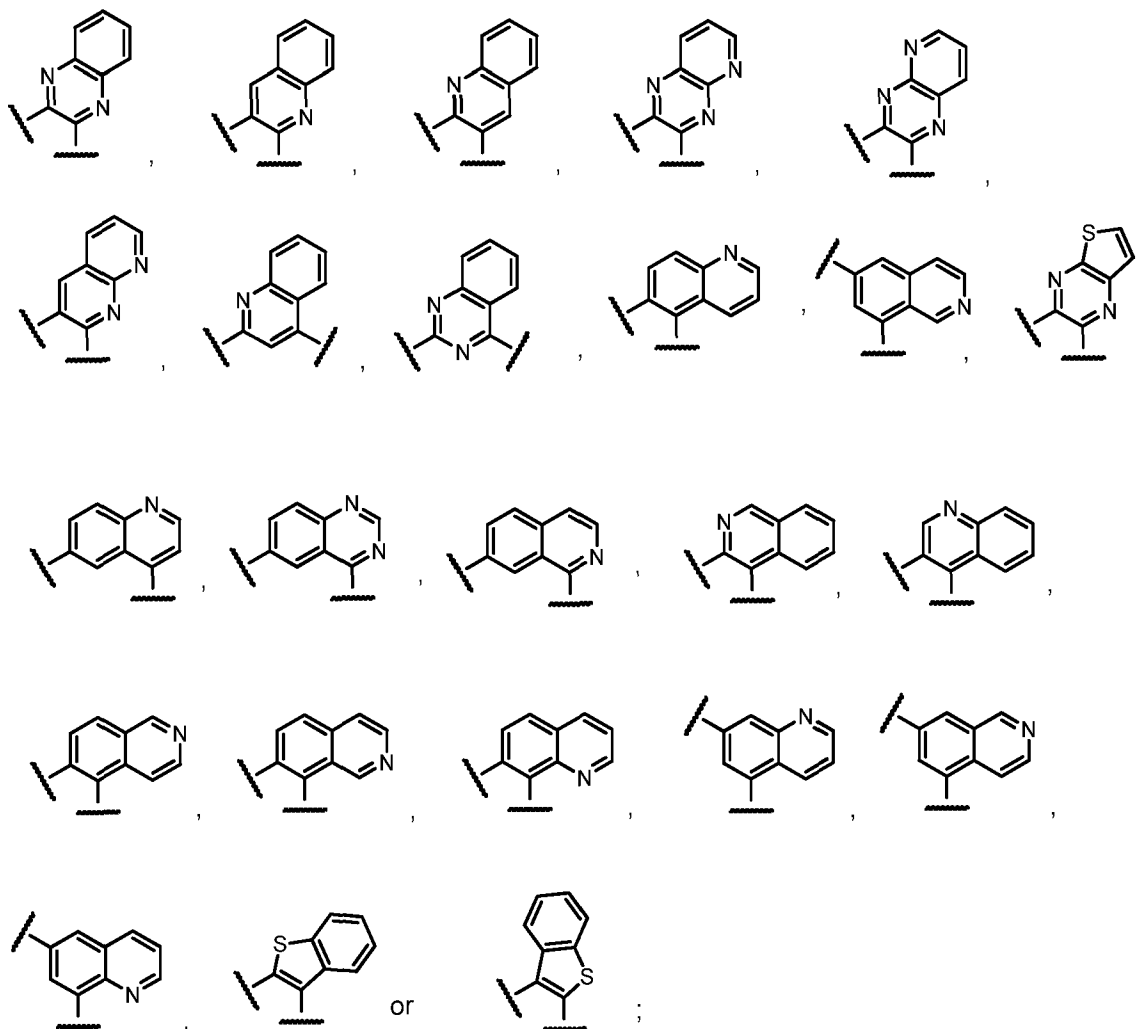
5 wherein each U^3 is optionally substituted with 1-2 Z^1 groups.

In some embodiments, U^4 is



wherein each U^4 is optionally substituted with 1-2 Z^1 groups.

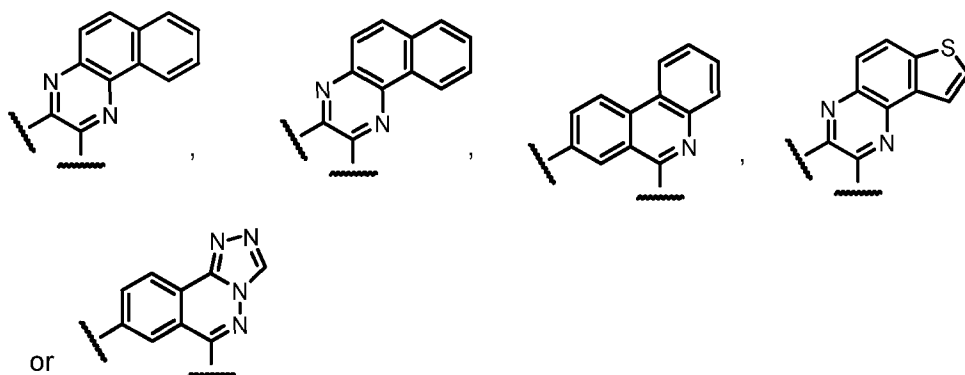
In some embodiments, U⁵ is



wherein each U⁵ is optionally substituted with 1-2 Z¹ groups.

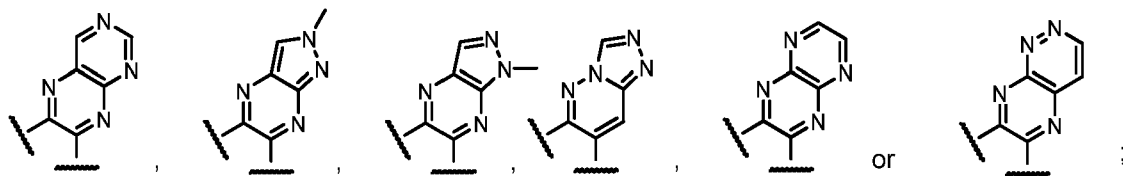
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In some embodiments, U⁶ is



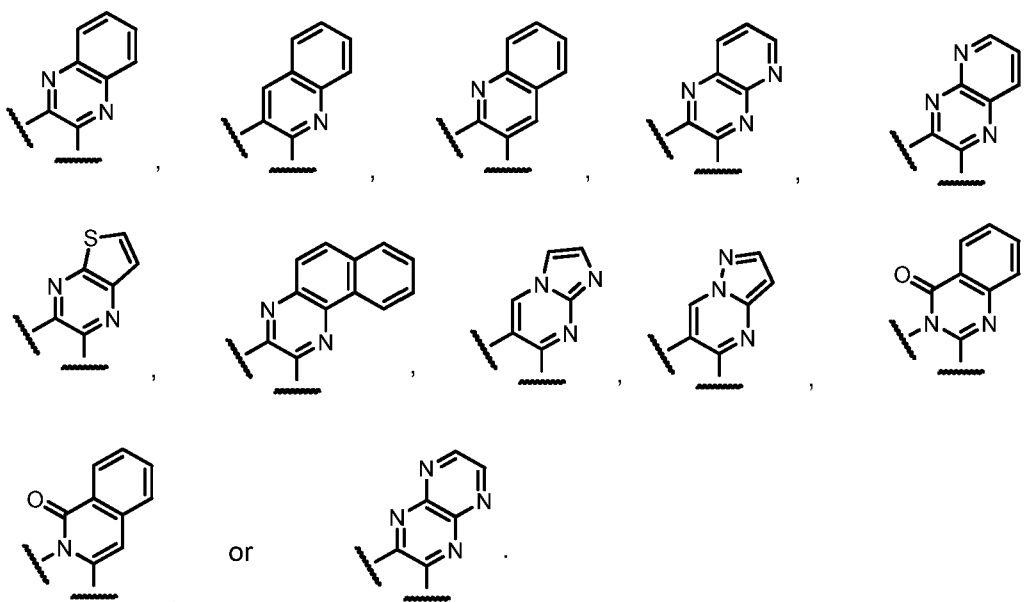
wherein each U⁶ is optionally substituted with 1-2 Z¹ groups.

In some embodiments, U^7 is

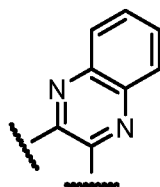


wherein each U^7 is optionally substituted with 1-2 Z^1 groups.

In other embodiments, $\textcircled{U}$ is optionally substituted with one or two W at any substitutable position, and each W is independently W^1 , W^2 , W^3 , W^4 , W^5 , W^6 or W^7 wherein $\textcircled{U}$ is

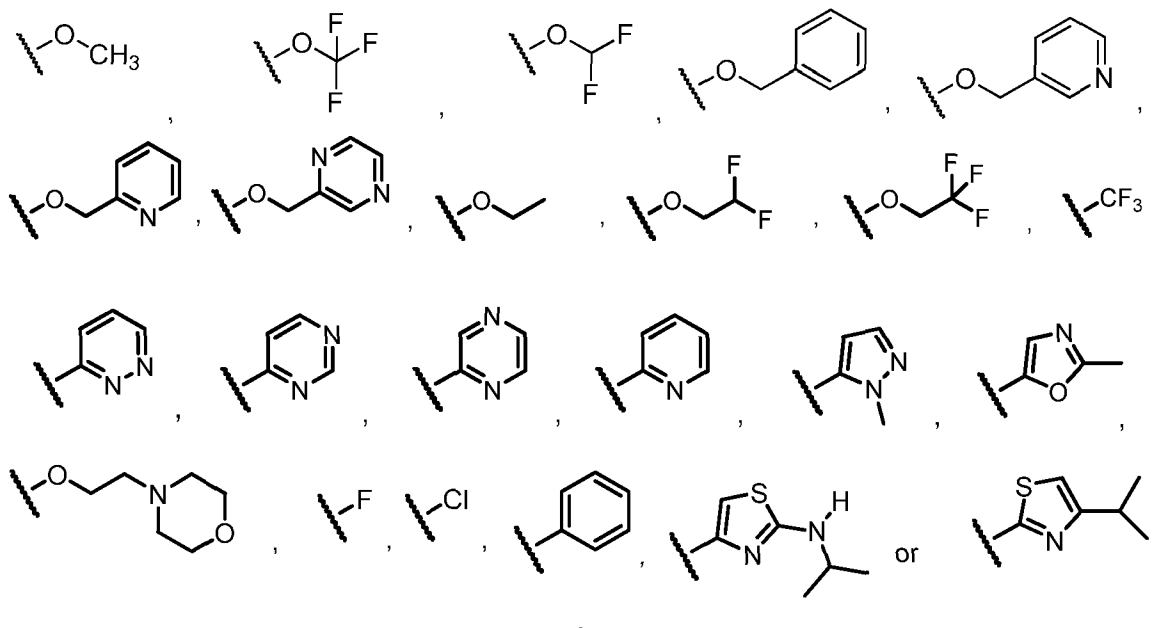


In other embodiments, $\textcircled{U}$ is optionally substituted with one W at any substitutable position, and each W is independently W^1 , W^2 , W^3 , W^4 , W^5 , W^6 or W^7 wherein $\textcircled{U}$ is

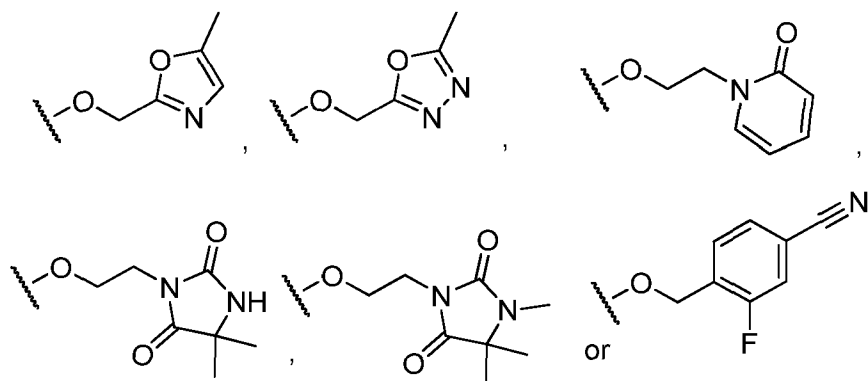


In other embodiments, each W is independently W^1 , W^2 , W^3 , W^4 , W^5 , W^6 or W^7 .

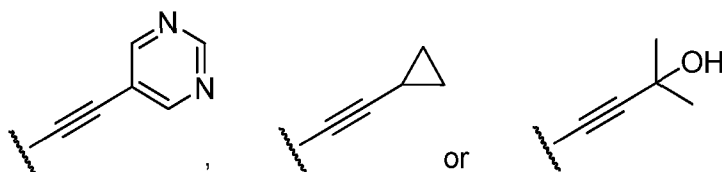
In some embodiments, W^1 is



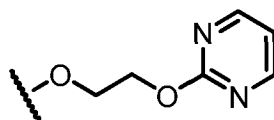
In some embodiments, W^2 is



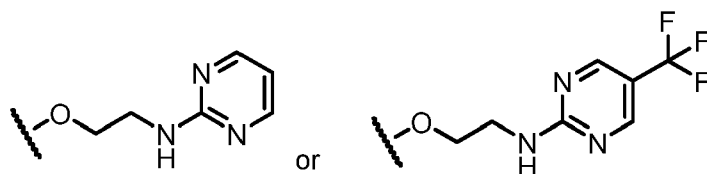
In some embodiments, W^3 is



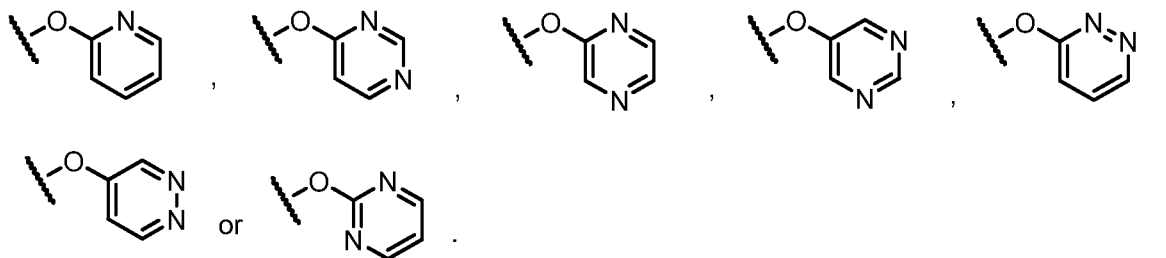
In some embodiments, W^5 is



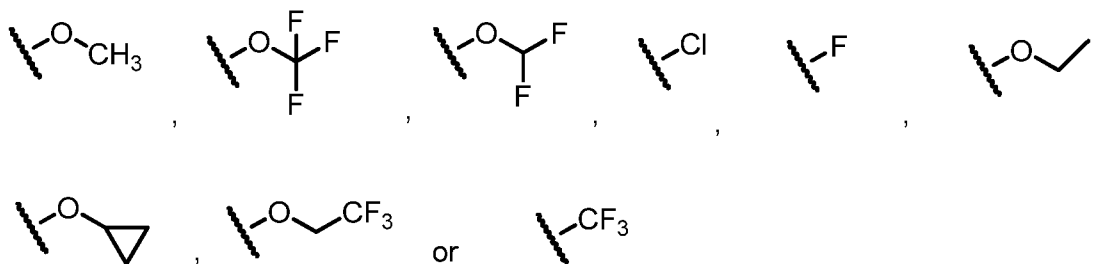
In some embodiments, W^6 is



In some embodiments, W⁷ is



5 In other embodiments, W is

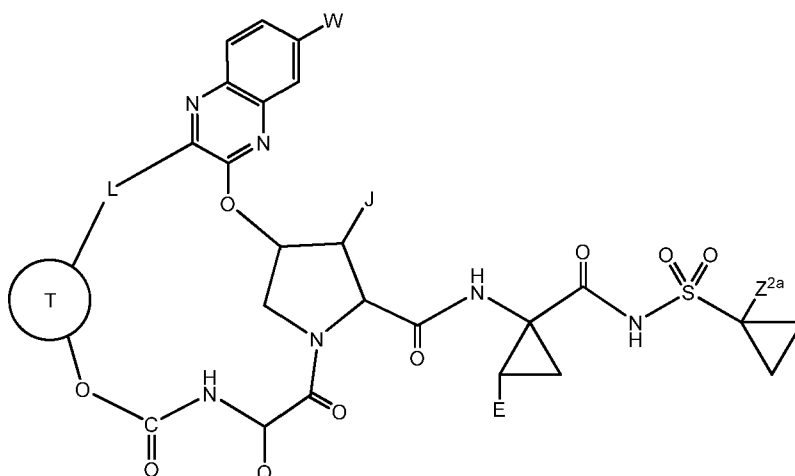


In certain embodiments, each W is independently halogen or C₁-C₄ alkoxy.

10 In a specific embodiment, J is methyl or ethyl; E is substituted with 1-2 halogen atoms; L is substituted with 1-2- halogen atoms, and T is unsubstituted.

In a further embodiment, J is methyl or ethyl; E is C₁-C₃ haloalkyl; L is C₅-alkyl or C₅-alkenyl.

In another embodiment, a compound of Formula (IV):



(IV),

or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically

5 acceptable salt thereof, is provided, wherein:

J is C₁-C₄ alkyl or C₃-C₆ carbocyclyl, wherein C₁-C₄ alkyl or C₃-C₆ carbocyclyl is optionally substituted with halogen, -OH, aryl or cyano;

10 $\textcircled{\text{T}}$ is C₃-C₅ carbocyclylene that is attached to L and to the remainder of the compound through two adjacent carbons, wherein said C₃-C₅ carbocyclylene is optionally substituted with C₁-C₄ alkyl, C₁-C₃ haloalkyl, halogen, -OH, or cyano, or $\textcircled{\text{T}}$ is C₅-C₈ bicyclic carbocyclylene that is attached to L and to the remainder of the compound through two adjacent carbons, or $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons, wherein said C₃-C₆ carbocyclylene is optionally substituted with C₁-C₄ alkyl or C₁-C₃ haloalkyl;

15 L is C₃-C₆ alkylene, C₃-C₆ alkenylene or -(CH₂)₃-cyclopropylene-, optionally substituted with 1-4 halogen, -OH, or cyano;

20

Q is C₂-C₄ alkyl or C₃-C₆ carbocyclyl optionally substituted with C₁-C₃ alkyl, halogen, -OH, or cyano;

E is C₁-C₃ alkyl or C₂-C₃ alkenyl, optionally substituted with C₁-C₃ alkyl, halogen, -OH, or cyano;

5 W is H, -OH, -O(C₁-C₃)alkyl, -O(C₁-C₃)haloalkyl, halogen or cyano; and Z^{2a} is H or C₁-C₃ alkyl, halogen, -OH, or cyano.

In a further embodiment of Formula (IV), J is C₁-C₃ alkyl.

In a further embodiment of Formula (IV), J is methyl or ethyl.

10 In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons, wherein said C₃-C₆ carbocyclylene is optionally substituted with C₁-C₄ alkyl or C₁-C₃ haloalkyl.

15 In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₃-C₆ carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons, wherein the C₃-C₆ carbocyclylene is optionally substituted with methyl, ethyl or trifluoromethyl.

In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is cyclopropylene.

20 In a further embodiment of Formula (IV), $\textcircled{\text{T}}$ is C₆-C₈ bridged bicyclic carbocyclylene or C₆-C₈ fused bicyclic carbocyclylene that is attached to L and to the remainder of the compound of Formula IV through two adjacent carbons.

In a further embodiment of Formula (IV), L is C₃-C₆ alkylene, substituted with 1-4 halogens. In another embodiment of Formula (IV), L is C₅ alkylene, substituted with two halogens. In some embodiments, the halogens are each fluoro.

25 In a further embodiment of Formula (IV), L is C₃-C₆ alkylene.

In a further embodiment of Formula (IV), L is C₅ alkylene.

In a further embodiment of Formula (IV), Q is t-butyl or C₅-C₆ carbocyclyl.

In a further embodiment of Formula (IV), Q is t-butyl.

In a further embodiment of Formula (IV), E is C₁-C₃ alkyl optionally substituted with 1-3 halogen atoms.

In a further embodiment of Formula (IV), E is difluoromethyl.

In a further embodiment of Formula (IV), W is hydrogen, -O(C₁-C₃)alkyl, halogen or cyano.

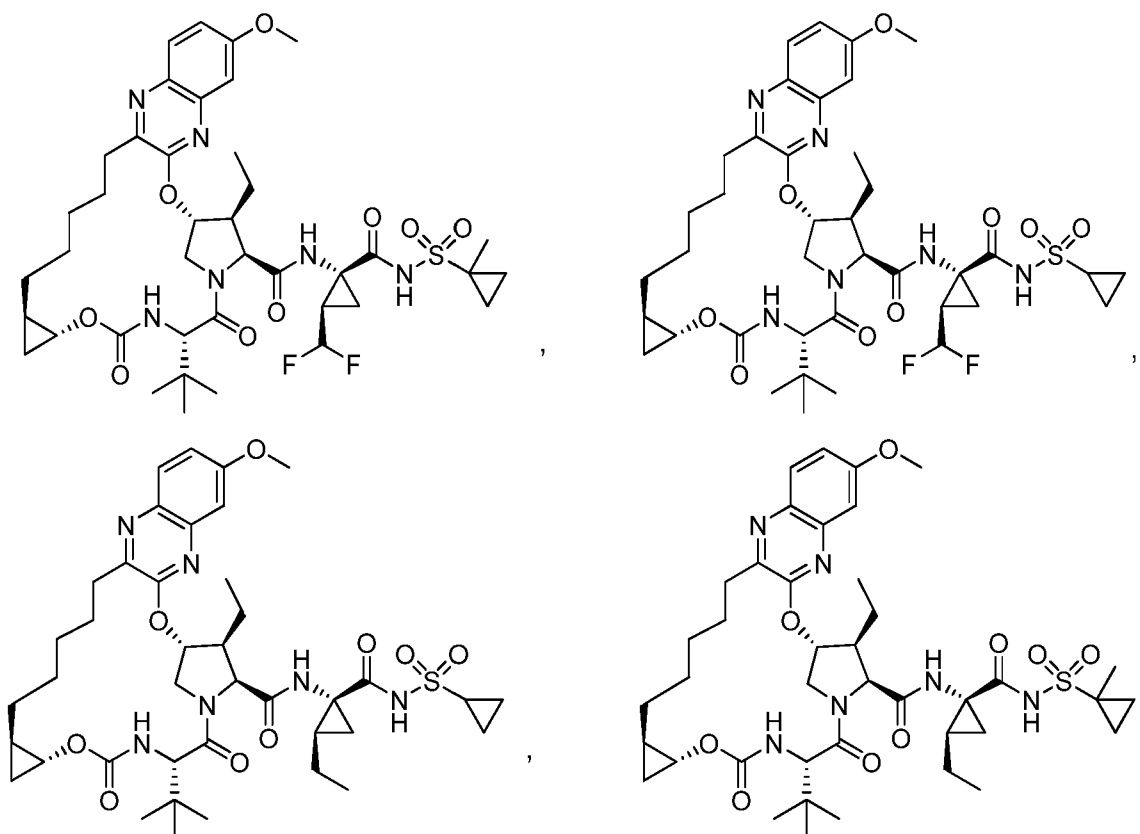
In a further embodiment of Formula (IV), W is methoxy.

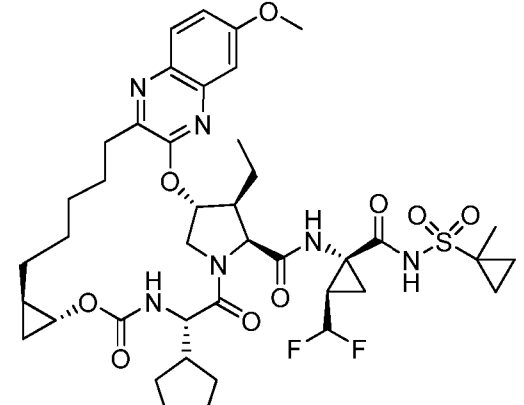
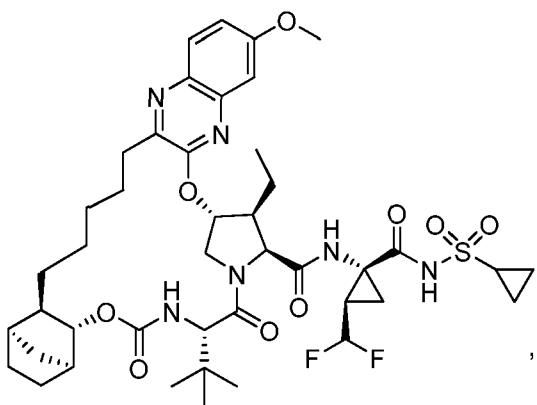
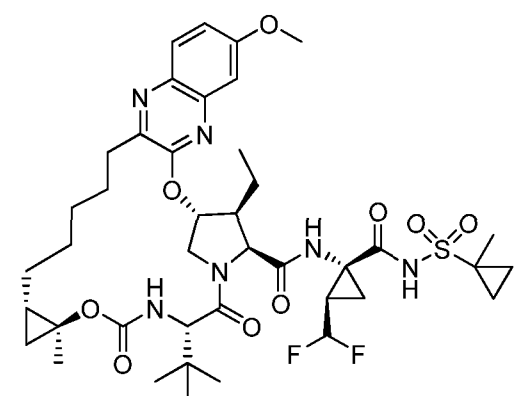
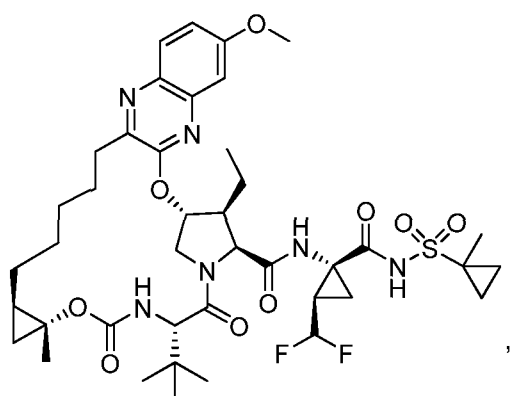
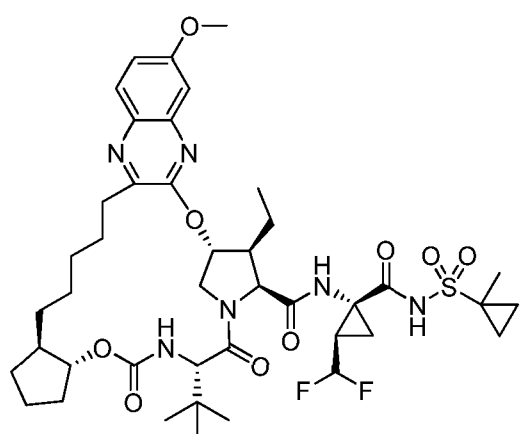
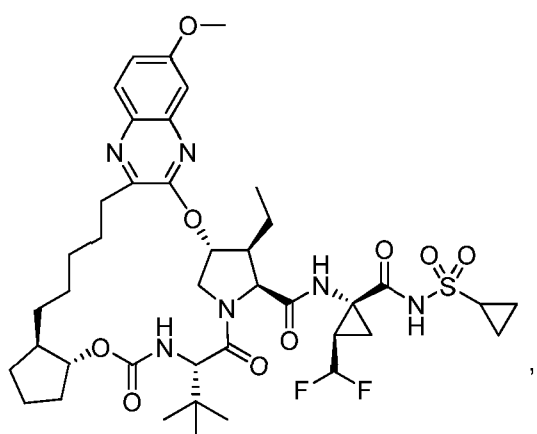
In a further embodiment of Formula (IV), Z^{2a} is hydrogen or methyl.

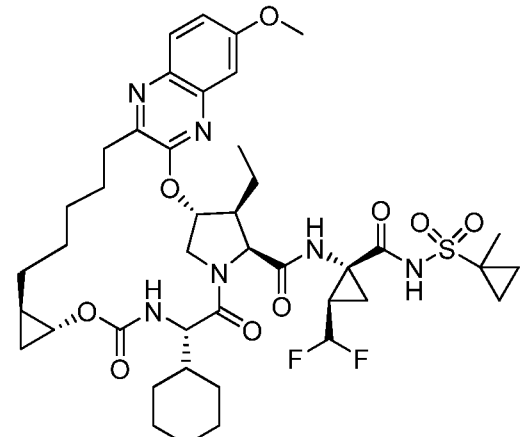
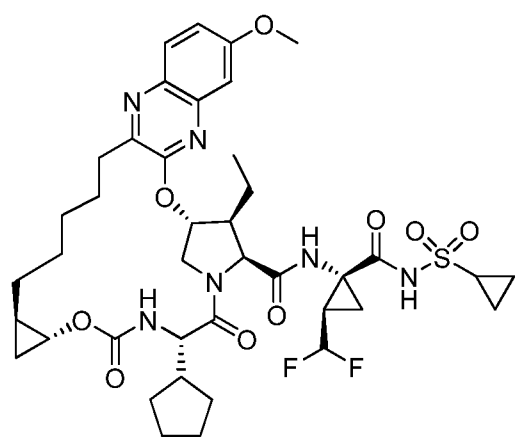
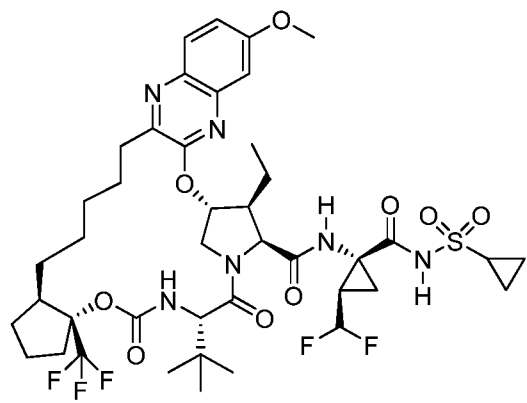
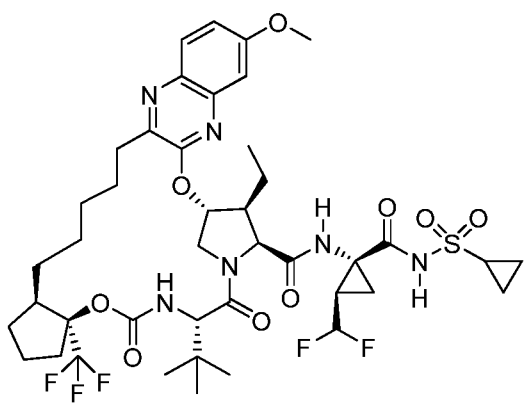
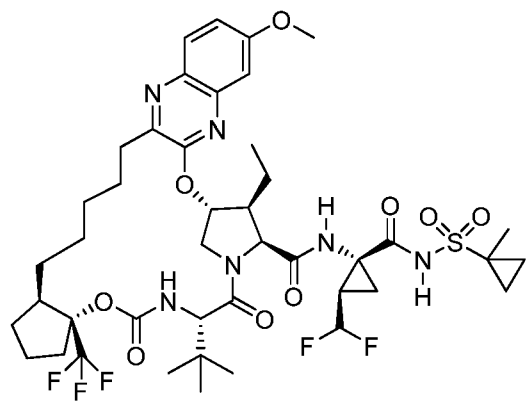
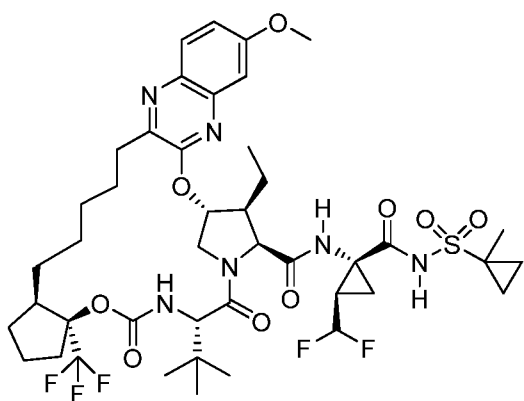
In a further embodiment of Formula (IV), Z^{2a} is methyl.

There is further provided a compound selected from the group consisting

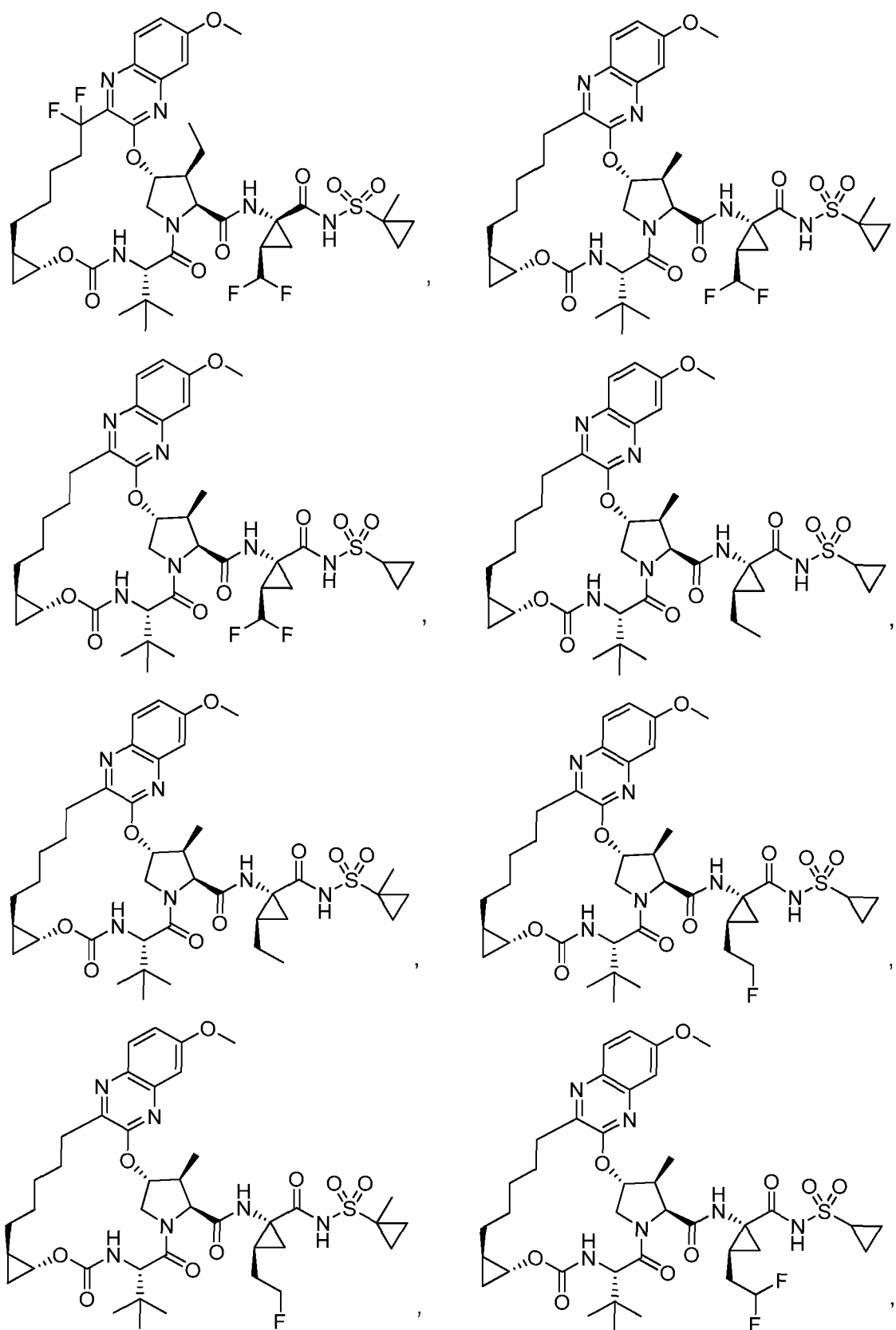
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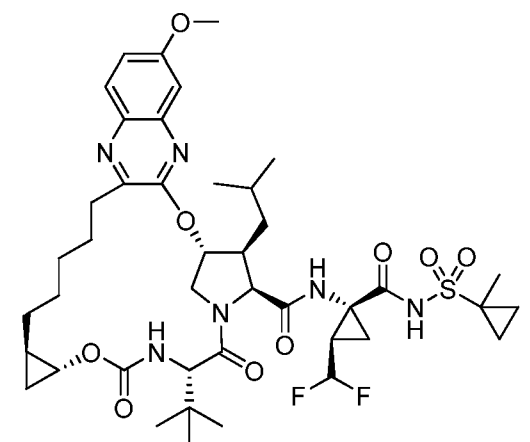
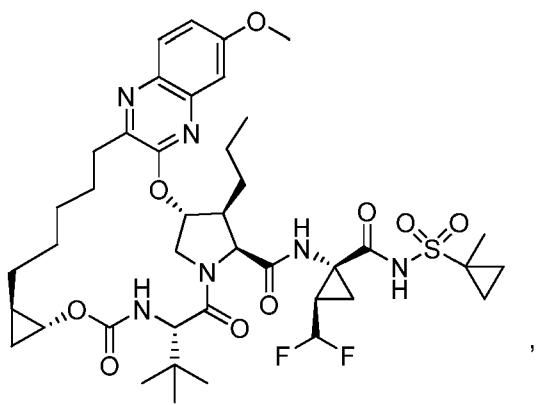
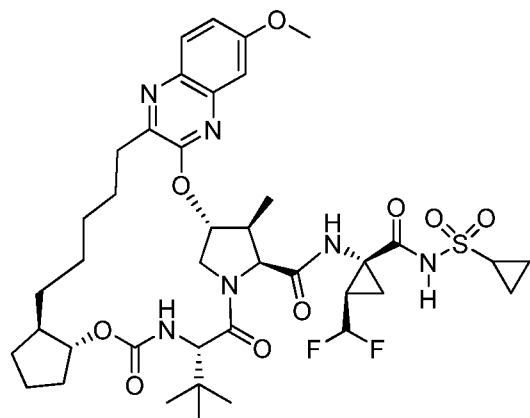
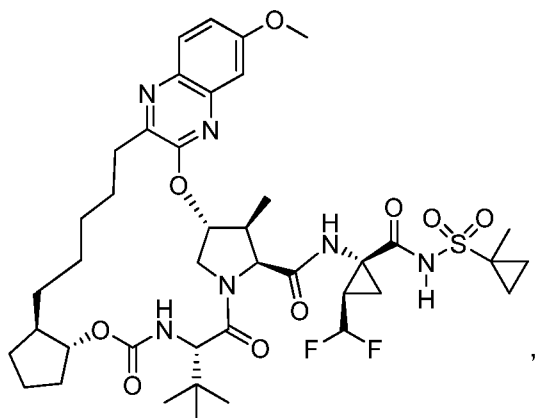
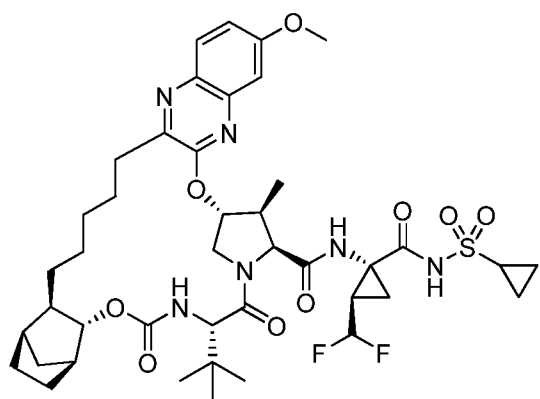
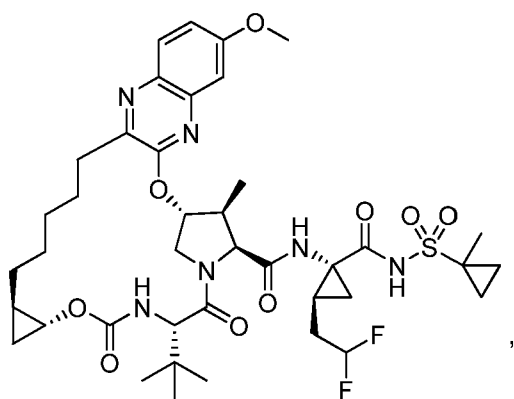


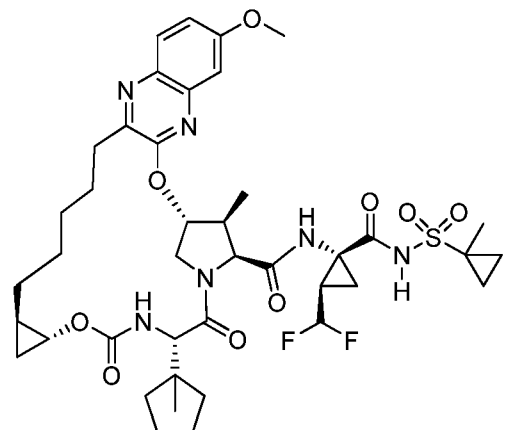
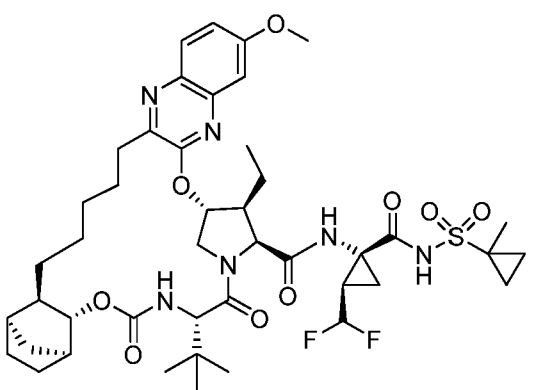
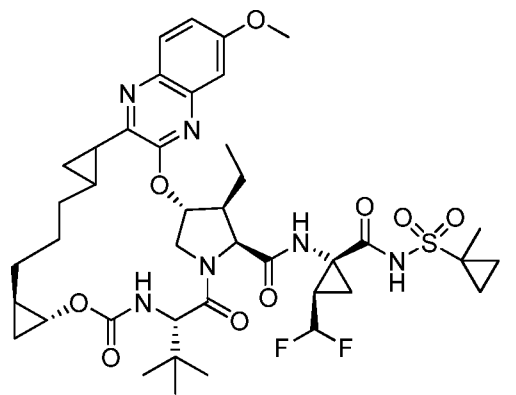
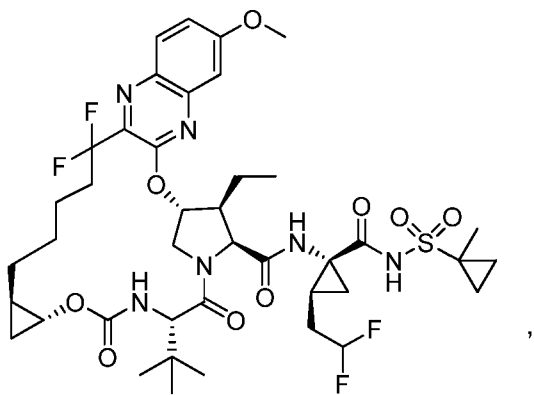
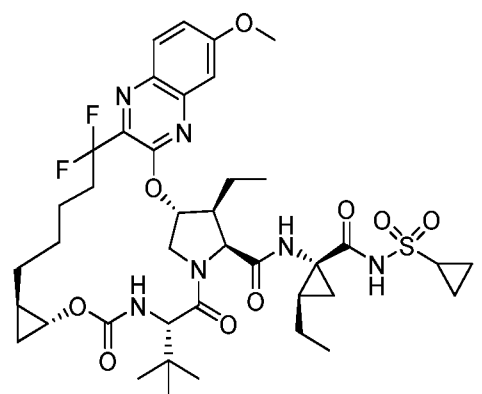
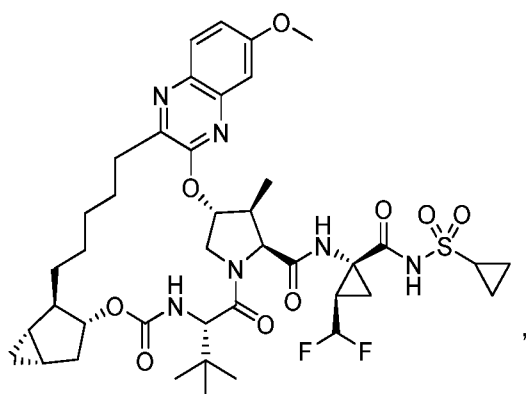
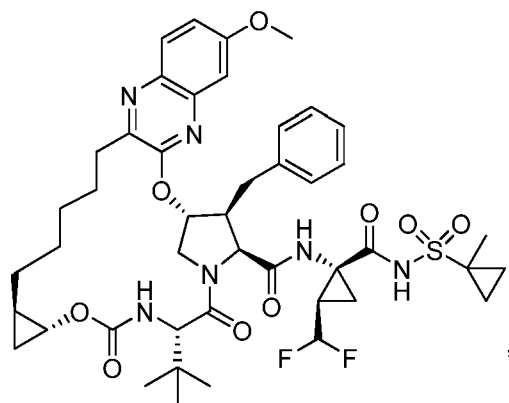
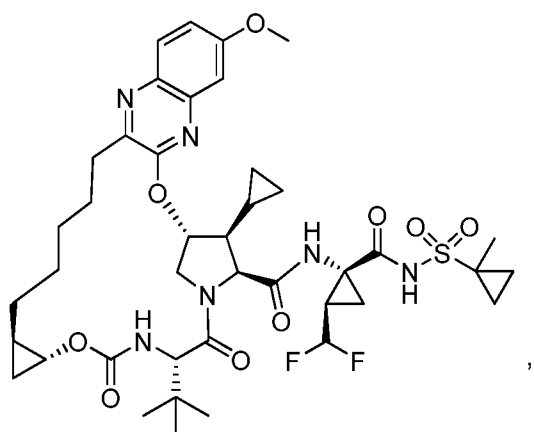


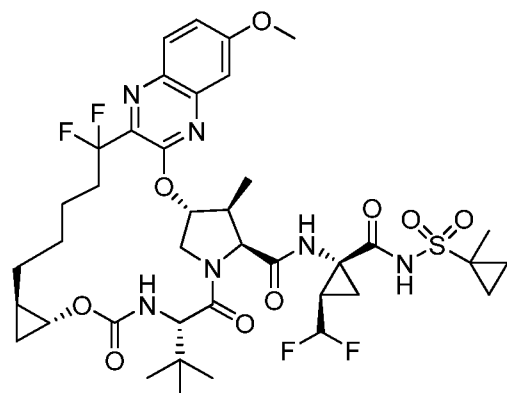
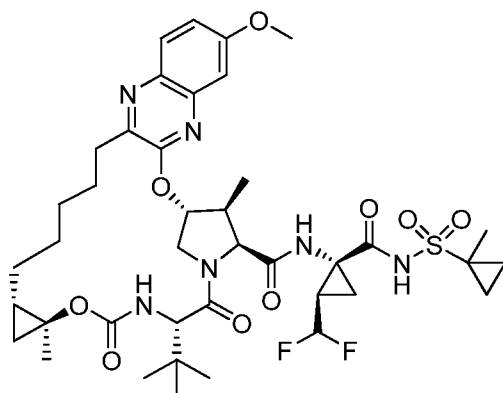
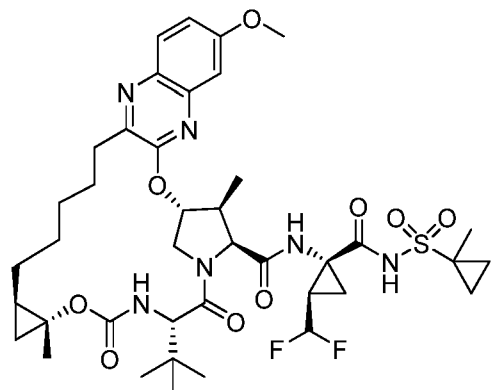
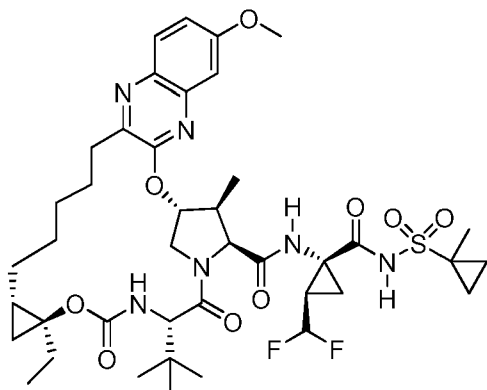
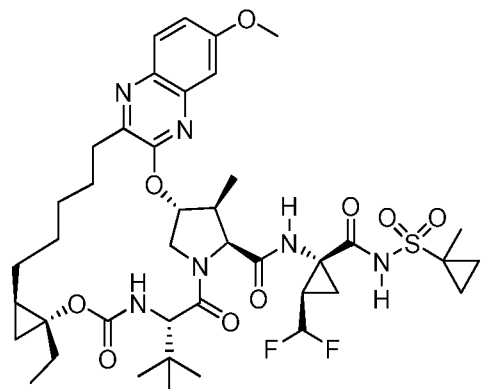
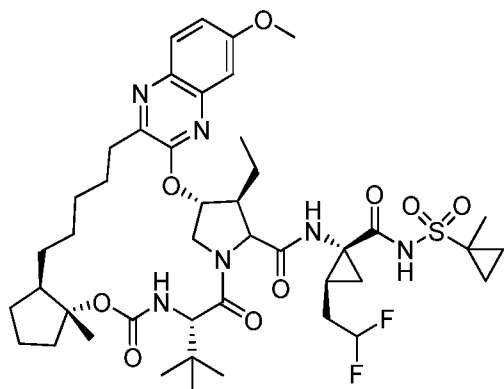
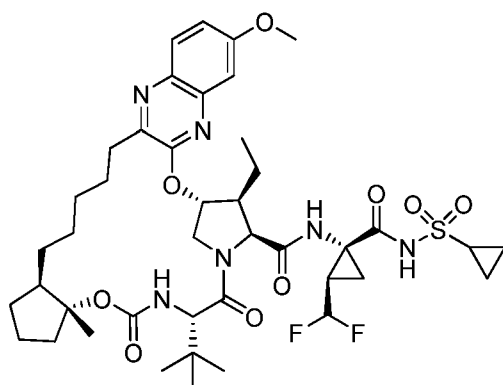
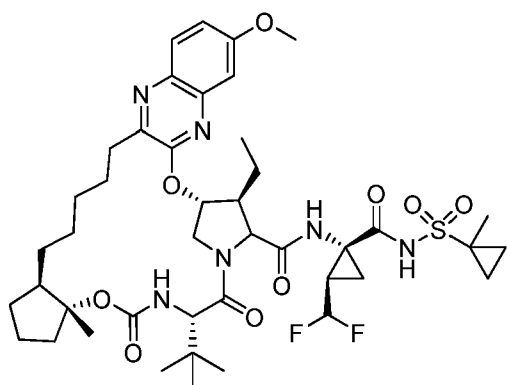


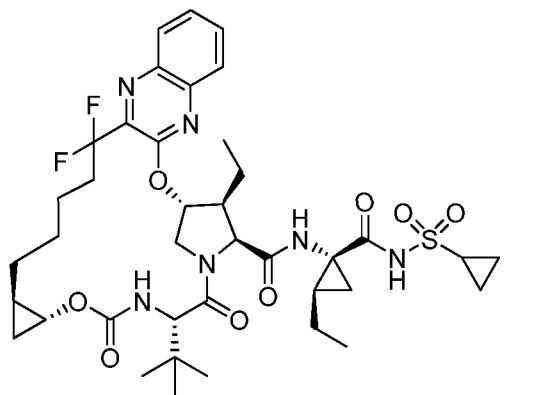
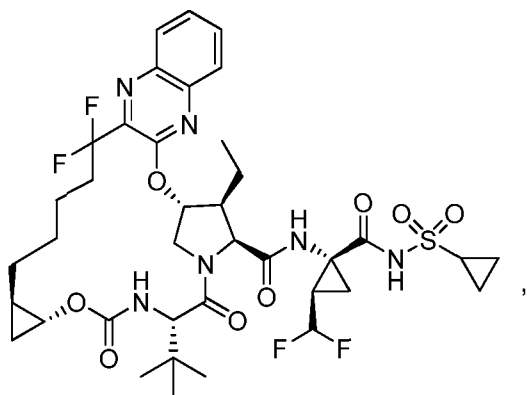
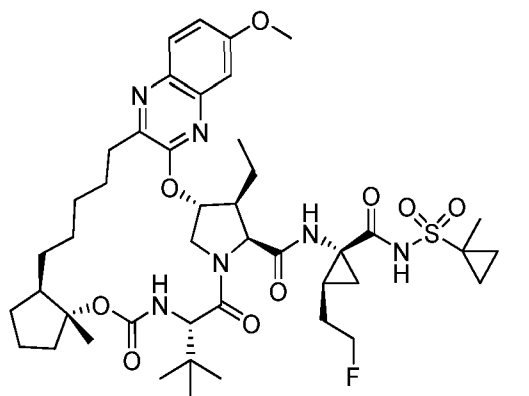
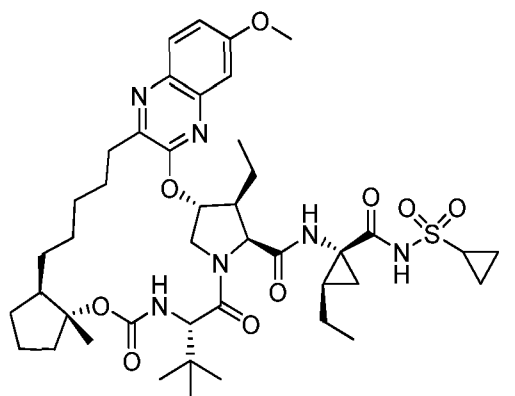
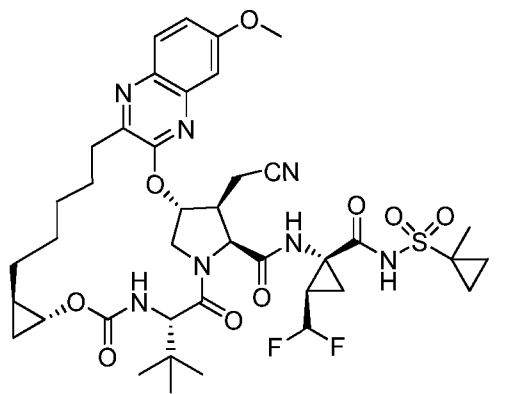
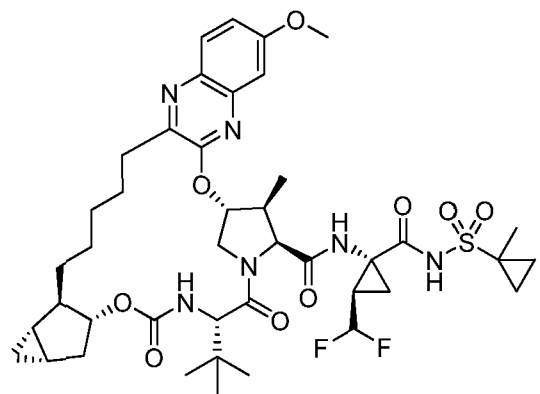
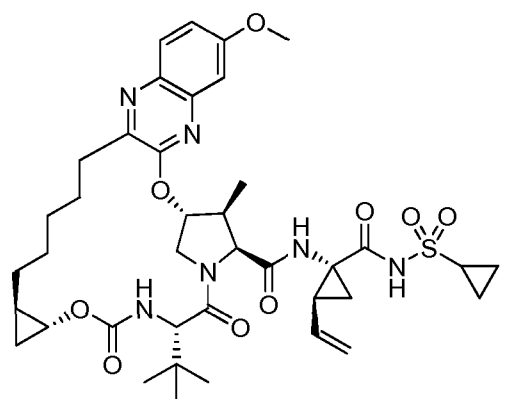
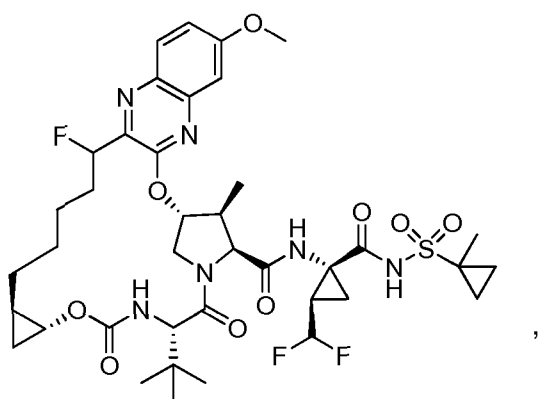
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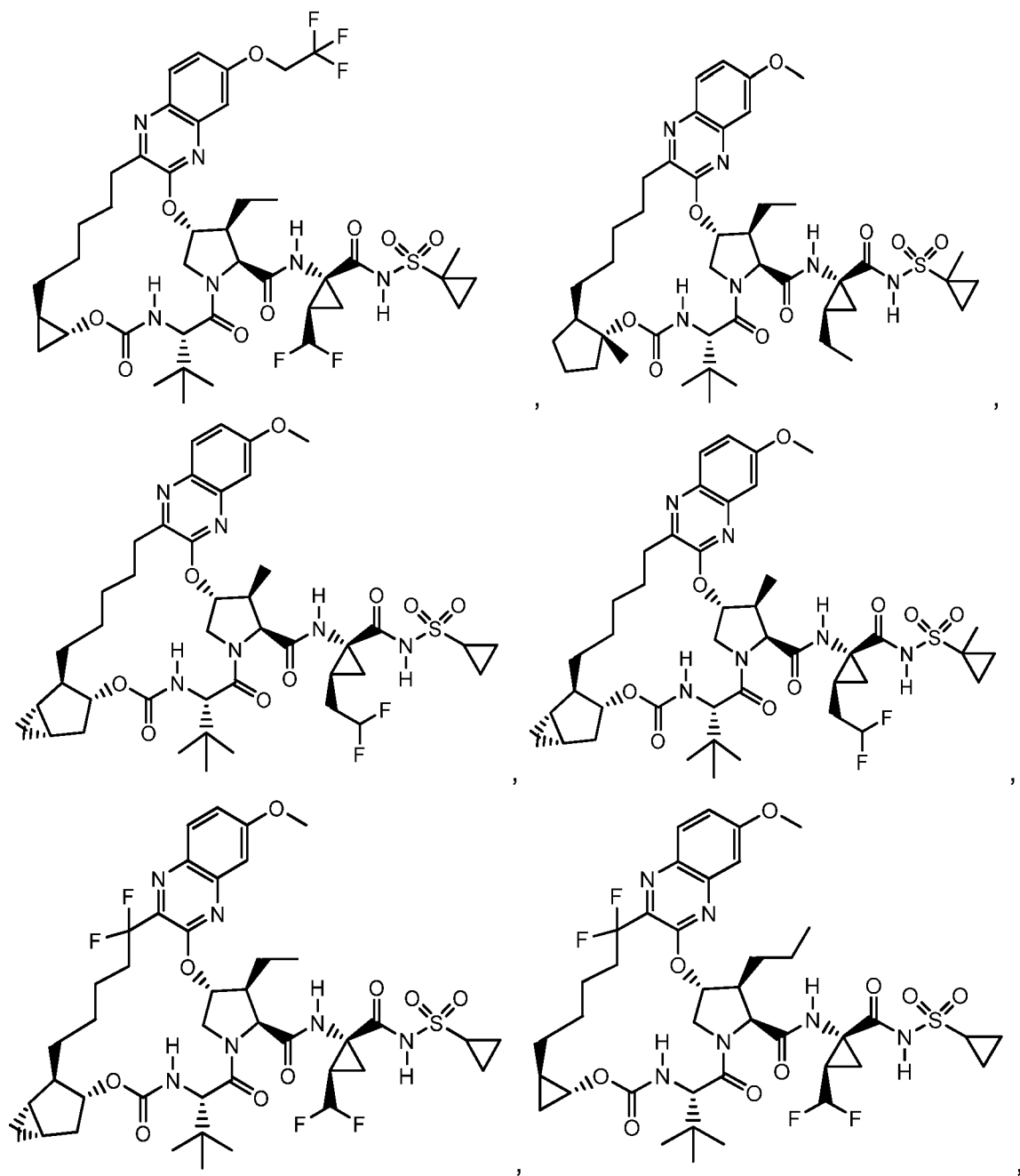


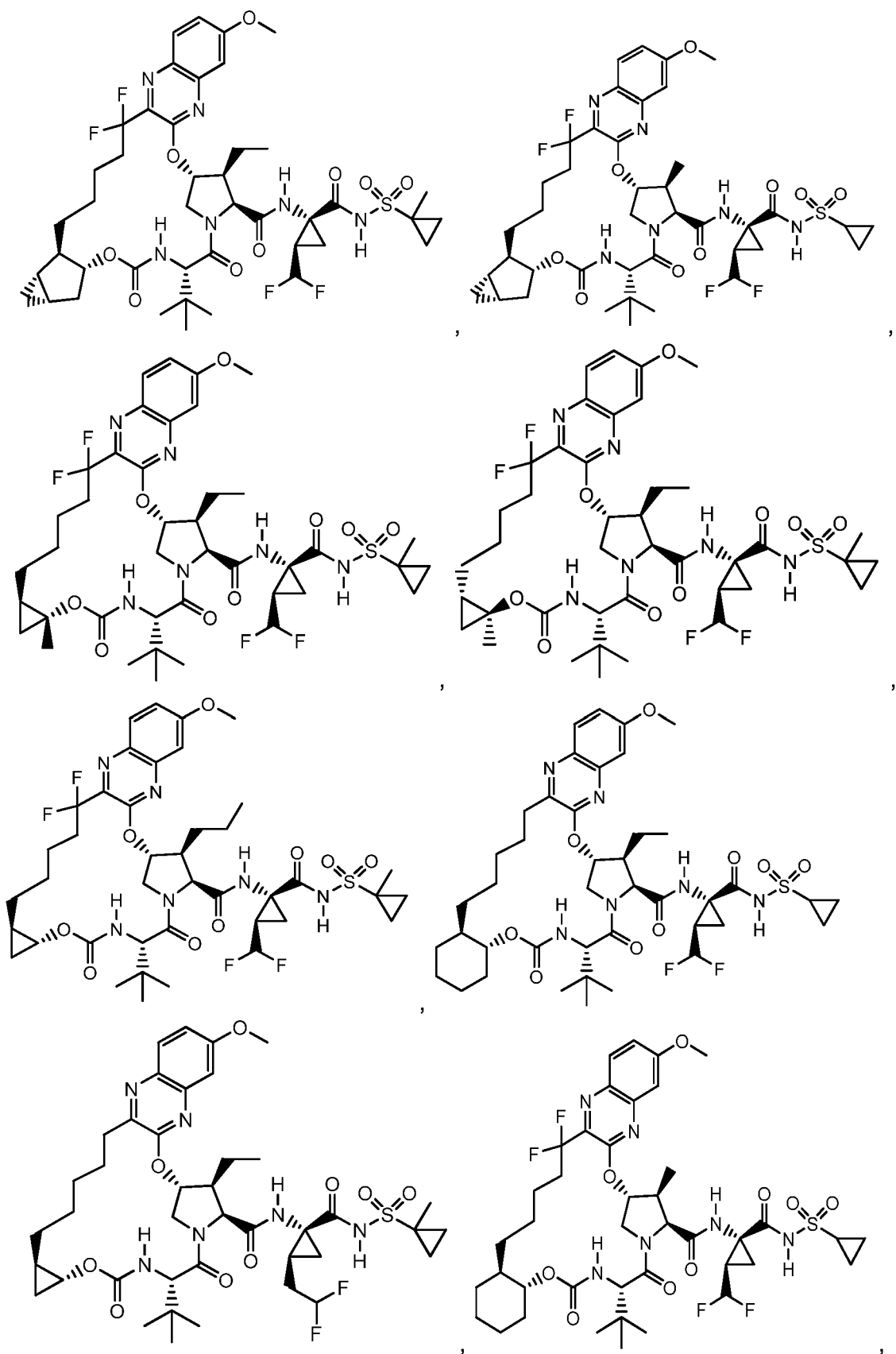


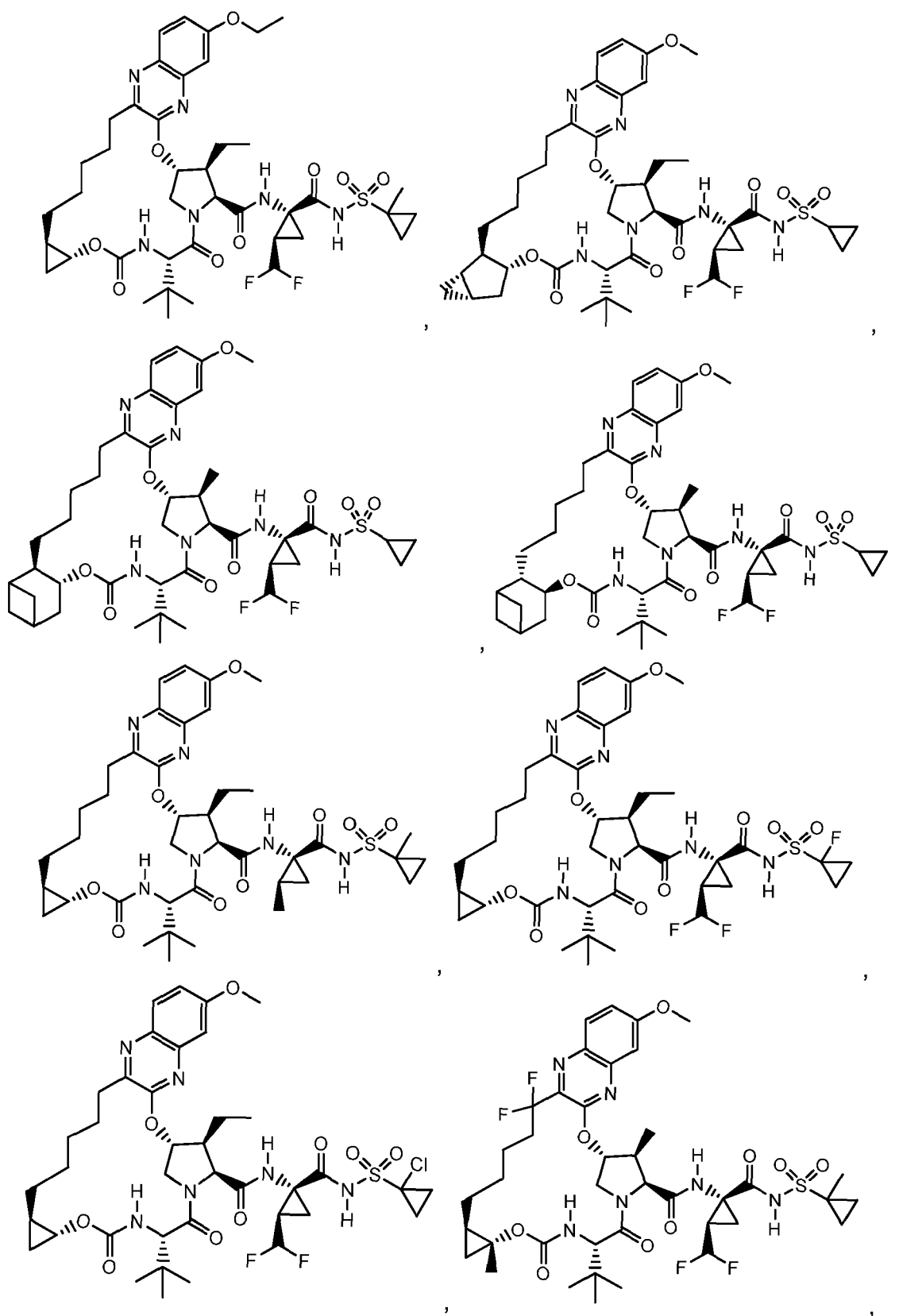


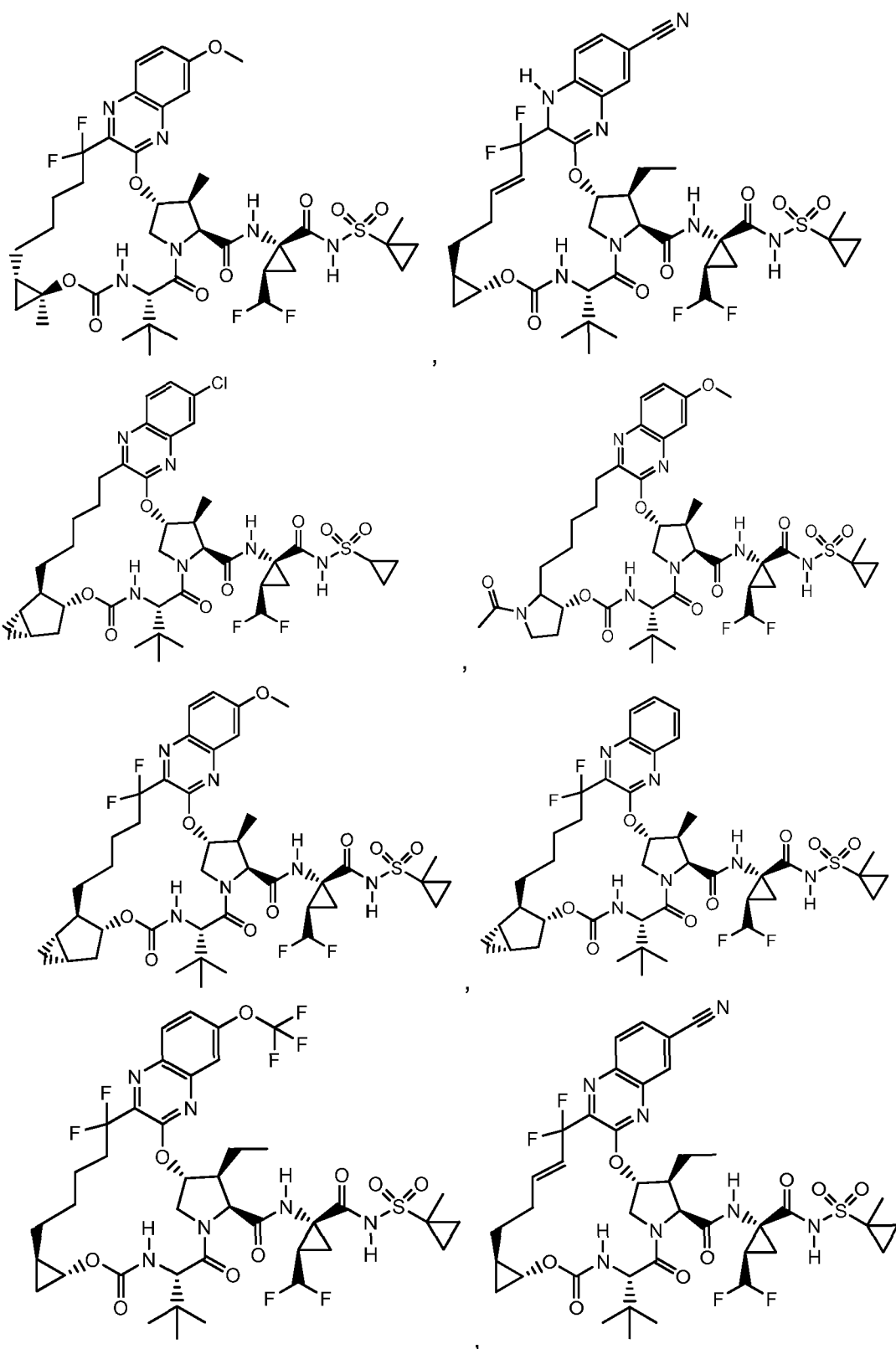


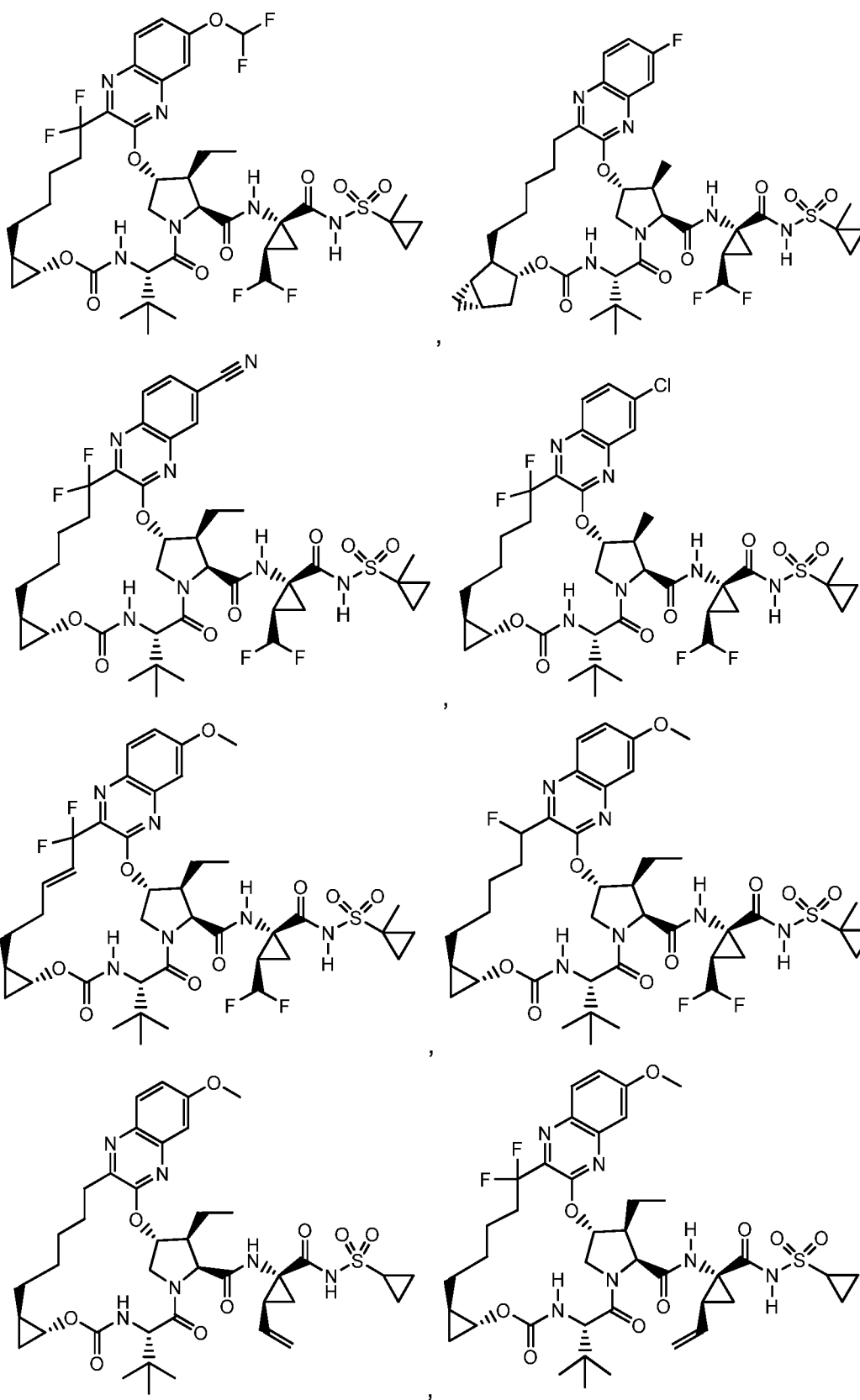


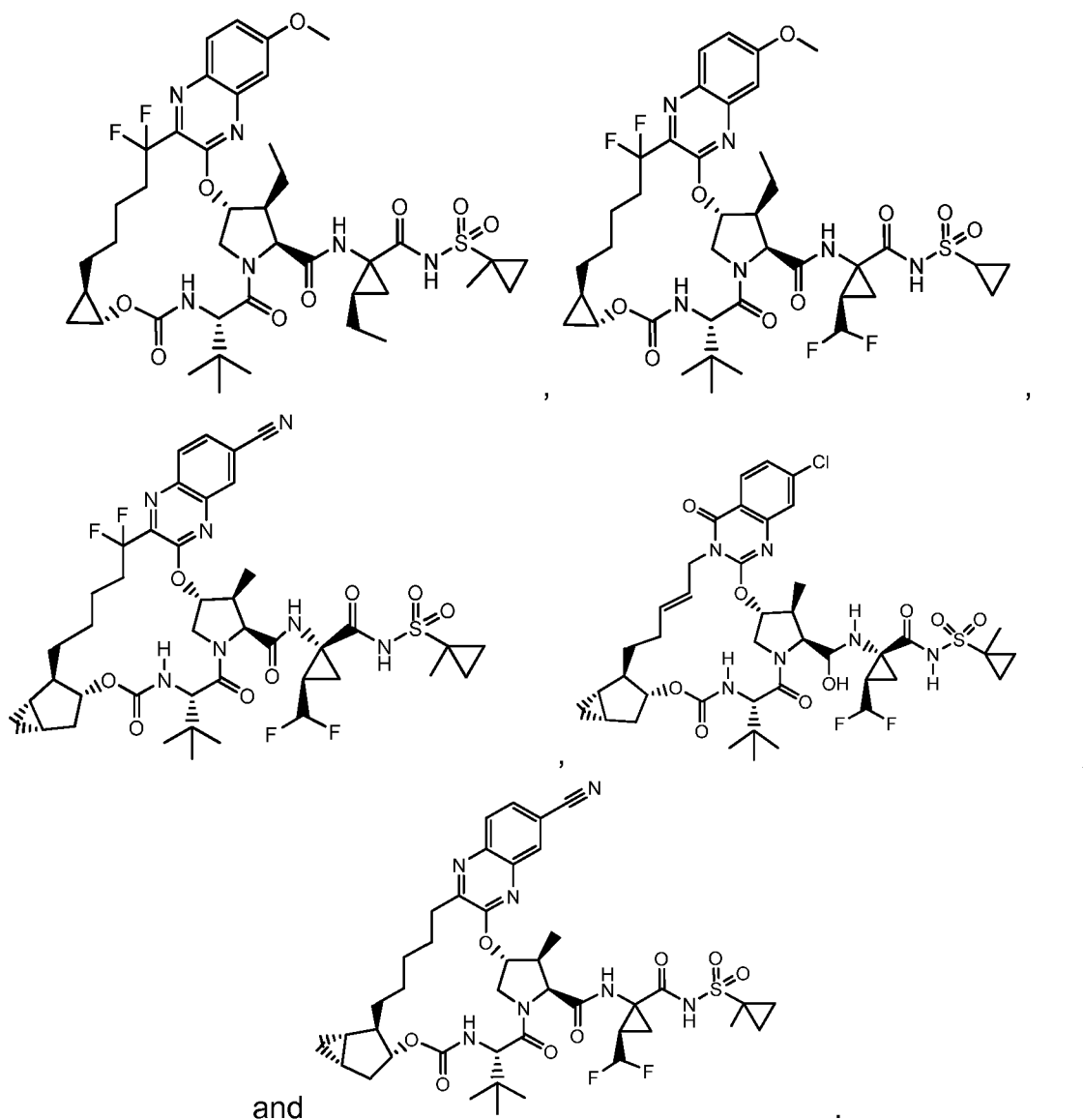




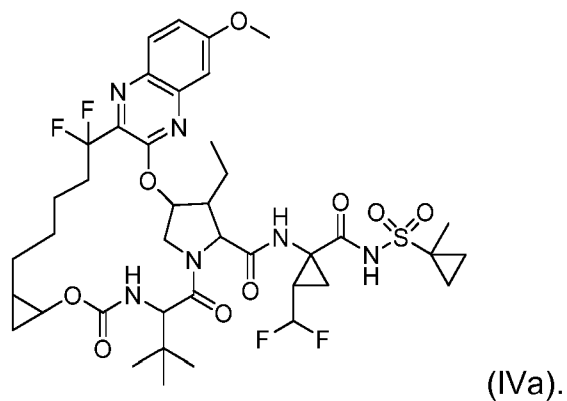




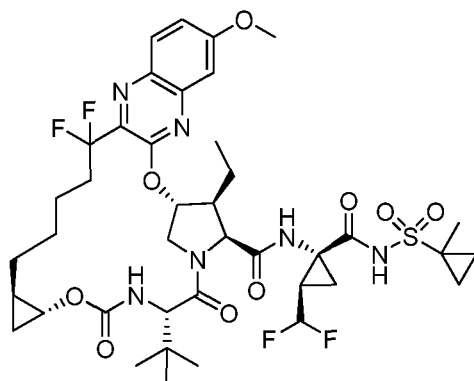




- 5 In one embodiment, a compound of Formula IVa, or a pharmaceutically acceptable salt thereof, is provided:

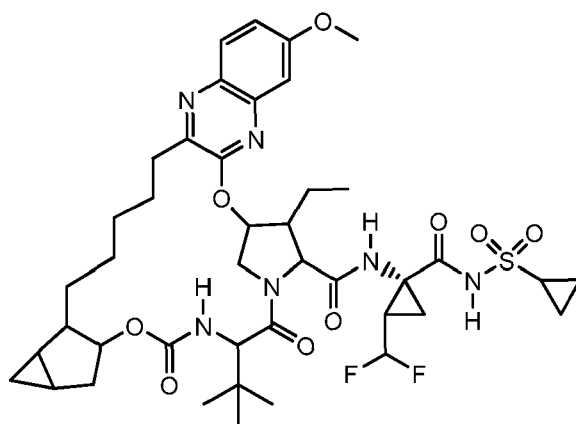


In one embodiment, a compound of Formula IVb: or a pharmaceutically acceptable salt thereof, is provided:



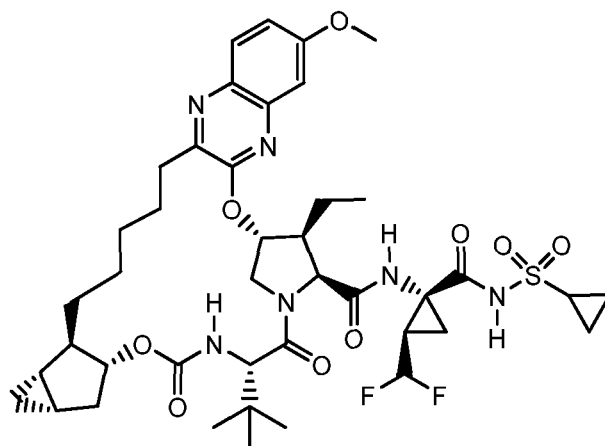
(IVb).

5 In one embodiment, a compound of Formula IVc, or a pharmaceutically acceptable salt thereof, is provided:



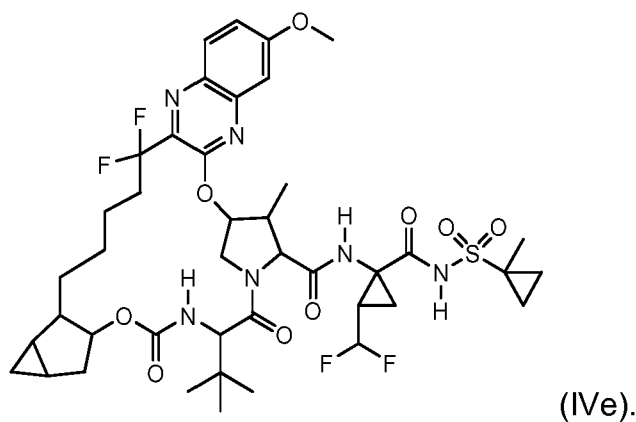
(IVc).

In one embodiment, a compound of Formula IVd, or a pharmaceutically acceptable salt thereof, is provided:

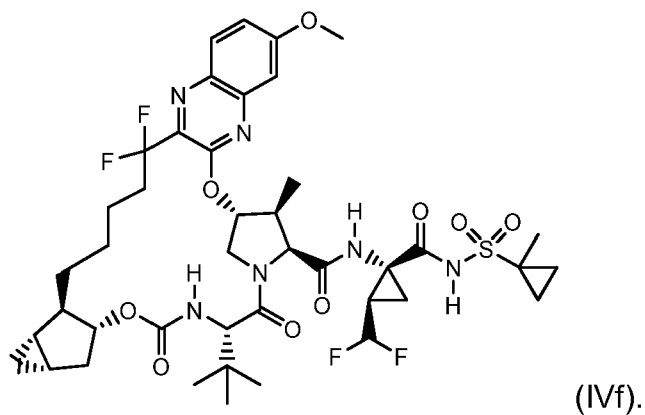


(IVd).

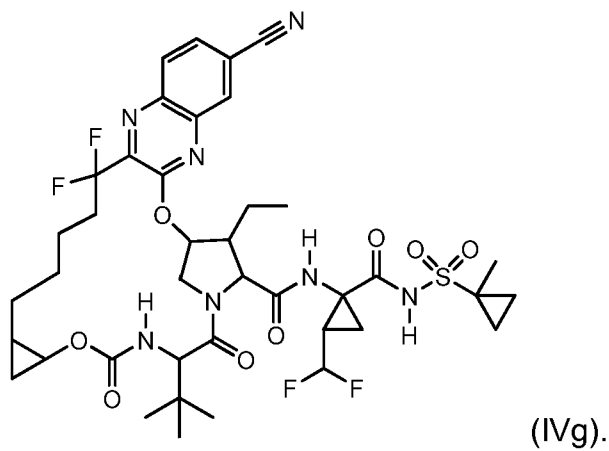
In one embodiment, a compound of Formula IVe, or a pharmaceutically acceptable salt thereof, is provided:



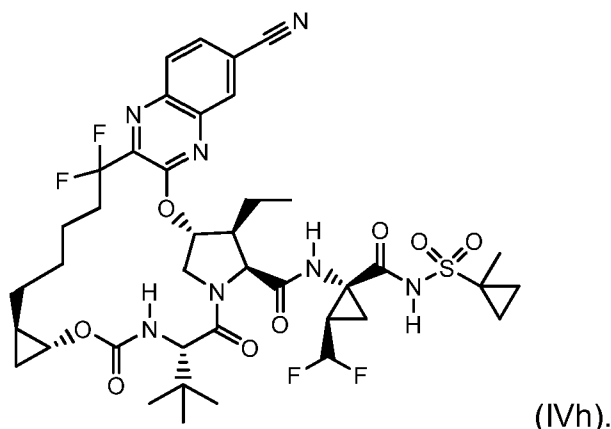
5 In one embodiment, a compound of Formula IVf, or a pharmaceutically acceptable salt thereof, is provided:



In one embodiment, a compound of Formula IVg, or a pharmaceutically acceptable salt thereof, is provided:



In one embodiment, a compound of Formula IVh, or a pharmaceutically acceptable salt thereof, is provided:



In one embodiment, a compound of any one of Formula IVa, IVb, IVc, IVd, IVe, IVf, IVg, or IVh, or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, is provided.

Methods of Treatment

One embodiment provides a method for treating a *Flaviviridae* viral infection (e.g., an HCV viral infection) in a patient in need thereof (e.g., a mammal such as a human). The method includes administering a compound of Formula I, II, III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for inhibiting the proliferation of the HCV virus, treating HCV infection or delaying the onset of HCV symptoms in a patient in need thereof (e.g., a mammal such as a human). The method includes administering a compound of Formula I, II, III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a compound of Formula I, II, III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof for use in medical therapy (e.g., for use in treating a *Flaviviridae* viral infection (e.g., an HCV viral infection) or the

proliferation of the HCV virus or delaying the onset of HCV symptoms in a patient (e.g., a mammal such as a human).

One embodiment provides a compound of Formula I, II, III, or IV (such as any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or a
5 pharmaceutically acceptable salt thereof for use in the manufacture of a medicament for treating a *Flaviviridae* viral infection (e.g., an HCV viral infection) or the proliferation of the HCV virus or delaying the onset of HCV symptoms in a patient in need thereof (e.g., mammal such as a human).

One embodiment provides a compound of Formula I, II, III, or IV (such as
10 any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of the proliferation of a *Flaviviridae* virus, an HCV virus or for use in the therapeutic treatment of delaying the onset of HCV symptoms.

One embodiment provides a compound of Formula I, II, III or IV (such as
15 any one of IVa-IVh) or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of a *Flaviviridae* virus infection (e.g., an HCV virus infection).

One embodiment provides the use of a compound of Formula I, II, III or IV
20 (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for a *Flaviviridae* virus infection (e.g., an HCV virus infection) in a mammal (e.g., a human).

In certain embodiments, a method of treating chronic hepatitis C infection
25 is provided. The method includes administering to a patient in need thereof, a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

In certain embodiments, a method of treating hepatitis C infection in
30 treatment-naïve patients is provided. The method includes administering to a treatment-naïve patient, a compound of Formula I, II III or IV (such as any one of

IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof.

In certain embodiments, a method of treating hepatitis C infection in treatment-experienced patients is provided. The method includes administering
5 to a treatment-experienced patient, a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof.

In certain embodiments, a method of treating hepatitis C infection in an interferon ineligible or an interferon intolerant patient is provided. The method
10 includes administering, a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

In certain embodiments, the methods of treatment described herein include administering the compound of Formula I, II III or IV (such as any one of
15 IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient for a fixed period of duration. In some embodiments, the fixed period of duration is 4 weeks, 6 weeks, 8 weeks, 10 weeks or 12 weeks. In other embodiments, the fixed period of duration is not more than 12 weeks.

20 In some embodiments, the compound is administered for about 12 weeks. In further embodiments, the compound is administered for about 12 weeks or less, for about 10 weeks or less, for about 8 weeks or less, for about 6 weeks or less, or for about 4 weeks or less.

The compound may be administered once daily, twice daily, once every
25 other day, two times a week, three times a week, four times a week, or five times a week.

In certain embodiments, the methods of treatment described herein includes administering a compound of Formula I, II III or IV (such as any one of
30 IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to is infected with HCV genotype (GT) 1, 2, 3, 4, 5, or 6 (i.e., a method for treating a GT 1, 2, 3, 4, 5, or 6 HCV infection).

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 1. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 2. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 3. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 4. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 5. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

One embodiment provides a method for treating an HCV infection in a patient in need thereof (e.g., a mammal such as a human), wherein the patient is infected with HCV genotype 6. The method includes administering a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient.

In the methods of treatment described herein, the administering step includes administering a therapeutically effective amount of a compound of Formula I, II III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof, to the patient in need of treatment.

In certain embodiments, methods of inhibiting the activity of HCV are provided. Such methods include the step of treating a sample suspected of containing HCV with a compound or composition disclosed herein.

In one embodiment, compounds disclosed herein act as inhibitors of HCV, as intermediates for such inhibitors or have other utilities as described below.

In certain embodiments, compounds binding in the liver may bind with varying degrees of reversibility.

In one embodiment, a method for treating HCV includes adding a compound disclosed herein to the sample. The addition step comprises any method of administration as described above.

If desired, the activity of HCV after application of the compound can be observed by any method including direct and indirect methods of detecting HCV activity. Quantitative, qualitative, and semiquantitative methods of determining HCV activity are all contemplated. Typically one of the screening methods described above are applied, however, any other method such as observation of the physiological properties of a living organism are also applicable.

Many organisms contain HCV. The compounds of this invention are useful in the treatment or prophylaxis of conditions associated with HCV activation in animals or in humans.

Pharmaceutical Formulations

“Pharmaceutically-acceptable” means suitable for use in pharmaceutical preparations, generally considered as safe for such use, officially approved by a regulatory agency of a national or state government for such use, or being listed in the U. S. Pharmacopoeia or other generally recognized pharmacopoeia for use in animals, and more particularly in humans.

“Pharmaceutically-acceptable carrier” refers to a diluent, adjuvant, excipient, or carrier, or other ingredient which is pharmaceutically-acceptable and with which a compound of the invention is administered.

The compounds of this invention are formulated with conventional carriers (e.g., inactive ingredient or excipient material), which will be selected in accordance with ordinary practice. Tablets will contain excipients including glidants, fillers, binders and the like. Aqueous formulations are prepared in sterile form, and when intended for delivery by other than oral administration generally will be isotonic. All formulations will optionally contain excipients such as those set forth in the *Handbook of Pharmaceutical Excipients* (1986). Excipients include ascorbic acid and other antioxidants, chelating agents such as EDTA, carbohydrates such as dextrin, hydroxyalkylcellulose, hydroxyalkylmethylcellulose, stearic acid and the like. One embodiment provides the formulation as a solid dosage form including a solid oral dosage form. The pH of the formulations ranges from about 3 to about 11, but is ordinarily about 7 to 10.

While it is possible for the active ingredients to be administered alone it may be preferable to present them as pharmaceutical formulations (compositions). The formulations, both for veterinary and for human use, of the invention comprise at least one active ingredient, as above defined, together with one or more acceptable carriers therefor and optionally other therapeutic ingredients. The carrier(s) must be “acceptable” in the sense of being compatible with the other ingredients of the formulation and physiologically innocuous to the recipient thereof.

The formulations include those suitable for the foregoing administration

routes. The formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmacy.

Techniques and formulations generally are found in *Remington's Pharmaceutical Sciences* (Mack Publishing Co., Easton, PA). Such methods include the step of
5 bringing into association the active ingredient with inactive ingredients (e.g., a carrier, pharmaceutical excipient, etc.) which constitutes one or more accessory ingredients. In general the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

10 In certain embodiments, formulations suitable for oral administration are presented as discrete units such as capsules, cachets or tablets each containing a predetermined amount of the active ingredient.

In certain embodiments, the pharmaceutical formulations include one or more compounds of the invention together with one or more pharmaceutically
15 acceptable carriers or excipients and optionally other therapeutic agents.

Pharmaceutical formulations containing the active ingredient may be in any form suitable for the intended method of administration. When used for oral use for example, tablets, troches, lozenges, aqueous or oil suspensions, dispersible powders or granules, emulsions, hard or soft capsules, syrups or elixirs may be
20 prepared. Compositions intended for oral use may be prepared according to any method known to the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents including sweetening agents, flavoring agents, coloring agents and preserving agents, in order to provide a palatable preparation. Tablets containing the active ingredient in admixture with
25 non-toxic pharmaceutically acceptable excipient which are suitable for manufacture of tablets are acceptable. These excipients may be, for example, inert diluents, such as calcium or sodium carbonate, lactose, lactose monohydrate, croscarmellose sodium, povidone, calcium or sodium phosphate; granulating and disintegrating agents, such as maize starch, or alginic acid;
30 binding agents, such as cellulose, microcrystalline cellulose, starch, gelatin or acacia; and lubricating agents, such as magnesium stearate, stearic acid or talc.

Tablets may be uncoated or may be coated by known techniques including microencapsulation to delay disintegration and adsorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or glyceryl distearate alone or with a wax may be employed.

The amount of active ingredient that is combined with the inactive ingredients to produce a dosage form will vary depending upon the host treated and the particular mode of administration. For example, in some embodiments, a dosage form for oral administration to humans contains approximately 1 to 1000 mg of active material formulated with an appropriate and convenient amount of carrier material (e.g., inactive ingredient or excipient material). In certain embodiments, the carrier material varies from about 5 to about 95% of the total compositions (weight: weight). In some embodiments, the pharmaceutical compositions described herein contain about 1 to 800 mg, 1 to 600 mg, 1 to 400 mg, 1 to 200 mg, 1 to 100 mg or 1 to 50 mg of the compound of Formula I, II, III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof. In some embodiments, the pharmaceutical compositions described herein contain not more than about 400 mg of the compound of Formula I, II, III or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof. In some embodiments, the pharmaceutical compositions described herein contain about 100 mg of the compound of Formula I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, or a pharmaceutically acceptable salt thereof.

It should be understood that in addition to the ingredients particularly mentioned above the formulations disclosed herein may include other agents conventional in the art having regard to the type of formulation in question, for example those suitable for oral administration may include flavoring agents.

Veterinary compositions comprising at least one active ingredient as above defined together with a veterinary carrier are further provided.

Veterinary carriers are materials useful for the purpose of administering the composition and may be solid, liquid or gaseous materials which are otherwise inert or acceptable in the veterinary art and are compatible with the active ingredient. These veterinary compositions may be administered orally,
5 parenterally or by any other desired route.

Effective dose of active ingredient depends at least on the nature of the condition being treated, toxicity, whether the compound is being used prophylactically (lower doses), the method of delivery, and the pharmaceutical formulation, and will be determined by the clinician using conventional dose
10 escalation studies.

Routes of Administration

One or more compounds of Formulas I, II, III, or IV (such as any one of IVa-IVh) (herein referred to as the active ingredients), or a pharmaceutically acceptable salt thereof, are administered by any route appropriate to the
15 condition to be treated. Suitable routes include oral, rectal, nasal, topical (including buccal and sublingual), vaginal and parenteral (including subcutaneous, intramuscular, intravenous, intradermal, intrathecal and epidural), and the like. It will be appreciated that the preferred route may vary with for example the condition of the recipient. An advantage of the compounds of this
20 invention is that they are orally bioavailable and can be dosed orally. Accordingly, in one embodiment, the pharmaceutical compositions described herein are oral dosage forms. In certain embodiments, the pharmaceutical compositions described herein are oral solid dosage forms.

One skilled in the art will recognize that substituents and other moieties of
25 the compounds of the generic formula herein should be selected in order to provide a compound which is sufficiently stable to provide a pharmaceutically useful compound which can be formulated into an acceptably stable pharmaceutical composition. Compounds which have such stability are contemplated as falling within the scope of the present invention. It should be understood by one skilled in
30 the art that any combination of the definitions and substituents described above should not result in an inoperable species or compound.

Combination Therapy

In yet another embodiment, the present application discloses pharmaceutical compositions comprising a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh), or a pharmaceutically acceptable salt thereof, in combination with at least one additional therapeutic agent (i.e., active ingredient), and a pharmaceutically acceptable carrier or excipient. In certain embodiments, additional therapeutic agents include additional antiviral agents.

The additional therapeutic agent used in combination with the compounds described herein includes, without limitation, any agent having a therapeutic effect when used in combination with the compound of the present invention. Such combinations are selected based on the condition to be treated, cross-reactivities of ingredients and pharmaco-properties of the combination. For example, in certain embodiments, the therapeutic agent used in combination with the compounds of Formulas I, II, III, or IV (such as any one of IVa-IVh) include, without limitation, one of more of the following: interferons, ribavirin analogs, NS3 protease inhibitors, NS5a inhibitors, NS5b inhibitors, alpha-glucosidase 1 inhibitors, hepatoprotectants, non-nucleoside inhibitors of HCV, nucleoside analogues, and other drugs for treating HCV infection. In some embodiments, the additional therapeutic agents include, without limitation, NS3 protease inhibitors, NS5a inhibitors, and/or NS5b inhibitors. In some embodiments, a pharmaceutical composition including a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh), or a pharmaceutically acceptable salt thereof and one or more of an NS3 protease inhibitor, an NS5a inhibitor, and/or an NS5b inhibitor is provided. In some embodiments, a pharmaceutical composition including a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh), or a pharmaceutically acceptable salt thereof and one or more of an NS5a inhibitor and/or an NS5b inhibitor is provided. In certain embodiments, pharmaceutical compositions is provided which includes a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh) and one or more additional antiviral agents, wherein the additional antiviral agent is not an interferon, ribavirin, or a ribavirin analogue. In further

embodiments, pharmaceutical compositions is provided which includes a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh), or a stereoisomer, or a mixture of stereoisomers, and one or more additional antiviral agents, wherein the additional antiviral agent is not ribavirin or a ribavirin analogue.

In certain embodiments, the compounds disclosed herein are combined with one or more other active ingredients (e.g., one or more additional antiviral agents) in a unitary dosage form for simultaneous or sequential administration to a patient. The combination therapy may be administered as a simultaneous or sequential regimen. When administered sequentially, the combination is administered in two or more administrations. In certain embodiments, the active ingredients are: (1) co-formulated and administered or delivered simultaneously in a combined pharmaceutical composition; (2) delivered by alternation or in parallel as separate pharmaceutical composition; or (3) by some other regimen.

When delivered in alternation therapy, the active ingredients are administered or delivered sequentially, e.g., in separate tablets, pills or capsules, or by different injections in separate syringes. In general, during alternation therapy, an effective dosage of each active ingredient is administered sequentially, i.e. serially, whereas in combination therapy, effective dosages of two or more active ingredients are administered together.

Exemplary interferons include, without limitation, pegylated rIFN-alpha 2b (PEG-Intron), pegylated rIFN-alpha 2a (Pegasys), rIFN-alpha 2b (Intron A), rIFN-alpha 2a (Roferon-A), interferon alpha (MOR-22, OPC-18, Alfaferone, Alfaferone, Multiferon, subalin), interferon alfacon-1 (Infergen), interferon alpha-n1 (Wellferon), interferon alpha-n3 (Alferon), interferon-beta (Avonex, DL-8234), interferon-omega (omega DUROS, Biomed 510), albinterferon alpha-2b (Albinterferon), IFN alpha XL, BLX-883 (Locteron), DA-3021, glycosylated interferon alpha-2b (AVI-005), PEG-Infergen, PEGylated interferon lambda (PEGylated IL-29), or beleroferon, IFN alpha-2b XL, rIFN-alpha 2a, consensus IFN alpha, infergen, rebif, pegylated IFN-beta, oral interferon alpha, feron, reaferon, intermax alpha, r-IFN-beta, and infergen + actimmune.

Exemplary ribavarin analogs include, without limitation, ribavirin (Rebetol, Copegus), levovirin VX-497, and taribavirin (Viramidine).

Exemplary NS5A inhibitors include, without limitation, ledipasvir (GS-5885), GS-5816, JNJ-47910382, daclatasvir (BMS-790052), ABT-267, MK-8742,
5 EDP-239, IDX-719, PPI-668, GSK-2336805, ACH-3102, A-831, A-689, AZD-2836 (A-831), AZD-7295 (A-689), and BMS-790052.

Exemplary NS5B inhibitors include, without limitation, polymerase inhibitor is sofosbuvir (GS-7977), tegobuvir (GS-9190), GS-9669, TMC647055, ABT-333, ABT-072, setrobuvir (ANA-598), filibuvir (PF-868554), VX-222, IDX-375, IDX-
10 184, IDX-102, BI-207127, valopicitabine (NM-283), R1626, PSI-6130 (R1656), PSI-7851, BCX-4678, nesbuvir (HCV-796), BILB 1941, MK-0608, NM-107, R7128, VCH-759, GSK625433, XTL-2125, VCH-916, JTK-652, MK-3281, VBY-708, A848837, GL59728, A-63890, A-48773, A-48547, BC-2329, BMS-791325, and BILB-1941.

Exemplary NS3 protease inhibitors include, without limitation, GS-9451, GS-9256, simeprevir (TMC-435), ABT-450, boceprevir (SCH-503034), narlaprevir (SCH-900518), vaniprevir (MK-7009), MK-5172, danoprevir (ITMN-191), sovalprevir (ACH-1625), neceprevir (ACH-2684), Telaprevir (VX-950), VX-813, VX-500, faldaprevir (BI-201335), asunaprevir (BMS-650032), BMS-605339,
20 VBY-376, PHX-1766, YH5531, BILN-2065, and BILN-2061.

Exemplary alpha-glucosidase 1 inhibitors include, without limitation, celgosivir (MX-3253), Miglitol, and UT-231B.

Exemplary hepatoprotectants include, without limitation, IDN-6556, ME 3738, MitoQ, and LB-84451.

Exemplary non-nucleoside inhibitors of HCV include, without limitation, benzimidazole derivatives, benzo-1,2,4-thiadiazine derivatives, and phenylalanine derivatives.

Exemplary nucleoside analogues include, without limitation, ribavirin, viramidine, levovirin, a L-nucleoside, or isatoribine and said interferon is α -
30 interferon or pegylated interferon.

Exemplary other drugs for treating HCV infection include, without limitation, imiquimod, 852A, GS-9524, ANA-773, ANA-975, AZD-8848 (DSP-3025), PF-04878691, and SM-360320, cyclophilin inhibitors (*e.g.*, DEBIO-025, SCY-635, or NIM811) or HCV IRES inhibitors (*e.g.*, MCI-067); emericasan (IDN-6556), ME-3738, GS-9450 (LB-84451), silibinin, or MitoQ. BAS-100, SPI-452, PF-4194477, TMC-41629, GS-9350, GS-9585, and roxythromycin.

Additional exemplary other drugs for treating HCV infection include, without limitation, zadaxin, nitazoxanide (alinea), BIVN-401 (virostat), DEBIO-025, VGX-410C, EMZ-702, AVI 4065, bavituximab, oglufanide, PYN-17, KPE02003002, actilon (CPG-10101), KRN-7000, civacir, GI-5005, ANA-975 (isatoribine), XTL-6865, ANA 971, NOV-205, tarvacin, EHC-18, and NIM811.

Still further exemplary other drugs for treating HCV infection include, without limitation, thymosin alpha 1 (Zadaxin), nitazoxanide (Alinea, NTZ), BIVN-401 (virostat), PYN-17 (altirex), KPE02003002, actilon (CPG-10101), GS-9525, KRN-7000, civacir, GI-5005, XTL-6865, BIT225, PTX-111, ITX2865, TT-033i, ANA 971, NOV-205, tarvacin, EHC-18, VGX-410C, EMZ-702, AVI 4065, BMS-650032, Bavituximab, MDX-1106 (ONO-4538), Oglufanide, FK-788, VX-497 (merimepodib), DEBIO-025, ANA-975 (isatoribine), XTL-6865, or NIM811.

General Synthetic Procedures

The schemes, procedures, and examples provided herein describe the synthesis of compounds disclosed herein as well as intermediates used to prepare the compounds. It is to be understood that individual steps described herein may be combined. It is also to be understood that separate batches of a compound may be combined and then carried forth in the next synthetic step.

The following schemes describe methods that are useful for preparing compounds disclosed herein.

L_F is a "linker fragment," (*that is to say*, a precursor to L) wherein an attached unsaturated carbon-carbon bond (*e.g.* alkene or alkyne) at the portion

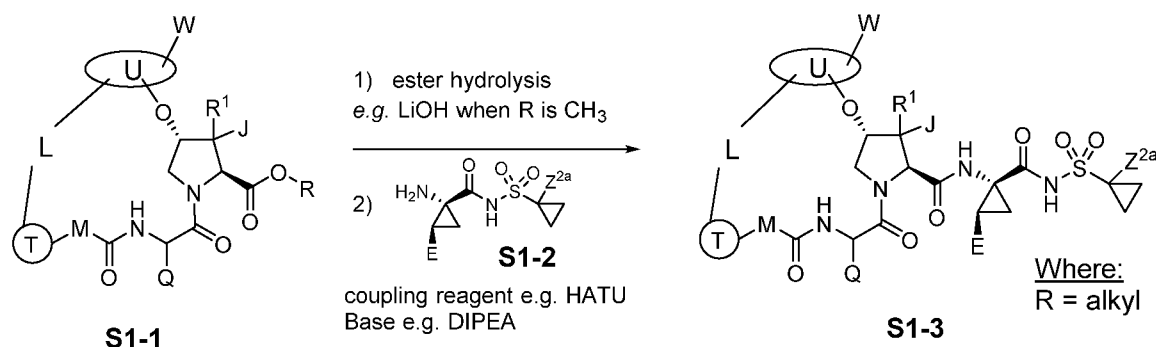
of L_F distal to $\textcircled{T}$ facilitates, as a non-limiting example, a metal catalyzed reaction that results in the connection of L_F to U to form an L group. Non-limiting

examples of metal catalyzed reactions that result in such a connection include Ru catalyzed ring closing metathesis or a Pd catalyzed cross coupling reaction (e.g. Negishi, Heck, or Sonagashira couplings).

¹H Nuclear magnetic resonance (NMR) spectra were in all cases

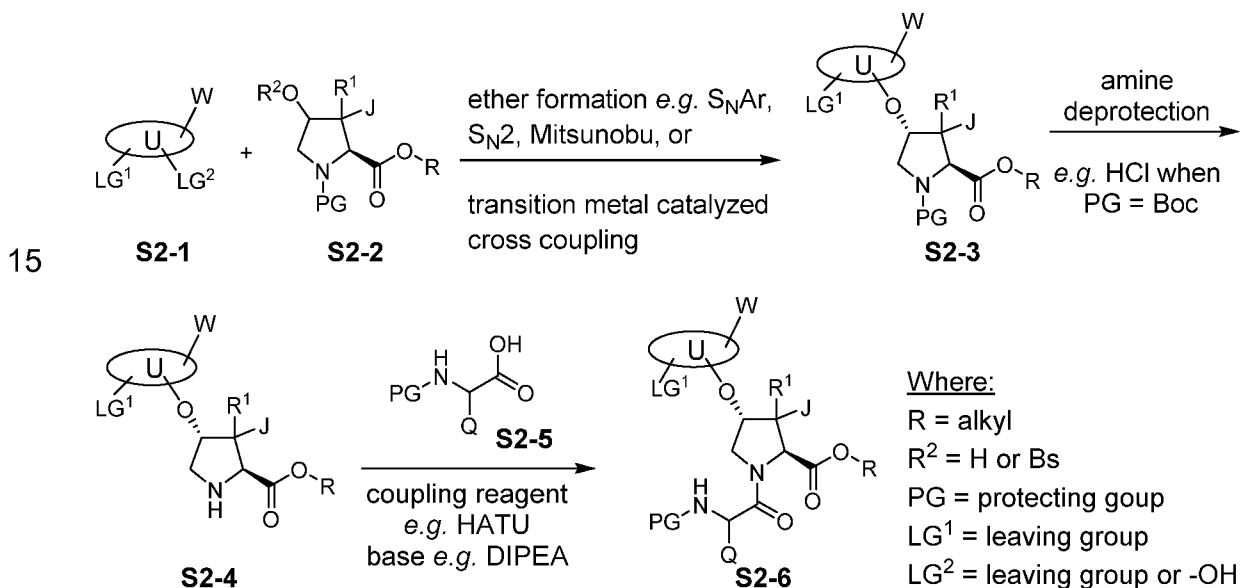
- 5 consistent with the proposed structures. Characteristic chemical shifts (δ) are given in parts-per-million downfield from tetramethylsilane using conventional abbreviations for designation of major peaks: e.g. s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad. The following abbreviations have been used for common solvents used in nuclear magnetic resonance experiments: CDCl₃,
10 deuteriochloroform; CD₃OD, perdeuteromethanol; CD₃CN, perdeuteroacetonitrile; d₆-DMSO, perdeuterodimethylsulfoxide. Mass spectra were obtained using Thermo Scientific or Agilent Technologies mass spectrometers equipped with electrospray ionisation (ESI). Masses are reported as ratios of mass to charge (m/z) of, for example, an ion of the compound (represented by [M]⁺), an ion
15 formed from the compound with another ion, such as a hydrogen ion (represented by [M+H]⁺), a sodium ion (represented by [M+Na]⁺), an ion formed from the compound by losing an ion, such as the deprotonated compound (represented by [M-H]⁻), etc. Analytical HPLC measurements were performed on Agilent Technologies Series 1100 HPLC using Phenomenex Kinetex C18, 2.6
20 μ m 100 Å, 4.6 x 100 mm column with an elution program of 2% Solvent B for 0.55 min, gradient to 98% solvent B over 8 min which is maintained at 98% solvent B for 0.40 min before returning to 2% solvent B over 0.02 min and maintaining at 2% solvent B for 2.03 min at a flow rate of 1.5 mL/min (Solvent A = MiliQ filtered H₂O + 0.1% TFA, Solvent B = MeCN + 0.1% TFA). The term “thin
25 layer chromatography (TLC)” refers to silica gel chromatography using silica gel 60 F₂₅₄ plates. The retention factor (“R_f”) of a compound is the distance travelled by a compound divided by the distance travelled by the solvent front on a TLC plate. Terms such as “early eluting” and “late eluting” refer to the order in which a compound elutes or is recovered from a solid stationary phase/liquid solvent
30 mobile phase based chromatography method (e.g. normal phase silica gel chromatography or reverse phase high pressure liquid chromatography (HPLC)).

Scheme 1



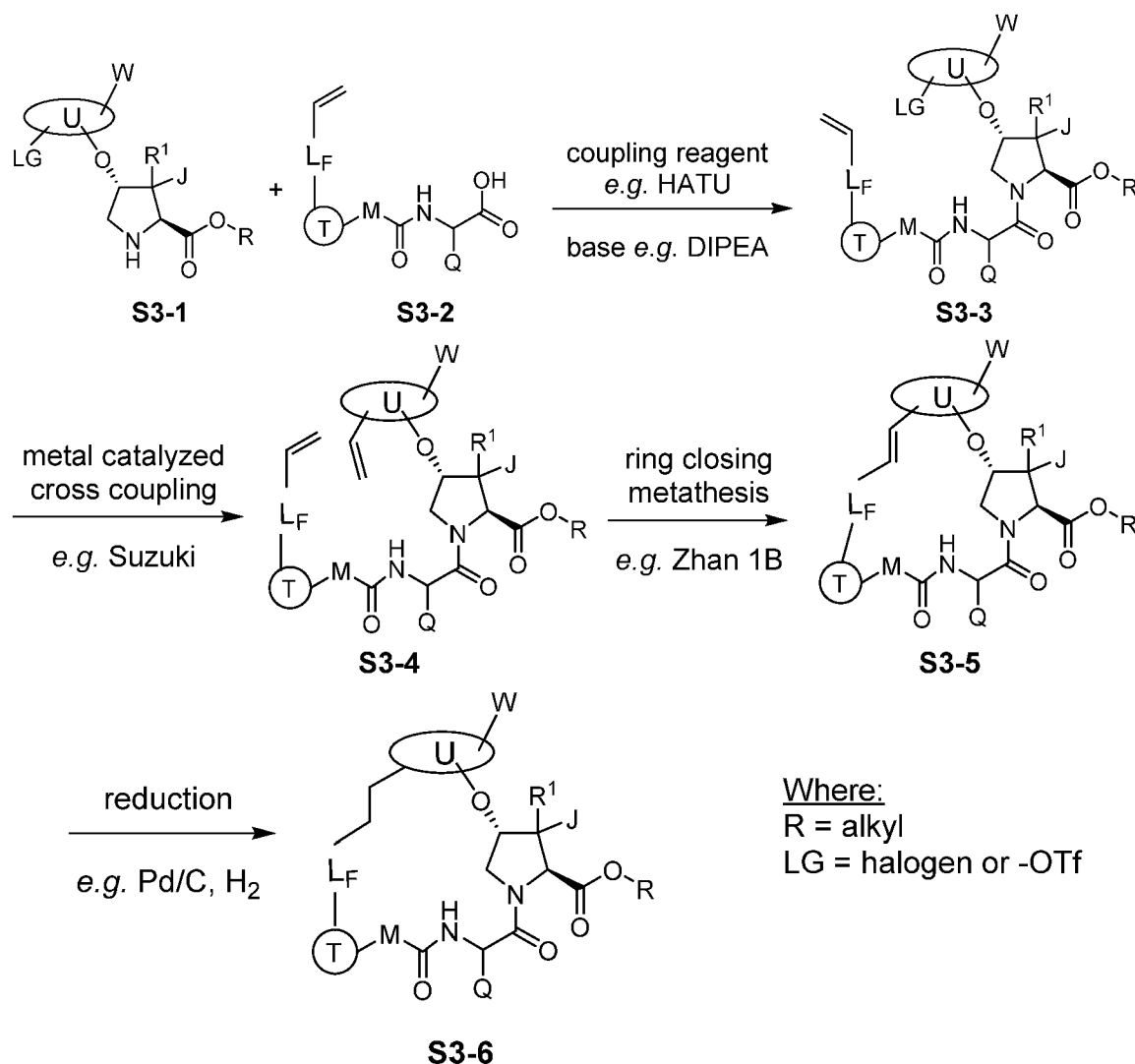
- 5 Scheme 1 demonstrates a general route to **S1-3**, where J, R¹, R, M, L, T, U, W and Q are as defined herein, Z^{2a} is as defined in Formula IV or III, or is H or Z^{2a} as defined in Formula I or II. In scheme 1, ester intermediate **S1-1** is hydrolyzed with a base such as lithium hydroxide when R is C₁-C₃ alkyl (e.g., methyl), or with acid such as trifluoroacetic acid when R is *tert*-butyl. The product of the ester hydrolysis is then coupled to an intermediate **S1-2** through a coupling reaction (e.g. using a peptide coupling agent such as HATU and a base such as DIPEA) to generate compounds of the general structure **S1-3**.
- 10

Scheme 2



Scheme 2 shows a general synthesis of an intermediate **S2-6** where U, W, R¹, J, and Q are as defined herein. In scheme 2, an appropriately substituted and protected proline species **S2-2** undergoes an etherification reaction such as S_NAr (e.g. treatment with Cs₂CO₃ and **S2-1** where R² is H and LG² is halogen), S_N2 (e.g. preconversion of **S2-2** to a brosylate (R² is Bs) followed by treatment with **S2-1** where LG² is -OH and base such as DABCO), Mitsunobu reaction (e.g. treatment of **S2-2** with DIAD and triphenylphosphine followed by **S2-1** where LG² is -OH) or metal catalyzed cross coupling reaction (LG² is halogen, R² is H) to generate intermediate **S2-3**. Intermediate **S2-3** is deprotected (e.g. 4 N HCl in dioxane when PG is Boc) to make intermediate **S2-4**. Amide bond formation via activation of the carboxylic acid of **S2-5** using peptide coupling agents or other carboxylic acid activation methods prior to treatment of **S2-4** provides intermediate **S2-6**.

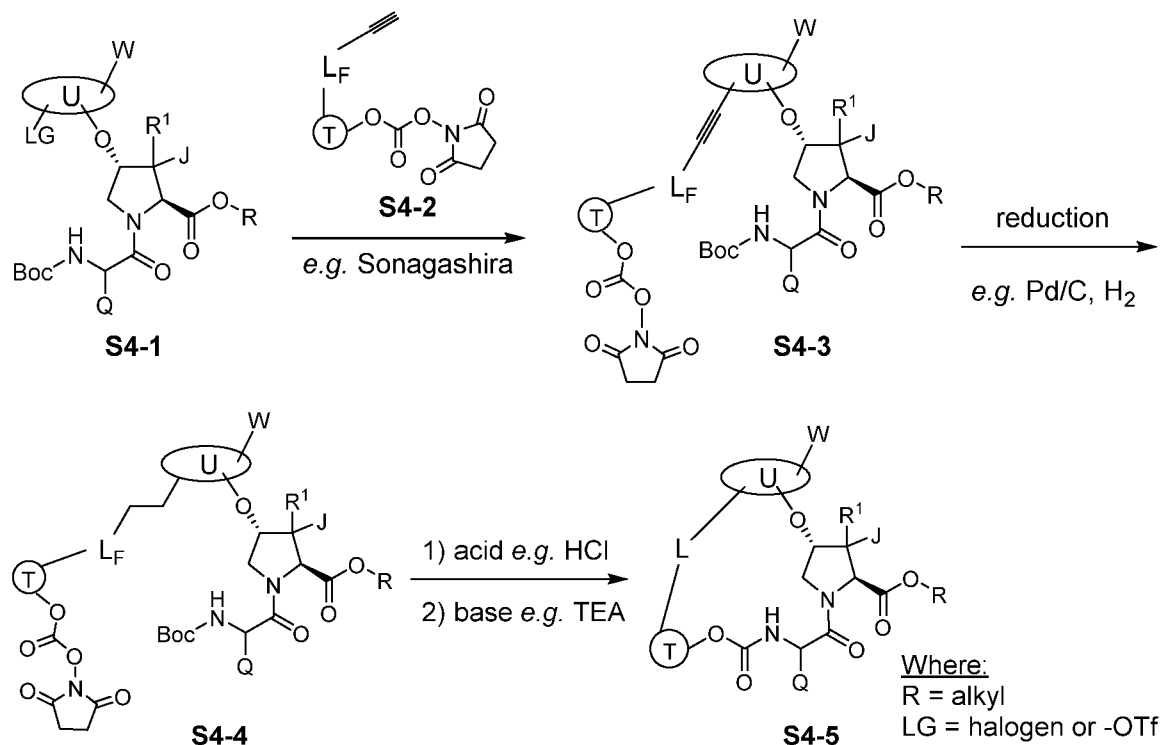
Scheme 3



5

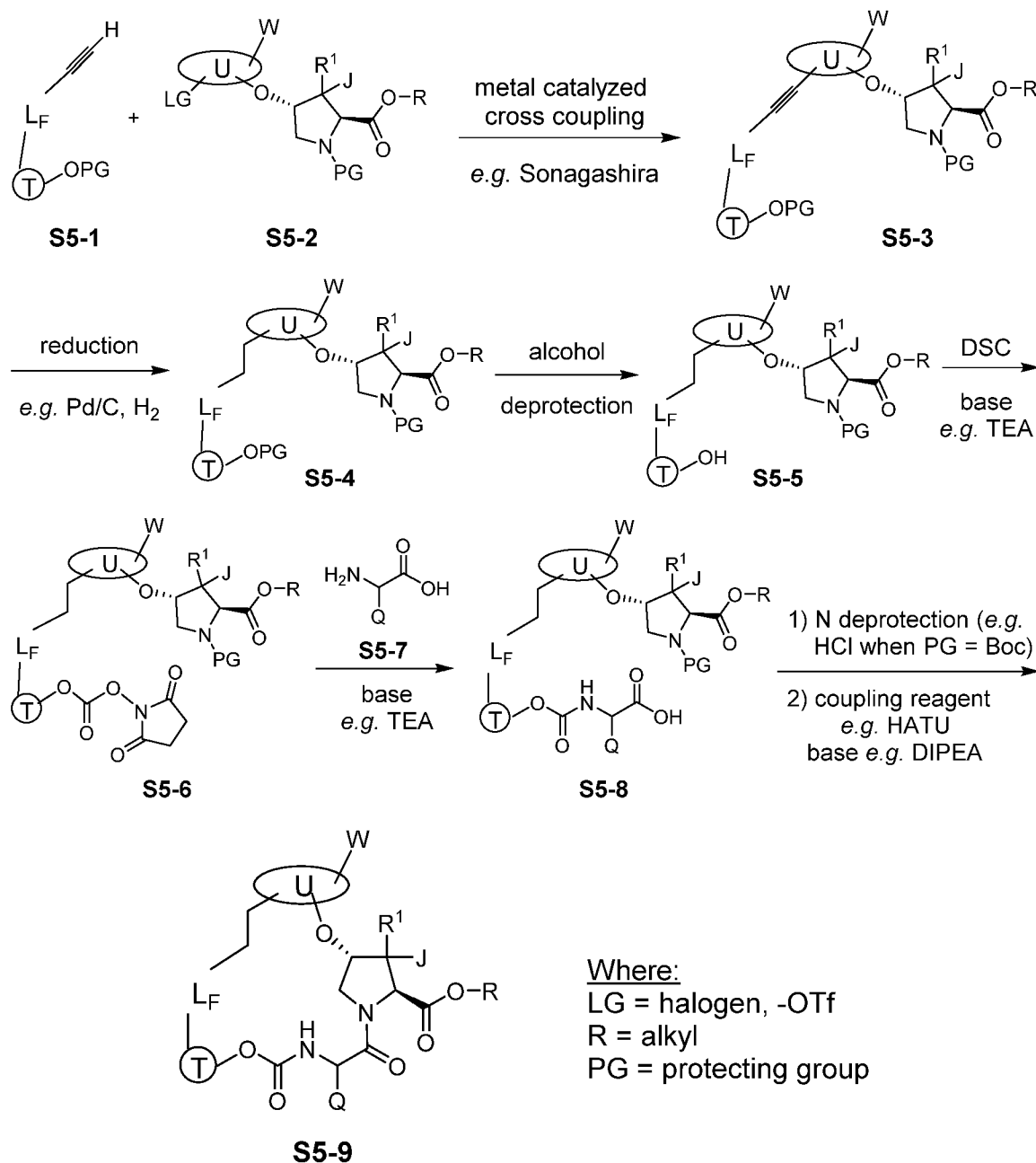
Scheme 3 shows a general synthesis of intermediate **S3-6** where $\text{L}_\text{F}-\text{CH}_2-\text{CH}_2$ is L, and U, W, R^1 , J, Q, M, T, and L are as defined herein. In scheme 3, an intermediate **S3-1** is coupled *via* amide bond formation reaction to an intermediate **S3-2** to provide intermediate **S3-3**. Metal catalyzed cross-coupling (e.g. Suzuki reaction using potassium vinyltrifluoroborate, Et_3N , $\text{Pd}(\text{dppf})\text{Cl}_2$) to give **S3-4**, followed by ring closing metathesis (e.g. Zhan 1B) to give **S3-5**, followed by reduction of the double bond (e.g. H_2 , 10% Pd/C) provides intermediate **S3-6**.

Scheme 4



- 5 Scheme 4 shows a general synthesis of an intermediate **S4-5** where $\text{L}_\text{F}-\text{CH}_2-\text{CH}_2$ is L, and U, W, R¹, J, Q, Q and L are as defied herein. In scheme 4, intermediate **S4-1** is protected with a protecting group such as Boc. **S4-1** undergoes a transition metal catalyzed cross coupling (e.g. Sonogashira coupling) to an intermediate **S4-2** to provide intermediate **S4-3**. The triple bond of intermediate **S4-3** is reduced to a single bond by hydrogenation (e.g. H₂, catalytic 10% Pd/C) to give intermediate **S4-4**. Deprotection of the Boc-amine followed by coupling under basic conditions (e.g. triethylamine) provides intermediate **S4-5**.
- 10

Scheme 5



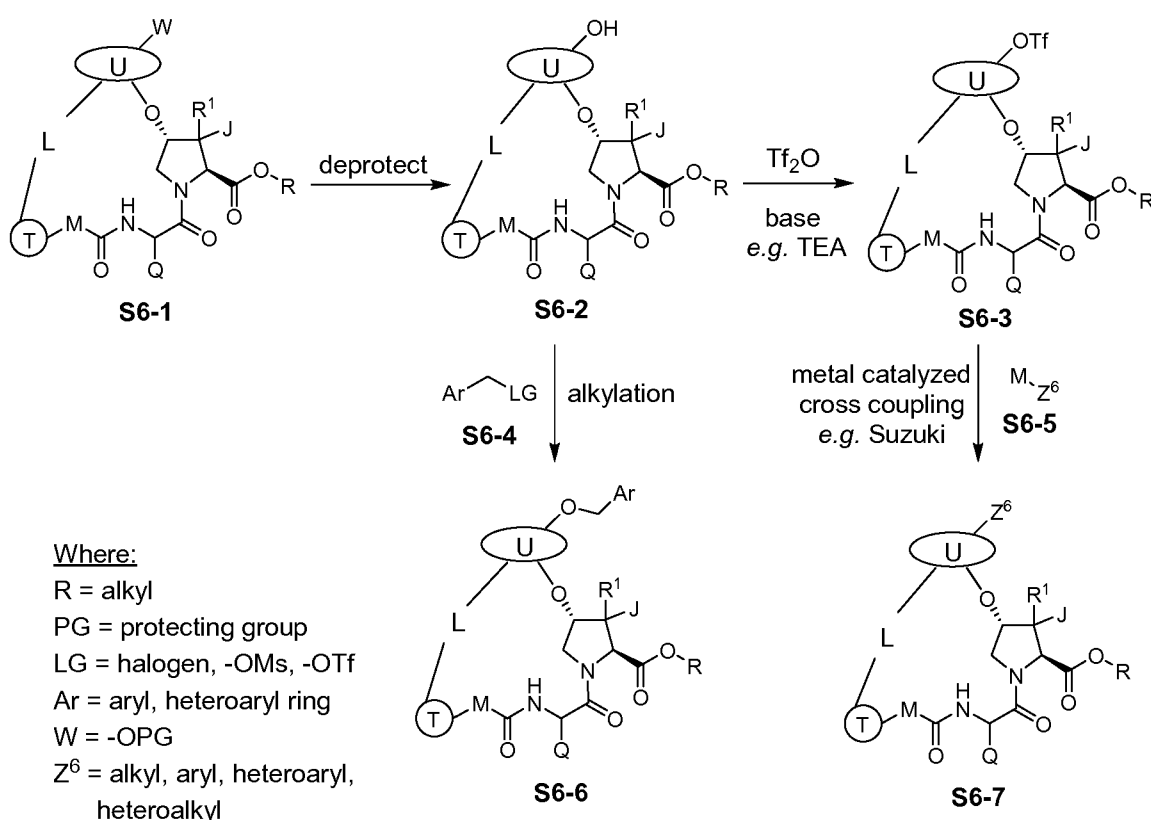
5

Scheme 5 shows a general synthesis of an intermediate **S5-9** where $\text{L}_\text{F}-\text{CH}_2-\text{CH}_2$ is L, and U, W, R^1 , J, Q, T and L are as defined herein. In scheme 5 intermediate **S5-1** undergoes a metal catalyzed cross coupling (such as Sonogashira reaction) with an intermediate **S5-2** to provide intermediate **S5-3**.

10 The triple bond of intermediate **S5-3** is reduced to a single bond under appropriate conditions such as by hydrogenation (e.g. using H_2 over catalytic

10% Pd/C) to give intermediate **S5-4**. Deprotection of the alcohol to provide **S5-5**, followed by activation (e.g. DSC under basic conditions, e.g. triethylamine) provides intermediate **S5-6**. Coupling of **S5-6** and **S5-7** under basic conditions provides **S5-8**. Deprotection of the proline nitrogen (e.g. HCl in dioxane when PG = Boc) followed by a macrolactamization (e.g. coupling agent such as HATU under basic conditions) provides intermediate **S5-9**.

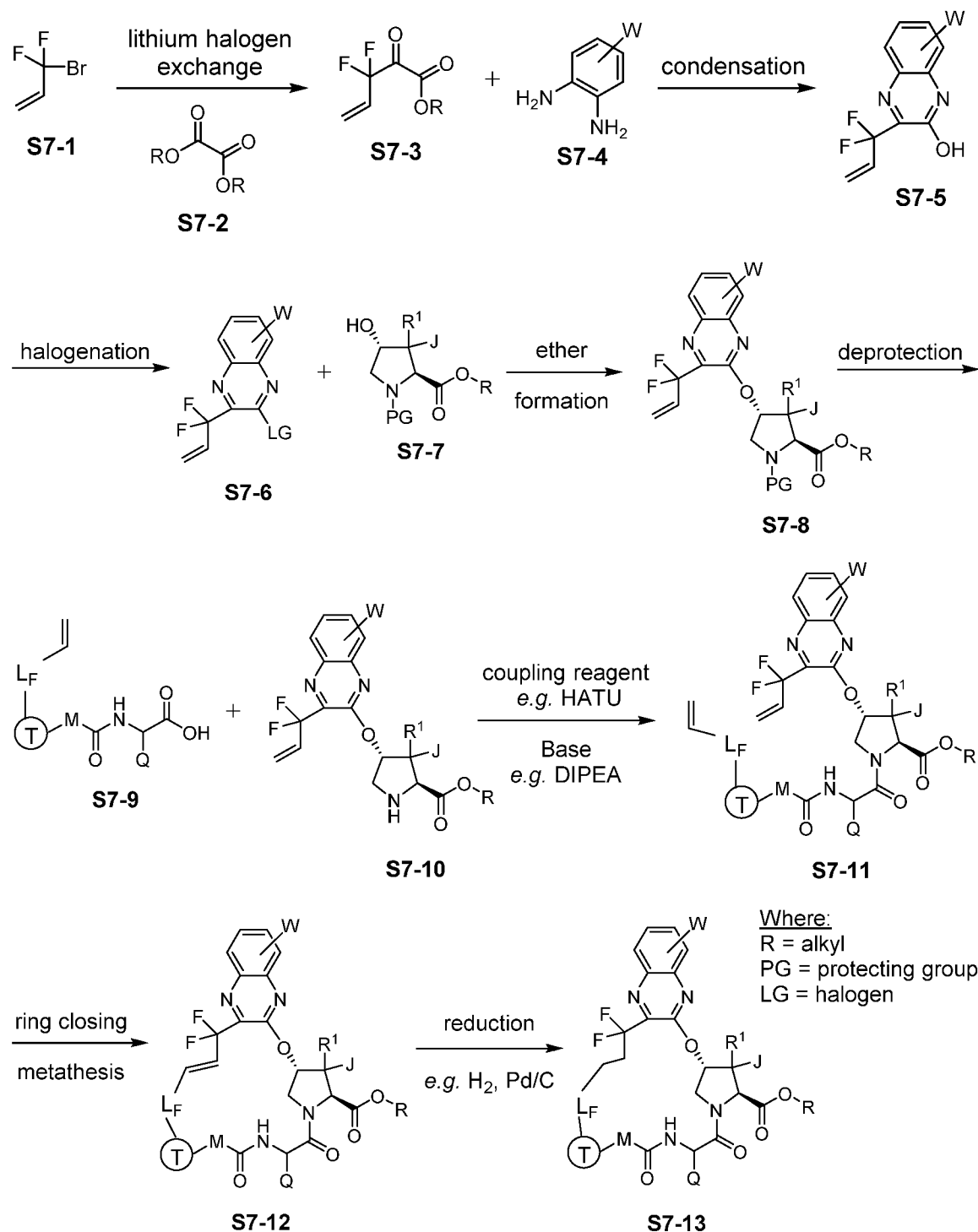
Scheme 6



Scheme 6 shows a general synthesis of the intermediates **S6-6** and **S6-7** where U, R¹, J, Q, M, T and L are as defined herein. In scheme 6 intermediate **S6-1**, W is OPG, where PG is a protecting group. **S6-1** is first deprotected to give intermediate **S6-2**. Alkylation of intermediate **S6-2** with an appropriate electrophile such as **S6-4** provides intermediate **S6-6**. Reaction of **S6-2** with triflic anhydride provides **S6-3**, which then undergoes metal catalyzed cross

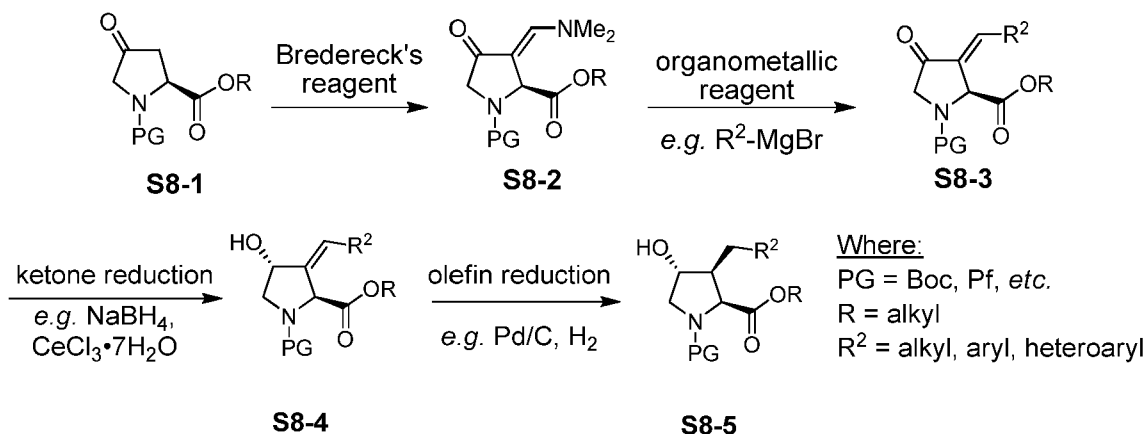
coupling with an appropriate nucleophilic coupling partner such as **S6-5** (e.g. Sonagashira or Suzuki reaction) to provide intermediate **S6-7**.

Scheme 7

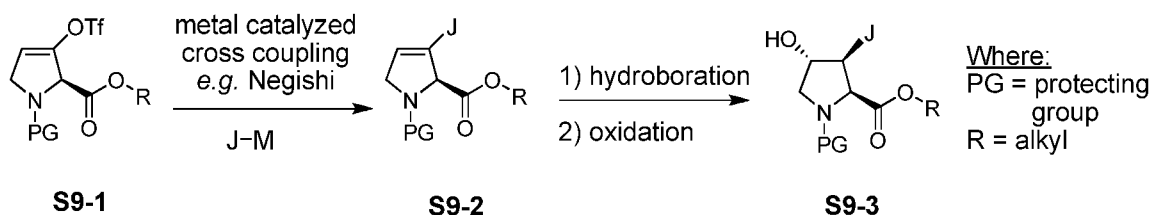


Scheme 7 shows a general synthesis of intermediate **S7-13** where $L_F-CH_2-CH_2-CF_2$ is L, and W, R^1 , J, Q, M, and T are as defined herein. In **S7-13**, L is C_1-C_3 alkyl. In Scheme 7, intermediate **S7-1** first undergoes lithium halogen exchange and then is treated with intermediate **S7-2** to generate intermediate **S7-3**, which is then condensed with intermediate **S7-4** to provide quinoxaline intermediate **S7-5**. Halogenation of **S7-5** (e.g. $POCl_3$) provides intermediate **S7-6**. Intermediate **S7-6** is attached via an ether formation to intermediate **S7-7** through an S_NAr reaction (e.g. Cs_2CO_3) to generate intermediate **S7-8**. Deprotection of the N-PG of intermediate **S7-8** provides **S7-10**. An amide bond coupling reaction of intermediate **S7-9** and intermediate **S7-10** (e.g. EDC and HOBT, or HATU, NMM, DIPEA) provides intermediate **S7-11**. Ring closing metathesis of **S7-11** generates intermediate **S7-12**. Reduction of the double bond (e.g. hydrogenation over palladium on carbon) provides intermediate **S7-13**.

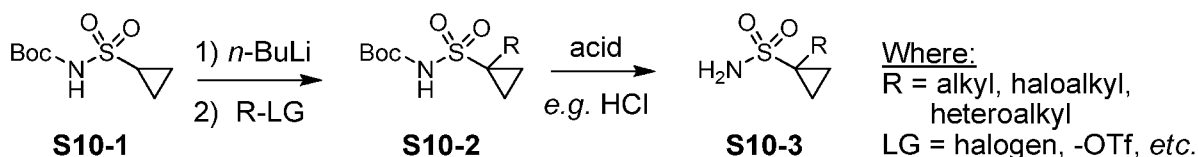
Scheme 8



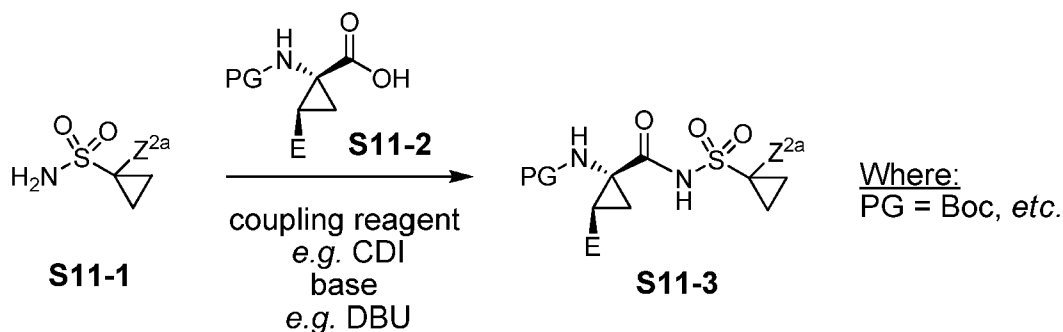
Scheme 8 shows a general syntheses of intermediate **S8-5** wherein an appropriately protected 4-oxo proline **S8-1** is reacted with Brederick's reagent to generate enaminone **S8-2**. Addition of an organometallic species provides enone **S8-3**, which undergoes reduction to hydroxyl intermediate **S8-4** in a stereoselective manner (e.g. Luche reduction or CBS reduction). Subsequent olefin reduction gives 3-substituted hydroxy proline intermediate **S8-5**.

Scheme 9

Scheme 9 shows a general synthesis of intermediate **S9-3** wherein a vinyl triflate **S9-1** (prepared for example, by methods in Kamenecka, T.M., *et al.* *Tetrahedron Letters*, **2001**, 8571) undergoes metal catalyzed cross coupling (e.g. Negishi coupling) to generate intermediate **S9-2**. Hydroboration and subsequent oxidation of intermediate **S9-2** provides intermediate **S9-3**.

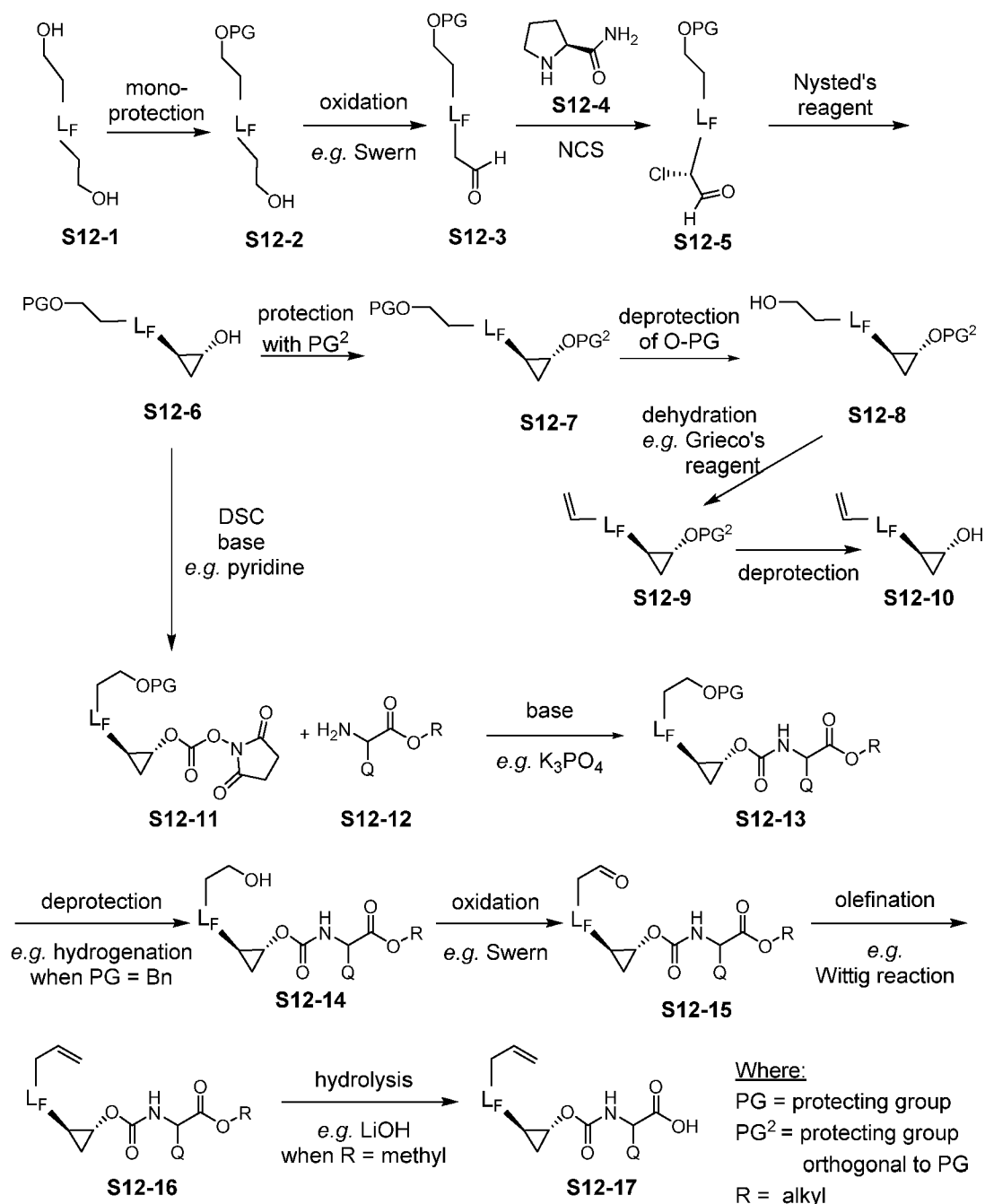
Scheme 10

Scheme 10 shows a general synthesis of substituted sulfonamide intermediate **S10-3**. *Tert*-butyl cyclopropylsulfonylcarbamate **S10-1** is deprotonated (e.g. *n*-BuLi) and reacted with an electrophile (e.g. alkyl halide) to give the protected substituted sulfonamide intermediate **S10-2**, which is then deprotected (e.g. 4 N HCl in dioxane) to provide intermediate **S10-3**.

Scheme 11

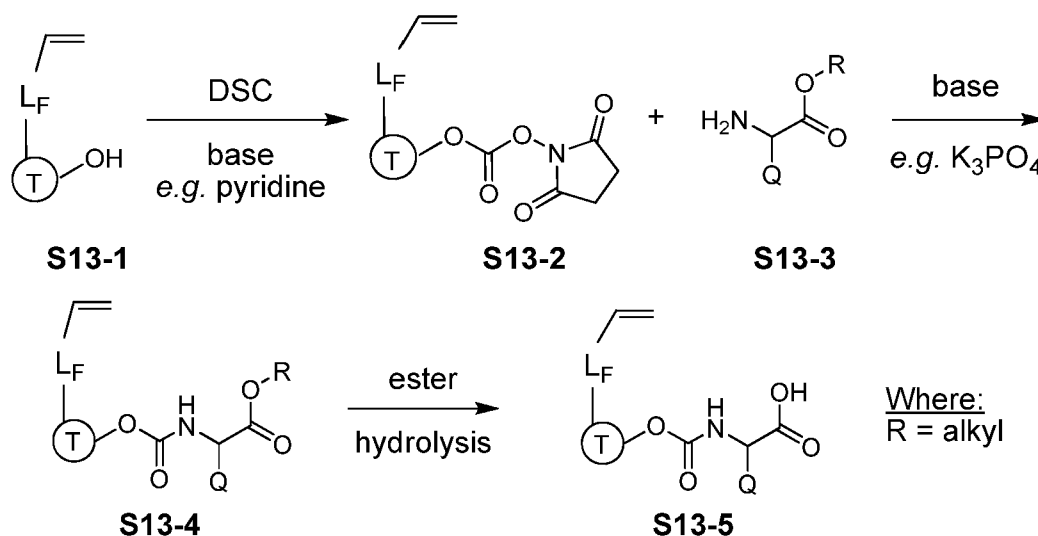
Scheme 11 shows a general synthesis of an intermediate **S11-3** where E is as defined herein. In Scheme 11, a sulfonamide **S11-1** is coupled to a protected amino acid **S11-2** using a coupling agent such as CDI and a base such as DBU.

Scheme 12



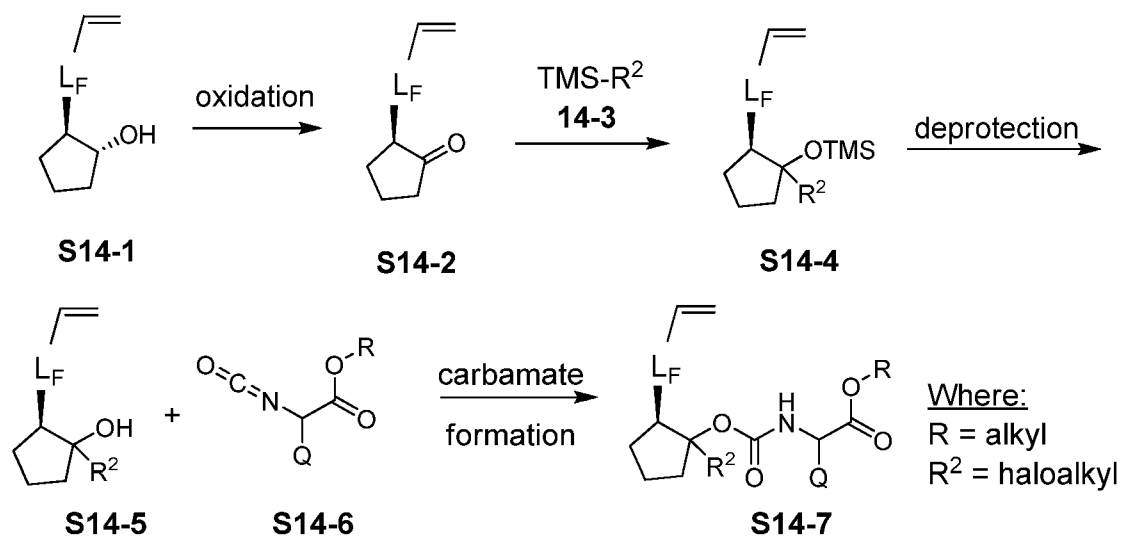
Scheme 12 shows a general synthesis of intermediates **S12-10** and **S12-17**, where L_F is C_1 - C_3 alkylene. In Scheme 12, both syntheses begin with the monoprotection of intermediate **S12-1** to produce **S12-2**, followed by oxidation (e.g. Swern oxidation) to provide intermediate **S12-3**. Enantioselective alpha chlorination (e.g. organocatalyst **S12-4** and NCS) provides chloroaldehyde **S12-5**. Reaction of **S12-5** with a bis-zinciomethane derivative (e.g. Nysted's reagent) provides cyclopropane intermediate **S12-6**. Intermediate **S12-6** is orthogonally protected to provide intermediate **S12-7**. Deprotection of -OPG of **S12-7** provides intermediate **S12-8**, which is subsequently dehydrated (e.g. Grieco's reagent) to intermediate **S12-9** and finally O-PG² is removed to afford intermediate **S12-10**. Intermediate **S12-6** is alternatively be activated (e.g. DSC and a base such as pyridine) to provide intermediate **S12-11** which is coupled to intermediate **S12-12** to provide carbamate intermediate **S12-13**. Intermediate **S12-13** is deprotected to give intermediate **S12-14**, which is then oxidized (e.g. Swern oxidation) to provide aldehyde intermediate **S12-15**. Olefination (e.g. Wittig reaction) of intermediate **S12-15** provides intermediate **S12-16**. Ester hydrolysis (e.g. LiOH when R is methyl, TFA when R = *tert*-butyl) affords intermediate **S12-17**.

Scheme 13



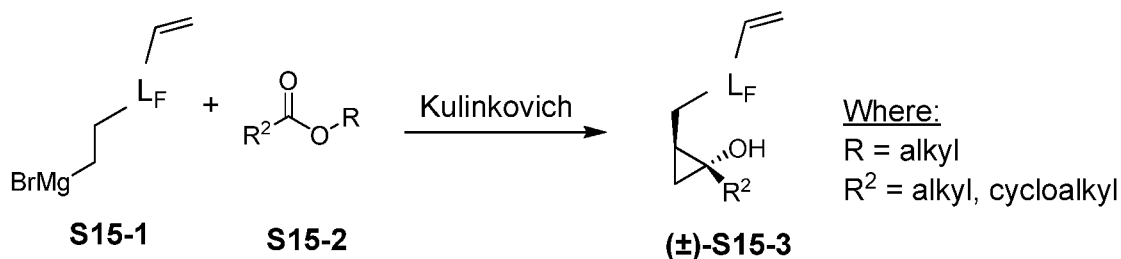
Scheme 13 shows a general synthesis of intermediate **S13-5** where Q and T are as defined herein and L_F is C_1 - C_3 alkylene. Activation of intermediate **S13-1** (e.g. DSC) followed by carbamate formation between intermediate **S13-2** and amino acid ester intermediate **S13-3** under basic conditions gives ester intermediate **S13-4**. Ester hydrolysis (e.g. LiOH when R = methyl or TFA when R = *tert*-butyl) provides intermediate **S13-5**.

Scheme 14



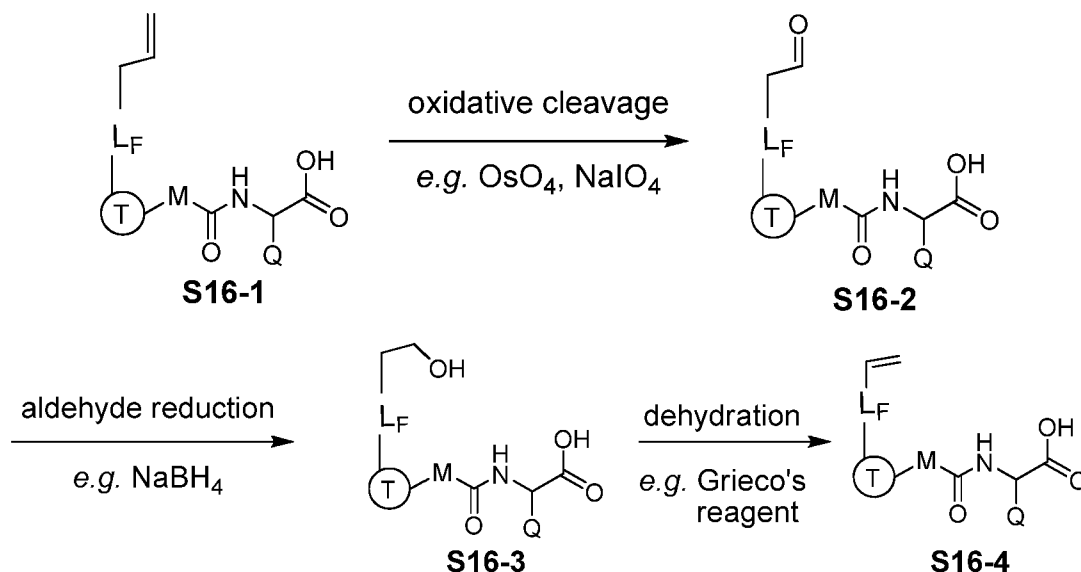
Scheme 14 shows a general synthesis of intermediate **S14-7** where Q is as defined herein and L_F is C_1 - C_3 alkylene. Oxidation of intermediate **S14-1** (e.g. Dess-Martin periodinane) produces ketone **S14-2**. Treatment of **S14-2** with **S14-3** (e.g. R^2 is $-CF_3$) in the presence of suitable reagent (such as CsF) provides intermediate **S14-4**. Deprotection of **S14-4** (e.g. TBAF) provides **S14-5**, which is then added to an isocyanate **S14-6** to give intermediate **S14-7**.

Scheme 15

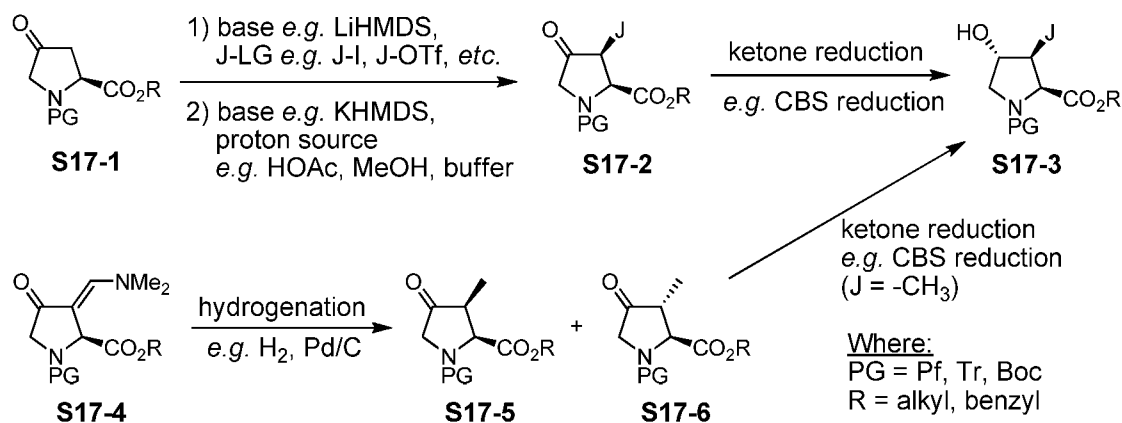


Scheme 15 shows a general synthesis of an intermediate ($\pm$)-**S15-3**, generated from the Kulinkovich reaction of a Grignard reagent **S15-1** and an ester **S15-2**, according to standard procedures as described in Kulinkovich, O.G. and Kananovich, D.G., *Eur. J. Org. Chem.* **2007**, 2007, 2121.

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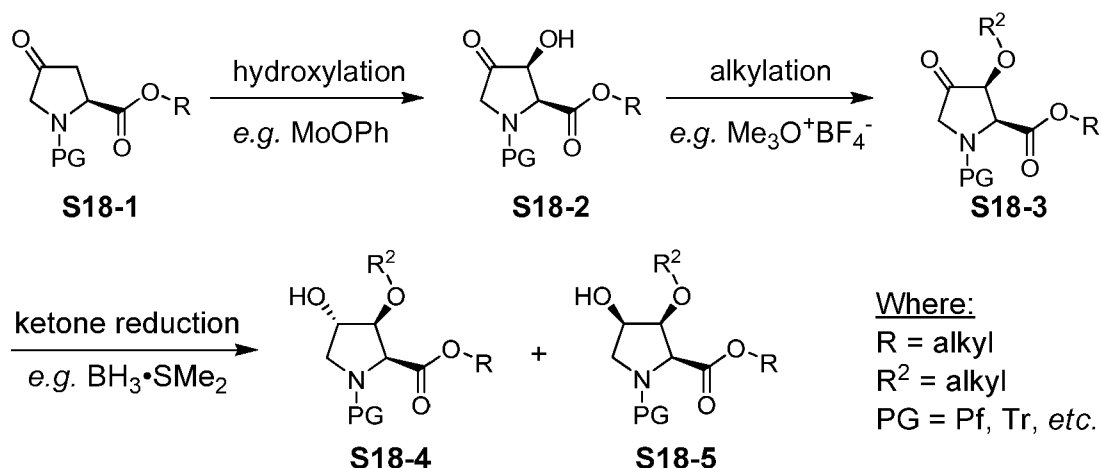
Scheme 16

Scheme 16 shows a general synthesis of an intermediate **S16-4** where Q, M, and T are as defined herein and L_F is C_1 - C_3 alkylene. In Scheme 16, olefin **S16-1** undergoes oxidative cleavage (e.g. OsO_4 , NaIO_4) to aldehyde **S16-2**, which is then reduced to alcohol **S16-3** (e.g. NaBH_4) and finally is dehydrated (e.g. Greico elimination) to afford intermediate **S16-4**.

15 **Scheme 17**

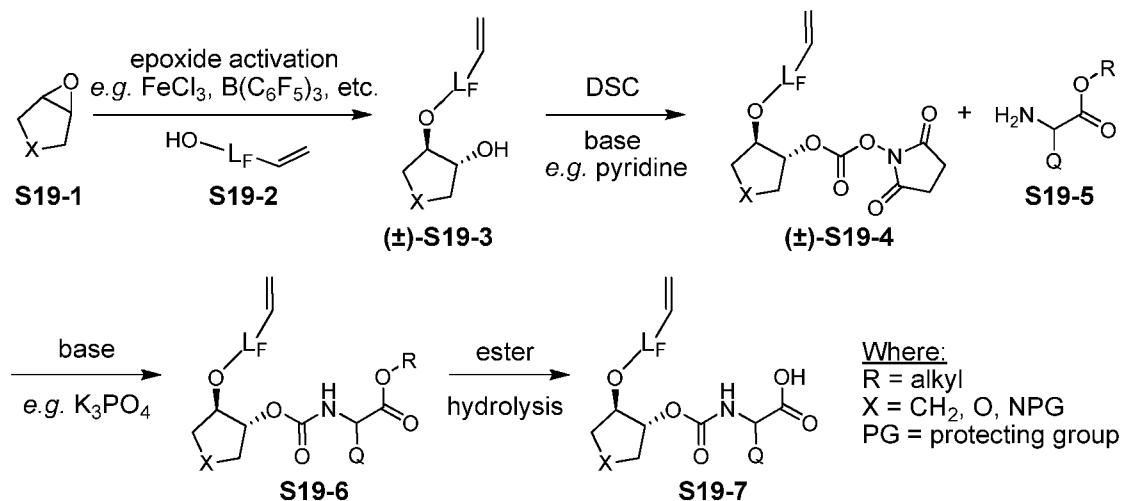
Scheme 17 shows two general synthetic strategies for producing intermediate **S17-3** where J is as defined herein. In Scheme 17, an appropriately protected 4-oxo proline **S17-1** is deprotonated and alkylated (e.g. LiHMDS followed by J-LG). A second deprotonation with base followed by re-protonation at low temperature generates stereo-enriched intermediate **S17-2**, based on a described protocol (Blanco, M-J. et. al. *J. Org. Chem.* **1999**, 64, 8786). Reduction of the ketone in a stereoselective manner (e.g. CBS reduction) provides alcohol **S17-3**. Where J is methyl, Scheme 17 shows an alternative general synthesis wherein intermediate **S17-4** is hydrogenated to generate a mixture of **S17-5** and **S17-6**. Ketone reduction of **S17-5** in a stereoselective manner (e.g. CBS reduction) provides intermediate **S17-3**, where J is methyl.

Scheme 18



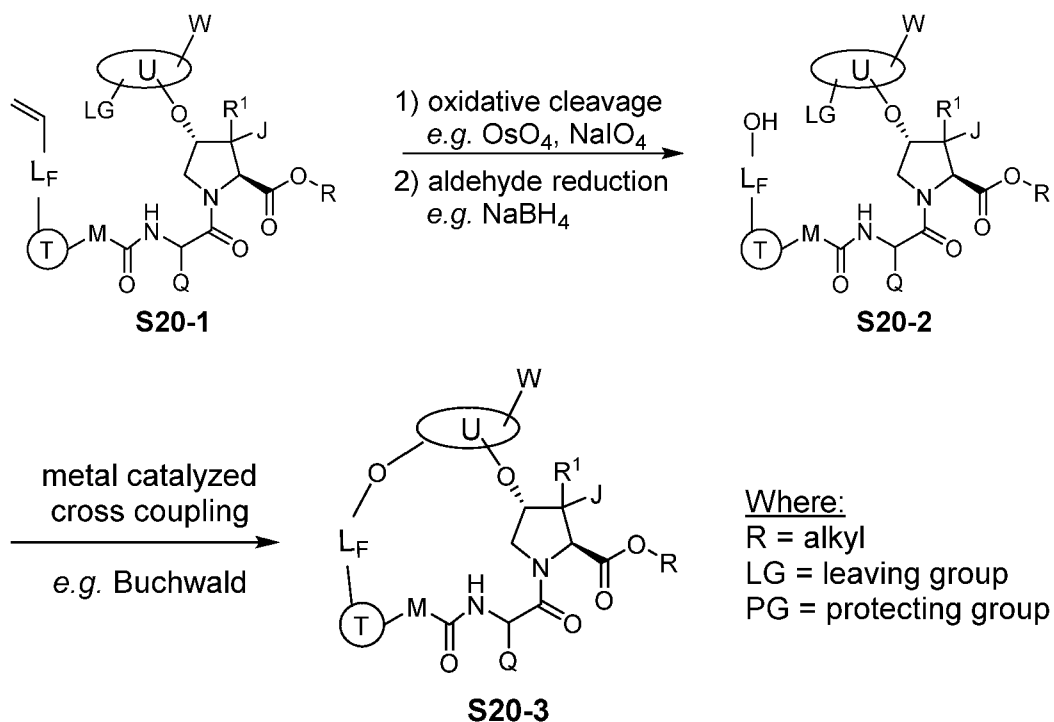
Scheme 18 shows a general synthesis of intermediates **S18-4** and **S18-5**, wherein an appropriately protected 4-oxo proline **S18-1** is hydroxylated in a stereoselective manner (e.g. MoOPh) to provide intermediate **S18-2**, which is subsequently reacted with an alkylating agent (e.g. trimethyloxonium tetrafluoroborate) to afford intermediate **S18-3**. Reduction of the ketone (e.g. $\text{BH}_3 \cdot \text{SMe}_2$ complex) provides intermediates **S18-4** and **S18-5**.

Scheme 19



Scheme 19 shows a general synthesis of an intermediate **S19-7** where Q is as defined herein and L_F is $\text{C}_1\text{-C}_3$ alkylene. In Scheme 19, an epoxide intermediate **S19-1** is converted to the (±)-*trans*- intermediate **S19-3**. Activation of the alcohol intermediate (±)-**S19-3** (e.g. DSC) produces carbonate (±)-**S19-4**, which is treated with intermediate **S19-5** to afford carbamate intermediate **S19-6**. Intermediate **S19-6** then undergoes ester hydrolysis (e.g. LiOH when R = methyl or TFA when R = *tert*-butyl) to provide intermediate **S19-7**.

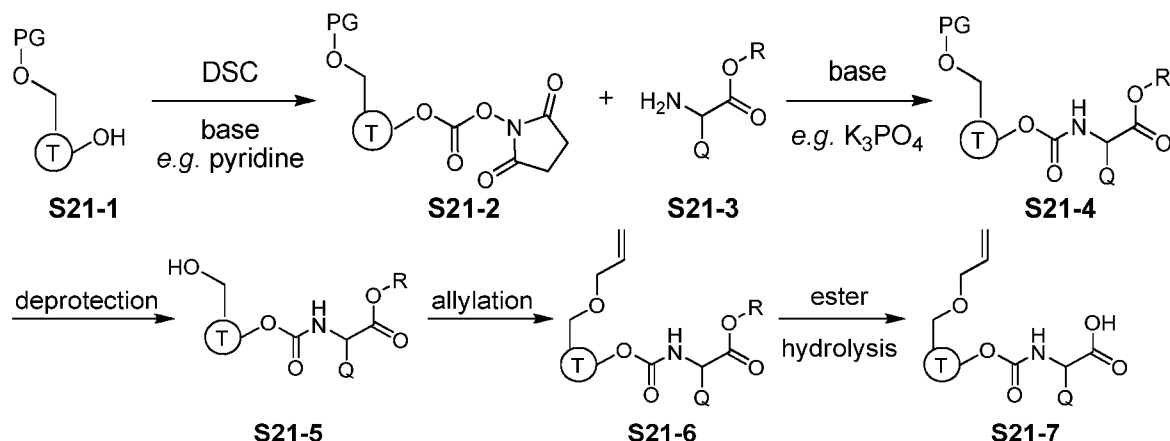
Scheme 20



Scheme 20 shows a general synthesis of an intermediate **S20-3** where

5 L_F-O is F, and U, W, R¹, J, Q, M, T and L are as defined herein. In scheme 20, intermediate **S20-1** first undergoes oxidative cleavage of an olefin (e.g. OsO₄, NaIO₄) and subsequent reduction of the resultant aldehyde (e.g. NaBH₄) to provide intermediate **S20-2**. Transition metal catalyzed cross coupling provides intermediate **S20-3**.

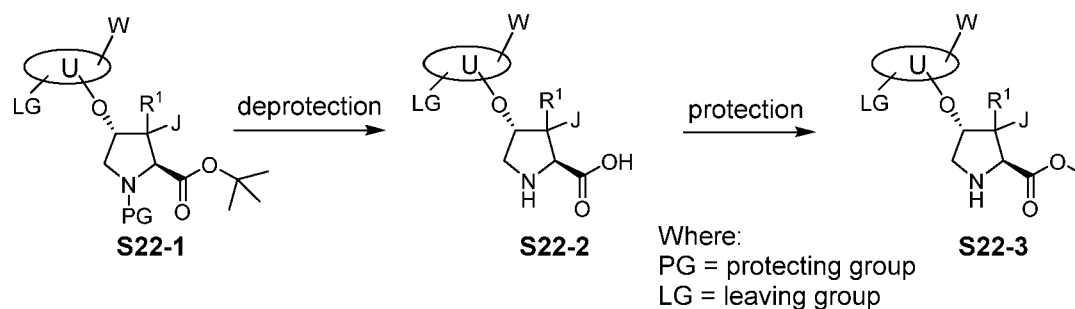
Scheme 21



Where:
 R = alkyl
 PG = protecting group

Scheme 21 shows a general synthesis of an intermediate **S21-7** where Q and T are as defined herein. In Scheme 21, activation of mono-protected diol **S21-1** (e.g. DSC) followed by coupling with amino ester intermediate **S21-3** provides carbamate intermediate **S21-4**. Intermediate **S21-4** is then deprotected to unmask the alcohol functionality (intermediate **S21-5**) which is then allylated to provide intermediate **S21-6**. Intermediate **S21-6** then undergoes ester hydrolysis (e.g. LiOH when R = methyl or TFA when R = *tert*-butyl) to provide intermediate **S21-7**.

Scheme 22



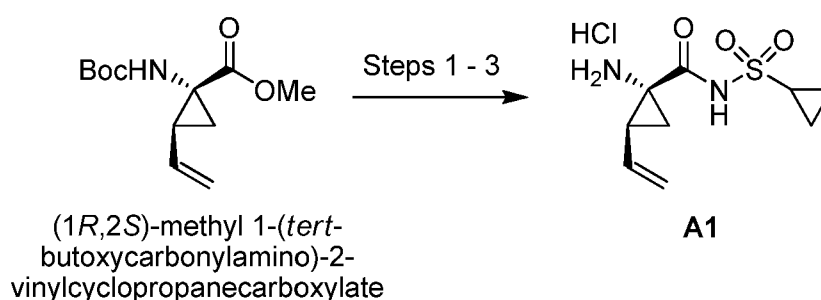
Scheme 22 shows a general synthesis of an intermediate **S22-3** where U, W, R¹, J, and Q are as defined herein. In scheme 22 intermediate **S22-1** is globally deprotected to provide amino acid intermediate **S22-2**. The acid

functionality of intermediate **S22-2** is then converted to a base-labile carboxylic acid ester (e.g. methyl ester), intermediate **S22-3**.

Preparation of Selected Intermediates

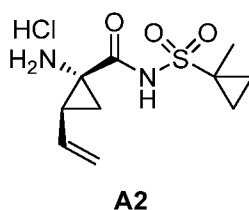
5

Preparation of Intermediate **A1**.

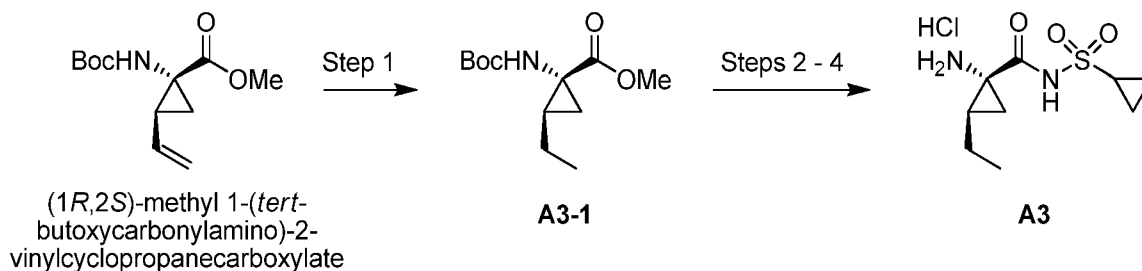


- 10 Steps 1–3. Preparation of Intermediate **A1**: Intermediate **A1** was prepared using the procedure detailed in Example 2.12 of International Patent Publication No. WO 2008/064066 (hereinafter “WO ‘066”) (p. 75–76) substituting (1R,2S)-methyl 1-(*tert*-butoxycarbonylamino)-2-vinylcyclopropane-carboxylate (prepared according to Beaulieu, P.L., *et al.*, *J. Org. Chem.* **2005**, 70, 5869) for (1R,2S)-
- 15 ethyl 1-(*tert*-butoxycarbonylamino)-2-vinylcyclopropane-carboxylate.

Preparation of Intermediate **A2**.

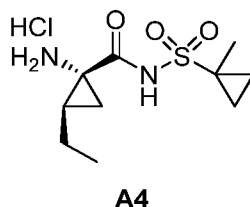


- 20 Intermediate **A2** was prepared similarly to Intermediate **A1**, substituting 1-methylcyclopropane-1-sulfonamide (prepared according to Example 1.2 of WO ‘066, p. 47) for cyclopropanesulfonamide.

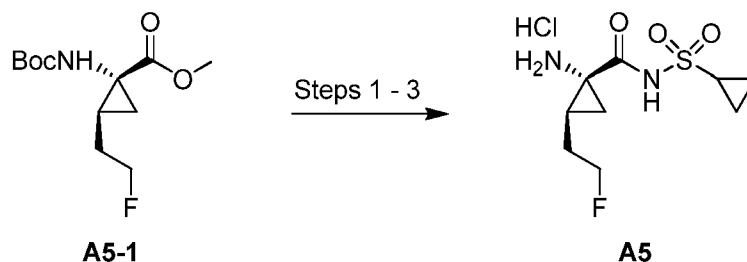
Preparation of Intermediate **A3**.

Step 1. Preparation of **A3-1**: Cyclopropane ester **A3-1** was prepared from (1R,2S)-methyl 1-(tert-butoxycarbonylamino)-2-vinylcyclopropanecarboxylate (prepared according to Beaulieu, P.L., *et al.*, *J. Org. Chem.* **2005**, 70, 5869) using the procedure detailed in Example 26 of International Patent Publication No. WO 2009/005677 (hereinafter "WO '677") (p. 176).

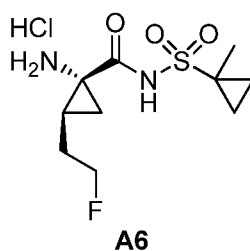
Steps 2–4. Preparation of Intermediate **A3**: Intermediate **A3** was prepared similarly to (1R,2S)-1-amino-N-(cyclopropylsulfonyl)-2-vinylcyclopropanecarboxamide hydrochloride of Example 2.12 of WO '066 (p. 75–76) substituting **A3-1** for (1R,2S)-ethyl 1-(tert-butoxycarbonylamino)-2-vinylcyclopropane-carboxylate.

Preparation of Intermediate **A4**.

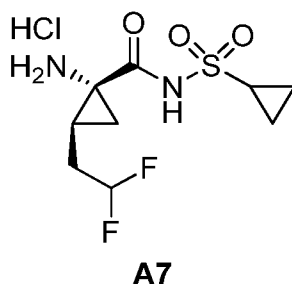
Intermediate **A4** was prepared similarly to Intermediate **A3**, substituting 1-methylcyclopropane-1-sulfonamide (prepared according to Example 1.2 of WO '066, p. 47) for cyclopropanesulfonamide.

Preparation of Intermediate **A5**.

Steps 1–3. Preparation of Intermediate **A5**: Intermediate **A5** was prepared similarly to (1R,2S)-1-amino-N-(cyclopropylsulfonyl)-2-vinylcyclopropanecarboxamide hydrochloride of Example 2.12 of WO '066 (p. 75–76) substituting **A5-1** (prepared according to Example 104 of WO '677, p. 265) for (1R,2S)-ethyl 1-(tert-butoxycarbonylamino)-2-vinylcyclopropanecarboxylate.

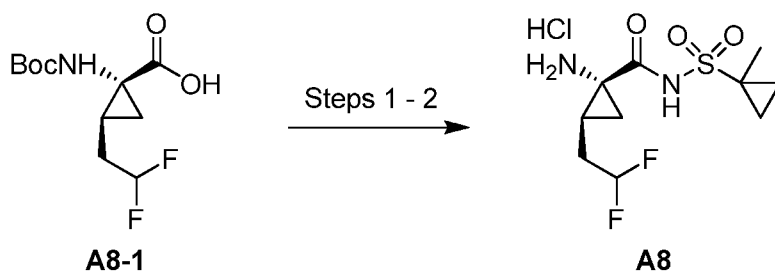
10 Preparation of Intermediate **A6**.

Intermediate **A6** was prepared similarly to Intermediate **A5**, substituting 1-methylcyclopropane-1-sulfonamide (prepared according to Example 1.2 of WO '066, p. 47) for cyclopropanesulfonamide.

Preparation of Intermediate **A7**.

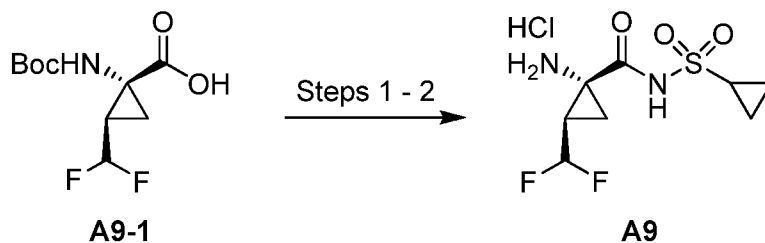
Intermediate **A7** was prepared according to Example 97.1.6 of U.S. Patent Publication No. 2009/274652 (hereinafter "US '652"), p. 72–73.

5 Preparation of Intermediate **A8**.



Steps 1–2. Preparation of Intermediate **A8**: Intermediate **A8** was prepared similarly to (1R,2S)-1-amino-N-(cyclopropylsulfonyl)-2-vinylcyclopropane-carboxamide hydrochloride of Example 2.12 of WO '066 (p. 75–76) substituting **A8-1** (prepared according to the procedure detailed in Example 97.1.4 of US '652, p. 72–3) for (1R,2S)-1-(tert-butoxycarbonylamino)-2-vinylcyclopropanecarboxylic acid and substituting 1-methylcyclopropane-1-sulfonamide (prepared according to Example 1.2 of WO '066, p. 47) for cyclopropanesulfonamide. **A8-1** ¹H NMR (400 MHz, CDCl₃) δ 9.22 (br s, 1H), 6.05 – 5.75 (m, 1H), 5.38 (br s, 1H), 2.04 (m, 2H), 1.68 (m, 2H), 1.61 (m, 3H), 1.52 (m, 9H), 1.42 (m, 1H), 1.28 (m, 1H), 0.85 (m, 2H).

Preparation of Intermediate **A9**.

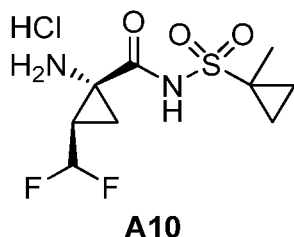


Step 1–2. Preparation of Intermediate **A9**: Intermediate **A9** was prepared similarly to (1R,2S)-1-amino-N-(cyclopropylsulfonyl)-2-vinylcyclopropane-

carboxamide hydrochloride of Example 2.12 of WO '066 (p. 75–76) substituting **A9-1** (prepared according to Example 1, Steps 1L–1O of International Patent Publication No. WO 2009/134987, p. 75–77) for (1R,2S)-1-(tert-butoxycarbonylamino)-2-vinylcyclopropanecarboxylic acid.

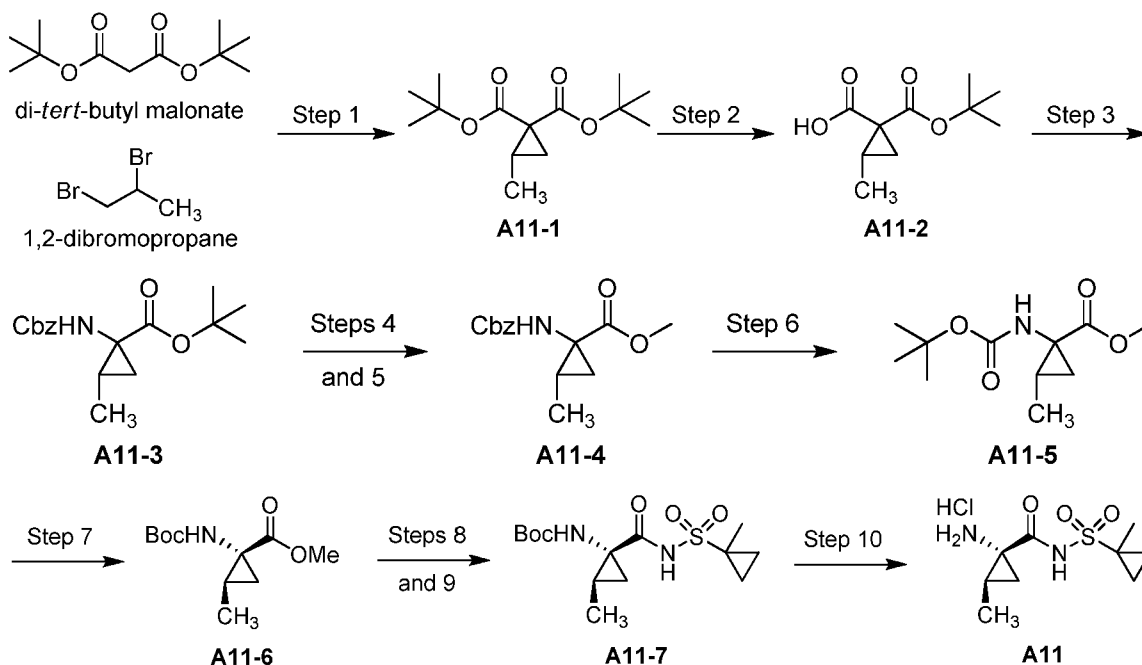
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Preparation of Intermediate **A10**.



Intermediate **A10** was prepared similarly to Intermediate **A9**, substituting 1-methylcyclopropane-1-sulfonamide (prepared according to Example 1.2 of WO '066, p. 47) for cyclopropanesulfonamide.

Preparation of Intermediate **A11**.



15

Step 1. Preparation of **A11-1**: To a solution of NaOH (46.2 g, 50% w/w in water) at rt was added BnEt₃NCl (10.5 g, 46 mmol), di-*tert*-butyl malonate (10 g, 46 mmol) and 1,2-dibromopropane (14 g, 69.3 mmol). The mixture was stirred at rt overnight and was extracted with DCM (3×100 mL). The organic layers were washed with water (80 mL) and brine (50 mL), dried over anhydrous Na₂SO₄. Concentration *in vacuo* produced **A11-1** that was used subsequently without further purification. ¹H NMR (400 MHz, CDCl₃) δ 1.83-1.62 (m, 1H); 1.42 (s, 9H); 1.40 (s, 9H); 1.24-1.05 (m, 2H); 1.03-1.02 (d, 3H).

Step 2. Preparation of **A11-2**: To a mixture of *t*-BuOK (175 g, 1.56 mol) in ether (1.2 L) at 0 °C was added water (3.4 mL) followed by addition of diester **A11-1** (91 g, 0.35 mol). The mixture was stirred at rt for three days, then quenched with ice-water. The aqueous layer was extracted with ether (2×400 mL), acidified with critic acid, and then extracted with EA (3×400 mL). The combined ethyl acetate extracts were washed with water (2×100 mL), brine (200 mL), dried over anhydrous Na₂SO₄, and concentrated *in vacuo* to produce **A11-2** that was used subsequently without further purification. ¹H NMR (400 MHz, DMSO-*d*₆) δ 12.60 (s, 1H); 1.70-1.64 (s, 1H); 1.37 (s, 9H); 1.19-1.13 (m, 1H); 1.03-1.00 (m, 4H).

Step 3. Preparation of **A11-3**: To a mixture **A11-2** (33.5 g, 0.17 mol) and triethylamine (70 mL) in THF (200 mL) at 0 °C was added ethyl chloroformate (22 mL). The mixture was stirred at 0 °C for 1 h. To the mixture at 0 °C was added sodium azide (54 g, 0.83 mol, 4.9 eq) in water (100 mL), the mixture was stirred for 40 min. The mixture was extracted with EA (2×400 mL), washed with water (100 mL), brine (100 mL), dried over anhydrous Na₂SO₄ and concentrated *in vacuo* to produce a residue that was taken up in toluene (100 mL) and treated with benzyl alcohol (50 mL). The mixture was then heated at 70 °C for 2 h, cooled to rt, adjusted to pH 8 with sodium bicarbonate, and then extracted with ether (3×200 mL). The aqueous layer was then adjusted to pH 5 with 1 N HCl and extracted with EA (2×300 mL). The combined ethyl acetate extracts were washed with water (100 mL), brine (80 mL), dried over anhydrous Na₂SO₄, and concentrated *in vacuo* to give CBZ protected amine **A11-3** (16 g) that is used subsequently without further purification. ¹H NMR (400 MHz, DMSO-*d*₆) δ 7.85

(s, 1H); 7.28-7.15 (m, 5H); 4.97-5.03 (m, 2H); 1.33 (s, 9H); 1.33-1.17 (m, 2H); 1.10 (d, $J = 6.8$ Hz, 3H); 0.90-1.00 (m, 1H).

Steps 4 and 5. Preparation of **A11-4**: To a solution of Cbz protected amine **A11-3** (16 g, 52 mmol) in DCM (250 mL) was added dropwise TFA (250 mL, 3.24 mol) at rt and the mixture stirred at rt overnight. The mixture was concentrated *in vacuo*, adjusted to pH 8~9 using aqueous sodium carbonate and washed with ether (3×80 mL). The aqueous phase was then adjusted to pH 5~6 using 1 N HCl and extracted with EA (2×300 mL). The combined ethyl acetate phases were washed with water (80 mL), brine (80 mL), dried over anhydrous Na₂SO₄ and concentrated to give 13 g as a slightly yellow oil that was used in the next step without further purification. This material (8.0 g, 32 mmol) was taken up in methanol (200 mL), treated with thionyl chloride (15 mL) at 0 °C, then stirred at rt overnight. The resulting mixture was concentrated *in vacuo* and purified by flash chromatography on silica (eluent PE/EA 10:1-5:1) to give methyl ester **A11-4** (6 g). ¹H NMR (400 MHz, DMSO-*d*₆) δ 7.97 (s, 1H); 7.37-7.26 (m, 5H); 4.99 (s, 2H); 3.61 (s, 3H); 1.48-1.45 (m, 1H); 1.17-1.08 (m, 2H); 1.06-1.04 (d, 3H).

Step 6. Preparation of **A11-5**: Cbz carboxamide **A11-4** (36 g, 0.15 mol), Boc₂O (40 g, 0.18 mol), and Pd/C (3.6 g, 10% w/w) were combined in methanol under H₂ and stirred at 32 °C overnight. The reaction mixture was filtered to remove the catalyst, additional Boc₂O (40 g, 0.18 mol) and Pd/C (3.6 g, 10% w/w) were added and the reaction placed under a H₂ atmosphere with stirring at rt for a weekend. The reaction mixture was filtered to remove the catalyst, concentrated *in vacuo* and purified by flash chromatography on silica (eluent PE/EA 20:1-10:1) to produce Boc protected amine **A11-5**. ¹H NMR (400 MHz, DMSO-*d*₆) δ 7.48 (s, 1H), 3.59 (s, 3H), 1.43-1.41 (m, 1H), 1.34 (s, 9H), 1.21-1.18 (m, 1H), 1.07-1.01 (m, 4H).

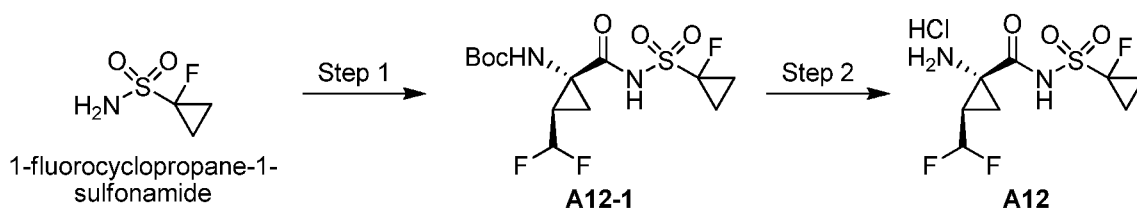
Step 7. Preparation of **A11-6**: To a solution of NaH₂PO₄ (1.9 g) in water (160 mL) at 40 °C was added Alcalase (2.4 U/g, 16 mL). The mixture was adjusted with 50% aqueous sodium hydroxide to pH 8. **A11-5** (2.80 g) in DMSO (32 mL) was added to the buffer dropwise over 30 min. The mixture was stirred at 40 °C and maintained at pH 8 with addition of 50% NaOH for 19 h. The mixture was

cooled to rt, with ether (3 x 100 mL) and the organic phase washed with sat. NaHCO₃ (2 x 40 mL), water (2 x 40 mL), brine (40 mL), dried over anhydrous Na₂SO₄, filtered and concentrated *in vacuo* to produce **A11-6**. ¹H NMR (300 MHz, DMSO-*d*₆) δ 5.18 (br s, 1H); 3.71 (s, 3H); 1.43-1.18 (m, 2H); 1.34 (s, 9H);
5 1.07-1.01 (m, 4H). Analysis of the product using chromegaChiral CC3 column (0.46 cm I.D. X 25 cm L, 3 μL injection, 80/20 hexane/IPA, 1 mL/min, 34 °C, 220 nM UV detection) determined the enantiomeric excess was 99.4% (desired RT = 5.238 min, undesired RT = 6.745 min).

Steps 8 and 9. Preparation of **A11-7**: Solid LiOH·H₂O (19.1 g, 455 mmol) is
10 taken up in 50 mL MeOH/50 mL water at rt. Once all LiOH has dissolved, methyl ester **A11-6** (10.4 g, 45.5 mmol) is taken up in 100 mL THF added to reaction mixture and stirred vigorously overnight. The resulting solution is diluted with water (150 mL), adjusted to pH ~ 3 with 12 M HCl and extracted with EtOAc.

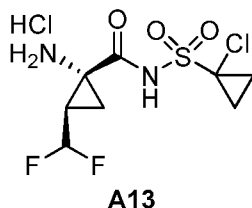
The combined organic layers are washed with brine, dried over anhydrous
15 MgSO₄ and concentrated *in vacuo* to produce a fine white powder (9.2 g). This material (1.5 g, 7 mmol) is taken up in THF (30 mL) and treated with CDI (1.47 g, 9.1 mmol). The resulting solution was heated to 65 °C for 2 h, cooled to rt and treated with DBU (2.1 mL, 13.9 mmol) and 1-methylcyclopropane-1-sulfonamide (1.4 g, 10.5 mmol). The resulting solution is stirred at rt overnight. Addition of 1
20 M HCl is used to adjust the pH ~ 1 prior to removing the majority of THF *in vacuo*. The resulting slurry is extracted with EtOAc and the combined organics washed with brine, dried over anhydrous MgSO₄ and concentrated *in vacuo* to produce 2.29 g of acyl sulfonamide **A11-7**. LCMS-ESI⁺ (*m/z*): [M+Na]⁺ calcd for C₁₄H₂₄N₂NaO₅S: 355.41; found: 355.84.

25 Step 10. Preparation of Intermediate **A11**. Acyl sulfonamide **A11-7** (0.25 g, 0.75 mmol) in dioxane (1 mL) is treated with HCl (4 M in dioxane, 2.8 mL, 11.2 mmol) at rt. After 4 h, the reaction is concentrated *in vacuo* to produce 0.20 g of Intermediate **A-11** that is used subsequently without additional purification. ¹H NMR (400 MHz, CD₃OD) δ 1.87-1.84 (m, 0.5 H); 1.77-1.65 (m, 1.5H); 1.58-1.46
30 (m, 2H); 1.54 (d, J = 8 Hz, 3H); 1.34-1.26 (m, 3+1H); 1.02-0.92 (m, 1H); 0.83-0.77 (m, 1H).

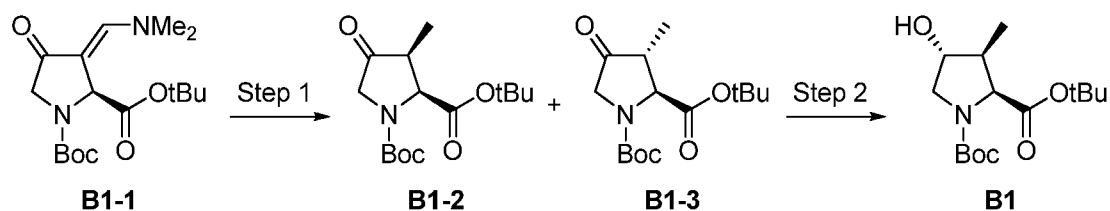
Preparation of Intermediate **A12**.

- 5 Step 1. Preparation of **A12-1**: A vessel containing a solution of carboxylic acid **A9-1** (1 g, 4 mmol) in THF (15 mL) was treated with CDI (0.84 g, 5.2 mmol), sealed and heated to 75 °C for 2 h. The clear tan colored solution is divided in half and used subsequently without further purification for the remainder of Step 1 in the preparation of Intermediate **A12** as well as the preparation of
- 10 Intermediate **A13** as detailed below. This solution is treated with 1-fluorocyclopropane-1-sulfonamide (0.42 g, 3 mmol; prepared according to Steps 1, 4, and 9 of Example 7 of International Patent Publication No. WO 2009/14730, p. 107-110) and DBU (0.6 mL, 4 mmol) and allowed to stir overnight at rt. The solution was acidified to pH ~1 with 1 M HCl and concentrated *in vacuo* to
- 15 remove the majority of THF. The aqueous layer was extracted with EtOAc and the combined organics washed with brine, dried over anhydrous MgSO_4 and concentrated *in vacuo* to dryness to afford 0.73 g of the **A12-1** that was used without further purification.

- Step 2. Preparation of Intermediate **A12**: Acyl sulfonamide **A12-1** (0.25 g, 0.67 mmol) was taken up in 1 mL dioxane and treated with HCl (4 M in dioxane, 2.5 mL, 11 mmol). The reaction was stirred at rt for 2 h and concentrated *in vacuo* to dryness to afford a quantitative yield of Intermediate **A12**. ^1H NMR (400 MHz, CD_3OD) δ 6.04 (td, $J_{\text{H-F}} = 55.6$ Hz, $J = 5.2$ Hz, 1H); 2.25-2.14 (m, 1H); 1.78-1.62 (m, 2H); 1.52-1.38 (m, 4H).

Preparation of Intermediate **A13**.

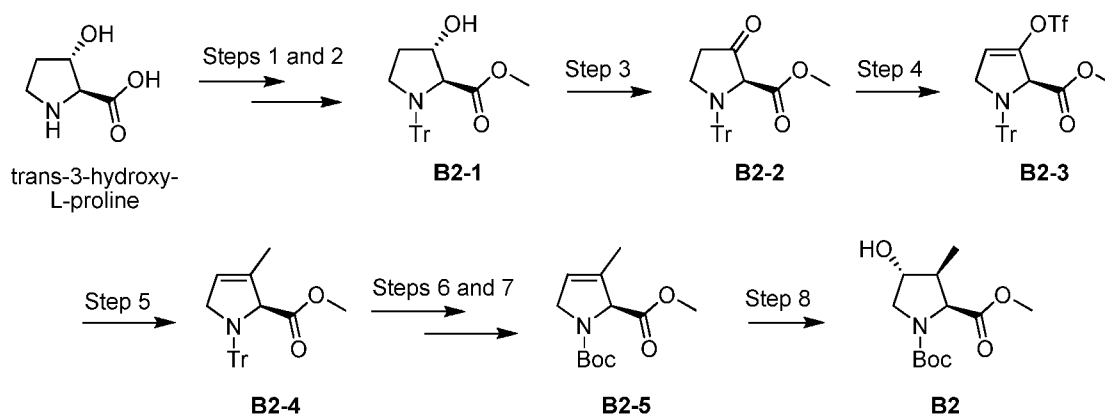
Intermediate **A13** was prepared similarly to Intermediate **A12**, substituting 1-chlorocyclopropane-1-sulfonamide (prepared according to Li, J, *et al. Synlett*, **2006**, 5, pp. 725-728) for 1-chlorocyclopropane-1-sulfonamide in Step 1. ¹H NMR (400 MHz, CD₃OD) δ 6.03 (td, J_{H-F} = 54.8 Hz, J = 6 Hz, 1H); 2.32-2.18 (m, 1H); 2.06-1.92 (m, 2H); 1.80-1.68 (m, 2+1H); 1.56-1.44 (m, 1H); 1.44-1.37 (m, 1H).

Preparation of Intermediate **B1**.

Steps 1 and 2. Preparation of Intermediate **B1**: Enaminone **B1-1** (4.0 g, 11.8 mmol, prepared according to Camplo, M., *et al. Tetrahedron* **2005**, 61, 3725) was dissolved in acetone (120 mL) and the reaction vessel was purged with Ar. Pd/C (10 wt. % Pd, 820 mg) was added in a single portion and the reaction vessel was purged twice with H₂. The reaction was stirred under 1 atm H₂ at rt for 15 h and was then filtered through a pad of Celite with acetone. The filtrate was concentrated and filtered through a plug of silica gel with 30% EtOAc in hexanes to afford a ~2:1 mixture of ketones **B1-2** and **B1-3** (3.48 g) as a white solid. This mixture (3.37 g, 11.3 mmol) was dissolved in THF (100 mL) under Ar. A 1 M solution of (*R*)-(+)-2-methyl-CBS-oxazaborolidine in toluene (11.3 mL, 11.3 mmol) was added in a single portion and the resulting solution was cooled to – 78 °C. A 1 M solution of BH₃•SMe₂ in CH₂Cl₂ (11.3 mL) was then added dropwise

over 5 min. The resulting solution was stirred for 20 min and was removed from the cold bath. After an additional 15 min, the reaction was placed in a water bath at ambient temperature. After an additional 7 min, the reaction was quenched by dropwise addition of MeOH (20 mL). After stirring an additional 2.5 h, the reaction mixture was concentrated, dissolved in EtOAc (300 mL), and washed with 0.2 M HCl (200 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (100 mL). The combined organic phase was filtered to remove solids, dried over Na₂SO₄, filtered, and concentrated. The crude residue was dissolved in CH₂Cl₂ and was concentrated onto 20 g silica gel. Purification by silica gel chromatography (25 to 40% EtOAc in hexanes) provided partial separation of Intermediate **B1** from other diastereomeric products. Mixed fractions were pooled and concentrated onto 9 g silica gel. Purification by silica gel chromatography provided Intermediate **B1** contaminated with minor diastereomeric components as a white solid (1.96 g). ¹H NMR (400 MHz, CDCl₃, rotamers observed) δ 4.25 – 4.15 (m, 1H), 4.13 – 4.04 (m, 1H), 3.91 – 3.79 (m, 1H), 3.28 – 3.09 (m, 1H), 2.41 – 2.23 (m, 1H), 2.04 (bs, 1H), 1.51 – 1.39 (m, 18H), 1.09 – 1.01 (m, 3H).

Preparation of Intermediate **B2**.



Steps 1 and 2. Preparation of **B2-1**: *trans*-3-Hydroxy-L-proline (571 mg, 4.35 mmol, Chem-Impex International, Inc.) was suspended in MeOH and cooled to

0 °C. Thionyl chloride (1.6 mL, 22 mmol) was added over 5 min and the solution was warmed to rt. After stirring for 24 h, the reaction mixture was concentrated under reduced pressure to afford the methyl ester, which was carried on without further purification. The crude ester was suspended in DCM (22 mL) and treated with TEA (1.3 mL, 9.57 mmol). The stirred mixture was cooled to 0 °C and trityl chloride (1.21 g, 4.35 mmol) was added. The reaction mixture was allowed to gradually come to rt o/n, and then poured into saturated aqueous NaHCO₃. The aqueous layer was extracted three times with DCM. The combined organics were dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (25% to 50% EtOAc/Hex to afford alcohol **B2-1** (1.27 g).

Step 3. Preparation of **B2-2**: Alcohol **B2-1** (1.23 g, 3.18 mmol) and 2 g 4 Å MS were suspended in DCM (16 mL) and treated with NMO (560 mg, 4.78 mmol) and TPAP (76 mg, 0.218 mmol). After stirring for 30 min, the mixture was filtered over a short pad of silica and eluted off with 50% EtOAc/Hex. The filtrate was concentrated and the crude residue was purified by silica gel chromatography (10% to 30% EtOAc/Hex to afford ketone **B2-2** (0.99 g).

Step 4. Preparation of **B2-3**: LiHMDS (1.0 M in THF, 5.8 mL, 5.8 mmol) was added to THF (22 mL) and the stirred solution was cooled to -78 °C. A rt solution of ketone **B2-2** (2.14 g, 5.55 mmol) in THF (6 mL) was added dropwise by cannula over 5 min. The flask that had contained **B2-2** was then rinsed with THF (4 mL) and the rinsing was added dropwise by cannula to the reaction mixture. After 35 min, *N*-(5-chloro-2-pyridyl)bis(trifluoromethanesulfonimide) (2.40 g, 6.11 mmol) in THF (6 mL) was added to the reaction mixture dropwise by syringe over 5 min. After another 1 h, the reaction mixture was warmed to rt. Following an additional 30 min, the reaction was quenched by addition of 20 mL H₂O and diluted with Et₂O. The organic solution was washed with 10% NaOH and dried over K₂CO₃, filtered and concentrated under reduced pressure. The crude residue was loaded onto a silica column that had been pre-equilibrated with 1% TEA/Hex. The material was purified by silica gel chromatography (0% to 15% EtOAc/Hex doped with 1% TEA) to afford enol triflate **B2-3** (1.89 g).

Step 5. Preparation of **B2-4**: Enol triflate **B2-3** (957 mg, 1.85 mmol) was dissolved in THF (9 mL) and treated with $\text{Pd}(\text{PPh}_3)_4$ (107 mg, 0.0925 mmol) and dimethyl zinc (2.0 M in PhMe, 1.9 mL, 3.7 mmol). The reaction mixture was stirred at rt for 5 h, then more dimethyl zinc (2.0 M in PhMe, 1.9 mL, 3.7 mmol)

5 was added and the reaction was heated to 50 °C for 15 min. After cooling to rt, the mixture was diluted with Et_2O . The organic solution was washed with 10% NaOH twice, then dried over MgSO_4 , filtered and concentrated under reduced pressure. The crude **B2-4** residue was carried on without further purification.

Steps 6 and 7. Preparation of **B2-5**: Compound **B2-4** (1.85 mmol theoretical) was

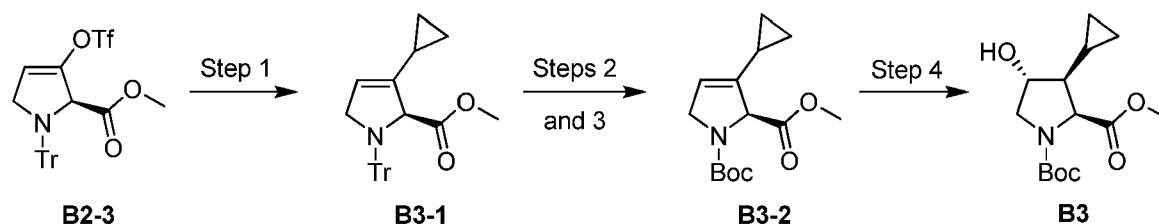
10 dissolved in 1:1 MeOH/DCM (20 mL) and treated with HCl (4.0 M in dioxane, 2 mL, 8.0 mmol). After stirring for 2 h at rt, the reaction mixture was concentrated and the crude material was carried on without further purification. The crude product amine hydrochloride was treated with Boc_2O (2.02 g, 9.25 mmol), DCM (18 mL), MeOH (1.8 mL) and TEA (0.52 mL, 3.7 mmol). After stirring for 2 h at rt,

15 the reaction mixture was diluted with EtOAc and washed with 10% HCl, saturated aqueous NaHCO_3 and brine. The organic solution was dried over MgSO_4 , filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (15% to 40% EtOAc/Hex) to afford carbamate **B2-5** (331 mg). LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{12}\text{H}_{20}\text{NO}_4$: 242.14; found: 243.26.

20 Step 8. Preparation of Intermediate **B2**: Carbamate **B2-5** (345 mg, 1.43 mmol) was dissolved in THF (7 mL) and cooled to 0 °C. $\text{BH}_3\cdot\text{SMe}_2$ complex (2.0 M in THF, 0.79 mL, 1.58 mmol) was added dropwise and the reaction mixture was allowed to come to rt gradually. After 15 h, the reaction was quenched by dropwise addition of H_2O (added until bubbling ceased), then cooled to 0 °C.

25 Hydrogen peroxide (30% w/w in H_2O , 0.73 mL, 7.2 mmol) and NaOH (2.0 M in H_2O , 0.86 mL, 1.72 mmol) were added in quick succession and the stirred mixture was heated to 50 °C for 35 min. The mixture was then diluted with Et_2O and washed successively with H_2O , saturated aqueous NaHCO_3 and brine, then dried over MgSO_4 , filtered and concentrated under reduced pressure.

30 Intermediate **B2** was used in subsequent reactions without further purification. LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{12}\text{H}_{22}\text{NO}_5$: 260.15; found: 259.99.

Preparation of Intermediate **B3**.

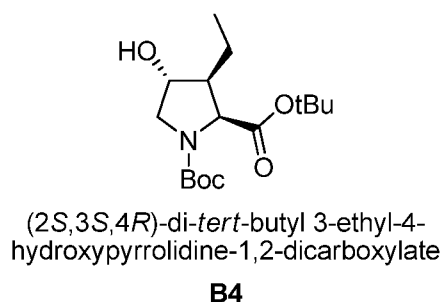
- 5 Step 1. Preparation of **B3-1**: Enol triflate **B2-3** (91 mg, 0.176 mmol) was dissolved in THF (1.7 mL) and treated with cyclopropyl zinc bromide (0.5 M in THF, 1.7 mL, 0.85 mmol) and Pd(PPh₃)₄ (20 mg, 0.018 mmol). The stirred reaction mixture was heated to 50 °C for 2 h then cooled to rt and diluted with EtOAc. The organic solution was washed successively with saturated aqueous
- 10 NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (0% to 20% EtOAc/Hex) to afford cyclopropane **B3-1** (43 mg). LCMS-ESI⁺ (*m/z*): [M-Tr+H]⁺ calcd for C₉H₁₄NO₂: 168.10; found: 168.04.

- Steps 2 and 3. Preparation of **B3-2**: Vinyl cyclopropane **B3-1** (43 mg, 0.11
- 15 mmol) was dissolved in 1:1 MeOH/DCM (10 mL) and treated with HCl (4.0 M in dioxane, 1 mL, 4.0 mmol). After stirring for 1.5 h at rt, the reaction mixture was concentrated and the crude material was carried on without further purification. The crude product of step 2 was treated with Boc₂O (229 mg, 1.05 mmol), DMAP (13 mg, 0.105 mmol), DCM (5 mL) and TEA (0.293 mL, 2.10 mmol). After stirring
- 20 for 5 h at rt, the reaction mixture was diluted with EtOAc and washed with 10% HCl, saturated aqueous NaHCO₃ twice and brine. The organic solution was dried over MgSO₄, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (10% to 30% EtOAc/Hex) to afford carbamate **B3-2** (20 mg). LCMS-ESI⁺ (*m/z*): [M-(*t*-Bu)+H]⁺ calcd for C₁₀H₁₄NO₄:
- 25 212.09; found: 211.91.

Step 4. Preparation of Intermediate **B3**: Carbamate **B3-2** (152 mg, 0.569 mmol) was dissolved in THF (5.7 mL) and cooled to 0 °C. BH₃•SMe₂ complex (2.0 M in THF, 0.31 mL, 0.63 mmol) was added dropwise and the reaction mixture was

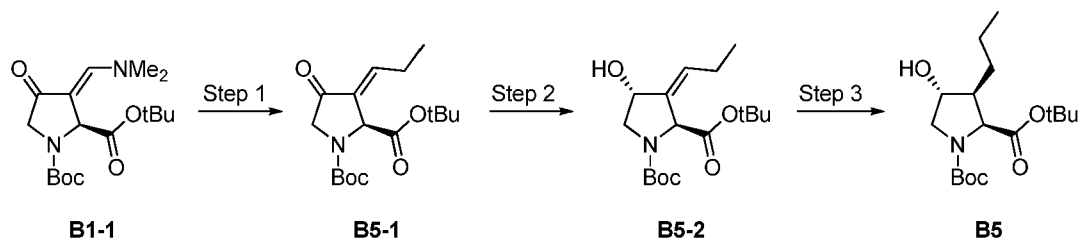
allowed to come to rt gradually. After 20 h, the reaction was quenched by dropwise addition of H₂O (added until bubbling ceased), then cooled to 0 °C. Hydrogen peroxide (30% w/w in H₂O, 0.29 mL, 2.85 mmol) and NaOH (2.0 M in H₂O, 0.43 mL, 0.86 mmol) were added in quick succession and the stirred mixture was heated to 50 °C for 30 min. The mixture was then diluted with Et₂O and washed successively with H₂O, saturated aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. Intermediate **B3** was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M-(*t*-Bu)+H]⁺ calcd for C₁₀H₁₆NO₅: 230.10; found: 230.03.

Preparation of Intermediate **B4**.



Intermediate **B4** ((2*S*,3*S*,4*R*)-di-*tert*-butyl 3-ethyl-4-hydroxypyrrolidine-1,2-dicarboxylate) was prepared according to Camplo, M., *et al. Tetrahedron* **2005**, 61, 3725.

Preparation of Intermediate **B5**.

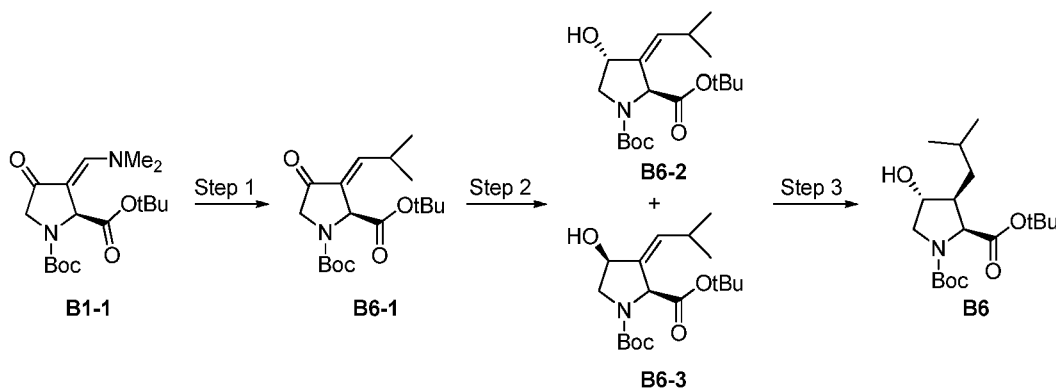


Step 1. Preparation of enone **B5-2**: To a solution of **B1-1** in tetrahydrofuran (7.35 mL) was added ethylmagnesium bromide (3 M in diethyl ether, 1.47 mL 4.41 mmol) via syringe at -78 °C under an argon atmosphere. After 2.5 h, the reaction

mixture was allowed to warm to rt over 30 min at which point the reaction mixture was diluted with saturated aqueous ammonium chloride solution (20 mL). The resulting mixture was extracted with ethyl acetate (20 mL twice), and the combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford intermediate **B5-1** (308.8 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₂₈NO₅: 326.2; found: 326.2.

Step 2. Preparation of **B5-2**: To a solution of enone **B5-1** (308 mg, 0.95 mmol) in methanol (4.7 mL) was added cerium(III) chloride heptahydrate (566 mg, 1.52 mmol) at rt under an argon atmosphere. The resulting mixture was cooled to –78 °C, and sodium borohydride (57.7 mg, 1.52 mmol) was added as a solid. After 1 h, the reaction mixture was warmed to 0 °C and saturated aqueous ammonium chloride (20 mL) was added. The resulting mixture was extracted with ethyl acetate (20 mL twice), and the combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford allylic alcohol **B5-2** (319.3 mg) as a colorless oil, which was used directly in the next step without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₂₉NO₅: 328.2; found: 328.2.

Step 3. Preparation of Intermediate **B5**: To a solution of alcohol **B5-2** (319 mg, 0.98 mmol) in ethanol (4.9 mL) was added Pd/C (10%, 103.9 mg, 0.097 mmol) at rt under an argon atmosphere. The atmosphere was replaced with hydrogen and the reaction mixture was stirred vigorously at rt. After 16 h, the reaction mixture was diluted with ethyl acetate (25 mL) and was filtered through a pad of Celite with ethyl acetate washings (10 mL three times). The filtrate was concentrated *in vacuo* to afford Intermediate **B5** (188 mg), which was used directly in the next step without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₃₂NO₅: 330.2; found: 330.3.

Preparation of Intermediate **B6**.

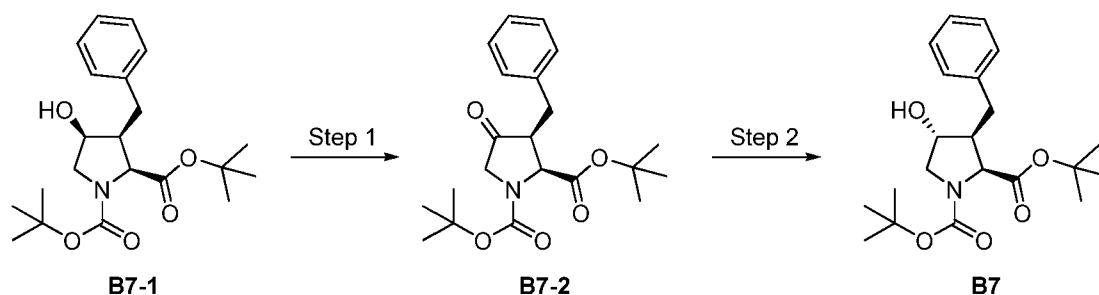
Step 1. Preparation of **B6-1**: A solution of isopropylmagnesium bromide (2.9 M in MeTHF, 3.2 mL, 9.3 mmol) was added dropwise to a cooled solution of **B1-1** (1.02 g, 3.00 mmol) in 60 mL of ether at -78°C under argon. Reaction mixture was warmed to room temperature and stirred for 3 hours. Reaction mixture was quenched with sat. aqueous NH_4Cl and extracted three times with ether.

Combined organics were washed with sat. aqueous NaHCO_3 and brine, dried (MgSO_4), filtered, and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to yield **B6-1** (743 mg) as a light yellow oil. ^1H NMR (400 MHz, CDCl_3): δ 6.60 (dd, $J = 10.8, 2.4$ Hz, 1H), 5.14 and 5.06 (rotamers, d, $J = 2.4$ Hz, 1H), 3.96 (m, 2H), 2.91 (m, 1H), 1.46 (s, 9H), 1.27 (s, 9H), 1.04 (d, $J = 8.8$ Hz, 6H).

Step 2. Preparation of **B6-2** and **B6-3**: $\text{CeCl}_3 \cdot 7\text{H}_2\text{O}$ (1.32 g, 3.50 mmol) was added to a solution of **B6-1** (740 mg, 2.18 mmol) in 47 mL of methanol at room temperature under argon. After cooling to -78°C , sodium borohydride (127 mg, 3.34 mmol) was added slowly portionwise. After two hours, reaction mixture was warmed to 0°C . After fifteen minutes, reaction mixture was quenched with sat. aqueous NH_4Cl and extracted three times with ethyl acetate. Combined organics were washed with brine, dried (MgSO_4), filtered, and concentrated under reduced pressure to yield a ~3:1 mixture of **B6-2** (major) and **B6-3** (minor) as a colorless film (738 mg), which was used in the next step without further purification. ^1H NMR (400 MHz, CDCl_3): δ 5.68–5.48 (m, 1H), 4.90–4.31 (m, 2H), 4.05–3.15 (m, 2H), 2.90–2.61 (m, 1H), 1.50–1.39 (br s, 18H), 1.02 (d, $J = 9.2$ Hz, 6H).

Step 3. Preparation of Intermediate **B6**: The ~3:1 mixture of **B6-2** and **B6-3** (341 mg, 1.00 mmol) was dissolved in 28 mL of ethyl acetate. Palladium on carbon (10 wt %, 109 mg, 0.11 mmol) was then added and mixture was hydrogenated under an atmosphere of hydrogen for nineteen hours. Mixture was then filtered over Celite, washing with ethyl acetate, and filtrate was concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) to yield Intermediate **B6** (141 mg) as a colorless oil. ¹H NMR (400 MHz, CDCl₃): δ 4.31–4.17 (m, 2H), 3.97–3.85 (m, 1H), 3.21–3.07 (m, 1H), 2.35–2.18 (m, 1H), 1.92–1.78 (m, 1H), 1.47–1.37 (m, 18H), 1.35–1.19 (m, 2H), 0.94 (d, J = 8.8 Hz, 6H).

Preparation of Intermediate **B7**.

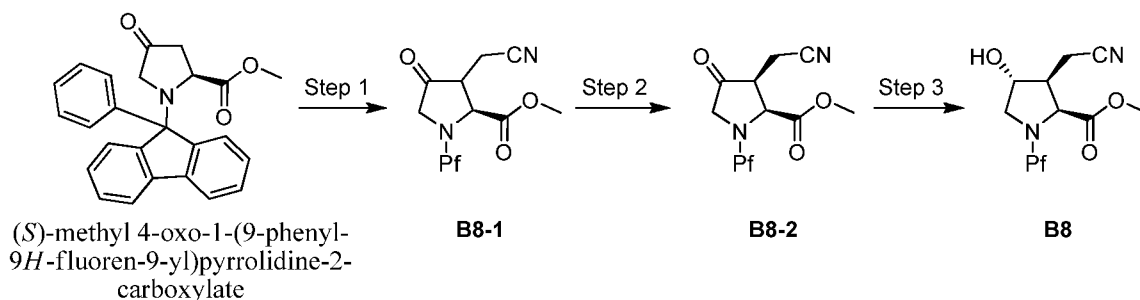


Step 1. Preparation of **B7-2**: To a solution of alcohol **B7-1** (500 mg, 1.33 mmol; prepared according to Barreling, P., *et al. Tetrahedron* **1995**, 51, 4195) in DCM (6.65 mL) was added Dess-Martin periodinane (564 mg, 1.33 mmol) at rt under an argon atmosphere. After 2 h, the reaction mixture was purified directly by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford ketone **B7-2** (431 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₁H₃₀NO₅: 376.2; found: 376.2.

Step 2. Preparation of Intermediate **B7**: To a solution of intermediate **B7-2** (410 mg, 1.09 mmol) and (*R*)-(+)-2-methyl-CBS-oxazaborolidine (Aldrich, 1 M in toluene, 1.09 mL, 1.09 mmol) in THF (5.45 mL) was added BH₃•THF (1 M in toluene, 2.18 mL, 2.18 mmol) at –78 °C under an argon atmosphere. After 1 h, the reaction mixture was quenched with saturated aqueous ammonium chloride solution (15 mL) and the resulting mixture was allowed to warm to rt. The phases were separated and the aqueous phase was extracted twice (20 mL)

with DCM. The combined organic layers were dried over anhydrous sodium sulfate, and were concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford Intermediate **B7** (390.9 mg, 4:1 diastereomeric mixture) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₁H₃₂NO₅: 378.2; found: 378.5.

Preparation of Intermediate **B8**.



Step 1. Preparation of **B8-1**. n-BuLi (0.44 mL, 1.1 mmol, 2.5 M in hexane) was added to a cold (–78 °C) solution of (*S*)-methyl 4-oxo-1-(9-phenyl-9H-fluoren-9-yl)pyrrolidine-2-carboxylate (383 mg, 1 mmol, prepared as described in Sardina, F.J., Blanco, M.-J. *J. Org. Chem.* **1996**, 61, 4748) in THF/HMPA (3.8 mL/ 0.4 mL). The resulting solution was stirred at –78 °C to –50 °C for 1.5 h, and then bromoacetonitrile (0.2 mL, 3 mmol) was added. The reaction mixture was stirred while the temperature was allowed to reach –10 °C (4 h). To the reaction mixture was charged with saturated aqueous NH₄Cl (1 mL) and EtOAc (15 mL). The organic layer was separated, and the aqueous layer was extracted with EtOAc (10 mL). Both organic layers were combined, washed with H₂O and brine, and dried over Na₂SO₄. The organic layer was concentrated and purified via silica gel chromatography to afford diastereomeric mixture **B8-1** (170 mg) as colorless oil.

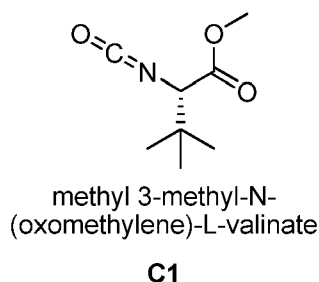
Step 2. Preparation of **B8-2**. KHMDS (0.4 mL, 0.4 mmol, 1 M in THF) was added to a cold (–78 °C) solution of **B8-1** (140 mg, 0.33 mmol) in THF/DMPU (1.5 mL/0.75 mL). The resulting solution was stirred at –78 °C for 1.5 h. Then HOAc (0.1 mL) was added. To the reaction mixture was charged with saturated aqueous NH₄Cl (1 mL) and EtOAc (15 mL). The organic layer was separated, and the aqueous layer was extracted with EtOAc (10 mL). Both organic layers

were combined, washed with H₂O and brine, and dried over Na₂SO₄. The organic layer was concentrated and purified via silica gel chromatography to afford ketone **B8-2** (120 mg) as colorless oil.

Step 3. Preparation of Intermediate **B8**. To an oven-dried, nitrogen-flushed flask was added BH₃•THF (0.28 mL, 0.28 mmol,) followed by (*R*)-(+)-2-methyl-CBS-oxazaborolidine (0.012 mL, 0.03 mmol, 1.0 M in toluene). A solution of **B8-2** (120 mg, 0.28 mmol) in THF (0.5 mL) was added dropwise. The reaction mixture was stirred at rt for 60 min, and then quenched by addition of 1.0 M aqueous HCl (0.2 mL). EtOAc (20 mL) was added and organic phase washed with sat.

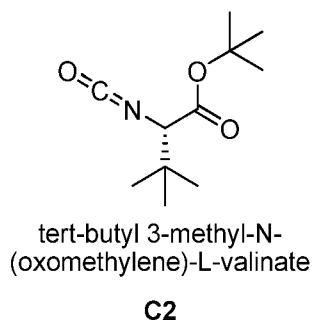
aqueous NaHCO₃ and brine, and dried over Na₂SO₄. The organic layer was concentrated and purified via silica gel chromatography to afford Intermediate **B8** (100 mg) as colorless oil. LCMS-ESI⁺ (*m/z*): [M]⁺ calcd for C₂₇H₂₄N₂O₃: 424.49; found: 424.77.

Preparation of Intermediate **C1**.

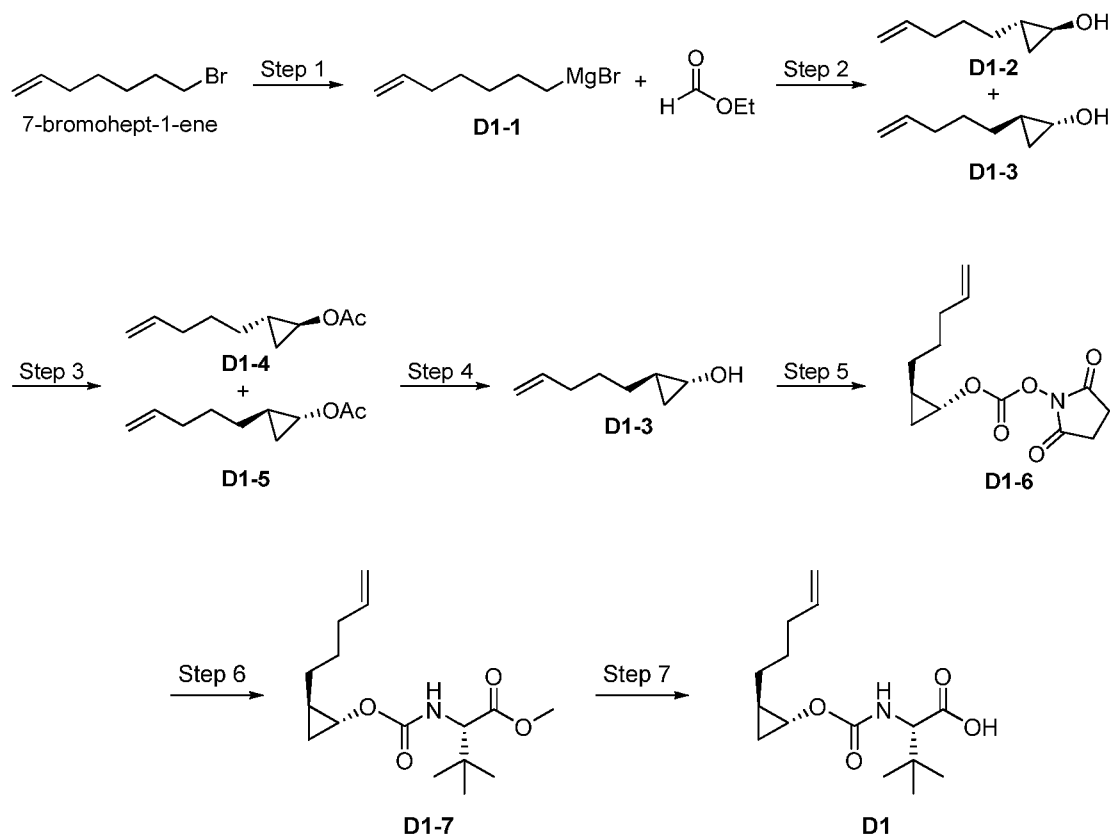


Methyl 3-methyl-N-(oxomethylene)-L-valinate (Intermediate **C1**) was prepared according to Step 3 of Intermediate B1 of International Patent Publication No.

WO 2010/11566 (hereinafter "WO'566"), p 14.

Preparation of Intermediate **C2**.

Intermediate **C2** (tert-butyl 3-methyl-N-(oxomethylene)-L-valinate) was prepared in a similar fashion to Intermediate **C1**, substituting tert-butyl 3-methyl-L-valinate (Bachem AG) for methyl 3-methyl-L-valinate in Step 3 of intermediate B1 of WO'566, p 14.

Preparation of Intermediate **D1**.

Steps 1 and 2. Preparation of *trans*-cyclopropanol mixture **D1-2** and **D1-3**: THF (1000 mL) was introduced in a three neck round bottomed flask containing Mg (32.2 g, 1.34 mol). A solution of 7-bromohept-1-ene (216 g, 1.22 mol) in THF

(600 mL) was introduced to an addition funnel. One crystal of iodine and 20 mL of 7-bromohept-1-ene solution were added to the reaction. The solution was heated to reflux, and the remainder of the 7-bromohept-1-ene solution was added drop wise. After the addition was complete, the mixture was refluxed for an additional 2 h then allowed to cool to rt to produce a solution of Grignard reagent **D1-1**, which was then added dropwise to a solution of ethyl formate (30 g, 0.41 mol) and Ti(*Oi*-Pr)₄ (115.2 g, 0.41 mol) in THF (1200 mL) at rt. After stirring overnight, the mixture was poured into 1600 mL of 10% aqueous H₂SO₄ and extracted with MTBE (1500 mL three times). The combined organic layers were washed with brine, dried over MgSO₄, filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography to afford 31.0 g of a mixture of *trans*-cyclopropyl alcohols **D1-2** and **D1-3** as a yellow oil. ¹H NMR: (400 MHz, CDCl₃): δ 5.77–5.70 (m, 1H), 4.96–4.86 (m, 2H), 3.15–3.12 (m, 1H), 2.03–1.98 (m, 2H), 1.75 (br s, 1H), 1.45–1.37 (m, 2H), 1.20–1.15 (m, 1H), 1.06–1.01 (m, 1H), 0.89–0.82 (m, 1H), 0.63–0.59 (m, 1H), 0.24 (q, *J* = 6.0 Hz, 1H).

Step 3. Preparation of cyclopropyl acetate mixture **D1-4** and **D1-5**: To a 1000 mL round bottom flask was added *trans*-cyclopropyl alcohol mixture **D1-2** and **D1-3** (60.3 g, 0.48 mol), 700 mL of DCM and TEA (62.9 g, 0.62 mol) prior to cooling the solution in an acetone/ice bath to an internal temp of < 5 °C. Acetyl chloride (41.3 g, 0.53 mol) was added dropwise to the solution over a 30 min period while maintaining an internal temp < 10 °C. The resulting slurry was then warmed to rt and stirred for 2 h. The reaction mixture was diluted with 350 mL of water. The biphasic mixture was transferred to a separatory funnel and the aqueous layer removed. The organic layer was washed with 480 mL of 2 N aqueous HCl and then with 500 mL of sat. aqueous NaHCO₃ prior to drying over MgSO₄. The solvent was removed *in vacuo*. The residue was purified by silica gel chromatography to afford a mixture **D1-4** and **D1-5** (56.3 g) as a yellow oil. TLC Information (PE/EtOAc =5/1) R_f (starting material) = 0.4; R_f (product) = 0.8.

Step 4. Preparation of **D1-3**: To a 1000 mL round-bottom flask was added a solution of mixture **D1-4** and **D1-5** (39 g, 0.23 mol) in 680 mL of MTBE saturated with aqueous 0.1 M pH 7 phosphate buffer. The flask was placed in an ice bath

to maintain an internal temperature of approximately 10 °C throughout the hydrolysis reaction which was initiated by the addition of 3.0 g of Novozyme 435. The reaction was aged at 10 °C for approximately 6 h until conversion had reached about 40%. The reaction mixture was filtered, and the solid immobilized

5 enzyme was washed three times with 200 mL of MTBE. The resulting MTBE solution was concentrated *in vacuo*. The residue was purified by silica gel chromatography to afford **D1-3** (11.3 g) as a yellow oil. ¹H NMR: (400 MHz, CDCl₃) δ 5.80–5.75 (m, 1H), 5.02–4.91 (m, 2H), 3.20–3.17 (m, 1H), 2.09–2.03 (m, 3H), 1.50–1.43 (m, 2H), 1.26–1.22 (m, 1H), 1.17–1.08 (m, 1H), 1.07–0.89 (m,
10 1H), 0.70–0.65 (m, 1H), 0.32–0.27 (m, 1H).

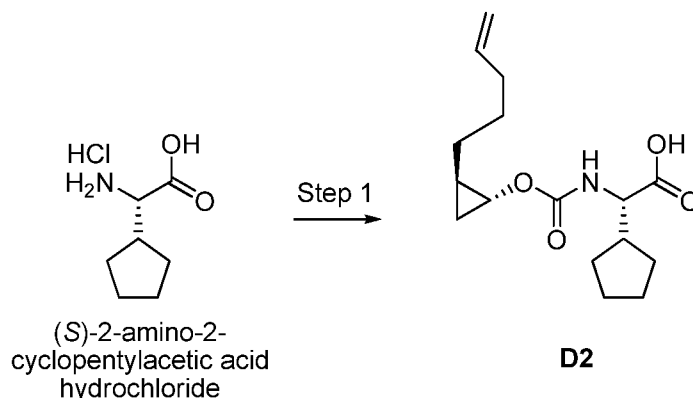
Step 5. Preparation of **D1-6**: Cyclopropanol **D1-3** (17.7 g, 0.140 mol) was dissolved in 300 mL of MeCN at 0 °C. To the solution was added DSC (72.0 g, 0.280 mol) and TEA (42.42 g, 0.420 mol). The reaction mixture was warmed to 40 °C and stirred overnight and then concentrated *in vacuo*. The residue was
15 purified by silica gel chromatography to afford **D1-6** (25.8 g) as a yellow solid. ¹H NMR: (400 MHz, CDCl₃) δ 5.84–5.77 (m, 1H), 5.05–4.96 (m, 2H), 4.09–4.03 (d, *J* = 24 Hz, 1H), 2.86 (s, 4H), 2.12–2.06 (m, 2H), 1.58–1.51 (m, 2H), 1.33–1.27 (m, 3H), 1.09 (m, 1H), 0.68–0.62 (m, 1H).

Step 6. Preparation of **D1-7**: To a solution of **D1-6** (10 g, 0.0374 mol) in THF (374
20 mL) was added L-tert-leucine methyl ester hydrochloride (10.2 g, 0.056 mol) and TEA (11.3 g, 0.112 mol). The solution was stirred overnight at 40 °C. The mixture was concentrated *in vacuo*. The residue was diluted with EtOAc and washed with water and brine, dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography to afford **D1-7**
25 (10.2 g) as a yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₂₈NO₄: 298.2; found: 298.0.

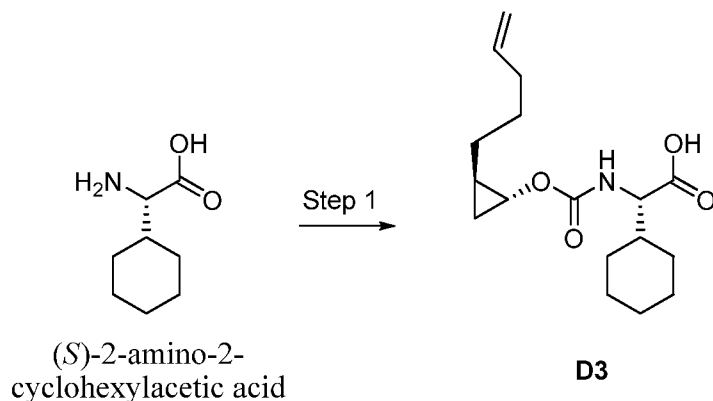
Step 7. Preparation of Intermediate **D1**: A solution of **D1-7** (20 g, 0.067 mol) in 2:1 mixture of MeOH/H₂O (447 mL/223 mL) was treated with LiOH•H₂O (11.3 g, 0.269 mol) and then heated at 60 °C for 4 h. The reaction mixture was cooled,
30 concentrated to half volume and extracted with MTBE. Then the aqueous solution was acidified with aqueous 1 N HCl (400 mL) and extracted with EtOAc

(400 mL × 3), the combined organic layers were washed with brine, dried over Na₂SO₄, filtered and concentrated to afford Intermediate **D1** (18 g). ¹H NMR: (400 MHz, CDCl₃) δ 10.5–9.4 (br, 1H), 5.82–5.71 (m, 1H), 5.20–5.17 (m, 1H), 4.99–4.91 (m, 2H), 4.19–4.16 (m, 1H), 3.86–3.68 (m, 1H), 2.09–2.03 (m, 2H),
 5 1.53–1.32 (m, 2H), 1.30–1.20 (m, 2H), 1.18–1.13 (m, 1H), 1.11–0.99 (s, 9H), 0.80–0.75 (m, 1H), 0.49–0.47 (m, 1H).

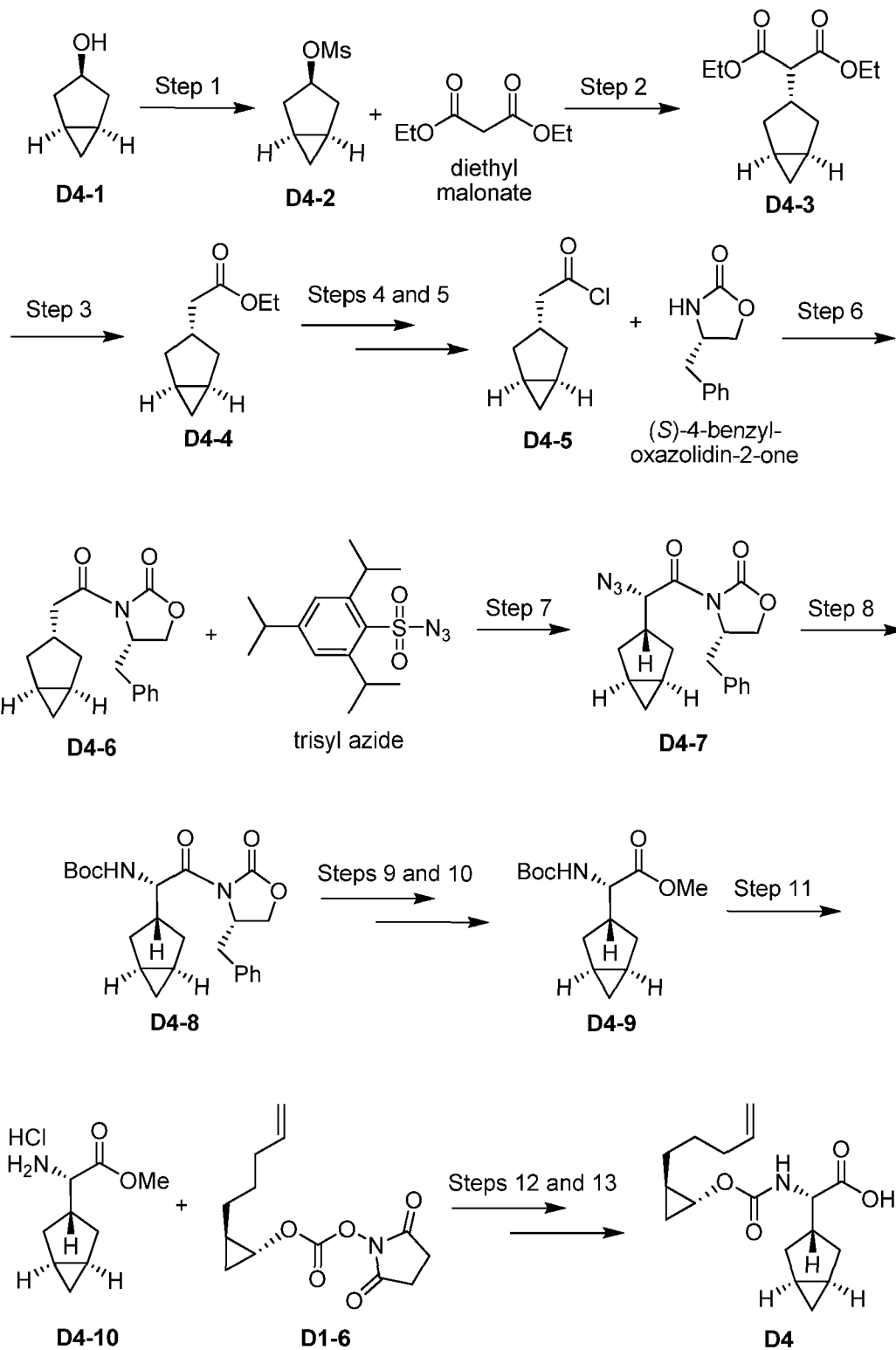
Preparation of Intermediate **D2**.



10 Step 1. Preparation of Intermediate **D2**: To a suspension of **D1-6** (600 mg, 2.25 mmol) and (S)-2-amino-2-cyclopentylacetic acid hydrochloride salt (386 mg, 2.7 mmol, Betapharma Inc.) in THF (20 mL) were added distilled water (6 mL) and triethylamine (0.94 mL, 6.74 mmol). The homogeneous solution was allowed to stir for ~ 18 h. The THF was evaporated and the aqueous residue was diluted
 15 with water (20 mL). The mixture was basified with 1 N NaOH (pH > 10) and then washed twice (20 mL) with ethyl acetate. The aqueous phase was then acidified with 1 N HCl (pH < 2) and the resulting solution was extracted twice (20 mL) with ethyl acetate. The combined organic phase was dried over anhydrous MgSO₄ and concentrated to afford Intermediate **D2** (500 mg) as a brown oil. This was
 20 used without purification in a subsequent step. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₂₆NO₄: 296.2; found: 296.3.

Preparation of Intermediate **D3**.

Step 1. Preparation of Intermediate **D3**: To a suspension of **D1-6** (800 mg, 3 mmol) and (S)-2-amino-2-cyclohexylacetic acid (519 mg, 3.3 mmol; Alfa Aesar) in water (15 mL) was added K_3PO_4 (1.27 g, 6 mmol). The homogeneous solution was allowed to stir at rt for 5 h. To the reaction mixture was charged with water (15 mL) and EtOAc (15 mL). The organic layer was separated, and the aqueous layer was extracted with EtOAc (10 mL). Organic layers were combined, washed with 1 N HCl, H_2O and brine, and dried over Na_2SO_4 . Concentration of the organic solution afforded Intermediate **D3** (850 mg) as an oil that was used subsequently without further purification. LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{17}\text{H}_{28}\text{NO}_4$: 310.4; found: 310.3.

Preparation of Intermediate **D4**.

Step 1. Preparation of **D4-2**: Bicyclic alcohol **D4-1** (2.9 g, 29.5 mmol, prepared according to Section A, Intermediate 1 of U.S. Patent No. 8,178,491 B2 (hereinafter "US '491"), p 192.) was dissolved in DCM (60 mL) and TEA (8.2 mL, 59 mmol) was added. The stirred solution was cooled to 0 °C and MsCl (3.4 mL, 44 mmol) was added. The reaction mixture was allowed to warm to rt gradually. After 18 h, the reaction mixture was poured into H₂O. The aqueous layer was extracted 2 x with DCM then the combined organics were dried over MgSO₄, filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (20% to 50% EtOAc/Hex) to afford **D4-2** (3.73 g).

Step 2. Preparation of **D4-3**: NaH (1.69 g, 42.3 mmol) was suspended in 100 mL THF and the mixture was cooled to 0 °C. Diethyl malonate (6.4 mL, 47 mmol) was added dropwise over 4 min and the stirred mixture was warmed to rt. After another hour, mesylate **D4-2** (3.73 g, 21.2 mmol) in 20 mL THF was added and the reaction mixture was heated to reflux for 15 h. After this period, the reaction mixture was cooled to rt and poured into saturated aqueous NaHCO₃. The aqueous layer was extracted 2 x with EtOAc. Then, the organics were dried over MgSO₄, filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (0% to 15% EtOAc/Hex) to afford **D4-3** (4.64 g).

Step 3. Preparation of **D4-4**: Malonate **D4-3** (4.64 g, 19.3 mmol) was dissolved in 20 mL DMSO then NaCl (1.24 g, 21.2 mmol) and water (0.694 mL, 38.6 mmol) were added. The stirred mixture was heated to 170 °C for 48 h then cooled to rt and diluted with Et₂O. The organic solution was washed with H₂O twice, then brine, dried over MgSO₄, filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (5% to 15% EtOAc/Hex) to afford **D4-4** (2.83 g).

Steps 4 and 5. Preparation of **D4-5**: A solution of ethyl ester **D4-4** (2.83 g, 16.8 mmol) and LiOH (1 M in H₂O, 34 mL, 34 mmol) in EtOH (68 mL) was stirred at rt o/n then concentrated under reduced pressure to remove EtOH. The remaining material was diluted with H₂O and washed twice with DCM. The aqueous phase

was acidified to pH 1–2 with 10% HCl and then extracted three times with DCM. This DCM solution was dried over MgSO_4 , filtered and concentrated under reduced pressure. The resulting crude carboxylic acid was dissolved in DCM (100 mL) and treated with DMF (5 drops). Oxalyl chloride (2.2 mL, 25 mmol) was added carefully. After stirring o/n, the reaction mixture was concentrated under reduced pressure to afford **D4-5**, which was carried on without further purification.

Step 6. Preparation of **D4-6**: (S)-4-Benzyl-2-oxazolidinone (3.57 g, 20.2 mmol) was dissolved in THF (80 mL) and cooled to -78°C . *n*-BuLi (1.6 M in hexane, 12.6 mL, 20.2 mmol) was added dropwise over 7 min and the reaction mixture was allowed to stir at -78°C for 30 min. This solution, containing the lithiated oxazolidinone was then added by cannula to a -78°C solution of acid chloride **D4-5** (16.8 mmol) in THF (80 mL) over 6 min. After stirring at -78°C for an additional 30 min, the reaction mixture was quenched by addition of 1 M aqueous NaHSO_4 . The aqueous phase was extracted with EtOAc and the organic layer was dried over MgSO_4 , filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (10% to 40% EtOAc/Hex) to afford **D4-6** (4.32 g). LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{18}\text{H}_{22}\text{NO}_3$: 300.16; found: 300.14.

Step 7. Preparation of **D4-7**: A solution of KHMDS (0.5 M in PhMe, 3.4 mL, 1.7 mmol) in THF (5 mL) was cooled to -78°C and a separate -78°C solution of oxazolidinone **D4-6** (465 mg, 1.55 mmol) in THF (5 mL) was added dropwise by cannula. After 30 min, a -78°C solution of trisyl azide (576 mg, 1.86 mmol) in THF (5 mL) was added by cannula. Three min later, the reaction was quenched by addition of AcOH (0.41 mL, 7.13 mmol) and the reaction mixture was heated to 30°C for 2 h. After cooling, the mixture was poured into brine. The aqueous layer was extracted three times with DCM. The combined organics were dried over MgSO_4 , filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (4% to 25% EtOAc/Hex) to afford azide **D4-7** (367 mg). LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{18}\text{H}_{21}\text{N}_4\text{O}_3$: 341.16; found: 341.10.

Step 8. Preparation of **D4-8**: Azide **D4-7** (367 mg, 1.08 mmol) and di-*tert*-butyl dicarbonate (471 mg, 2.16 mmol) were dissolved in EtOAc (20 mL). 10% Pd/C (197 mg) was added and the atmosphere replaced with H₂. The suspension was stirred under 1 atm H₂ for 20 h, then filtered over Celite and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (15% to 30% EtOAc/Hex) to afford **D4-8** (376 mg). LCMS-ESI⁺ (*m/z*): [M-(*t*-Bu)+H]⁺ calcd for C₁₉H₂₃N₂O₅: 359.16; found: 359.43.

Steps 9 and 10. Preparation of **D4-9**: Carbamate **D4-8** (376 mg, 0.907 mmol) was dissolved in THF (9 mL) and cooled to 0 °C. H₂O₂ (30% in H₂O, 0.463 mL, 4.54 mmol) and LiOH (1 M in H₂O, 2.7 mL, 2.7 mmol) were added. The reaction was allowed to stir at 0 °C for another 2 h and was then concentrated under reduced pressure. The resulting concentrate was poured into H₂O and the aqueous solution was washed twice with Et₂O, then acidified to pH 1–2 and extracted three times with DCM. The combined extracts were dried over MgSO₄, filtered and concentrated under reduced pressure. The resulting crude residue was dissolved in DCM (8 mL) and MeOH (1 mL) and treated with trimethylsilyldiazomethane (2 M in hexane, 0.9 mL, 1.8 mmol). After stirring for 40 min at rt, the reaction was quenched by addition of 10% AcOH/MeOH and concentrated under reduced pressure. The residue was purified by silica gel chromatography (4% to 25% EtOAc/Hex) to afford **D4-9** (167 mg). ¹H NMR (400 MHz, CDCl₃) δ 4.98 (d, *J* = 7.8 Hz, 1H), 4.22 (t, *J* = 7.0 Hz, 1H), 3.70 (s, 3H), 1.89 (m, 1H), 1.77–1.46 (m, 4H), 1.42 (s, 9H), 1.22 (m, 2H), 0.28 (dd, *J* = 7.2 Hz, 13.3 Hz, 1H), 0.13 (d, *J* = 3.7 Hz, 1H).

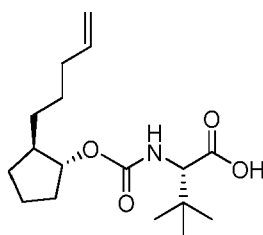
Step 11. Preparation of **D4-10**: Carbamate **D4-9** (223 mg, 0.828 mmol) was dissolved in DCM (4 mL) and treated with HCl (4.0 M in dioxane, 1 mL, 4.0 mmol). After stirring at rt for 17 h, the reaction mixture was concentrated under reduced pressure to afford amine hydrochloride salt **D4-10**, which was carried on without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₉H₁₆NO₂: 170.12; found: 170.04.

Steps 12 and 13. Preparation of Intermediate **D4**: Amine hydrochloride salt **D4-10** (0.828 mmol, theoretical) in H₂O (1.4 mL) was treated with a freshly prepared

solution of **D1-6** (1.35 mmol) in DMF (1.4 mL). K_3PO_4 (703 mg, 3.31 mmol) was added and the reaction mixture was stirred for 2 h at rt. After dilution with EtOAc, the organic layer was washed with 10% aqueous HCl and brine, then dried over $MgSO_4$, filtered and concentrated under reduced pressure. The residue was

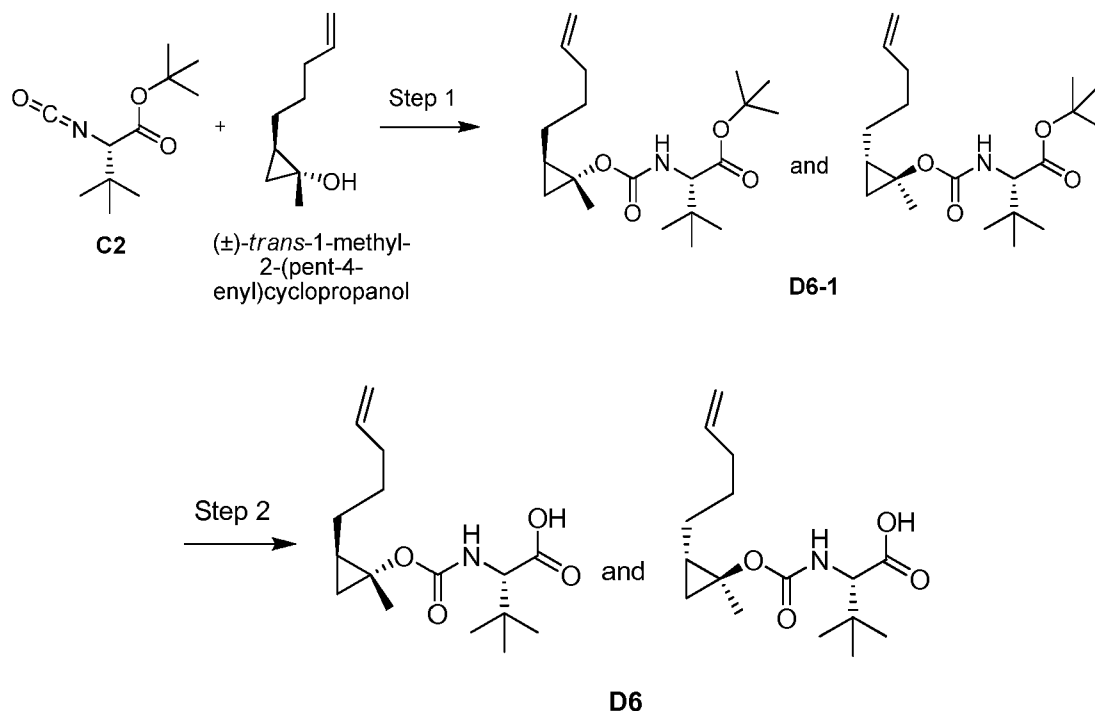
- 5 purified by silica gel chromatography (0% to 25% EtOAc/Hex) to afford the expected carbamate (239 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $C_{18}H_{28}NO_4$: 322.20; found: 323.00. This material (239 mg, 0.744 mmol) was dissolved in MeOH and treated with LiOH (1.0 M in H_2O , 5.0 mL, 5.0 mmol). After stirring at rt for 1 h, the MeOH was removed under reduced pressure. The aqueous solution
- 10 was acidified to pH 1–2 with 10% aqueous HCl and was extracted three times with DCM. The combined organics were dried over $MgSO_4$, filtered and concentrated under reduced pressure to afford Intermediate **D4** (229 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $C_{17}H_{26}NO_4$: 308.2; found: 307.9.

15 Preparation of Intermediate **D5**.



D5

Intermediate **D5** was prepared according to the procedure detailed in Li, H., *et al. Synlett* **2011**, 10, 1454.

Preparation of Intermediate mixture **D6**.

5

Step 1. Preparation of diastereomeric carbamate mixture **D6-1**: Intermediate **C2** (1.34 g, 6.31 mmol), $(\pm)$ -trans-1-methyl-2-(pent-4-enyl)cyclopropanol (590 mg, 4.208 mmol; prepared according to procedure for Intermediate **C3**,

10 WO2011014487, p. 36), DMAP (514 mg, 4.21 mmol), and DIPEA (2.93 mL, 16.83 mmol) were combined in toluene (14 mL). The reaction was heated at 90 °C for 18 h. The reaction was diluted with Et₂O (25 mL) and 1 N aqueous HCl (75 mL), stirred well, and organics were removed. The aqueous layer was extracted three times with ether (50 mL), the organics were combined, washed with brine, dried over MgSO₄, filtered, and concentrated to give a crude oil, which

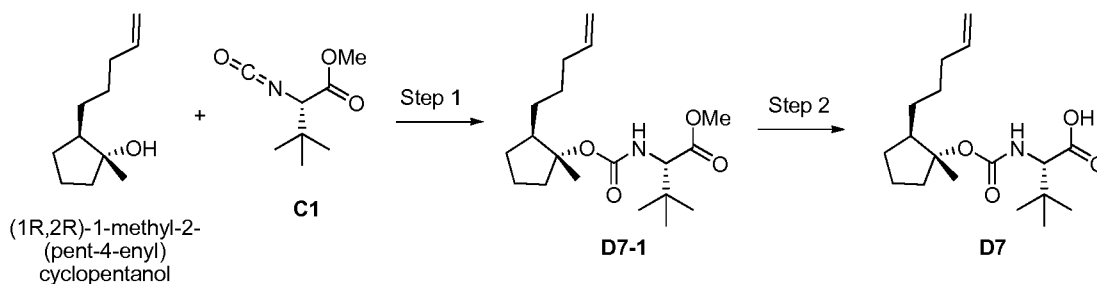
15 was purified via silica gel chromatography to give 1:1 diastereomeric mixture **D6-1** as a clear oil (820 mg). LCMS-ESI⁺ (*m/z*): [M+Na]⁺ calcd for C₂₀H₃₅NNaO₄: 376.3; found: 376.2.

Step 2: Preparation of diastereomeric Intermediate mixture **D6**. The diastereomeric mixture **D6-1** was taken up in DCM (2 mL) and treated with TFA (2 mL) at room temperature. After 1.5 h, the reaction was concentrated *in vacuo* and co-evaporated with chloroform repeatedly to remove residual TFA and

20

purified via silica gel chromatography to give 1:1 diastereomeric mixture of Intermediate **D6** as a brown oil, (536 mg). LCMS-ESI⁺ (*m/z*): [M+Na]⁺ calcd for C₁₆H₂₇NNaO₄: 320.2; found: 320.1.

5 Preparation of Intermediate **D7**.



Step 1. Preparation of **D7-1**: (1R,2R)-1-methyl-2-(pent-4-enyl)cyclopentanol

(220.9 mg, 1.313 mmol; prepared according to procedure for Intermediate B26,

10 International Patent Publication No. WO 2008/057209 (hereinafter "WO '209"), p.

45) and Intermediate **C1** (337.1 mg, 1.969 mmol) were treated with DIPEA (0.91 mL, 5.252 mmol) and DMAP (160.4 mg, 1.313 mmol) in toluene (4.4 mL). The mixture was heated at 85 °C for 21 h. The solution was diluted with ether (80 mL). The solution was washed with 1 N aqueous HCl (30 mL) and brine (30 mL)

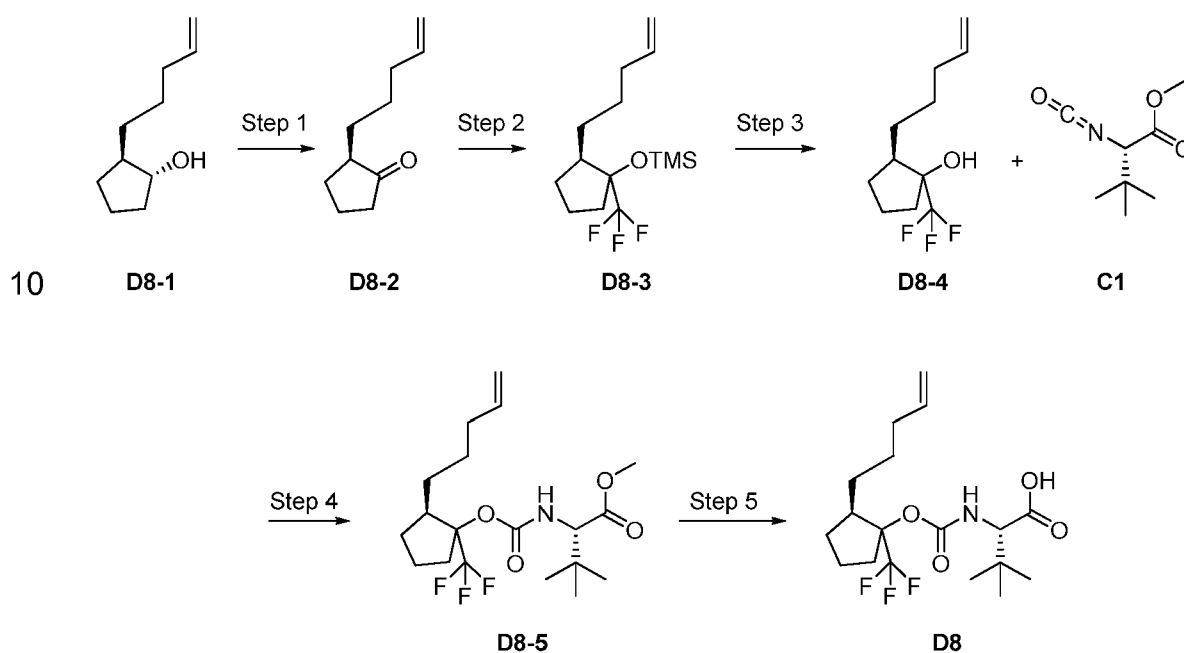
15 successively. Obtained organic layer was dried over Na₂SO₄. After removal of drying agent by a filtration, the solvent was removed under reduced pressure.

The residue was purified by silica gel chromatography (13% ethyl acetate in hexanes) to give **D7-1** (249.5 mg, 0.735 mmol) as colorless oil. ¹H NMR (300 MHz, CDCl₃, rotamers expressed as total H value x fraction present) δ 5.76–5.92 (m, 1H), 5.12 (d, *J* = 9.6 Hz, 1H), 5.02 (d, *J* = 16.8 Hz, 1H), 4.96 (d, *J* = 9.6 Hz, 1H), 4.13 (d, *J* = 9.6 Hz, 1H), 3.81 (s, 3 x 4/10H), 3.73 (s, 3 x 6/10H), 1.80–2.15 (m, 7H), 1.04–1.74 (m, 6H), 1.36 (s, 3H), 1.04 (s, 9 x 4/10H), 0.97 (s, 9 x 6/10H).

Step 2. Preparation of Intermediate **D7**: Ester **D7-1** (249.5 mg, 0.735 mmol) was treated with 2 M aqueous LiOH aqueous solution (2 mL, 4.0 mmol) in MeOH/THF (4 mL / 4 mL) at rt for 25 h. The reaction mixture was then treated with 1 N aqueous HCl (5 mL) and aqueous brine (25 mL) to slightly acidify. The mixture was extracted three times with CH₂Cl₂ (30 mL). The organic layer was washed

with aqueous brine (30 mL). Obtained organic layer was dried over Na₂SO₄. After removal of drying agent by filtration, the solvent was removed under a reduced pressure to give Intermediate **D7** (191.2 mg, 0.587 mmol) as a colorless oil which was used subsequently without further purification. ¹H NMR (300 MHz, CDCl₃) δ 9.00 (br s, 1H), 5.72–5.90 (m, 1H), 5.12 (d, *J* = 9.6 Hz, 1H), 5.00 (d, *J* = 16.8 Hz, 1H), 4.94 (d, *J* = 9.6 Hz, 1H), 4.13 (d, *J* = 9.6 Hz, 1H), 1.80–2.16 (m, 7H), 1.04–1.74 (m, 6H), 1.35 (s, 3H), 1.02 (s, 9H).

Preparation of Intermediate mixture **D8**.



Step 1. Preparation of **D8-2**: To a solution of intermediate **D8-1** (500 mg, 3.24 mmol, prepared according to WO '209, p. 36) in DCM (6.65 mL) was added Dess-Martin periodinane (1.37 g, 3.24 mmol) at rt under an argon atmosphere. After 6 h, the reaction mixture was filtered through a pad of Celite and was directly purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford ketone **D8-2** (252 mg) as a colorless oil. ¹H NMR (400 MHz, CDCl₃) δ 5.81 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.05 – 4.92 (m, 2H), 2.38 – 1.93 (m, 7H), 1.87 – 1.68 (m, 2H), 1.60 – 1.37 (m, 3H), 1.35 – 1.20 (m, 1H).

Step 2. Preparation of diastereomeric mixture **D8-3**: To a solution of ketone **D8-2** (385 mg, 2.53 mmol) and TMSCF_3 (749 μL , 5.07 mmol) in THF (2.3 mL) was added CsF (7.0 mg, 46 μmol) at rt under an argon atmosphere. After 2.5 h, the reaction mixture was diluted with water (10 mL) and the resulting mixture was extracted twice with DCM (10 mL). The combined organic layers were dried over anhydrous sodium sulfate, and were concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford silyl ether **D8-3** (714 mg, 1:1 diastereomeric mixture) as a colorless oil. ^1H NMR (400 MHz, CDCl_3) δ 5.67 (ddt, $J = 13.3, 10.1, 6.7$ Hz, 1H), 4.91 – 4.76 (m, 2H), 2.02 – 1.00 (m, 13H), 0.00 (s, 9H).

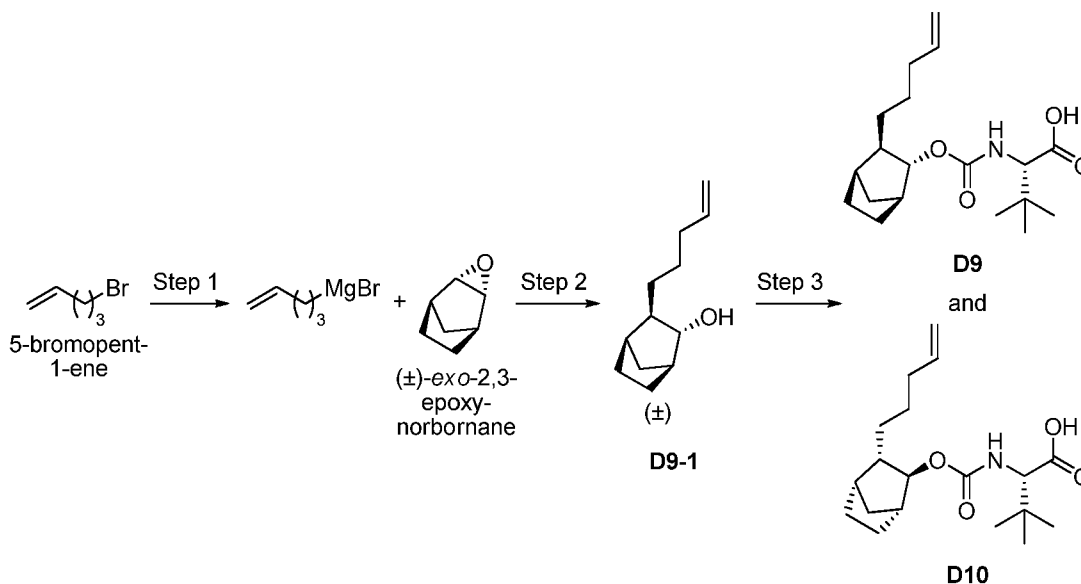
Step 3. Preparation of diastereomeric mixture **D8-4**: To a solution of **D8-3** (700 mg, 2.38 mmol) in THF (11.9 mL) was added TBAF (1M in THF, 2.38 mL, 2.38 mmol) at rt under an argon atmosphere. After 30 min, the reaction mixture was diluted with dichloromethane (100 mL). The resulting mixture was washed with saturated aqueous sodium bicarbonate solution (75 mL), was dried over anhydrous sodium sulfate, and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford alcohol **D8-4** (418 mg, 1:1 diastereomeric mixture) as a colorless oil. ^1H NMR (400 MHz, CDCl_3) δ 5.81 (dt, $J = 16.8, 6.6$ Hz, 1H), 5.09 – 4.88 (m, 2H), 2.20 – 1.91 (m, 4H), 1.86 – 1.08 (m, 10H).

Step 4. Preparation of diastereomeric mixture **D8-5**: A solution of **D8-4** (380 mg, 1.72 mmol), Intermediate **C1** (295.7 mg, 1.72 mmol), DIPEA (1.20 mL, 6.88 mmol), and DMAP (210 mg, 1.72 mmol) in toluene (8.6 mL) was heated to 85 °C under an argon atmosphere. After 20 h, the reaction mixture was allowed to cool to rt and was diluted with ethyl acetate (100 mL). The resulting mixture was washed with 1 N HCl solution (50 mL), saturated aqueous sodium bicarbonate solution (50 mL), and brine (50 mL). The organic layer was dried over anhydrous sodium sulfate, and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford carbamate **D8-5** (550 mg, 1:1 diastereomeric mixture) as a colorless oil. ^1H NMR (400 MHz, CDCl_3) δ 5.81 (ddt, $J = 16.7, 9.8, 6.6$ Hz, 1H), 5.37 (d, $J = 9.4$ Hz, 1H),

5.06 – 4.89 (m, 2H), 4.16 – 4.07 (m, 1H), 3.75 (s, 3H), 2.84 – 2.29 (m, 2H), 2.27 – 1.89 (m, 3H), 1.85 – 1.12 (m, 8H), 0.98 (s, 9H).

Step 5. Preparation of diastereomeric Intermediate mixture **D8**: To a solution of carbamate **D8-5** (500 mg, 1.27 mmol) in DCE (6.4 mL) was added trimethyltin hydroxide (2.30 g, 12.7 mmol) at rt under an argon atmosphere, and the resulting mixture was heated to 65 °C. After 21 h, the reaction mixture allowed to cool to rt and was diluted with 1 N HCl solution (50 mL). The resulting mixture was extracted with ethyl acetate (2 × 50 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford Intermediate **D8** (575 mg, 1:1 diastereomeric mixture) as a colorless oil, which was used subsequently without further purification. ¹H NMR (400 MHz, CDCl₃) δ 5.90 – 5.71 (m, 1H), 5.32 (d, *J* = 9.3 Hz, 1H), 5.07 – 4.89 (m, 2H), 4.16 (d, *J* = 9.8 Hz, 1H), 2.83 – 2.30 (m, 2H), 2.27 – 1.87 (m, 3H), 1.83 – 1.12 (m, 8H), 1.04 (s, 9H).

Preparation of Intermediate mixture **D9** and **D10**.



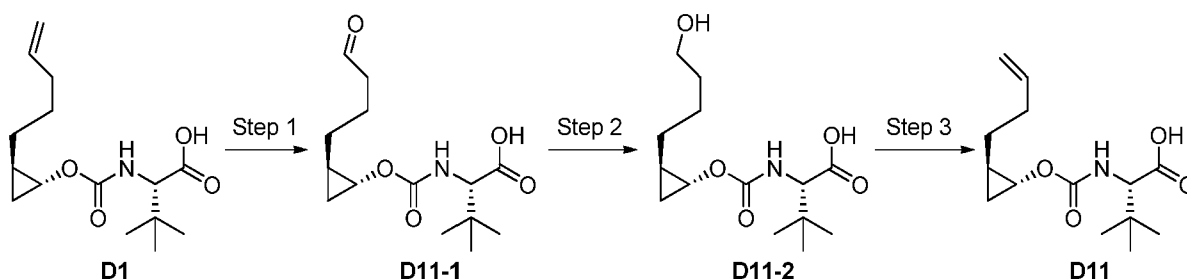
Steps 1 and 2: Preparation of racemate **D9-1**: Magnesium metal (1.32 g, 54.3 mmol) was added to a 2-neck flask fitted with a reflux condenser and the vessel was flushed with Ar. THF (42 mL) was added followed by iodine (ca. 5 mg). The

stirred suspension was heated to 45 °C and 5-bromopent-1-ene was added (1.2 g, 8.1 mmol) in one portion. After stirring several minutes, additional 5-bromopent-1-ene (5.5 g, 37 mmol) was added at a rate sufficient to maintain gentle reflux. The resulting mixture was stirred at 50 °C for 15 min and was then cooled to ambient temperature and used immediately in the following step. A suspension of CuI (630 mg, 3.3 mmol) in THF (24 mL) under Argon was cooled to –5 °C. An aliquot of pent-4-enylmagnesium bromide (ca. 0.95 M, 20 mL, 19 mmol) prepared in step 1 was added over 5 min, and the resulting mixture was stirred for an additional 15 min. The reaction mixture was then cooled to –20 °C, and (±)-*exo*-2,3-epoxynorbornane (1.5 g, 14 mmol) was added as a solution in THF (5 mL) over 1 min. Two additional portions of THF (2.5 mL each) were used to ensure complete transfer, and the resulting mixture was stirred for 20 min. The reaction was then removed from the cold bath and warmed to rt. After stirring an additional 1.75 h, the reaction was quenched with saturated aqueous NH₄Cl (5 mL) and was filtered with EtOAc (100 mL) and H₂O (100 mL) through Celite. The phases were separated, and the organic phase was dried over Na₂SO₄, filtered, and concentrated to afford (±)-**D9-1** as a colorless residue (813 mg). ¹H NMR (300 MHz, CDCl₃) δ 5.90 – 5.67 (m, 1H), 5.04 – 4.86 (m, 2H), 3.12 (s, 1H), 2.20 – 1.92 (m, 5H), 1.69 – 1.57 (m, 1H), 1.55 – 1.12 (m, 9H), 1.03 – 0.84 (m, 1H).

Step 3. Preparation of diastereomeric Intermediate mixture **D9** and **D10**: Alcohol mixture (±)-**D9-1** (813 mg, 4.51 mmol) was dissolved in DMF (4.5 mL). Pyridine (370 µL, 4.5 mmol) was added followed by DSC (1.5 g, 5.8 mmol). The reaction mixture was heated to 45 °C and was stirred for 4 h. The reaction mixture was then cooled to 0 °C and water (4.5 mL) was added dropwise over 2 min. The reaction mixture was stirred for 5 min and was removed from the cold bath. After an additional 5 min, the reaction mixture was cooled to 0 °C and L-tert-leucine (835 mg, 6.37 mmol) and K₃PO₄ (2.70 g, 12.7 mmol) were added. The mixture was stirred for 10 min and was removed from the cold bath. After stirring an additional 24 h, the mixture was diluted with EtOAc (30 mL), acidified with 1 M aqueous HCl (15 mL), and diluted with 0.2 M aqueous HCl (15 mL). The phases were separated, and the organic phase was washed with 0.2 M aqueous HCl (2 x

20 mL), dried over Na_2SO_4 , filtered, and concentrated to afford diastereomeric Intermediate mixture **D9** and **D10** (1.64 g). LCMS-ESI⁻ (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{19}\text{H}_{30}\text{NO}_4$: 336.2; found: 336.0.

5 Preparation of Intermediate **D11**.



Step 1. Preparation of **D11-1**: To a mixture of **D1** (1.0 g, 3.53 mmol), sodium periodate (2.26 g, 10.59 mmol) in 24 mL THF and 12 mL water was added Os EnCat[™] 40 (0.25 mmol/g loading, 282 mg, 0.071 mmol, Sigma-Aldrich). The mixture was stirred for 3 days. Water (50 mL) was added and the mixture was filtered. The filter cake was washed with water (total volume 400 mL) and ethyl acetate (total volume 600 mL). The filtrate layers were separated. The organic phase was dried over sodium sulfate, filtered and concentrated to give **D11-1** (1.56 g) which was used without further purification. LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{14}\text{H}_{24}\text{NO}_5$: 286.2 found: 286.1.

Step 2. Preparation of **D11-2**: To a solution of **D11-1** (3.05 g, 10.7 mmol) in MeOH (50 mL) at 0 °C was added sodium borohydride in portions (809 mg, 21.4 mmol). The reaction mixture was stirred at rt for 6 h. The mixture was diluted with 50 mL ethyl acetate and 50 mL brine and the layers were separated. The organic phase was extracted with two 25 mL portions of ethyl acetate. The combined organic phase was dried over sodium sulfate, filtered and concentrated. The crude product mixture was purified by silica gel chromatography (EtOAc in hexanes: 10% to 100%) to give **D11-2** (380 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{14}\text{H}_{26}\text{NO}_5$: 288.2; found: 288.1.

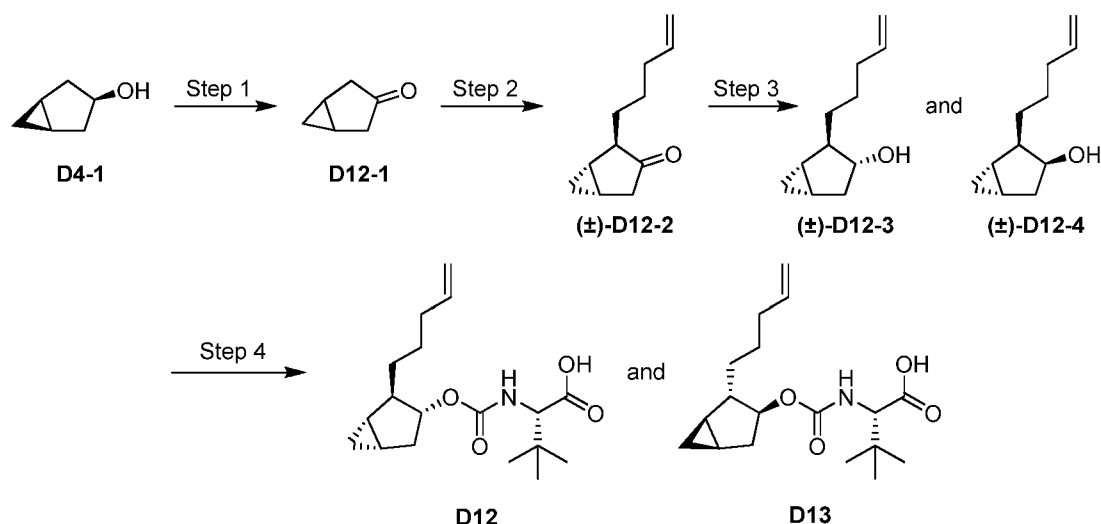
Step 3. Preparation of Intermediate **D11**: To a solution of **D11-2** (283 mg, 0.98 mmol) in THF (2.8 mL) at 0 °C was added 1-nitro-2-selenocyanatobenzene (336

mg, 1.47 mmol) and tributylphosphine (363 μ L, 1.47 mmol). The cooling bath was removed and the mixture was stirred for 25 minutes at rt. The reaction was again cooled to 0 °C and was treated with 30% hydrogen peroxide solution (0.665 mL, 5.85 mmol) and stirred for 1 h at rt and then heated at 60 °C for 1 h.

- 5 The reaction was diluted with EtOAc and the desired product was extracted into aqueous sodium bicarbonate. The bicarbonate extract was acidified with 2 N HCl and extracted with ethyl acetate. The organic phase was dried over sodium sulfate and concentrated to give Intermediate **D11** (136 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₄H₂₄NO₄: 270.2; found: 270.1.

10

Preparation of Intermediate mixture **D12** and **D13**.



- 15 Step 1: Preparation of **D12-1**: To a solution of K₂Cr₂O₇ (121 g, 0.41 mol) in H₂O (1.5 L) was added dropwise H₂SO₄ (143 g, 1.46 mol) at rt and the mixture was stirred for 1 h. The mixture was then cooled to 0 °C and **D4-1** (80 g, 0.814 mol; prepared according to Section A, Intermediate 1 of US '491, p 192.) in MTBE (1.5 L) was added dropwise. The reaction mixture was stirred at rt for 2 h. The
- 20 aqueous phase was extracted with MTBE (3 x 500 mL), dried over MgSO₄, filtered, and concentrated *in vacuo*. The crude product was purified by distillation (20 mmHg, bp: 60 – 62 °C) to provide **D12-1** as a pale yellow liquid (60 g). ¹H

NMR (400 MHz, CDCl₃) δ 2.57 – 2.63 (m, 2H), 2.14 – 2.19 (d, J = 20 Hz, 2H), 1.52 – 1.57 (m, 2H), 0.89 – 0.94 (m, 1H), -0.05 – -0.02 (m, 1H).

Step 2: Preparation of (±)-**D12-2**: Under Ar, a mixture of THF (4.4 mL) and HMPA (1.8 mL) was cooled to -78 °C. A 1 M solution of LiHMDS in THF (2.2 mL, 2.2

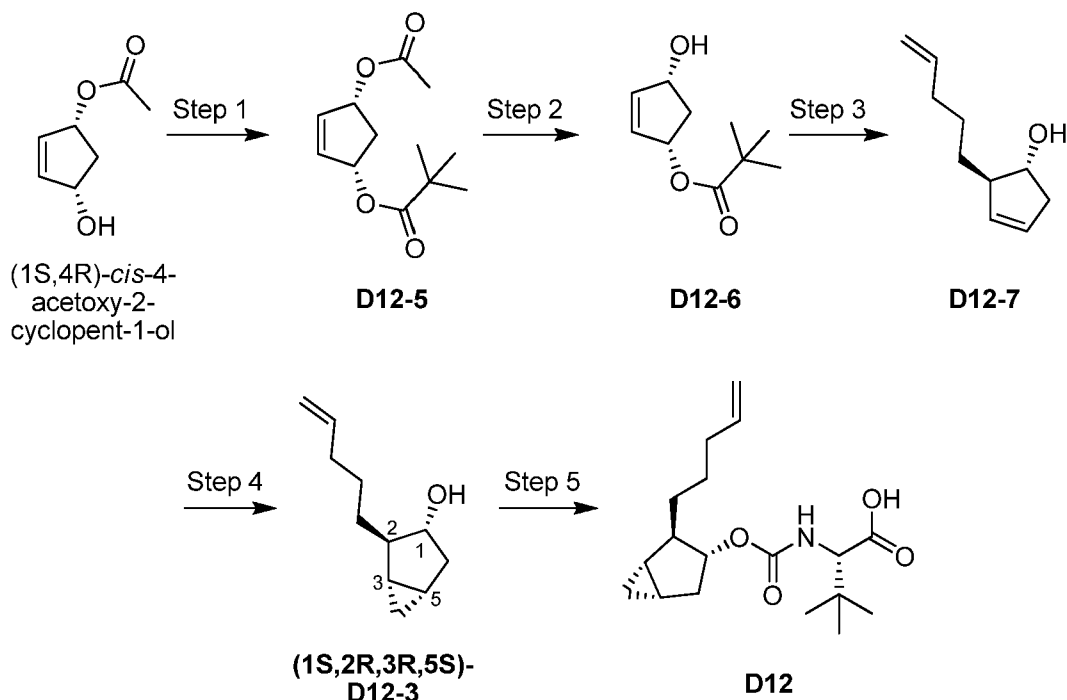
5 mmol) was added. Ketone **D12-1** (202 mg, 2.10 mmol) was added as a solution in THF (2 mL) over 1 min, washing with additional THF (2 x 1 mL) to ensure complete transfer. After 25 min, 5-iodopent-1-ene (prepared according to Jin, J. et. al. *J. Org. Chem.* **2007**, 72, 5098-5103) (880 mg, 4.5 mmol) was added over 30 s by syringe. After 10 min, the reaction was placed in a cold bath at -45 °C
10 and was warmed to -30 °C over 1.5 h. The reaction was quenched with saturated aqueous NH₄Cl (15 mL) and was diluted with EtOAc (30 mL) and H₂O (15 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (30 mL). The combined organics were dried over Na₂SO₄, filtered, and concentrated to afford a crude residue that was purified by silica gel
15 chromatography (0% to 15% EtOAc in hexanes) to provide (+/-) -**D12-2** a colorless oil (162 mg). ¹H NMR (400 MHz, CDCl₃) 5.82 – 5.67 (m, 1H), 5.03 – 4.87 (m, 2H), 2.61 – 2.51 (m, 1H), 2.11 (d, J = 19.1 Hz, 1H), 2.08 – 1.99 (m, 3H), 1.61 – 1.40 (m, 5H), 1.36 – 1.28 (m, 1H), 0.92 – 0.81 (m, 1H), -0.03 – -0.11 (m, 1H).

20 Step 3: Preparation of (±)-**D12-3** and (±)-**D12-4**: A solution of (±)-**D12-2** (142 mg, 0.865 mmol) in THF (4 mL) was cooled to -78 °C. A 1 M THF solution of LiBHEt₃ (1.3 mL, 1.3 mmol) was added dropwise over 30 s. The reaction was stirred 15 min and was removed from the cold bath. After warming to rt (15 min), the reaction was quenched with saturated aqueous NH₄Cl (1 mL). The resulting
25 mixture was diluted with Et₂O (20 mL) and H₂O (20 mL). The phases were separated, and the aqueous phase was extracted with Et₂O (20 mL). The combined organics were dried over MgSO₄, filtered, and concentrated to a crude residue. Purification by silica gel chromatography (0% to 10% EtOAc in hexanes) provided 133 mg of a mixture of diastereomers (±)-**D12-3** and (±)-**D12-4**. The
30 combined material from two experiments (253 mg) was further purified by silica gel chromatography (0% to 15% EtOAc in hexanes) to provide (±)-**D12-3** (150

mg) and (±)-**D12-4** (58 mg) as colorless oils. ¹H NMR for (±)-**D12-3** (300 MHz, CDCl₃) δ 5.91 – 5.69 (m, 1H), 5.07 – 4.88 (m, 2H), 3.97 (d, *J* = 6.7 Hz, 1H), 2.19 – 1.99 (m, 3H), 1.84 – 1.73 (m, 1H), 1.62 (d, *J* = 14.1 Hz, 1H), 1.54 – 1.40 (m, 2H), 1.32 – 1.17 (m, 3H), 1.16 – 1.06 (m, 1H), 0.60 – 0.43 (m, 2H). ¹H NMR for (±)-**D12-4** (300 MHz, CDCl₃) δ 5.95 – 5.73 (m, 1H), 5.09 – 4.88 (m, 2H), 4.05 – 3.86 (m, 1H), 2.17 – 1.84 (m, 4H), 1.72 – 1.34 (m, 5H), 1.28 – 1.08 (m, 3H), 0.49 – 0.36 (m, 1H), 0.21 – 0.11 (m, 1H).

Step 4: Preparation of diastereomeric Intermediate mixture **D12** and **D13**: A mixture of (±)-**D12-3** (150 mg, 0.90 mmol) was dissolved in DMF (1.0 mL).

Pyridine (75 µL, 0.92 mmol) and DSC (302 mg, 1.18 mmol) were added, and the reaction was stirred at 45 °C for 21.5 h. The reaction was then placed in an ice water bath and H₂O (1.0 mL) was added dropwise via syringe over 1 min. The mixture was removed from the cold bath and allowed to stir 5 min. The mixture was re-cooled in an ice water bath and L-tert-leucine (154 mg, 1.17 mmol) was added followed by K₃PO₄ (502 mg, 2.36 mmol). The reaction mixture was removed from the cold bath and allowed to stir at rt for 24 h. The mixture was then diluted with EtOAc (40 mL) and 1 M aqueous HCl (20 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was washed with 0.2 M aqueous HCl (2 x 20 mL), dried over MgSO₄, filtered, and concentrated to afford diastereomeric Intermediate mixture **D12** and **D13** (300 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M-H]⁺ calcd for C₁₈H₂₈NO₄: 322.2; found: 322.0).

Preparation of Intermediate **D12**.

- Step 1: Preparation of **D12-5**: To a solution of (1S,4R)-*cis*-4-acetoxy-2-cyclopent-1-ol (Aldrich, 10 g, 70.4 mmol), triethylamine (48.8 mL, 350 mmol), and DMAP (4.29 g, 35.2 mmol) in dichloromethane (352 mL) was added pivaloyl chloride (10.8 mL, 87.75 mmol) dropwise via syringe at 0 °C under an argon atmosphere. After 2 h, the reaction mixture was diluted with saturated aqueous sodium bicarbonate solution (500 mL), and extracted with dichloromethane (2 × 500 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford **D12-5** (15.0 g) as a colorless oil. ¹H NMR (300 MHz, CDCl₃) δ 6.08 (br s, 2H), 5.54 (td, *J* = 8.0, 4.1 Hz, 2H), 2.88 (dt, *J* = 14.9, 7.5 Hz, 1H), 2.07 (s, 3H), 1.69 (dt, *J* = 14.7, 4.1 Hz, 1H), 1.20 (s, 9H).
- Step 2: Preparation of **D12-6**: To a solution of **D12-5** (15.0 g, 70.4 mmol) in methanol (352 mL) was added potassium carbonate (9.73 g, 70.4 mmol) at rt under an argon atmosphere. After 5 h, the reaction mixture was filtered and was concentrated *in vacuo*. The residue was dissolved into ethyl acetate (500 mL) and the resulting mixture was washed with water (500 mL) and brine (500 mL), dried over anhydrous sodium sulfate, and concentrated *in vacuo*. The crude

residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **D12-6** (12.0 g) as a colorless oil. ¹H NMR (300 MHz, CDCl₃) δ 6.11 (br d, *J* = 5.5 Hz, 1H), 5.97 (br d, *J* = 5.6 Hz, 1H), 5.48 (br s, 1H), 4.73 (br s, 1H), 2.82 (dt, *J* = 14.6, 7.3 Hz, 1H), 1.67 (s, 1H), 1.61 (dt, *J* = 14.5, 4.0 Hz, 1H), 1.20 (s, *J* = 3.8 Hz, 9H).

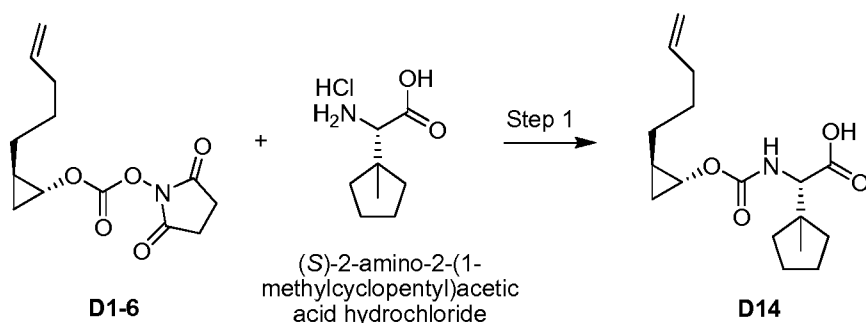
Step 3: Preparation of **D12-7**: To a solution of copper(I) cyanide (5.10 g, 57.0 mmol) in diethyl ether (95 mL) was added pent-4-enylmagnesium bromide (Novel Chemical Solutions, 0.5 M in THF, 114 mL, 57.0 mmol) dropwise via cannula over a 30 min period at 0 °C under an argon atmosphere. After 10 min, a solution of **D12-6** (3.50 g, 19.0 mmol) in diethyl ether (10 mL) was added slowly via cannula. The reaction mixture was then allowed to slowly warm to rt. After 16 h, the resulting mixture was quenched with saturated aqueous ammonium chloride solution (400 mL) and the resulting mixture was extracted into ethyl acetate (2 × 400 mL). The combined organic phases were washed with brine (400 mL), dried over anhydrous sodium sulfate, and concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **D12-7** (2.4 g) as a colorless oil. ¹H NMR (400 MHz, CDCl₃) δ 5.80 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 5.69 (dd, *J* = 5.8, 1.7 Hz, 1H), 5.65 (d, *J* = 7.2 Hz, 1H), 5.00 (dd, *J* = 17.1, 1.3 Hz, 1H), 4.94 (d, *J* = 10.2 Hz, 1H), 4.12 – 4.05 (m, 1H), 2.69 (ddd, *J* = 17.2, 6.4, 1.5 Hz, 1H), 2.54 – 2.45 (m, 1H), 2.24 (d, *J* = 17.2 Hz, 1H), 1.69 (br s, 1H), 1.52 – 1.19 (m, 6H).

Step 4: Preparation of **(1S,2R,3R,5S)-D12-3**: To a solution of **D12-7** (20 mg, 0.13 mmol), and diethyl zinc (1 M in hexanes, 132 μL, 0.132 mmol) in diethyl ether (0.66 mL) was added diiodomethane (21 μL, 0.26 mmol) at rt under an argon atmosphere. After 2 h, the reaction mixture was quenched with 1 N aqueous HCl solution (0.66 mL). After 5 min, the resulting yellow mixture was diluted with saturated aqueous sodium bicarbonate solution (5 mL) and the resulting mixture was extracted with dichloromethane (3 × 5 mL). The combined organic extracts were dried over anhydrous sodium sulfate solution, and were concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **(1S,2R,3R,5S)-D12-3** (10 mg) as a colorless oil.

^1H NMR (400 MHz, CDCl_3) δ 5.83 (ddt, $J = 16.9, 10.2, 6.7$ Hz, 1H), 5.02 (d, $J = 17.2$ Hz, 1H), 4.96 (d, $J = 11.3$ Hz, 1H), 4.00 (d, $J = 6.7$ Hz, 1H), 2.19 – 2.02 (m, 3H), 1.82 (t, $J = 7.2$ Hz, 1H), 1.64 (d, $J = 14.2$ Hz, 1H), 1.55 – 1.42 (m, 2H), 1.38 – 1.20 (m, 4H), 1.19 – 1.08 (m, 1H), 0.62 – 0.47 (m, 2H).

- 5 Step 5: Preparation of Intermediate **D12**: Alcohol (**1S,2R,3R,5S**)-**D12-3** (0.450 g, 2.7 mmol) was taken up in DMF (2.7 mL) and treated subsequently with DSC (0.92 g, 3.52 mmol) and pyridine (0.22 mL, 2.8 mmol). The reaction was then heated to 50 °C o/n. The reaction was then cooled to 0 °C and water (5.5 mL) was added dropwise over 1 min. The resulting opaque suspension was stirred at
- 10 rt for 10 min before recooling to 0 °C. The reaction was then treated subsequently with L-tert-leucine (0.462 g, 3.5 mmol) and K_3PO_4 (1.5 g, 7.0 mmol) and allowed to warm to rt overnight with vigorous stirring. The resulting opaque suspension was diluted with EtOAc and 1 M aqueous HCl. Additional HCl (12 M) was added dropwise to adjust the pH ~ 3. The aqueous layer was extracted with
- 15 EtOAc and the combined organics were washed with brine and dried over anhydrous MgSO_4 . Following concentration *in vacuo*, Intermediate **D12** was obtained (1.72 g) as a viscous, colorless oil that is contaminated with small amounts of DMF and EtOAc. The material was used in subsequent reactions without further purification. LCMS-ESI $^+$ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{18}\text{H}_{30}\text{NO}_4$:
- 20 324.2; found 324.7.

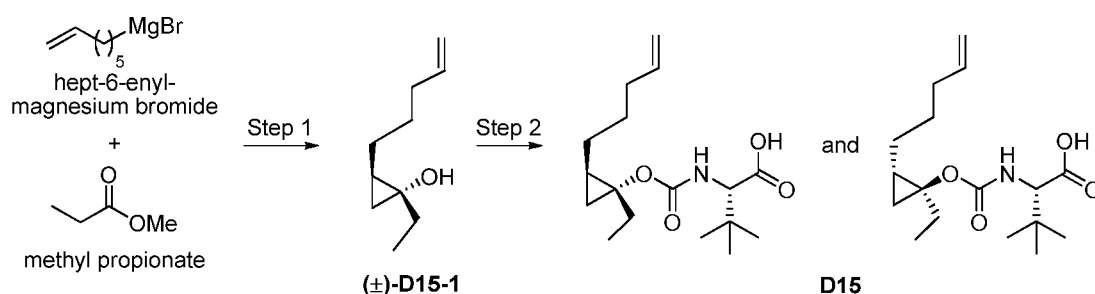
Preparation of Intermediate **D14**.



- 25 Step 1. Preparation of Intermediate **D14**. Carbonate **D1-6** (862 mg, 3.23 mmol) was treated with (S)-2-amino-2-(1-methylcyclopentyl)acetic acid hydrochloride

(750 mg, 3.87 mmol; prepared according to Robl, J.A., *et al. J. Med. Chem.*, **2004**, 47, 2587), THF (28 mL), H₂O (8.4 mL) and TEA (1.4 mL, 9.7 mmol). The reaction mixture was stirred for 16 h and the THF was removed *in vacuo*. The remaining material was diluted with H₂O and the pH adjusted to ~10–12 by addition of 10% aqueous NaOH. The aqueous phase was washed twice with EtOAc and then acidified to pH ~ 1–2 with 10% aqueous HCl. The acidic solution was extracted 3x with EtOAc. The combined extractions were dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The initial EtOAc washings (of the basic aqueous solution) were washed with 10% aqueous HCl, dried over MgSO₄, filtered and concentrated *in vacuo*. The combined concentrates were purified by silica gel chromatography (50% to 100% EtOAc/Hex) to afford Intermediate **D14** (980 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₂₈NO₄: 310.2; found 310.0.

15 Preparation of Intermediate mixture **D15**.

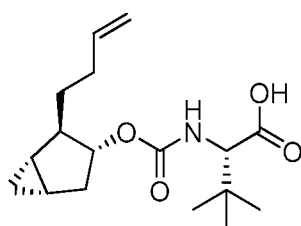


Step 1. Preparation of (±)-**D15-1**: To a solution of titanium(IV) isopropoxide (11.3 g, 40.0 mmol) in THF (160 mL) was added methyl magnesium bromide (3 M in Et₂O, 20 mL, 60.0 mmol) dropwise via syringe at rt under an argon atmosphere. After 10 min, the reaction mixture was cooled to 0 °C and a solution of methyl propionate (3.80 mL, 40.0 mmol) in THF (10 mL) was added slowly via syringe. After 5 min, hept-6-enylmagnesium bromide (Novel Chemical Solutions, 0.5 M in THF, 160 mL, 80 mmol) was added dropwise via addition funnel over 1 h. After 2.5 h, the reaction mixture was quenched with 10% aqueous sulfuric acid (100 mL) and the resulting mixture was extracted with diethyl ether (2 × 200 mL). The organic phase was dried over anhydrous sodium sulfate and was concentrated *in*

vacuo. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford (**±**)-**D15-1** (3.03 g, 50%) as a colorless oil. ¹H NMR (300 MHz, CDCl₃) δ 5.77 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 5.03 – 4.86 (m, 2H), 2.04 (q, *J* = 6.1 Hz, 2H), 1.75 – 1.14 (m, 6H), 1.04 (t, *J* = 7.4 Hz, 3H), 1.01 – 0.91 (m, 1H), 0.89 – 0.71 (m, 2H), 0.02 (t, *J* = 5.5 Hz, 1H).

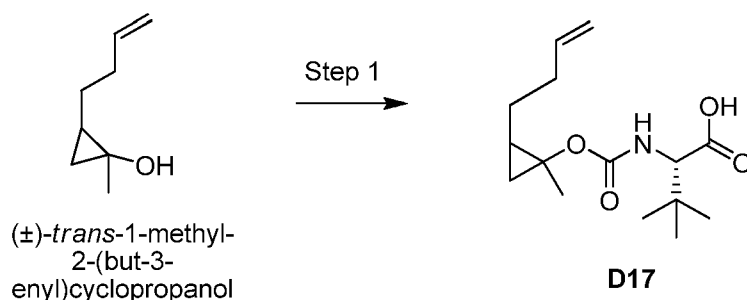
Step 2. Preparation of diastereomeric Intermediate mixture **D15**: Racemic alcohol mixture (**±**)-**D15-1** (2.00 g, 13.0 mmol) was dissolved in DMF (13.0 mL). Pyridine (1.05 mL, 13.0 mmol) was added followed by DSC (4.00 g, 15.6 mmol). The reaction mixture was heated to 50 °C and was stirred for 20 h. The reaction mixture was then cooled to rt and water (13 mL) was added dropwise over 2 min. L-tert-leucine (2.17 g, 13.0 mmol) and K₃PO₄ (8.28 g, 39.0 mmol) were then added and the reaction mixture was warmed to 50 °C. After 5 h, the reaction mixture was allowed to cool to rt and was diluted with water (500 mL). The resulting mixture was washed with dichloromethane (100 mL). The aqueous phase was then acidified to pH 2 with 2 N aqueous HCl solution, and was extracted with DCM (2 × 400 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated under reduced pressure to afford diastereomeric Intermediate mixture **D15** (4.5 g) as a pale orange oil, which was used subsequently without further purification.

Preparation of Intermediate **D16**:

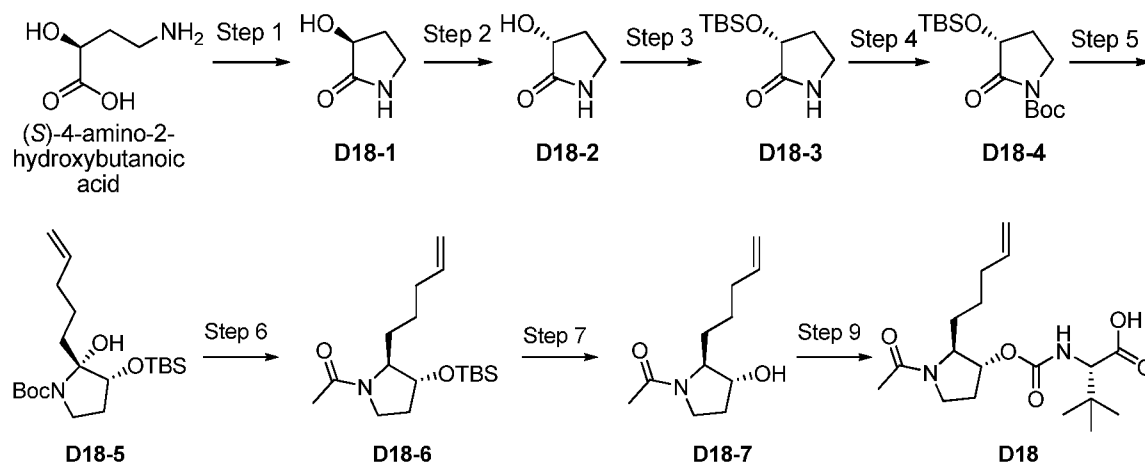


D16

Intermediate **D16** was prepared in a similar fashion to the preparation of Intermediate **D12**, substituting but-3-enylmagnesium bromide for pent-4-enylmagnesium bromide in Step 3. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₂₈NO₄: 310.2; found 310.8.

Preparation of Intermediate **D17**:

- 5 Step 1. Preparation of intermediate mixture **D17**. (±)-*trans*-1-methyl-2-(but-3-enyl)cyclopropanol (900 mg, .13 mmol), prepared according to procedure for Intermediate B2, International Patent Publication No. WO 2012/40040 (hereinafter "WO '040"), p. 38, was dissolved in DMF (6 mL). Pyridine (577 μ L, 7.13 mmol) was added followed by DSC (2.37 g, 9.27 mmol).
- 10 The reaction mixture was heated to 40 °C and was stirred for 18 h. The reaction mixture was then cooled to 0 °C and water (6 mL) was added dropwise over 5 min. The reaction mixture was stirred for 5 min and was removed from the cold bath. After an additional 5 min, the reaction mixture was cooled to 0 °C and L-tert-leucine (1.21 g, 9.27 mmol) and K_3PO_4 (4.69 g, 22.1 mmol) were added. The
- 15 mixture was stirred for 10 min and was removed from the cold bath. After stirring an additional 6 h, the mixture was diluted with EtOAc (30 mL), acidified with 1 M aqueous HCl (25 mL), and diluted with 0.2 M aqueous HCl (25 mL). The phases were separated, and the organic phase was washed with 0.2 M aqueous HCl (2 x 20 mL), dried over Na_2SO_4 , filtered, and concentrated to afford diastereomeric
- 20 carbamate mixture **D17** (2.10 g). LCMS-ESI⁺ (m/z): $[M+Na]^+$ calcd for $C_{15}H_{25}NNaO_4$: 306.2; found: 306.1.

Preparation of Intermediate **D18**:

5 Step 1. Preparation of **D18-1**: (Prepared according to WO2011013141) To a solution of (S)-4-amino-2-hydroxybutanoic acid (15 g, 126 mmol) in methanol (95 mL) was added concentrated sulfuric acid (8 mL), and the reaction was heated to reflux. After 18 h, the resulting mixture was allowed to cool to room temperature and was concentrated *in vacuo*. The residue was slurried with ethyl acetate (95 mL) and **D18-1** was collected by vacuum filtration. ¹H NMR (400 MHz, CDCl₃) δ 5.69 (br s, 1H), 4.31 (ddd, *J* = 9.2, 8.1, 2.2 Hz, 1H), 3.49 (d, *J* = 5.6 Hz, 1H), 3.41 (tt, *J* = 9.2, 1.7 Hz, 1H), 3.33 (td, *J* = 9.4, 6.5 Hz, 1H), 2.81 (br s, 1H), 2.59 – 2.48 (m, 1H), 2.09 (dq, *J* = 12.9, 9.1 Hz, 1H).

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Step 2. Preparation of **D18-2**: To a solution of **D18-1** (4.5 g, 44 mmol), 4-nitrobenzoic acid (8.19 g, 49 mmol), and triphenylphosphine (22.4 g, 132 mmol) in tetrahydrofuran (220 mL) was added diisopropyl azodicarboxylate (12.1 mL, 61.6 mmol) dropwise via syringe at 23 °C under an argon atmosphere. After 20 h, the resulting cloudy orange reaction mixture was concentrated *in vacuo* and methanol (200 mL) followed by potassium carbonate (15 g, 109 mmol) were added and the reaction was stirred at 23 °C. After an additional 5 h, the resulting mixture was diluted with chloroform (200 mL) and was filtered. The filtrate was concentrated *in vacuo* and the crude residue was taken up into water (150 mL) and 1 N aqueous hydrochloric acid solution (50 mL). The aqueous layer was washed with ethyl acetate (3 × 200 mL) to remove organic by-products, and was concentrated *in vacuo* to crude afford **D18-2** that was used directly in the next

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step. ^1H NMR (300 MHz, CD_3OD) δ 4.28 (t, J = 8.4 Hz, 1H), 3.43 – 3.20 (m, 1H), 2.56 – 2.39 (m, 1H), 1.96 (dq, J = 12.7, 8.7 Hz, 1H).

Step 3. Preparation of **D18-3**: To a solution of crude **D18-2** (5 g, 49.5 mmol) and imidazole (3.4 g, 49.5 mmol) in DMF (247 mL) was added TBSCl (7.5 g, 49.5 mmol) at 0 °C under an argon atmosphere. The resulting mixture was allowed to warm to 23 °C. After 7 h, additional imidazole (7 g, 102 mmol) and TBSCl (16 g, 106 mmol) were added sequentially. After an additional 16 h, the resulting mixture was diluted with 1 N aqueous hydrochloric acid solution (1 L) and was extracted with ethyl acetate (1 L). The organic layer was split and was washed with brine (1 L), was dried with anhydrous sodium sulfate, and was concentrate *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **D18-3**. ^1H NMR (300 MHz, CDCl_3) δ 5.99 (s, 1H), 4.26 (t, J = 7.7 Hz, 1H), 3.44 – 3.33 (m, 1H), 3.30 – 3.19 (m, 1H), 2.45 – 2.29 (m, 1H), 2.11 – 1.95 (m, 1H), 0.91 (s, 9H), 0.02 (s, 3H), 0.00 (s, 3H).

Step 4. Preparation of **D18-4**: To a solution of **D18-3** (1.00 g, 4.65 mmol), DMAP (57.8 mg, 0.465 mmol), and triethylamine (1.29 mL, 9.3 mmol) in dichloromethane (23.3 mL) was added di-*tert*-butyl dicarbonate (1.5 g, 6.97 mmol) at 23 °C under and argon atmosphere. After 20 h, the reaction mixture was purified directly by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **D18-4**. ^1H NMR (400 MHz, CDCl_3) δ 4.31 (dd, J = 9.4, 7.9 Hz, 1H), 3.79 (ddd, J = 11.0, 8.9, 2.2 Hz, 1H), 3.53 – 3.41 (m, 1H), 2.34 – 2.21 (m, 1H), 1.92 (dq, J = 12.2, 9.2 Hz, 1H), 1.53 (s, 9H), 0.91 (s, 9H), 0.17 (s, 3H), 0.13 (s, 3H).

Step 5. Preparation of **D18-5**: To a solution of **D18-4** (700 mg, 2.22 mmol) in tetrahydrofuran (11.1 mL) was added pent-4-enylmagnesium bromide (Novel Chemical Solutions, 0.5 M in 2-MeTHF, 4.89 mL, 2.44 mmol) at –78 °C dropwise via syringe under an argon atmosphere. After 1 h, the reaction mixture was quenched with saturated aqueous ammonium chloride solution (50 mL) and was allowed to warm to room temperature. The resulting mixture was extracted with ethyl acetate (2 × 100 mL), and the combined organic extracts were washed with

brine (100 mL), were dried over anhydrous sodium sulfate and were concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **D18-5**. ¹H NMR (400 MHz, CDCl₃) δ 5.77 – 5.62 (m, 1H), 4.95 (d, *J* = 15.8 Hz, 1H), 4.92 (d, *J* = 10.2 Hz, 1H), 4.26 (app t, *J* = 8.4 Hz, 1H), 3.77 – 3.69 (m, 1H), 3.41 (td, *J* = 10.4, 6.7 Hz, 1H), 2.48 (t, *J* = 7.4 Hz, 2H), 2.28 – 2.17 (m, 1H), 1.91 – 1.78 (m, 2H), 1.77 – 1.65 (m, 1H), 1.60 (quin, *J* = 7.3 Hz, 2H), 1.47 (s, 9H), 0.85 (s, 9H), 0.11 (s, 3H), 0.07 (s, 3H).

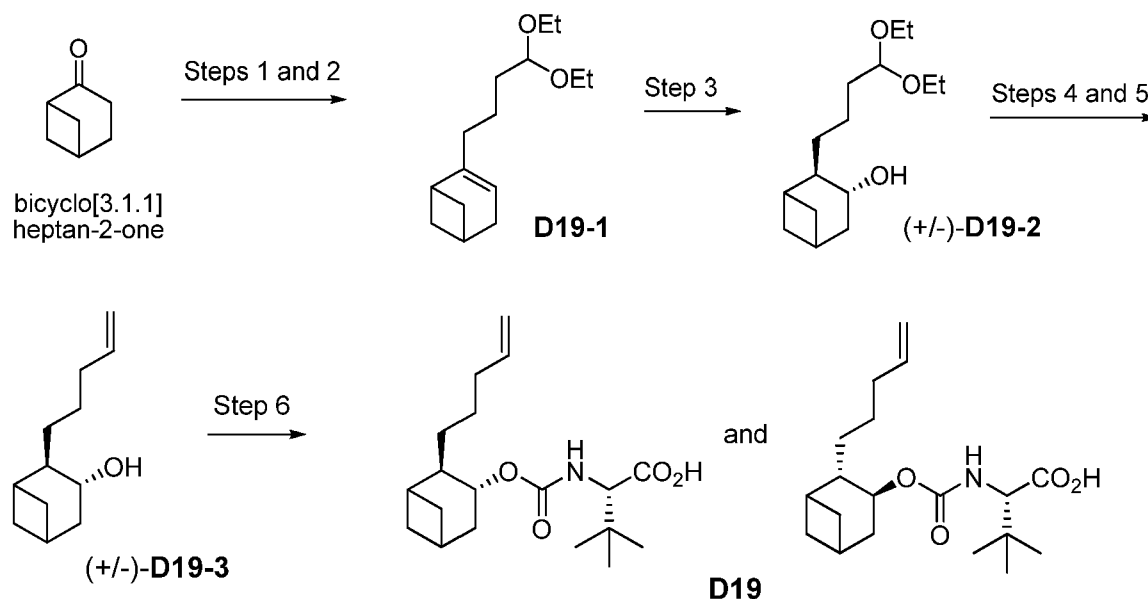
Step 6. Preparation of **D18-6**: To a solution of **D18-5** (740 mg, 1.92 mmol) and triethylsilane (6.10 mL, 38.4 mmol) in dichloromethane (9.6 mL) was added boron trifluoride diethyl etherate (308 μL, 2.50 mmol) at –78 °C dropwise via syringe under an argon atmosphere. After 1 h, the reaction mixture was allowed to warm to room temperature. After an additional 4 h, the reaction was quenched with saturated aqueous ammonium chloride solution (10 mL), and was diluted with saturated sodium bicarbonate solution (50 mL). The resulting mixture was extracted with ethyl acetate (50 mL), and the organic layer was dried over anhydrous sodium sulfate and was concentrated *in vacuo* to afford crude free amine which was used directly in the next step. To a solution of the crude free amine, and triethylamine (535 μL, 3.84 mmol) in tetrahydrofuran (9.6 mL) was added acetic anhydride (146.5 μL, 1.55 mmol) at room temperature under an argon atmosphere. After 1 h, the resulting mixture was concentrated *in vacuo* and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **D18-6** (2:1 diastereomeric mixture favoring desired 1-((2*S*,3*R*)-3-(tert-butyldimethylsilyloxy)-2-(pent-4-enyl)pyrrolidin-1-yl)ethanone diastereomer). ¹H NMR (400 MHz, CDCl₃, Minor diastereomer denoted by *) δ 5.80 – 5.64 (m, 1H, 1H*), 5.01 – 4.82 (m, 2H, 2H*), 4.10 (d, *J* = 4.2 Hz, 1H*), 4.04 (d, *J* = 3.7 Hz, 1H), 3.82 (dd, *J* = 10.3, 4.0 Hz, 1H), 3.66 – 3.56 (m, 1H*), 3.55 – 3.29 (m, 2H, 1H*), 3.24 – 3.16 (m, 1H*), 2.37 – 2.25 (m, 1H*), 2.08 – 1.88 (m, 2H, 1H*), 2.03 (s, 3H*), 2.00 (s, 3H), 1.81 – 1.61 (m, 2H, 2H*), 1.50 – 1.01 (m, 4H, 4H*), 0.85 (s, 9H*), 0.80 (s, 9H), 0.10 (s, 3H*), 0.09 (s, 3H*), 0.00 (br s, 6H).

Step 7. Preparation of **D18-7**: To a solution of **D18-6** (338 mg, 1.08 mmol) in tetrahydrofuran (21 mL) was added TBAF (1M in tetrahydrofuran, 21 mL, 21 mmol) at 0 °C under an argon atmosphere. After 17 h, the reaction mixture was concentrated *in vacuo* and was directly purified by silica gel chromatography (0–

100% ethyl acetate/hexanes gradient) to afford **D18-7** (102 mg, 2:1 diastereomeric mixture favoring desired 1 1-((2S,3R)-3-hydroxy-2-(pent-4-enyl)pyrrolidin-1-yl)ethanone diastereomer). ¹H NMR (400 MHz, CDCl₃ Minor diastereomer denoted by *) δ 5.84 – 5.70 (m, 1H, 1H*), 5.06 – 4.91 (m, 2H, 2H*), 4.25 (d, *J* = 3.7 Hz, 1H*), 4.20 (d, *J* = 3.7 Hz, 1H), 3.98 (dd, *J* = 9.2, 4.2 Hz, 1H), 3.76 – 3.68 (m, 1H*), 3.67 – 3.59 (m, 1H, 1H*), 3.55 – 3.46 (m, 1H, 2H*), 3.02 – 2.94 (m, 1H), 2.22 – 1.85 (m, 2H, 2H*), 2.10 (s, 3H*), 2.07 (s, 3H), 1.82 – 1.59 (m, 2H, 2H*), 1.55 – 1.13 (m, 4H, 4H*).

Step 8. Preparation of **D18-8**: To a solution of **D18-7** (102 mg, 0.518 mmol) and pyridine (8 μL, 0.104 mmol) was added DSC (159.2 mg, 0.621 mmol) at room temperature, and the resulting mixture was heated to 45 °C. After 16 h, the reaction mixture was allowed to cool to room temperature and water (518 μL), L-*tert*-leucine (86.5 mg, 0.518 mmol), and K₃PO₄ (330 mg, 1.55 mmol) were sequentially added, and the resulting mixture was heated to 50 °C. After 6 h, the reaction mixture was allowed to cool to room temperature and was diluted with

1N aqueous hydrochloric acid solution (10 mL). The resulting mixture was extracted with dichloromethane (2 × 10 mL), and the combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford **D18-8** (2:1 diastereomeric mixture favoring the desired (S)-2-(((2S,3R)-1-acetyl-2-(pent-4-enyl)pyrrolidin-3-yloxy)carbonylamino)-3,3-dimethylbutanoic acid). ¹H NMR (400 MHz, CDCl₃, Minor diastereomer denoted by *) δ 5.85 – 5.65 (m, 1H, 1H*), 5.39 (d, *J* = 9.3 Hz, 1H*), 5.34 (d, *J* = 9.2 Hz, 1H), 5.07 – 4.87 (m, 3H, 3H*), 4.16 – 4.03 (m, 1H, 1H*), 3.83 – 3.45 (m, 3H, 3H*), 2.30 – 1.95 (m, 8H), 2.30 – 1.95 (m, 2H, 3H*), 1.82 – 1.65 (m, 2H, 1H*), 2.11 (s, 3H), 2.09 (s, 3H*), 1.58 – 1.13 (m, 4H, 4H*), 1.01 (br s, 9H, 9H*).

Preparation of Intermediate mixture **D19**.

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Steps 1 and 2: Preparation of **D19-1**: A 1.0 M THF solution of KHMDS (10 mL, 10 mmol) was diluted with THF (10 mL) under Ar and the resulting solution was cooled to -78°C in a CO_2 :acetone bath. Bicyclo[3.1.1]heptan-2-one (1.0 g, 9.1 mmol, see: Yin, et. al. *J. Org. Chem.* **1985**, 50, 531) was added as a solution in THF (5 mL) over 2 min, washing with additional THF (2 x 2.5 mL) to ensure complete transfer. The resulting mixture was stirred for 30 min, and *N*-(5-Chloro-2-pyridyl)bis(trifluoromethanesulfonylimide) (3.8 g, 9.7 mmol) was added as a solution in THF (10 mL) over 2 min, washing with additional THF (2 x 2.5 mL). The resulting mixture was stirred for 5 min and removed from the cold bath. After stirring an additional 30 min, the reaction was diluted with Et_2O (70 mL) and 1 M aqueous HCl (50 mL). The phases were separated, and the organic phase was washed with 1 M aqueous NaOH (2 x 30 mL). The combined organic phase was dried over MgSO_4 , filtered and concentrated to afford a crude residue. This was filtered through a plug of silica with 30% EtOAc in hexanes to afford a crude residue of (1.24 g) that was used directly in the following step. Step 2: To a solution of 3-butenal diethyl acetal (1.4 mL, 8.3 mmol) under Ar cooled in an ice water bath was added a 0.5 M THF solution of 9-borabicyclo[3.3.1]nonane (15.9 mL, 7.95 mmol) over 3 min. The reaction was stirred for 20 h, with the cold bath

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being allowed to expire overnight. A 3 M aqueous solution of NaOH (2.9 mL, 8.7 mmol) was then added, and, after stirring 20 min, the resulting solution was transferred in its entirety to a flask containing the product from Step 1 (ca. 5.16 mmol) and PdCl₂(dppf)·CH₂Cl₂ (420 mg, 0.51 mmol). The resulting mixture was heated to 60 °C. After stirring 14 h, the reaction mixture was diluted with Et₂O (50 mL) and H₂O (50 mL). The phases were separated, and the organic phase was dried over MgSO₄, filtered, and concentrated. Purification by silica gel chromatography (0% to 10% EtOAc in hexanes following pre-equilibration with 1% Et₃N in EtOAc) provided intermediate **D19-1**. ¹H NMR (300 MHz, CDCl₃) 5.36 – 5.28 (m, 1H), 4.59 (t, *J* = 5.6 Hz, 1H), 3.73 – 3.58 (m, 2H), 3.54 – 3.39 (m, 2H), 2.72 – 2.60 (m, 1H), 2.45 – 2.34 (m, 3H), 2.23 – 2.08 (m, 4H), 1.89 – 1.76 (m, 2H), 1.67 (dt, *J* = 16.1, 6.9 Hz, 2H), 1.58 – 1.47 (m, 2H), 1.23 (t, *J* = 7.0 Hz, 6H).

Step 3: Preparation of **D19-2**: A solution of olefin **D19-1** (660 mg, 2.77 mmol) in THF (25 mL) was cooled in an ice water bath. BH₃·Me₂S was then added as a 1 M solution in CH₂Cl₂ (2.9 mL, 2.9 mmol) over 1 min. The resulting solution was stirred for 2 h in the ice water bath and was then allowed to warm to r.t. After stirring an additional 3 h, the reaction mixture was re-cooled in an ice water bath and was diluted with 2 M aqueous NaOH (7 mL) followed by 30 % aqueous H₂O₂ (7 mL). The resulting mixture was stirred an additional 16 h as the cold bath was allowed to gradually expire. The mixture was partitioned between Et₂O (100 mL) and H₂O (50 mL), the phases were separated, and the organic phase was washed with 0.5 M aqueous NaOH (50 mL). The organic phase was dried over MgSO₄, filtered, and concentrated to afford a crude residue that was purified by silica gel chromatography (15% to 40% EtOAc in hexanes) to afford 570 mg of Intermediate **D19-2**. ¹H NMR (300 MHz, CDCl₃) δ 4.60 (t, *J* = 5.6 Hz, 1H), 3.76 – 3.60 (m, 3H), 3.58 – 3.42 (m, 2H), 2.39 – 2.05 (m, 4H), 1.91 – 1.48 (m, 9H), 1.43 – 1.35 (m, 1H), 1.25 (t, *J* = 7.0 Hz, 6H), 1.06 – 0.98 (m, 1H).

Steps 4 and 5: Preparation of **D19-3**: Acetal **D19-2** (360 mg, 1.4 mmol) was dissolved in THF (8 mL) and H₂O (2 mL). *para*-Toluenesulfonic acid monohydrate (40 mg, 0.2 mmol) was added and the resulting solution was stirred 16 h at r.t. The reaction was diluted with Et₂O (50 mL) and H₂O (30 mL) and the

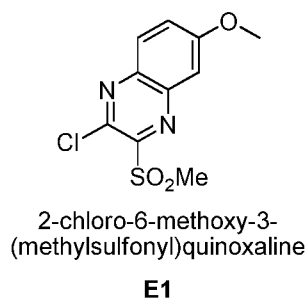
phases were separated. The aqueous phase was extracted with Et₂O (30 mL) and the combined organic phase was washed with saturated aqueous NaHCO₃ (15 mL). The organic phase was dried over MgSO₄, filtered, and concentrated to afford a crude residue that was used immediately in the following step. Step 5:

- 5 Methyl triphenylphosphonium bromide (1.66 g, 4.6 mmol) was suspended in THF (40 mL) under Ar and was cooled via a CO₂/acetone bath to -78 °C. A 1 M solution of NaHMDS in THF (4.2 mL, 4.2 mmol) was added in dropwise fashion and the resulting yellow suspension was stirred for 5 min. The mixture was removed from the cold bath and stirring continued an additional 30 min. The
- 10 mixture was then re-cooled to -78 °C and the crude residue from the previous step (ca. 1.4 mmol) was added as a solution in THF (5 mL) over 5 min, washing with additional THF (2 x 2.5 mL) to ensure complete transfer. The resulting mixture was stirred for 5 min and was then placed in an ice water bath and stirred an additional 1 h. The reaction was quenched with saturated aqueous NH₄Cl (20
- 15 mL) and was diluted with Et₂O (30 mL) and H₂O (20 mL). The phases were separated and the organic phase was dried over MgSO₄, filtered, and concentrated onto 5 g silica gel. Purification by silica gel chromatography (10% to 30% EtOAc in hexanes) provided **D19-3**. ¹H NMR (300 MHz, CDCl₃) δ 6.01 – 5.81 (m, 1H), 5.22 – 5.05 (m, 2H), 3.79 – 3.66 (m, 1H), 2.43 – 2.25 (m, 2H), 2.24
- 20 – 2.04 (m, 4H), 1.83 – 1.16 (m, 10H).

- Step 6: Intermediate **D19-3** (270 mg, 1.5 mmol) was dissolved in DMF (2.0 mL). Pyridine (125 µL, 1.5 mmol) and DSC (500 mg, 1.9 mmol) were added, and the reaction was stirred at 45 °C for 15 h. The reaction was then placed in an ice water bath and H₂O (2.0 mL) was added dropwise over 30 s. The mixture was
- 25 removed from the cold bath and allowed to stir 10 min. The mixture was re-cooled in an ice water bath and L-*tert*-leucine (259 mg, 1.97 mmol) was added followed by K₃PO₄ (835 mg, 3.93 mmol). The reaction mixture was removed from the cold bath and allowed to stir at r.t. for 5.25 h. The mixture was then diluted with EtOAc (40 mL), 1 M aqueous HCl (20 mL), and H₂O (15 mL). The phases
- 30 were separated, and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was washed with 0.2 M aqueous HCl (2 x 25 mL), dried

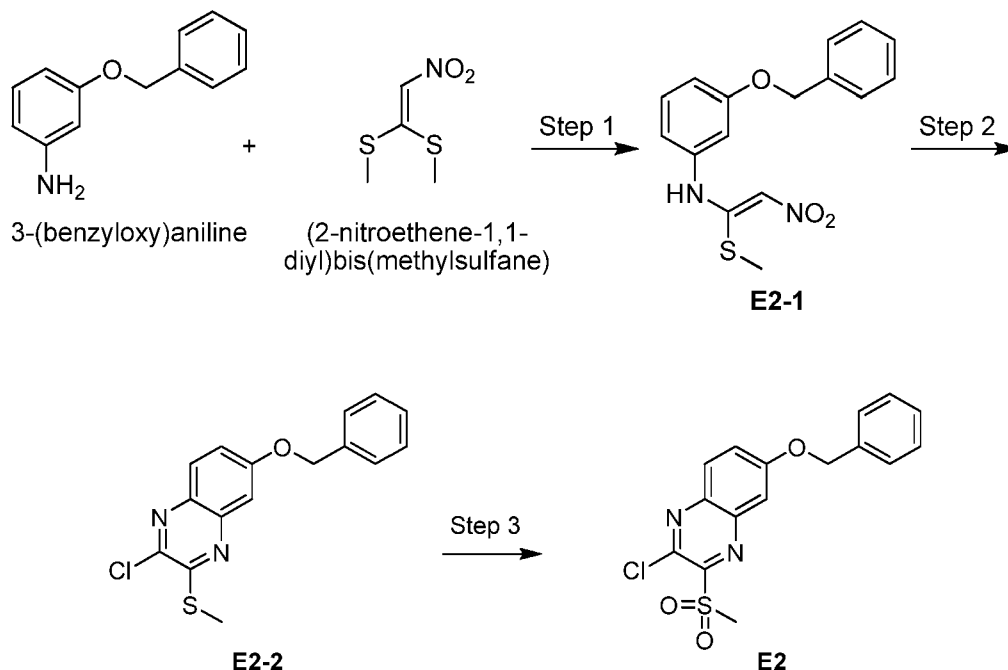
over Na_2SO_4 , filtered, and concentrated to afford a mixture of diastereomers **D19** (505 mg) as a colorless oil. LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{19}\text{H}_{32}\text{NO}_4$: 338.2; found: 337.8.

5 Preparation of Intermediate **E1**.



Intermediate **E1** (2-chloro-6-methoxy-3-(methylsulfonyl)quinoxaline) was prepared according to Mahata, P.K., *et al. Org. Lett.* **2005**, 7, 2169.

10 Preparation of Intermediate **E2**.

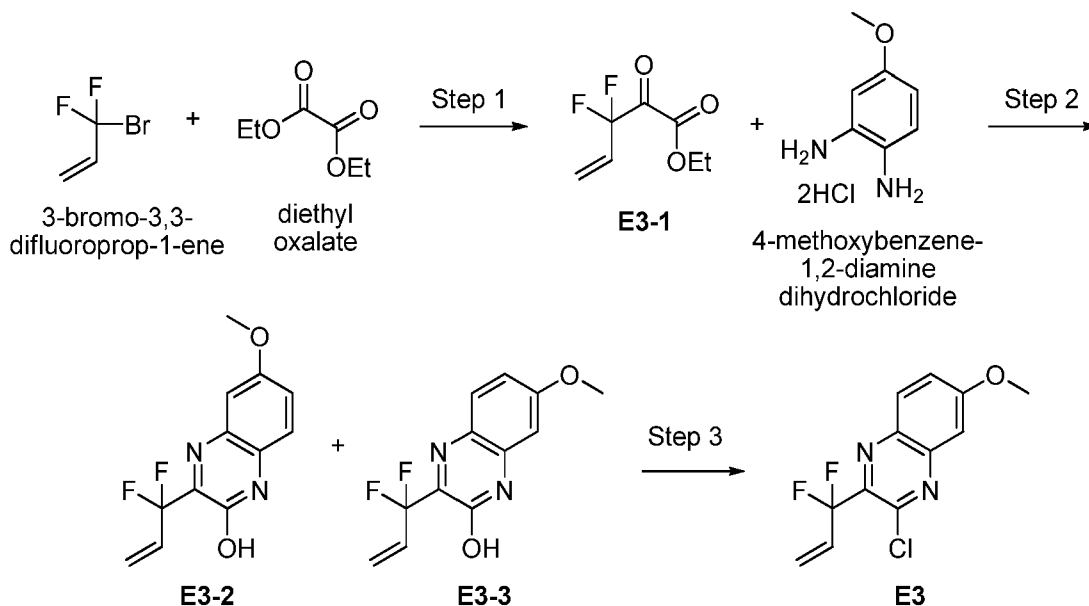


- 15 Step 1. Preparation of **E2-1**: In a round bottom flask, 3-(benzyloxy)aniline (4.025 g, 20.20 mmol) and 1,1-bis(methylthio)-2-nitroethylene (3.338 g, 20.20 mmol) in ethanol (40 mL) was refluxed for 24 h with constant stirring. The reaction mixture

was then cooled in an ice bath and diluted with ether (150 mL). The mixture was filtered and washed with ether to afford **E2-1** (3.32 g) as a yellow solid which was used directly in the following in step. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₁₇N₂O₃S: 317.1; found: 317.1.

- 5 Step 2. Preparation of **E2-2**: To a suspension of **E2-1** (3.32 g, 10.49 mmol) in 25 mL MeCN, POCl₃ (2.93 mL, 31.5 mmol) was added dropwise over 15 min with constant stirring. The reaction mixture was warmed to 80 °C and stirred for 5 h. The reaction was then cooled to ambient temperature and neutralized with ice cold saturated aqueous NaHCO₃ solution, extracted three times with CH₂Cl₂ (100
10 mL), washed with water, brine and dried over anhydrous Na₂SO₄. The solvent was removed under reduced pressure. The crude material was eluted through a plug of silica with CH₂Cl₂. The solvent was removed under reduced pressure and the solid was washed with MeCN to afford **E2-2** (1.56 g) as an off white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₁₄ClN₂OS: 317.1; found: 317.3.
- 15 Step 3. Preparation of Intermediate **E2**. A solution of *m*CPBA (1.87 g, 10.83 mmol) in CH₂Cl₂ (40 mL) was added dropwise to a stirred solution of **E2-2** (1.56 g, 4.92 mmol) in CH₂Cl₂ (40 mL) at 0 °C over a period of 30 min. The reaction mixture was further stirred at ambient temperature for 5 h. It was then poured into ice cold saturated aqueous NaHCO₃ and partitioned with CH₂Cl₂. The organic
20 layer was then washed subsequently with water, brine and dried over anhydrous Na₂SO₄. The solvent was removed under reduced pressure and the crude material was purified by normal phase chromatography with CH₂Cl₂ to provide the title compound Intermediate **E2** as a pale yellow solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₁₄ClN₂O₃S: 349.0; found: 349.0.

25

Preparation of Intermediate **E3**.

Step 1. Preparation of **E3-1**: To a solution of 3-bromo-3,3-difluoroprop-1-ene (25.0 g, 159 mmol) and diethyl oxalate (21.6 mL, 159 mmol) in THF (380 mL), diethyl ether (90 mL) and *n*-pentane (90 mL) at $-100\text{ }^{\circ}\text{C}$ was added dropwise *n*-butyllithium (2.5 M in hexane, 67 mL, 167.6 mmol) over 30 min. The reaction mixture was stirred at $-95\text{ }^{\circ}\text{C}$ for 1 h and $-78\text{ }^{\circ}\text{C}$ for 2 h, and quenched with aq. NH_4Cl (11 g in 150 mL of water). The mixture was extracted with ether (three times). The organic layers were washed with 1 N aqueous HCl, brine, and dried over Na_2SO_4 , and concentrated to give the crude residue, which was purified by silica gel chromatography (EtOAc in hexanes: 0% to 40%) to give **E3-1** (7.0 g). ^1H NMR (300 MHz, CDCl_3) δ 5.98–6.18 (m, 1H), 5.78 (dd, $J = 0.9\text{ Hz}$, 13 Hz, 1H), 5.60 (dd, $J = 0.9\text{ Hz}$, 11 Hz, 1H), 4.38 (q, $J = 6.9\text{ Hz}$, 2H), 1.37 (t, $J = 7.2\text{ Hz}$, 3H).

Step 2. Preparation of **E3-2** and **E3-3**: To a solution of **E3-1** (14.0 g, 78.6 mmol) and 4-methoxybenzene-1,2-diamine dihydrochloride (15.08 g, 71.4 mmol) in EtOH (360 mL) at rt was added triethylamine (19.9 mL, 142.8 mmol). The reaction mixture was stirred at rt overnight. The mixture was concentrated. Slurrying in dichloromethane (30 mL) and filtering gave some separation of regioisomers with **E3-2** as the precipitating species. (16.5 g total yield from

filtration and subsequent chromatography). ^1H NMR (400 MHz, CDCl_3) δ 11.940 (br s, 1H), 7.850 (d, J = 9 Hz, 1H), 6.985 (dd, J = 3 Hz, 9 Hz, 1H), 6.754 (d, J = 2 Hz, 1H), 6.625–6.498 (m, 1H), 5.907 (dt, J = 17, 2 Hz, 1H), 5.601 (d, J = 11 Hz, 1H), 3.938 (s, 3H). The mixture was slurried, filtered, and concentrated once

5 more, then was purified by silica gel chromatography (EtOAc in hexanes: 5% to 34%) to give **E3-3** (2.07 g) as the first eluting component. ^1H NMR (400 MHz, CDCl_3) δ 12.05 (br s, 1H), 7.850 (d, J = 9 Hz, 1H), 6.986 (dd, J = 3 Hz, 9 Hz, 1H), 6.761 (d, J = 3 Hz, 1H), 6.597–6.526 (m, 1H), 5.91 (dt, J = 17, 2 Hz, 1H), 5.601 (d, J = 11 Hz, 1H), 3.939 (s, 3H).

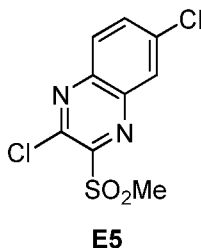
10 Step 3. Preparation of Intermediate **E3**: A solution of **E3-3** (2.07 g, 8.2 mmol in 1 mL DMF was treated with POCl_3 (0.8 mL) and heated at 65 °C for 2.5 h. The reaction was diluted with EtOAc and quenched by pouring into ice water. The organic phase was washed subsequently with saturated aqueous sodium bicarbonate and brine, dried over sodium sulfate and concentrated to give 2.1 g
15 of Intermediate **E3**. ^1H NMR (400 MHz, CDCl_3) δ 8.028 (d, J = 10 Hz, 1H), 7.46 (dd, J = 3 Hz, 9 Hz, 1H), 7.32 (d, J = 3 Hz, 1H), 6.549–6.478 (m, 1H), 5.86 (dt, J = 17, 2 Hz, 1H), 5.67 (d, J = 11 Hz, 1H), 3.981 (s, 3H).

Preparation of Intermediate **E4**.

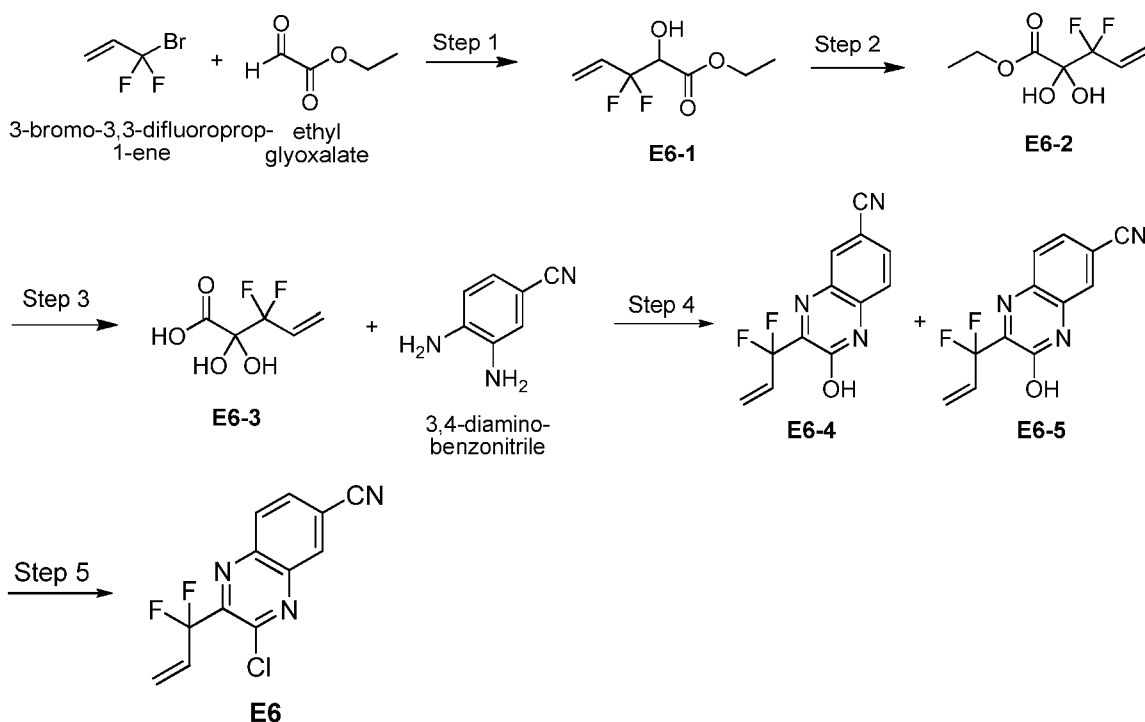


E4

Intermediate **E4** (2-chloro-3-(1,1-difluoroallyl)quinoxaline) was prepared in a similar fashion to Intermediate **E3**, substituting 1,2-diaminobenzene for 4-methoxybenzene-1,2-diamine dihydrochloride in Step 2.

Preparation of Intermediate **E5**.

Intermediate **E5** (2,6-dichloro-3-(methylsulfonyl)quinoxaline) was prepared according to Mahata, P.K., *et al. Org. Lett.* **2005**, 7, 2169.

Preparation of Intermediate **E6**.

Step 1. Preparation of **E6-1**: A 1-L 3-necked round-bottom flask was charged with a solution of 3-bromo-3,3-difluoroprop-1-ene (25 g, 159.3 mmol) in DMF (360 mL) and water (90 mL). The resulting solution was treated with ethyl 2-oxoacetate (33 mL, 1 M in toluene), and In (25 g). The reaction mixture was stirred overnight at rt and then extracted with 3x300 mL of ether. The organic layers were combined, washed with 1x100 mL of saturated aqueous NH_4Cl and

1x100 mL of brine, dried over anhydrous Na_2SO_4 and concentrated *in vacuo* to afford **E6-1** that was used subsequently without additional purification.

Step 2. Preparation of **E6-2**. To hydroxyester **E6-1** (58.1 g, 323 mmol) was added DCM (700 mL) in a 2 L 3-neck flask equipped with overhead stirring and an internal temperature probe. Then TEMPO (5.4 g, 35 mmol), buffer solution (prepared by dissolving 4.2 g NaHCO_3 and 0.53 g Na_2CO_3 per 100 mL water, 700 mL, 7v), and NaOCl (Clorox 6.15% wt, 422 mL, 395 mmol) were sequentially added to the flask at 20 °C. After 2 h the organic layer was separated and the aqueous phase extracted with ethyl acetate (2 × 300 mL). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated *in vacuo* to afford **E6-2**. $^1\text{H-NMR}$ (300 MHz, CDCl_3) δ 5.98-6.18 (m, 1H), 5.78 (dd, J = 0.9 Hz, 13 Hz, 1H), 5.60 (dd, J = 0.9 Hz, 11 Hz, 1H), 4.38 (q, J = 6.9 Hz, 2H), 1.37 (t, J = 7.2 Hz, 3H).

Step 3. Preparation of **E6-3**. To a solution of ethyl 3,3-difluoro-2,2-dihydroxypent-4-enoate **E6-2** (57.4 g, 292 mmol) in THF (725 mL) and water (131 mL) was added $\text{LiOH}\cdot\text{H}_2\text{O}$ (22 g, 529 mmol) at 20 °C. After 2.5 h, the reaction mixture was concentrated *in vacuo*. The solid residue was suspended in water (300 mL) and the resulting mixture was acidified to pH = 1 with concentrated aqueous hydrochloric acid solution. The resulting mixture was stirred until all solids were dissolved (~1.5 h), and then sodium chloride was added until the solution was saturated. The resulting solution was extracted with MTBE (2 × 500 mL) and ethyl acetate (2 × 500 mL), and the combined organic layers were dried over anhydrous Na_2SO_4 and were concentrated *in vacuo*. The crude orange solid residue was suspended into DCM (100 mL) and was stirred until the solids were finely distributed before hexanes (75 mL) were slowly added via addition funnel. The resulting solids were collected by vacuum filtration through a medium fritted funnel and washed with 1:1 dichloromethane/ hexanes (2 × 10 mL) to afford the desired product. $^1\text{H-NMR}$ (400 MHz, DMSO-d_6) δ 13.17 (bs, 1H), 6.18-6.01 (m, 1H), 5.64-5.52 (m, 2H).

Step 4. Preparation of **E6-4** and **E6-5**: A solution of **E6-3** (0.5 g, 3.3 mmol) in EtOH (12 mL) was treated with 3,4-diaminobenzonitrile (0.47 g, 3.5 mmol). The

reaction mixture was heated at 80 °C for 1 h, then concentrated *in vacuo*. The resulting residue was absorbed on silica gel, then was purified by column chromatography to give **E6-4** (0.5 g) as the first eluting component. ¹H-NMR (400 MHz, CD₃OD) δ 8.01 (d, 1H), 7.65 (dd, 2H), 6.49 (m, 1H), 5.80 (dt, 1H),

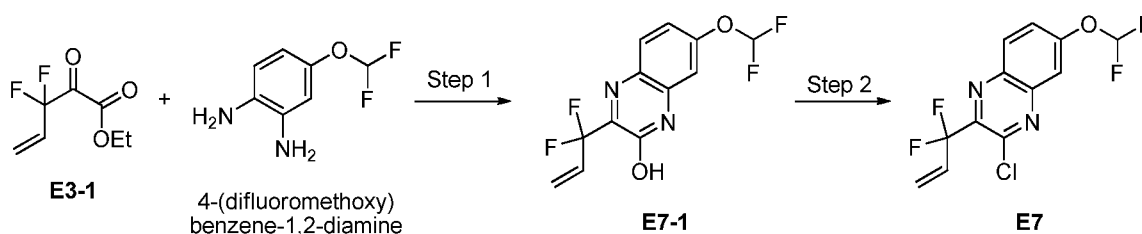
5 5.60 (d, 1H). **E6-5** (0.2 g) was recovered as the second eluting component. ¹H-NMR (400 MHz, CD₃OD) δ 8.25 (d, 1H), 7.87 (dd, 1H), 7.41 (d, 1H), 6.49 (m, 1H), 5.80 (dt, 1H), 5.59 (d, 1H).

Step 5. Preparation of Intermediate **E6**: A solution of **E6-4** (0.5 g, 2 mmol in 4.5 mL DMF was treated with POCl₃ (3 mL) and heated at 65 °C for 3 h. The

10 reaction was diluted with EtOAc and quenched by pouring into ice water. The organic phase was washed subsequently with saturated aqueous NaHCO₃ and brine, dried over anhydrous Na₂SO₄ and concentrated *in vacuo* to give 0.48 g of Intermediate **E6** (3-chloro-2-(1,1-difluoroallyl)quinoxaline-6-carbonitrile). ¹H-NMR (400 MHz, CD₃OD) δ 8.52 (s, 1H), 8.30 (d, 1H), 8.13 (dd, 1H), 6.55 (m, 1H), 5.84

15 (dt, 1H), 5.72 (d, 1H).

Preparation of Intermediate **E7**



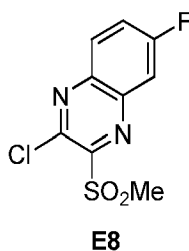
20 Step 1. Preparation of **E7-1**: To a solution of **E3-1** (1.84 g, 10.93 mmol) and 4-(difluoromethoxy)benzene-1,2-diamine (1.90 g, 10.93 mmol, prepared according to Reference Example 30y of WO2003035065, p. 511.) in DMF (40 mL) at rt was added DIPEA (9.5 mL, 54.65 mmol) and HATU (6.23 g, 16.4 mmol). The reaction mixture was stirred at room temperature for 24 h, diluted with ethyl acetate (100

25 mL), washed with water (100 mL) and brine (50 mL). The mixture was concentrated *in vacuo*. Purification via silica gel chromatography (EtOAc in hexanes: 20% to 60%) provided **E7-1** (800 mg) as the later eluting fraction of two

with the similar mass spectra. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₂H₉F₄N₂O: 289.2; found: 289.0.

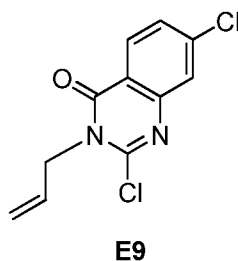
Step 2: Preparation of Intermediate **E7**: Hydroxyquinoxaline **E7-1** (800 mg, 2.8 mmol), POCl₃ (1.65 mL, 3.0 mmol) and DMF (10 mL) are combined at rt and then
5 heated to 65 °C for 2.5 h at which time additional POCl₃ (0.2 mL, 0.36 mmol) was added. The reaction was heated an additional 3 h at 65 °C then cooled to rt. The reaction was quenched by addition of cold water (30 mL), and taken up into ethyl acetate (50 mL), washed with saturated aqueous Na₂CO₃ (100 mL) followed by brine (50 mL), and dried over anhydrous MgSO₄. The resulting solution was
10 concentrated *in vacuo* to give Intermediate **E7** (859 mg) which was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₂H₈ClF₄N₂O: 307.0; found: 307.0.

Preparation of Intermediate **E8**.



Intermediate **E8** (2-chloro-6-fluoro-3-(methylsulfonyl)quinoxaline) was prepared according to Mahata, P.K., *et al. Org. Lett.* **2005**, 7, 2169.

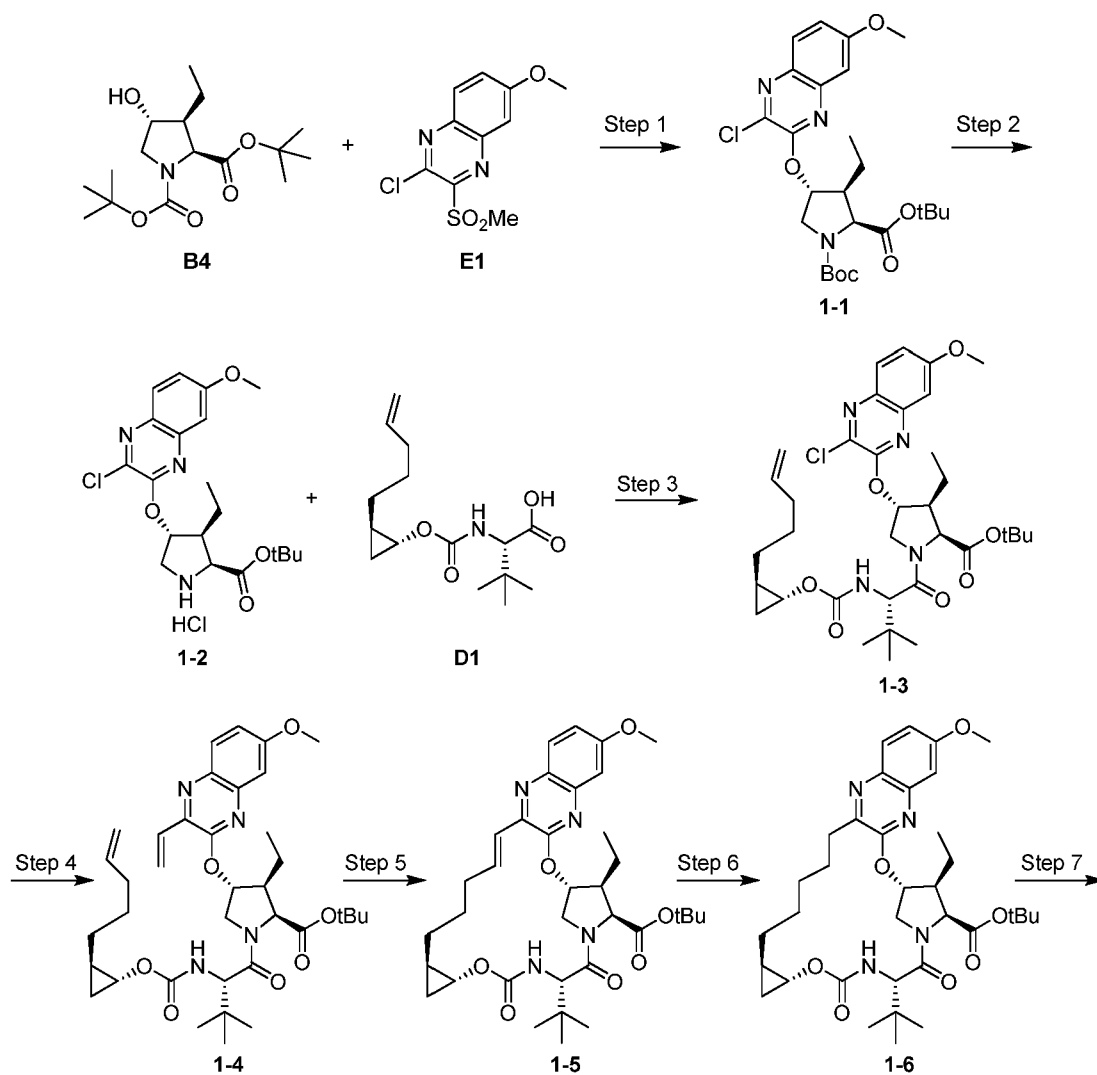
20 Preparation of Intermediate **E9**.

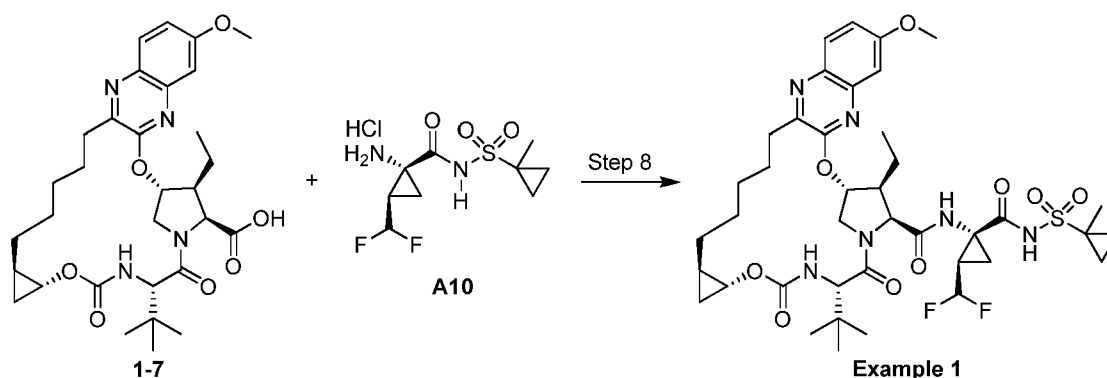


2,7-dichloro-3-(prop-2-en-1-yl)quinazolin-4(3H)-one (Intermediate **E9**) was prepared according to Step 3 of Intermediate D5 of WO '040 p 53-4.

Preparation of Examples

Example 1. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.





Step 1. Preparation of **1-1**: A mixture containing Intermediate **B4** (2.03 g, 6.44 mmol), Intermediate **E1** (1.6 g, 5.85 mmol), and cesium carbonate (3.15 g, 9.66 mmol) in MeCN (40 mL) was stirred vigorously at rt under an atmosphere of Ar for 16 h. The reaction was then filtered through a pad of Celite and the filtrate concentrated *in vacuo*. The crude material was purified by silica gel chromatography to provide **1-1** as a white solid (2.5 g). LCMS-ESI⁺ (*m/z*): [M-Boc+2H]⁺ calcd for C₂₀H₂₇ClN₃O₄: 408.9; found: 408.6.

Step 2. Preparation of **1-2**: To a solution **1-1** (2.5 g, 4.92 mmol) in dioxane (10 mL) was added hydrochloric acid in dioxane (4 M, 25 mL, 98.4 mmol) and the reaction stirred at rt for 5 h. The crude reaction was concentrated *in vacuo* to give **1-2** as a white solid (2.49 g) that was used in subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M]⁺ calcd for C₂₀H₂₆ClN₃O₄: 407.9; found: 407.9.

Step 3. Preparation of **1-3**: To a DMF (35 mL) solution of **1-2** (2.49 g, 5.61 mmol), Intermediate **D1** (1.75 mg, 6.17 mmol) and DIPEA (3.9 mL, 22.44 mmol) was added COMU (3.12 g, 7.29 mmol) and the reaction was stirred at rt for 3 h. The reaction was quenched with 5% aqueous citric acid solution and extracted with EtOAc, washed subsequently with brine, dried over anhydrous MgSO₄, filtered and concentrated to produce **1-3** as an orange foam (2.31 g) that was used without further purification. LCMS-ESI⁺ (*m/z*): [M]⁺ calcd for C₃₅H₄₉ClN₄O₇: 673.3; found: 673.7.

Step 4. Preparation of **1-4**: To a solution of **1-3** (2.31 g, 3.43 mmol), TEA (0.72 mL, 5.15 mmol) and potassium vinyltrifluoroborate (0.69 mg, 5.15 mmol) in EtOH (35 mL) was added PdCl₂(dppf) (0.25 g, 0.34 mmol, Frontier Scientific).

The reaction was sparged with Argon for 15 min and heated to 80 °C for 2 h. The reaction was adsorbed directly onto silica gel and purified using silica gel chromatography to give **1-4** as a yellow oil (1.95 g). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₃N₄O₇: 665.4; found: 665.3.

5 Step 5. Preparation of **1-5**: To a solution of **1-4** (1.95 g, 2.93 mmol) in DCE (585 mL) was added Zhan 1B catalyst (0.215 g, 0.29 mmol, Strem) and the reaction was sparged with Ar for 15 min. The reaction was heated to 80 °C for 1.5 h, allowed to cool to rt and concentrated. The crude product was purified by silica gel chromatography to produce **1-5** as a yellow oil (1.47 g; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.4; found: 637.3).

10 Step 6. Preparation of **1-6**: A solution of **1-5** (0.97 g, 1.52 mmol) in EtOH (15 mL) was treated with Pd/C (10 wt % Pd, 0.162 g). The atmosphere was replaced with hydrogen and stirred at rt for 2 h. The reaction was filtered through Celite, the pad washed with EtOAc and concentrated to give **1-6** as a brown foamy solid (0.803 g) that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₅₁N₄O₇: 639.4; found: 639.3.

15 Step 7. Preparation of **1-7**: To a solution of **1-6** (0.803 g, 1.26 mmol) in DCM (10 mL) was added TFA (5 mL) and stirred at rt for 3 h. An additional 2 mL TFA was added and the reaction stirred for another 1.5 h. The reaction was concentrated to a brown oil that was taken up in EtOAc (35 mL). The organic solution was washed with water. After separation of the layers, sat. aqueous NaHCO₃ was added with stirring until the aqueous layer reached a pH ~ 7–8. The layers were separated again and the aqueous extracted with EtOAc twice. The combined organics were washed with 1 M aqueous citric acid, brine, dried over anhydrous MgSO₄, filtered and concentrated to produce **1-6** as a brown foamy solid (0.719 g) that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₄₃N₄O₇: 583.3; found: 583.4 .

20 Step 8. Preparation of Example 1: To a solution of **1-7** (0.200 g, 0.343 mmol), Intermediate **A10** (0.157 g, 0.515 mmol), DMAP (0.063 g, 0.51 mmol) and DIPEA (0.3 mL, 1.72 mmol) in DMF (3 mL) was added HATU (0.235 g, 0.617 mmol) and the reaction was stirred at rt o/n. The reaction was diluted with MeCN

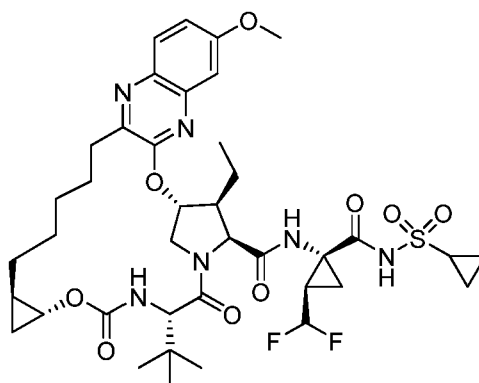
and purified directly by reverse phase HPLC (Gemini, 30–100% MeCN/H₂O + 0.1% TFA) and lyophilized to give Example 1 (118.6 mg) as a solid TFA salt.

Analytic HPLC RetTime: 8.63 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

C₄₀H₅₅F₂N₆O₉S: 833.4; found: 833.5. ¹H NMR (400 MHz, CD₃OD) δ 9.19 (s, 1H);

- 5 7.80 (d, *J* = 8.8 Hz, 1H); 7.23 (dd, *J* = 8.8, 2.4 Hz, 1H); 7.15 (d, *J* = 2.4 Hz, 1H); 5.89 (d, *J* = 3.6 Hz, 1H); 5.83 (td, *J*_{H-F} = 55.6 Hz, *J* = 6.4 Hz, 1H); 4.56 (d, *J* = 7.2 Hz, 1H); 4.40 (s, 1H) 4.38 (ap d, *J* = 7.2 Hz, 1H); 4.16 (dd, *J* = 12, 4 Hz, 1H); 3.93 (s, 3H); 3.75 (dt, *J* = 7.2, 4 Hz, 1H); 3.00–2.91 (m, 1H); 2.81 (td, *J* = 12, 4.4 Hz, 1H); 2.63–2.54 (m, 1H); 2.01 (br s, 2H); 1.88–1.64 (m, 3H); 1.66–1.33 (m,
- 10 11H) 1.52 (s, 3H); 1.24 (t, *J* = 7.2 Hz, 3H); 1.10 (s, 9H); 1.02–0.96 (m, 2H); 0.96–0.88 (m, 2H); 0.78–0.68 (m, 1H); 0.55–0.46 (m, 1H).

Example 2. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

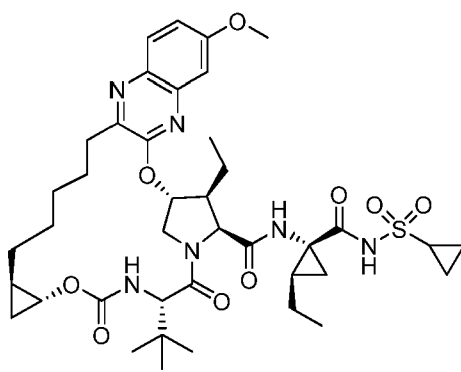


Example 2

Example 2 was prepared in a similar fashion to Example 1, substituting Intermediate A9 for Intermediate A10 in Step 8. Example 2 was isolated (37.9 mg) in approximately 85% purity as a TFA salt. Analytic HPLC RetTime: 8.54

min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₃F₂N₆O₉S: 819.35; found: 819.51. ¹H NMR (400 MHz, CDCl₃) δ 10.26 (s, 1H); 7.90 (d, *J* = 9.2 Hz, 1H); 7.26 (dd, *J* = 9.2, 2.4 Hz, 1H); 7.10 (d, *J* = 2.4 Hz, 1H); 6.68 (br s, 1H); 6.01 (td, *J*_{H-F} = 55.6 Hz, *J* = 6.8 Hz, 1H); 5.87 (d, *J* = 3.6 Hz, 1H); 5.38 (d, *J* = 10 Hz, 1H); 4.50–4.40 (m, 3H); 4.10 (dd, *J* = 12, 3.6 Hz, 1H); 3.95 (s, 3H); 3.79–3.72 (m, 1H); 2.96–2.82 (m, 3H); 2.63–2.56 (m, 1H); 2.14 (t, *J* = 6.8 Hz, 1H); 1.98–1.86 (m, 1H); 1.84–1.28 (m, 13H); 1.23 (t, *J* = 7.2 Hz, 3H); 1.16–0.92 (m, 3H); 1.09 (s, 9H); 0.74–0.64 (m, 1H); 0.48 (q, *J* = 6.4 Hz, 1H).

Example 3. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-((1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethylcyclopropyl)-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

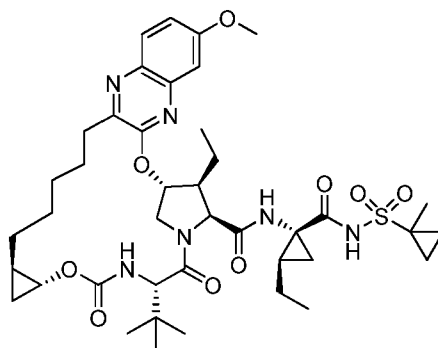


Example 3

Example **3** was prepared in a similar fashion to Example **1**, substituting Intermediate **A3** for Intermediate **A10** in Step 8. Example **3** was isolated (0.035 g) in approximately 88% purity as a TFA salt. Analytic HPLC RetTime: 8.63 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₇N₆O₉S: 797.4; found: 797.5. ¹H NMR (400 MHz, CD₃OD) δ 8.98 (s, 1H); 7.80 (d, *J* = 9.2 Hz, 1H); 7.23 (d, *J* = 9.2, 2.8 Hz, 1H); 7.15 (d, *J* = 2.8 Hz, 1H); 5.89 (d, *J* = 3.6 Hz, 1H); 4.58 (d, *J* = 7.6 Hz, 1H); 4.41–4.32 (m, 2H); 4.16 (dd, *J* = 12.4 Hz, 3.6 Hz, 1H); 3.93 (s, 3H); 3.74 (dt, *J* = 6.8, 2.8 Hz, 1H); 3.20–2.91 (m, 2H); 2.86–2.76 (m, 1H); 2.61–2.53 (m, 1H);

1.88–1.68 (m, 4H); 1.66–1.34 (m, 9H); 1.34–1.20 (m, 5H); 1.18–1.04 (m, 3H); 1.10 (s, 9H); 1.00–0.92 (m, 7H); 0.79–0.69 (m, 1H); 0.50 (br d, J = 7.2 Hz, 1H).

Example 4. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-9-ethyl-N-[(1R,2R)-2-ethyl-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Example 4

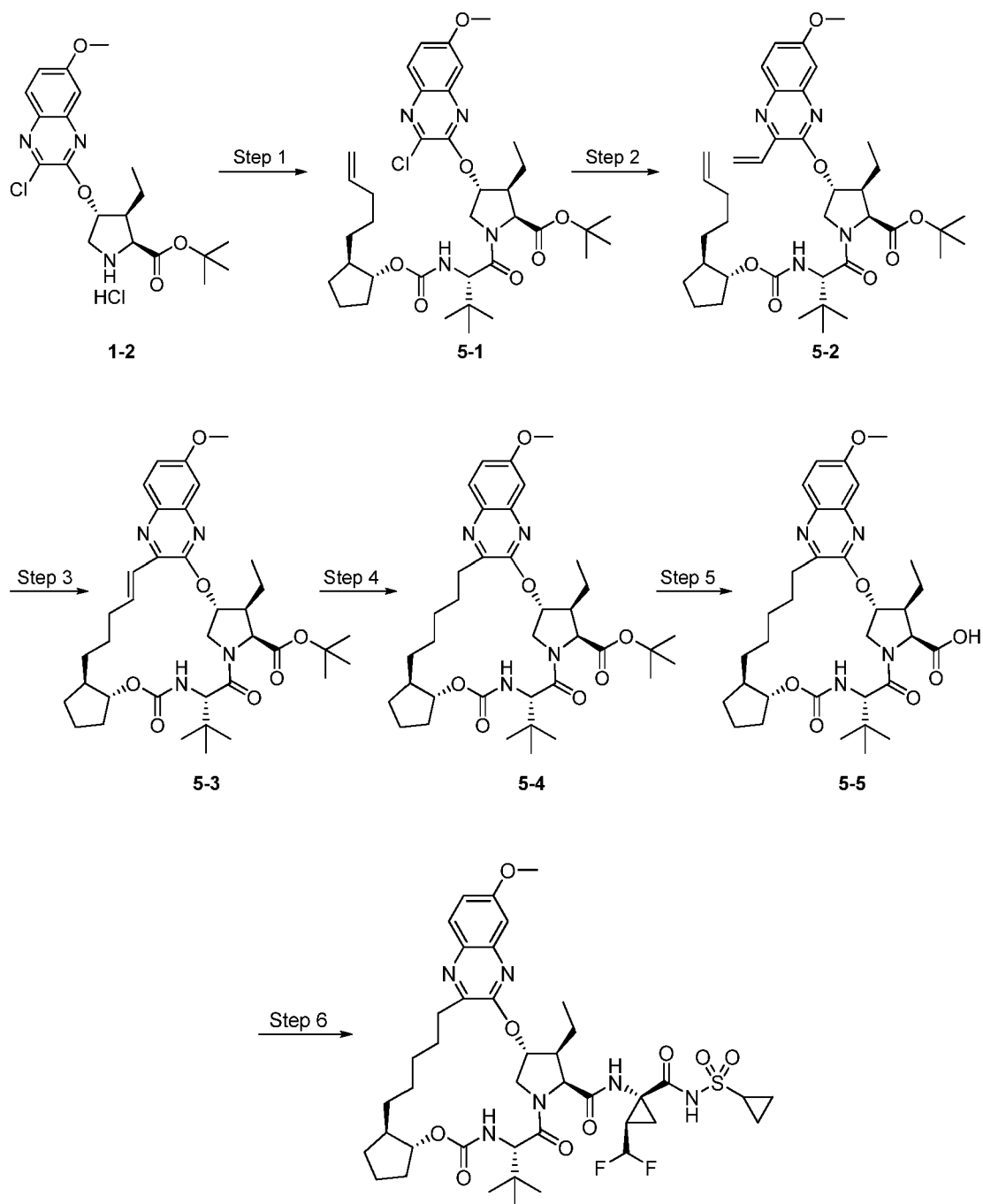
Example 4 was prepared in a similar fashion to Example 1, substituting Intermediate **A4** for Intermediate **A10** in Step 8. Example 4 was isolated (0.018 g) in approximately 88% purity as a TFA salt. Analytic HPLC RetTime: 8.75.

LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₉N₆O₉S: 811.4; found: 811.6. ¹H NMR (400 MHz, CD₃OD) δ 8.91 (s, 1H); 7.80 (d, J = 9.2 Hz, 1H); 7.23 (dd, J = 9.2, 2.8 Hz, 1H); 7.16 (d, J = 2.8 Hz, 1H); 5.90 (d, J = 3.6 Hz, 1H); 4.59 (d, J = 6.8 Hz, 1H); 4.38 (s, 1H); 4.37 (d, J = 11.6 Hz, 1H), 4.16 (dd, J = 11.6, 6.8 Hz, 1H), 3.93 (s, 3H); 3.74 (dt, J = 6.8, 3.6 Hz, 1H); 3.10–2.91 (m, 1H); 2.90–2.7 (m, 1H); 2.63–2.55 (m, 1H); 1.86–1.69 (m, 3H); 1.65–1.36 (m, 13H), 1.52 (s, 3H); 1.24 (t, J = 7.2 Hz, 3H); 1.16–1.06 (m, 2H); 1.10 (s, 9H); 1.02–0.85 (m, 7H); 0.79–0.68 (m, 1H); 0.50 (br d, J = 6.8 Hz, 1H).

Example 5. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-11-

ethyl-16-methoxy-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.

5



10

Step 1. Preparation of **5-1**: HATU (555 mg, 1.46 mmol, Oakwood) and DIPEA (1.10 mL, 6.35 mmol) were added to a mixture of **1-2** (533 mg, 1.20 mmol) and Intermediate **D5** (414 mg, 1.33 mmol) in 12 mL of DMF under argon. After stirring overnight, the reaction mixture was poured into water and extracted
5 three times with ethyl acetate. Combined organics were washed with water and brine, dried (MgSO₄), filtered, and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–35% ethyl acetate in hexanes) to yield **5-1** (713 mg) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₄ClN₄O₇: 701.36; found: 701.58.

Step 2. Preparation of **5-2**: Pd(dppf)Cl₂•CH₂Cl₂ (94 mg, 0.115 mmol, Strem) was added to a deoxygenated mixture of **5-1** (710 mg, 1.01 mmol), potassium vinyltrifluoroborate (213 mg, 1.59 mmol), and triethylamine (0.210 mL, 1.52 mmol) in 11 mL of EtOH at room temperature. Reaction mixture was heated at 78 °C under argon for one hour. After cooling to room temperature,
15 reaction mixture was poured into water and extracted three times with ethyl acetate. Combined organics were washed with water and brine, dried (MgSO₄), filtered, and concentrated under reduced pressure to yield **5-2** (699 mg), which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₇N₄O₇: 693.41; found: 693.47.

Step 3. Preparation of **5-3**: A mixture of **5-2** (699 mg, 1.01 mmol) and Zhan 1B catalyst (81 mg, 0.111 mmol, Strem) in 200 mL of DCE was deoxygenated under argon for 25 minutes. The mixture was then heated at 95 °C for 45 minutes. Reaction mixture was heated at 95 °C for 10 additional minutes, was cooled to room temperature, and then concentrated under reduced
25 pressure. The resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to yield **5-3** (336 mg) as a light brown solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₃N₄O₇: 665.38; found: 665.53.

Step 4. Preparation of **5-4**: Palladium on carbon (10 wt. % Pd, 102 mg, 0.096 mmol) was added to a solution of **5-3** (330 mg, 0.497 mmol) in 8 mL of ethanol and 3.5 mL of ethyl acetate. Mixture was stirred under an atmosphere of
30 hydrogen for 100 minutes and was then filtered over Celite, washing with ethyl

acetate. Filtrate was concentrated under reduced pressure to yield **5-4** (64 mg) as a light yellow-brown solid film, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₅N₄O₇: 667.40; found: 667.52.

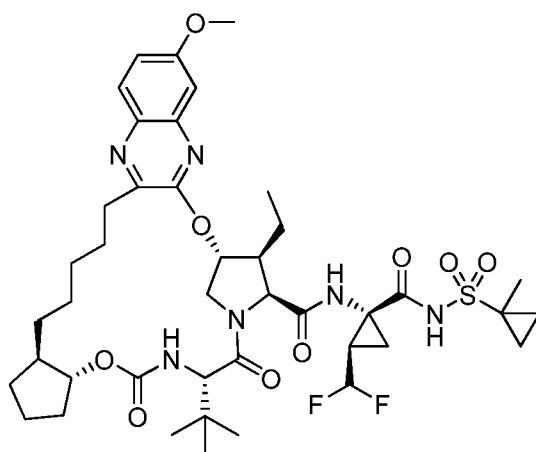
5 Step 5. Preparation of **5-5**: TMSOTf (0.53 mL, 2.91 mmol) was added dropwise to a solution of **5-4** (329 mg, 0.494 mmol) in 10 mL of dichloromethane under argon at room temperature. After one hour, an additional 0.3 mL of TMSOTf was added. After an additional hour, reaction mixture was concentrated under reduced pressure. The resulting film was taken up in 12 mL of toluene and
10 concentrated under reduced pressure. This process was repeated a second time to yield **5-5** (301 mg), which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₇N₄O₇: 611.34; found: 611.46.

 Step 6. Preparation of Example **5**: HATU (129 mg, 0.339 mmol) and DIPEA (0.22 mL, 1.27 mmol) were added to a mixture of **5-5** (134 mg, 0.22
15 mmol) and Intermediate **A9** (95 mg, 0.328 mmol) in 6.6 mL of MeCN under argon. After stirring for 5 h, reaction mixture was poured into water and extracted three times with ethyl acetate. Combined organics were washed with water and brine, dried (MgSO₄), filtered, and concentrated under reduced
20 pressure. The resulting residue was purified by reverse phase preparatory HPLC (15–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield Example **5** (43 mg) as a light yellow solid, trifluoroacetic acid salt, after lyophilization. Analytic HPLC RetTime: 9.11 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₇F₂N₆O₉S: 847.38; found: 847.62. ¹H NMR (400 MHz, CD₃OD): δ 9.31 (s, 1H), 7.80 (d, J = 9.2 Hz, 1H), 7.23 (dd, J = 15.4, 2.8 Hz, 1H), 7.19 (d, J = 2.8
25 Hz, 1H), 5.87 (td, J_{H-F} = 56 Hz, J = 6 Hz, 1H), 5.87–5.83 (m, 1H), 4.59 (d, J = 7.6 Hz, 1H), 4.38 (s, 1H), 4.23–4.14 (m, 2H), 3.93 (s, 3H), 3.06–2.94 (m, 2H), 2.77–2.67 (m, 1H), 2.65–2.58 (m, 1H), 2.07–2.01 (m, 2H), 1.98–1.74 (m, 4H), 1.72–1.52 (m, 4H), 1.50–1.20 (m, 12H), 1.18–1.02 (m, 8H), 1.06 (s, 9H).

30 Example **6**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-

methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-11-ethyl-16-methoxy-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6] dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.

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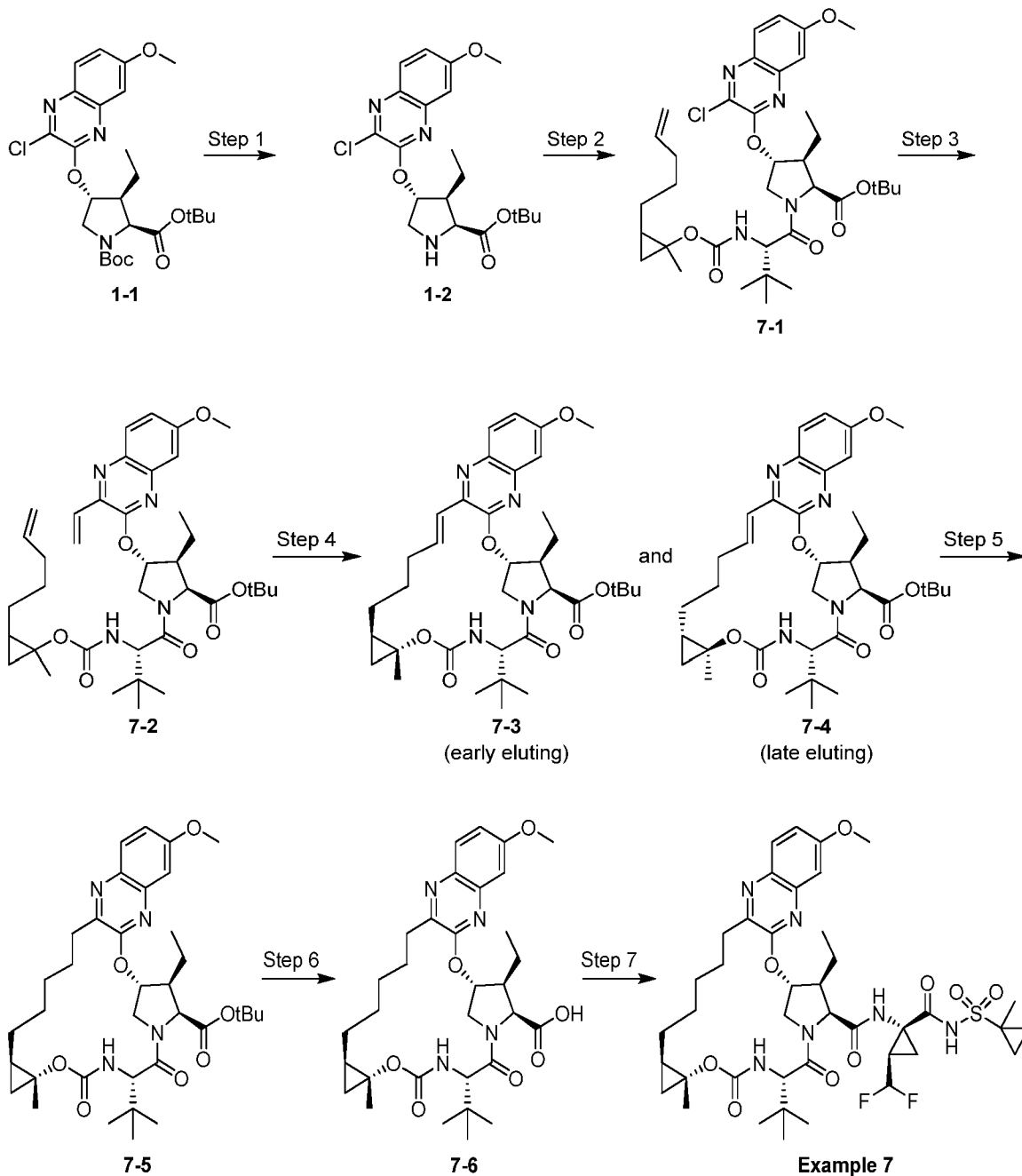


Example 6

Example 6 was prepared in a similar fashion to Example 5, substituting Intermediate **A10** for Intermediate **A9** in Step 6. Example 6 was isolated (29 mg) as a white solid. Analytic HPLC RetTime: 9.26 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₉F₂N₆O₉S: 861.40; found: 861.20. ¹H NMR (400 MHz, CDCl₃) δ 9.91 (s, 1H), 7.82 (d, J = 12Hz, 1H), 7.18 (d, J = 12 Hz 1H), 7.13–7.06 (m, 1H), 6.48 (s, 1H), 5.95 (td, J_{H-F} = 56 Hz, J = 6 Hz, 1H), 5.82 (d, J = 4.4 Hz, 1H), 5.33 (d, J = 10 Hz, 1H), 4.95–4.91 (m, 1H), 4.38–4.31 (m, 2H), 4.10–3.88 (m, 2H), 3.98 (s, 3H), 2.98–2.89 (m, 1H), 2.67–2.59 (m, 1H), 2.05–1.65 (m, 4H), 1.64–1.21 (m, 12H), 1.40 (s, 3H), 1.17–0.80 (m, 12H), 1.09 (s, 9H).

Example 7. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-1a-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

methanocyclopropa[18,19][1,10,3,6] dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



10 Step 1. Preparation of **1-2** (free base): Carbamate **1-1** (350 mg, 0.689 mmol) was added to a flask containing a 4:1 mixture of t-butyl acetate:DCM (3.5 mL). To this solution was then added methanesulfonic acid (447 μ L, 6.89 mmol).

The reaction mixture was allowed to stir for 20 min at rt, then diluted with methylene chloride (20 mL) and saturated aqueous sodium bicarbonate (20 mL). The solution was allowed to stir until evolution of gas ceased, then the organics were removed and the aqueous layer was extracted twice with methylene chloride (20 mL). The combined organics were then washed with brine, dried over Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting white solid **1-2** (free base, 280 mg) was used in the subsequent reaction without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₀H₂₇ClN₃O₄: 408.2; found: 408.1

Step 2. Preparation of mixture **7-1**: Amine **1-2** (281 mg, 0.689 mmol) was combined with diastereomeric Intermediate mixture **D6** (266 mg, 0.895 mmol), DIPEA (600 µL, 3.45 mmol) and DMF (2 mL). HATU (340 mg, 0.895 mmol) was then added to the reaction mixture, which was stirred at 40 °C for 5 h. Reaction mixture was then diluted with water (10 mL) and taken up into methylene chloride (10 mL). Organics were separated and aqueous layer was extracted once with methylene chloride (10 mL). Combined organics were then washed with brine, dried over MgSO₄, filtered, and concentrated *in vacuo*. Crude residue was then purified via silica gel chromatography to give **7-1** as a 1:1 diastereomeric mixture (280 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₂ClN₄O₇: 687.4; found: 687.3.

Step 3. Preparation of **7-2**: Pd(dppf)Cl₂ (29 mg, 0.0407 mmol) was added to a degassed mixture of **7-1** (280 mg, 0.407 mmol), potassium vinyltrifluoroborate (55 mg, 0.733 mmol), and triethylamine (91 µL, 0.651 mmol) in 2 mL of ethanol at room temperature. Reaction mixture was heated at 80 °C under N₂ for one hour. After cooling to room temperature, reaction mixture was diluted with toluene (10 mL), concentrated *in vacuo* to a small volume of solvent, and rediluted in toluene (1 mL). Mixture was then loaded directly onto a silica column and purified by silica gel chromatography to afford **7-2** as a 1:1 diastereomeric mixture which was carried on to the next step without concentrating fully to dryness. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₅N₄O₇: 679.4; found: 679.4.

Step 4. Preparation of **7-3** and **7-4**: Diastereomeric mixture **7-2** (276 mg, 0.407 mmol) and Zhan 1B catalyst (32 mg, 0.0407 mmol, Strem) were dissolved in 80 mL of DCE and degassed under N₂ for 25 minutes. The mixture was then heated to 100 °C for 1 h. Reaction was then cooled to room temperature and concentrated *in vacuo*. The resulting residue was purified via silica gel chromatography (0% to 30% ethyl acetate in hexanes) to yield single diastereomers **7-3** (20 mg, early eluting fraction) and **7-4** (25 mg, late eluting fraction) as light brown residues. Early eluting fraction: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.4; found: 651.3. Late eluting fraction: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.4; found: 651.3.

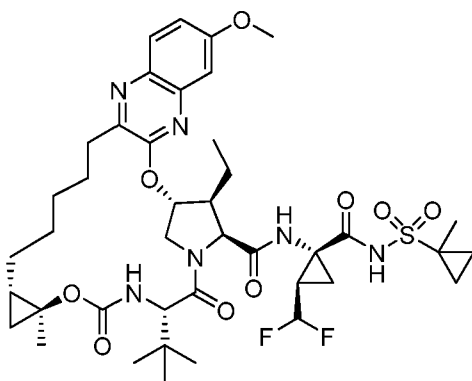
Step 5. Preparation of **7-5**: Palladium on carbon (10% w/w, 25 mg) was added to a solution of **7-3** (20 mg, 0.0307 mmol) in a 1:1 mixture of ethyl acetate and dioxane (2 mL). Mixture was stirred under an atmosphere of hydrogen for 30 min and was then filtered through a plug of Celite, and washed with ethyl acetate. Filtrate was concentrated under reduced pressure to yield **7-5** (16 mg) as a light brown film, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₃N₄O₇: 653.4; found: 653.4.

Step 6. Preparation of **7-6**: Intermediate **7-5** (16 mg, 0.023 mmol) was dissolved in 2 M HCl in dioxane (2 mL) and heated at 80 °C for 1.5 h via microwave reactor. Reaction mixture was then concentrated *in vacuo* to give **7-6** (15 mg) as a brown residue, which was used in the subsequent step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₄N₄O₇: 597.3; found: 597.3.

Step 7. Preparation of Example **7**: HATU (11.9 mg, 0.031 mmol) and DIPEA (22 µL, 0.126 mmol) were added to a mixture of **7-6** (15 mg, 0.025 mmol) and **A10** (11.5 mg, 0.0377 mmol) in 1 mL of DMF. After stirring overnight at room temperature, reaction mixture was poured into water, acidified to pH 1 with 1 N aqueous HCl, and extracted three times with methylene chloride (15 mL). Combined organics were washed with water, brine, dried over MgSO₄, filtered, and concentrated under reduced pressure. The resulting residue was purified by reverse phase prep HPLC (5–100% acetonitrile in water, with 0.1% trifluoroacetic

acid buffer) followed by silica gel chromatography to afford Example 7 (4.3 mg) as a white solid film. Analytic HPLC RetTime: 9.07 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₇F₂N₆O₉S: 847.4; found: 847.4. ¹H NMR (400 MHz, CDCl₃) δ 9.88 (s, 1H), 7.83 (d, J = 9.1 Hz, 1H), 7.20 (dd, J = 9.1 Hz, 2.8 Hz, 1H), 7.07 (d, J = 2.7 Hz, 1H), 6.56 (s, 1H), 5.98 (td, J_{H-F} = 55.7, J = 6.7 Hz, 1H), 5.95 (d, J = 9.6, 1H), 5.32 (d, J = 9.6 Hz, 1H), 4.45 (dd, J = 13.0 Hz, 9.6 Hz, 2H), 4.32 (d, J = 9.7 Hz, 1H), 4.13 (dd, J = 15.5 Hz, 8.8 Hz, 1H), 3.93 (s, 3H), 2.99 – 2.84 (m, 1H), 2.82 – 2.68 (m, 1H), 2.62 – 2.47 (m, 1H), 2.16 – 2.02 (m, 1H), 2.00 – 1.85 (m, 1H), 1.84 – 1.69 (m, 1H), 1.70 – 1.15 (m, 11H), 1.52 (s, 3H), 1.50 (s, 3H), 1.20 (t, J = 7.3 Hz, 3H), 1.14 – 0.77 (m, 5H), 1.09 (s, 9H), 0.11 (m, 1H).

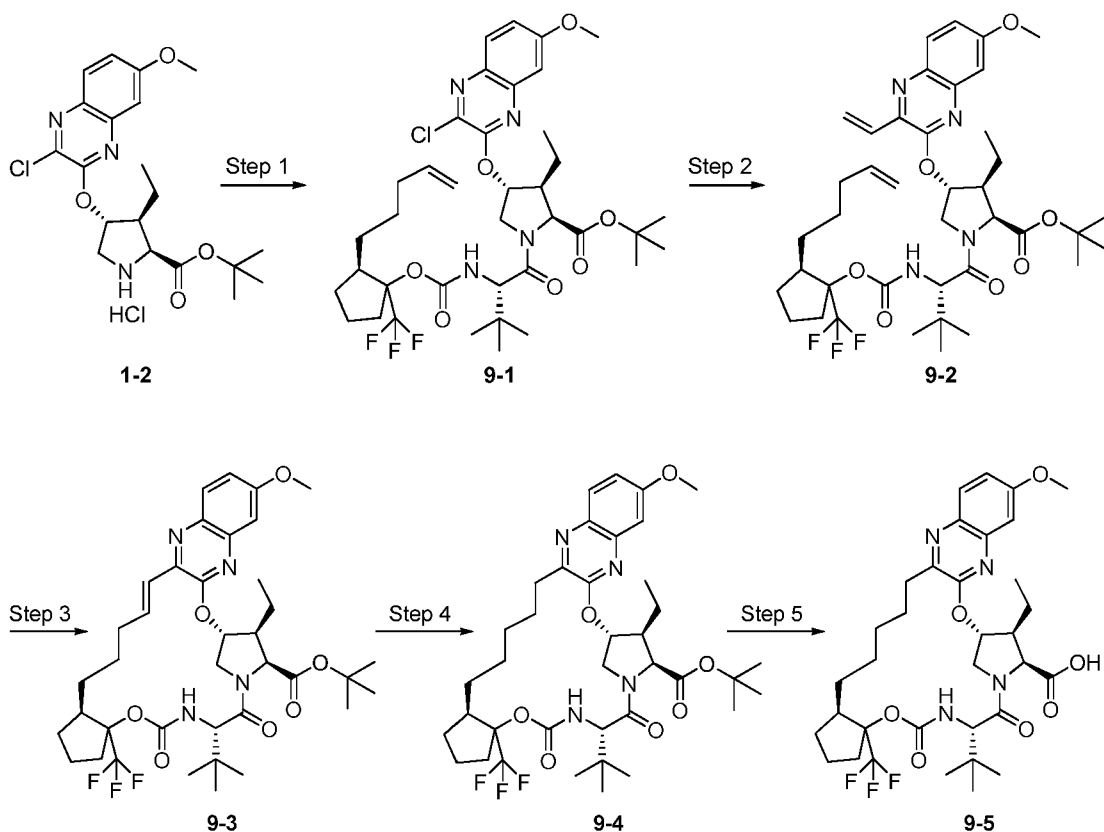
Example 8. Preparation of (1aS,5S,8S,9S,10R,22aS)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-1a-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6] dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

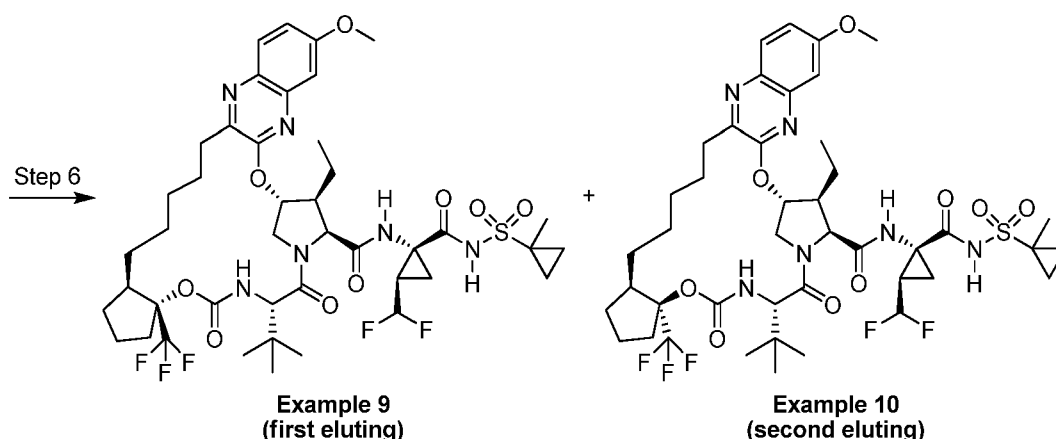


Example 8

Example 8 was prepared in a similar fashion to Example 7, substituting late eluting 7-4 for early eluting 7-3 in Step 5. Example 7 was isolated (2.9 mg) as a white solid. Analytic HPLC RetTime: 9.09 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₇F₂N₆O₉S: 847.4; found: 847.4.

- Examples **9** and **10**. Preparation of (7S,10S,11S,12R)-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-11-ethyl-16-methoxy-5,8-dioxo-3aR-(trifluoromethyl)-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide and (7S,10S,11S,12R)-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-11-ethyl-16-methoxy-5,8-dioxo-3aS-(trifluoromethyl)-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.





Step 1. Preparation of **9-1**: To a solution of Intermediate **D8** (322 mg, 0.85 mmol) and **1-2** (316 mg, 0.78 mmol) in MeCN (3.9 mL) was added HATU (323 mg, 0.85 mmol) followed by DIPEA (678 μ L, 3.90 mmol) at rt under an argon atmosphere. After 2 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford amide **9-1** (476 mg, 1:1 diastereomeric mixture) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₃ClF₃N₄O₇: 769.4; found: 769.5.

Step 2. Preparation of **9-2**: To a solution of **9-1** (470 mg, 612 μ mol), TEA (128 μ L, 918 μ mol), and potassium vinyltrifluoroborate (123 mg, 918 μ mol) in EtOH (3.06 mL) was added PdCl₂(dppf) (50 mg, 61 μ mol). The reaction mixture was deoxygenated with argon for 10 min and heated to 78 °C. After 1 h, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford vinyl quinoxaline **9-2** (329 mg, 1:1 diastereomeric mixture) as a yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₆F₃N₄O₇: 761.4; found: 761.6.

Step 3. Preparation of **9-3**: To a solution of **9-2** (329 mg, 485 μ mol) in DCE (97 mL) was added Zhan 1B catalyst (35 mg, 49 μ mol, Strem) and the reaction mixture was deoxygenated for 10 minutes with argon. The reaction mixture was then heated to 100 °C. After 30 min, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel

chromatography (0–100% ethyl acetate/hexanes gradient) to afford macrocycle **9-3** (301 mg, 7:4 diastereomeric mixtures) as a light yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₂F₃N₄O₇: 733.4; found: 733.5.

Step 4. Preparation of **9-4**: To a solution of **9-3** (300 mg, 410 μmol) in ethanol (2.00 mL) was added Pd/C (10 wt % Pd, 43 mg, 41 μmol) at rt under an argon atmosphere. The atmosphere of the reaction was replaced with hydrogen gas and the reaction mixture stirred vigorously at rt. After 30 min, the reaction mixture was diluted with ethyl acetate (10 mL) and filtered through a pad of Celite with ethyl acetate washings (3 × 5 mL). The filtrate was concentrated *in vacuo* to afford macrocycle **9-4** (295 mg, 7:4 diastereomeric mixture), which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₄F₃N₄O₇: 735.4; found: 735.5.

Step 5. Preparation of **9-5**: To a solution of **9-4** (295 mg, 401 μmol) in DCM (2 mL) was added TMSOTf (72.6 μL, 401 mmol) at rt under an argon atmosphere. After 1.5 h, additional TMSOTf (362.9 μL, 2.00 mmol) was added. After 1 h, additional TMSOTf (362.9 μL, 2.00 mmol) was added. After 2 h, the reaction mixture was added slowly to a 0.25 N aqueous NaOH solution (precooled to 0 °C, 3 mL). The resulting mixture was diluted with 1 N aqueous HCl solution (5 mL), and was extracted with DCM (3 × 5 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated to afford carboxylic acid **9-5** (353 mg, 7:4 diastereomeric mixture) as a tan solid, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₅F₃N₄O₇: 679.3; found: 679.5.

Step 6. Preparation of Example **9** and Example **10**: To a solution of acid **9-5** (150 mg, 220 μmol) and Intermediate **A10** (101 mg, 330 μmol) in MeCN (1.1 mL) was added HATU (127 mg, 330 μmol) followed by DIPEA (191 μL, 1.10 mmol) at rt under an argon atmosphere. After 1 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient). The fractions

containing the desired product were combined and were repurified by silica gel chromatography (0–50% acetone/hexanes gradient) to afford the first eluting

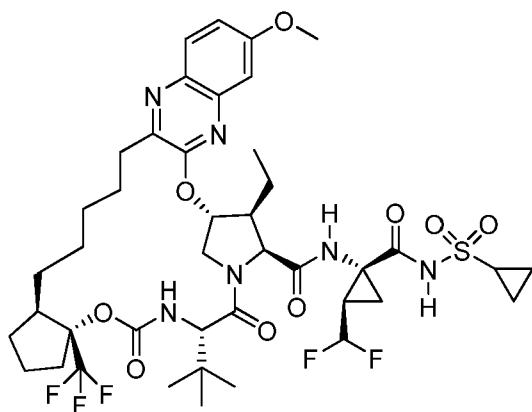
Example **9** (40 mg) as a white powder and the second eluting Example **10** (70 mg) as a white powder. First eluting Example **9**: Analytic HPLC RetTime:

- 5 9.42 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₈F₅N₆O₉S: 929.4; found: 929.5. ¹H NMR (400 MHz, CDCl₃) δ 9.83 (s, 1H), 7.92 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.0, 2.6 Hz, 1H), 7.13 (d, *J* = 2.6 Hz, 1H), 5.99 (br s, 1H), 5.96 (td, *J*_{H-F} 55.5, *J* = 6.6 Hz, 1H), 5.70 (d, *J* = 10.0 Hz, 1H), 4.63 (d, *J* = 6.6 Hz, 1H), 4.38 (d, *J* = 10.0 Hz, 1H), 4.22 – 4.04 (m, 2H), 3.96 (s, 3H), 3.12 – 2.89 (m, 1H), 2.71 – 2.51 (m, 2H), 2.17 (s, 3H), 2.15 – 1.82 (m, 4H), 1.83 – 1.34 (m, 8H), 1.36 – 0.98 (m, 12H), 1.26 (s, 9H), 0.92 – 0.79 (m, 4H). Second eluting Example **10**: Analytic HPLC RetTime: 9.55 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₈F₅N₆O₉S: 929.4; found: 929.5. ¹H NMR (400 MHz, CDCl₃) δ 9.61 (s, 1H), 7.91 (d, *J* = 9.1 Hz, 1H), 7.23 (dd, *J* = 9.0, 3.0 Hz, 1H), 7.18 (d, *J* = 2.7 Hz, 1H), 5.98 – 5.91 (m, 1H), 5.83 (td, *J*_{H-F} 55.5, *J* = 6.6 Hz, 1H), 5.33 (d, *J* = 9.8 Hz, 1H), 4.72 – 4.63 (m, 1H), 4.46 – 4.38 (m, 1H), 4.32 (d, *J* = 10.0 Hz, 1H), 4.25 – 4.14 (m, 1H), 3.97 (s, 3H), 3.73 (br d, *J* = 7.6 Hz, 1H), 3.23 – 3.07 (m, 1H), 2.86 – 2.37 (m, 2H), 2.14 – 1.79 (m, 2H), 1.78 – 1.38 (m, 8H), 1.51 (s, 3H), 1.35 – 1.08 (m, 8H), 1.25 (s, 9H), 1.05 (br s, 3H), 0.93 – 0.68 (m, 6H).

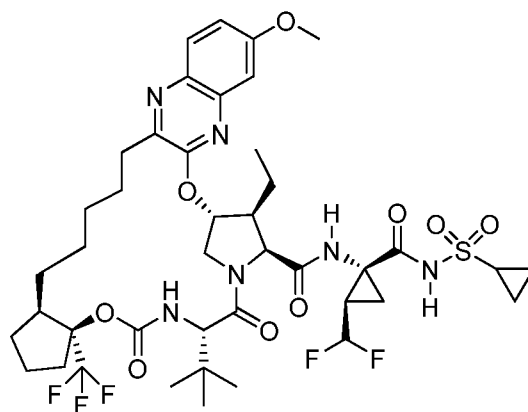
20

Examples **11** and **12**. Preparation of (7S,10S,11S,12R)-7-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-11-ethyl-16-methoxy-5,8-dioxo-3aR-(trifluoromethyl)-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide and (7S,10S,11S,12R)-7-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-11-ethyl-16-methoxy-5,8-dioxo-3aS-(trifluoromethyl)-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.

30



Example 11
(first eluting)



Example 12
(second eluting)

Preparation of Example **11** and Example **12**: To a solution of acid **9-5** (150 mg, 220 μmol) and Intermediate **A9** (96 mg, 330 μmol) in MeCN (1.1 mL) was added HATU (127 mg, 330 μmol) followed by DIPEA (191 μL , 1.10 mmol) at rt under an argon atmosphere. After 1 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–50% acetone/hexanes gradient). The fractions containing the desired product

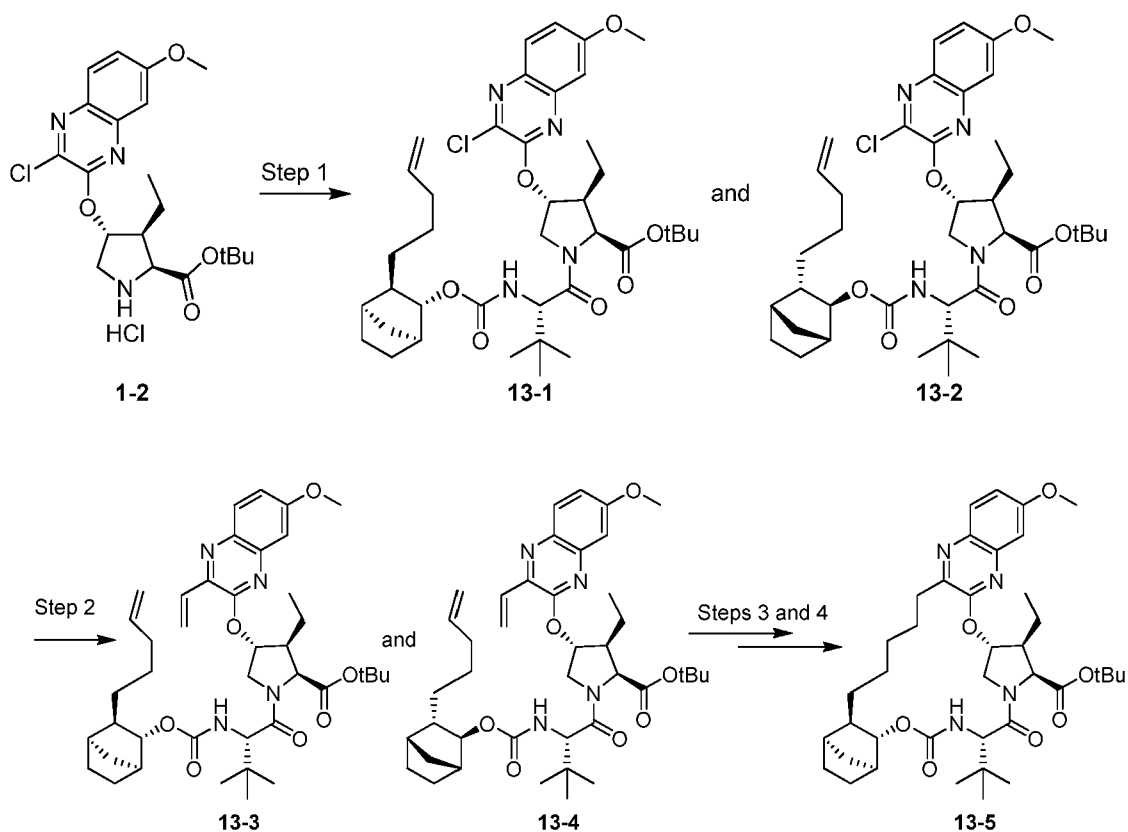
were combined and were repurified by silica gel chromatography (0–50% acetone/hexanes gradient) to afford the first eluting Example **11** (29 mg) as a white powder and the second eluting Example **12** (60.2 mg) as a white powder.

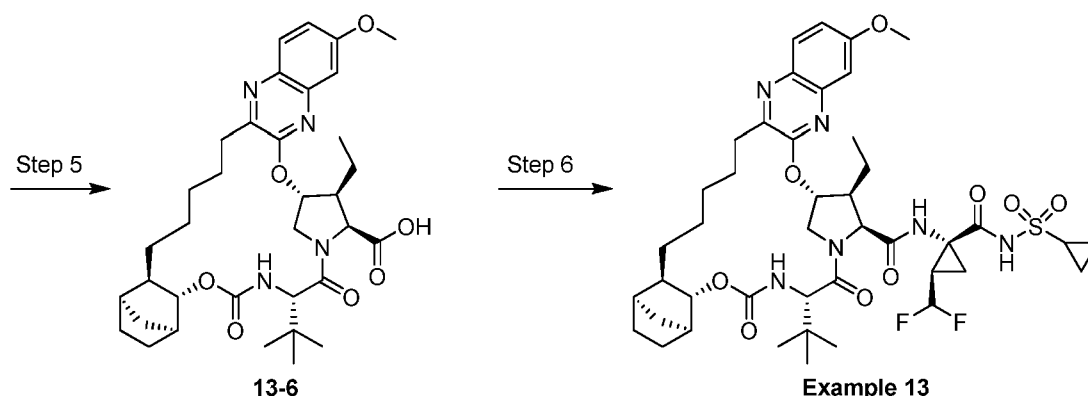
First eluting Example **11**: Analytic HPLC RetTime: 9.44 min. LCMS-ESI⁺ (m/z): [M+H]⁺ calcd C₄₂H₅₆F₅N₆O₉S: 915.4; found: 915.6. ¹H NMR (400 MHz, CDCl₃) δ 10.17 (br s, 1H), 7.83 (d, J = 9.1 Hz, 1H), 7.21 (dd, J = 9.1, 2.7 Hz, 1H), 7.17 – 7.07 (m, 1H), 5.99 (br s, 1H), 5.97 (td, $J_{\text{H-F}}$ 55.5, J = 6.6 Hz, 1H), 5.82 (d, J = 9.8 Hz, 1H), 4.55 (d, J = 7.2 Hz, 1H), 4.39 (d, J = 10.0 Hz, 1H), 4.20 – 4.03 (m, 2H), 3.95 (s, J = 5.9 Hz, 3H), 2.97 – 2.82 (m, 2H), 2.79 – 2.49 (m, 3H), 2.24 – 1.81 (m, 8H), 1.80 – 1.11 (m, 12H), 1.10 – 0.98 (m, 4H), 1.07 (s, 9H), 0.95 – 0.81 (m, 3H).

Second eluting Example **12**: Analytic HPLC RetTime: 9.48 min. LCMS-ESI⁺ (m/z): [M+H]⁺ calcd C₄₂H₅₆F₅N₆O₉S: 915.4; found: 915.6. ¹H NMR (400 MHz, CDCl₃) δ 10.07 (s, 1H), 7.93 (d, J = 9.6 Hz, 1H), 7.28 – 7.20 (m, 1H), 7.16 (s, 1H), 6.17 – 5.68 (m, 3H), 4.67 – 4.55 (m, 1H), 4.37 – 4.23 (m, 2H), 4.17 – 4.05 (m, 1H), 3.97 (s, 3H), 3.75 – 3.66 (m, 1H), 3.22 – 3.04 (m, 1H), 3.02 – 2.31 (m,

6H), 2.30 – 1.83 (m, 10H), 1.85 – 1.13 (m, 13H), 1.06 (s, 9H), 0.95 – 0.79 (m, 1H).

Example 13. Preparation of (1R,4S,4aR,8S,11S,12S,13R,25aR)-8-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-12-ethyl-17-methoxy-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-hexadecahydro-1H,11H-1,4:10,13-dimethanoquinoxalino[2,3-k][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide.





Step 1. Preparation of diastereomer mixture **13-1** and **13-2**: To a solution of **1-2** (354 mg, 0.87 mmol), Intermediate mixture **D9** and **D10** (323 mg, 0.96 mmol) and BEP (263 mg, 0.96 mmol; TCI America) was added DIPEA (0.45 mL, 2.61 mmol) and the reaction was stirred at 50 °C for 2 h. The reaction was quenched with sat. aqueous NaHCO₃ solution and extracted with EtOAc, the organic phase was washed with brine, dried over magnesium sulfate and concentrated. The crude product was purified by silica gel chromatography (0–30% EtOAc/hexanes) to yield an inseparable mixture of diastereomers **13-1** and **13-2** (338 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₆ClN₄O₇: 727.38; found: 727.46.

Step 2. Preparation of diastereomer mixture **13-3** and **13-4**: To a solution of the mixture of **13-1** and **13-2** (338 mg, 0.46 mmol), TEA (0.10 mL, 0.69 mmol) and potassium vinyltrifluoroborate (93 mg, 0.69 mmol) in EtOH (30 mL) was added PdCl₂(dppf) (38 mg, 0.046 mmol, Strem Chemicals). The reaction was deoxygenated with N₂ for 10 min and heated to 80 °C for 1 h. The reaction was quenched with sat. aqueous NaHCO₃ solution and extracted with EtOAc, washed subsequently with brine, dried over magnesium sulfate and concentrated. The residue was purified using silica gel chromatography to give an inseparable mixture of diastereomers **13-3** and **13-4** (285 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₉N₄O₇: 719.44; found: 719.70.

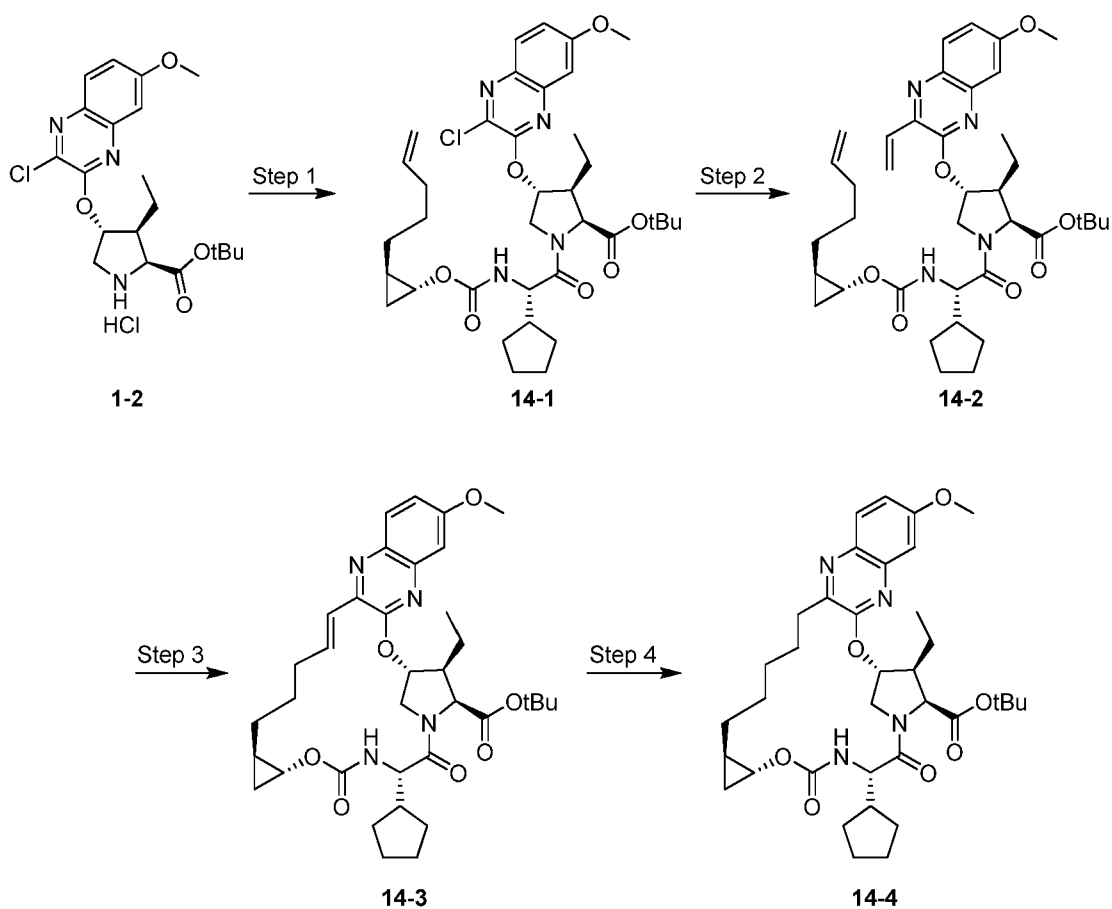
Step 3 and 4. Preparation of **13-5**: To a solution of the diastereomeric mixture **13-3** and **13-4** (285 mg, 0.40 mmol) in DCE (100 mL) was added Zhan 1B catalyst (30 mg, 0.04 mmol, Strem) and the reaction was deoxygenated for 30

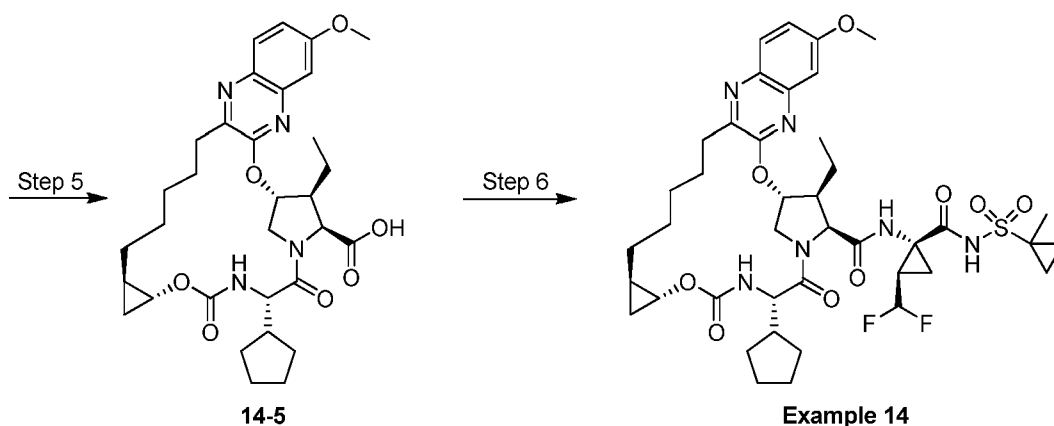
minutes with N₂. The reaction was heated to 100 °C for 45 min, allowed to cool to rt and concentrated. The crude product was purified by silica gel chromatography to produce macrocyclic olefin product (125 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₅N₄O₇: 691.41; found: 691.58) that was taken up in EtOH (6 mL) and treated with Pd/C (10%, 120 mg). The atmosphere was replaced with hydrogen and stirred at rt for 1.5 h. The reaction was filtered over Celite, washed with EtOAc and concentrated to give **13-5** as an oil (125 mg) that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₇N₄O₇: 693.42; found: 693.46.

Step 5. Preparation of **13-6**: To a solution of **13-5** (50 mg, 0.072 mmol) in DCM (4 mL) was added TFA (1 mL) and stirred at rt for 6 h. The reaction was diluted with EtOAc, washed with H₂O, aqueous pH 7 buffer, dried over magnesium sulfate, and concentrated to give **13-6** as a residue that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.36; found: 637.40.

Step 6. Preparation of Example **13**: To a solution of **13-6** (46 mg, 0.072 mmol), Intermediate **A9** (28 mg, 0.11 mmol), TBTU (34 mg, 0.10 mmol) and DMAP (13 mg, 0.11 mmol) in DCM (5 mL) was added DIPEA (0.038 mL, 0.22 mmol) and the reaction was stirred at rt for 16 h. The reaction was quenched with water, diluted with EtOAc, washed with sat. aqueous NaHCO₃, brine, dried over magnesium sulfate, and concentrated. The crude material was purified by reverse phase HPLC (Gemini, 30–85% MeCN/H₂O + 0.1% TFA) and lyophilized to give Example **13** (14.5 mg) as a TFA salt. Analytic HPLC RetTime: 9.39 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₉F₂N₆O₉S: 873.40; found: 873.42. ¹H NMR (400 MHz, CD₃OD) δ 9.28 (s, 1H), 7.82 (d, J = 9.2 Hz, 1H), 7.26 (dd, J = 6.4, 2.8 Hz, 1H), 7.19 (d, J = 2.8 Hz, 1H), 6.04 – 5.74 (m, 2H), 5.50 (s, 1H), 4.55 (d, J = 7.6 Hz, 1H), 4.47 (s, 1H), 4.26 – 4.16 (m, 2H), 3.94 (s, 3H), 3.03 – 2.95 (m, 2H), 2.78 – 2.66 (m, 2H), 2.17 (br, 2H), 2.05 (s, 3H), 1.90 – 1.85 (m, 1H), 1.76 – 1.74 (m, 2H), 1.61 – 1.21 (m, 20H), 1.15 – 1.11 (m, 2H), 1.08 (s, 9H), 0.93 – 0.90 (m, 1H).

Example 14. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-cyclopentyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-
 5 methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.





Step 1. Preparation of **14-1**: To a solution of **1-2** (223 mg, 0.50 mmol) and Intermediate **D2** (221 mg, 0.75 mmol) in acetonitrile (5 mL) was added HATU (306 mg, 0.80 mmol) followed by DIPEA (0.43 mL, 2.5 mmol) at room temperature. After 19 h, solvent was removed under reduced pressure and the resulting residue was diluted with ethyl acetate (15 mL). The resulting solution was washed with 1 M aqueous HCl (10 mL). The aqueous layer was extracted with ethyl acetate (2 × 10 mL) and combined organic layer was washed with brine (15 mL), dried over anhydrous magnesium sulfate and concentrated. The resulting crude residue was purified via silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **14-1** (173 mg) as colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₀ClN₄O₇: 685.33; found: 685.49.

Step 2. Preparation of **14-2**: To a solution of **14-1** (173 mg, 0.25 mmol) in EtOH (3 mL) was added potassium vinyltrifluoroborate (51 mg, 0.38 mmol), PdCl₂(dppf) (21 mg, 0.025 mmol) and TEA (0.053 mL, 0.38 mmol) sequentially and the resulting mixture was heated to 80 °C. After 1 h, additional potassium vinyltrifluoroborate (17 mg, 0.12 mmol) was added and continued stirring at 80 °C. After 2.5 h, additional potassium vinyltrifluoroborate (8 mg, 0.06 mmol) was added and the reaction was stirred for additional 10 minutes at 80 °C. The reaction was cooled to room temperature, diluted with ethyl acetate (20 mL), and washed with brine (20 mL). Aqueous layer was extracted with ethyl acetate (10 mL), and the combined organic layer was dried over anhydrous magnesium sulfate and concentrated to afford **14-2** as a residue which was used it without

purification in the next step. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₃N₄O₇: 677.38; found: 677.50.

Step 3. Preparation of **14-3**: To a solution of **14-2** in deoxygenated DCE (0.006 M) was added Zhan 1B catalyst (18 mg, 0.025 mmol, Strem) and the reaction was deoxygenated for another 10 minutes with Ar. The reaction was heated to 100 °C. After 1.5 h, Zhan 1B catalyst (9 mg, 0.012 mmol) was added and the reaction was stirred for another 30 min. The reaction mixture was allowed to cool to rt and concentrated to 4-5 mL volume. This was directly purified by silica gel chromatography to afford **14-3** as a brown oil (70 mg).

LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉N₄O₇: 649.35; found: 649.50.

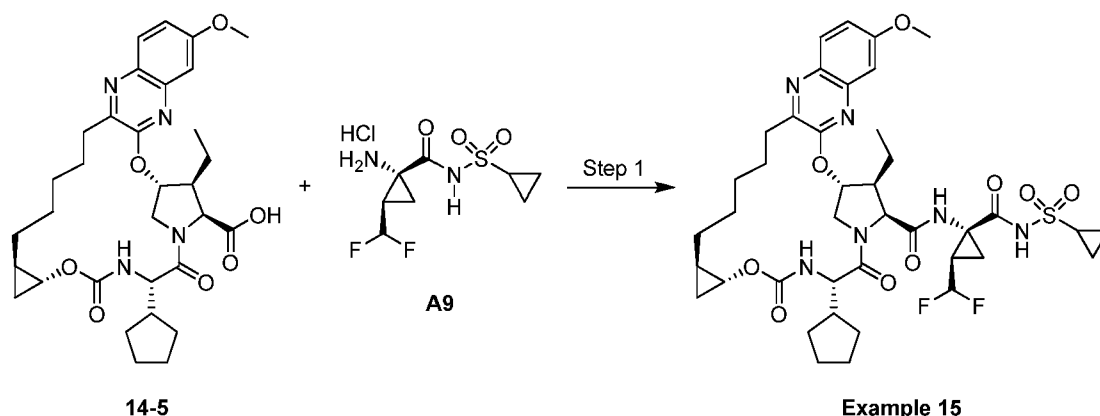
Step 4. Preparation of **14-4**: To a solution of **14-3** (70 mg, 0.11 mmol) in EtOH (5 mL) was added Pd/C (10 wt % Pd, 12 mg) under argon. The atmosphere was replaced with hydrogen and the reaction was stirred at rt for 16 h. The reaction was filtered over Celite, washed with EtOH and concentrated to give **14-4** as a brown oil that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.37; found: 651.60.

Step 5. Preparation of **14-5**: To a solution of **14-4** (70 mg, 0.11 mmol) in DCM (3 mL) was added TMSOTf (0.103 mL, 0.53 mmol) and the reaction was stirred at rt for 1 h. The reaction was concentrated to afford **14-5** which was used it for the next step without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₃N₄O₇: 595.31; found: 595.43.

Step 6. Preparation of Example **14**: To a solution of **14-5** (36.8 mg, 0.06 mmol) and Intermediate **A10** (28 mg, 0.09 mmol) in acetonitrile (1.5 mL) was added HATU (38 mg, 0.1 mmol) followed by DIPEA (0.065 mL, 0.37 mmol) at room temperature. After 20 minutes, the reaction mixture was directly purified by reverse phase HPLC (Gemini 5u C18 110Å column, 15–100% MeCN/H₂O + 0.1% TFA) and lyophilized to afford Example **14** as a yellow solid (24 mg) as a TFA salt. Analytic HPLC RetTime: 9.03 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₂N₆O₉S: 845.4; found: 845.6. ¹H NMR (400 MHz, CD₃OD) δ 9.31 (s, 1H), 7.80 (d, *J* = 9.1 Hz, 1H), 7.23 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.16 (d, *J* = 2.7 Hz, 1H), 6.03 – 5.66 (m, 2H), 4.53 (dd, *J* = 13.2, 9.6 Hz, 2H), 4.18 (dd, *J* = 17.2, 7.1 Hz,

2H), 3.92 (s, 3H), 3.68 (dt, $J = 6.8, 2.8$ Hz, 1H), 3.13 (quin, $J = 1.7$ Hz, 1H), 3.02 – 2.92 (m, 1H), 2.85 – 2.78 (m, 1H), 2.62 – 2.55 (m, 1H), 2.30 – 2.17 (m, 1H), 2.02 (s, 2H), 1.97 – 1.86 (m, 3H), 1.86 – 1.79 (m, 1H), 1.80 – 1.41 (m, 17H), 1.40 – 1.28 (m, 3H), 1.22 (t, $J = 7.4$ Hz, 3H), 1.03 – 0.87 (m, 4H), 0.76 – 0.68 (m, 1H), 0.51 – 0.44 (m, 1H).

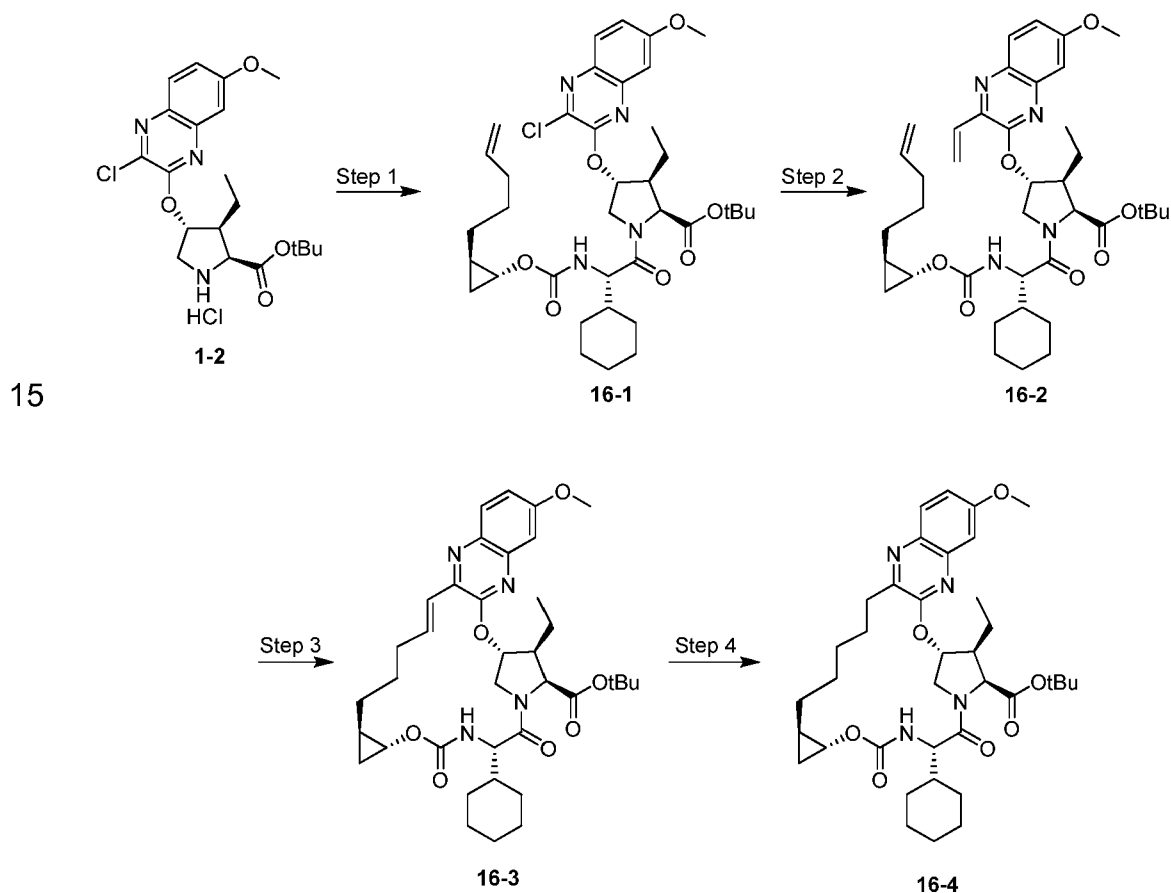
Example 15. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-cyclopentyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

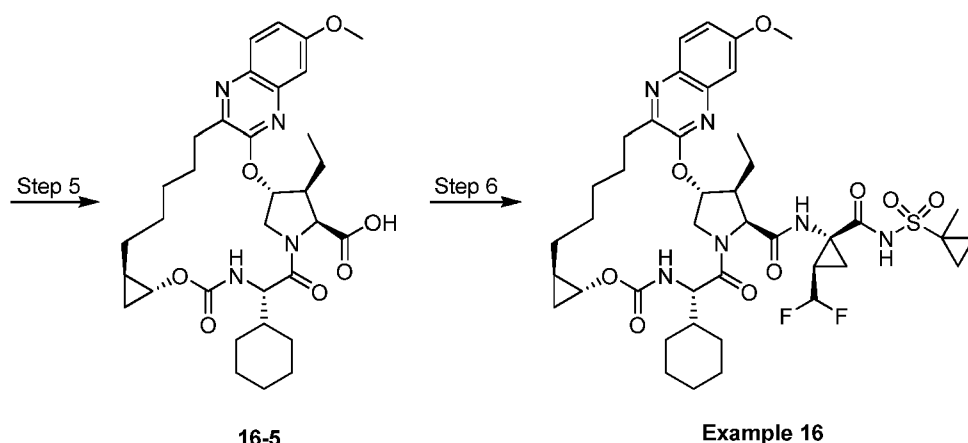


Step 1. Preparation of Example 15. To a solution of 14-5 (27 mg, 0.045 mmol) and Intermediate A9 (20 mg, 0.067 mmol) in acetonitrile (1.3 mL) was added HATU (27 mg, 0.072 mmol) followed by DIPEA (0.047 mL, 0.27 mmol) at room temperature. After 20 minutes, the reaction mixture was directly purified by reverse phase HPLC (Gemini 5u C18 110Å column, 15–100% MeCN/H₂O + 0.1% TFA) and lyophilized to afford Example 15 as a yellow solid (18.6 mg) as a TFA salt. Analytic HPLC RetTime: 8.89 min. LCMS-ESI⁺ (m/z): [M+H]⁺ calcd for C₄₀H₅₃F₂N₆O₉S: 831.4; found: 831.6. ¹H NMR (400 MHz, CD₃OD) δ 9.32 (s, 1H), 7.79 (d, $J = 9.1$ Hz, 1H), 7.23 (dd, $J = 9.1, 2.8$ Hz, 1H), 7.16 (d, $J = 2.8$ Hz, 1H),

6.03 – 5.66 (m, 2H), 4.53 (t, $J = 10.0$ Hz, 2H), 4.22 – 4.14 (m, 2H), 3.92 (s, 3H),
 3.67 (dt, $J = 6.5, 2.9$ Hz, 1H), 3.13 (quin, 1.6 Hz, 1H), 3.04 – 2.92 (m, 3H), 2.85 –
 2.77 (m, 1H), 2.63 – 2.55 (m, 1H), 2.26 – 2.19 (m, 1H), 2.05 – 2.02 (m, 2H), 1.99
 5 3H), 1.15 – 1.03 (m, 3H), 1.01 – 0.90 (m, 2H), 0.76 – 0.68 (m, 1H), 0.49 – 0.45
 (m, 1H).

Example 16. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-cyclohexyl-N-
 [(1R,2R)-2-(difluoromethyl)-1-[(1-
 10 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-
 1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-
 methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 b]quinoxaline-8-carboxamide.





Step 1. Preparation of **16-1**: To a solution of Intermediate **D3** (190 mg, 0.60 mmol) and **1-2** (264 mg, 0.60 mmol) in DMF (5 mL) was added DIPEA (0.31 mL, 1.8 mmol) followed by COMU (257 mg, 0.60 mmol) at rt. After 2 h, the solvent was removed under reduced pressure and the resulting residue diluted with ethyl acetate (15 mL). The resulting solution was washed with 10% aqueous citric acid solution. The aqueous layer was extracted with ethyl acetate (2 × 10 mL) and combined organic layer was washed with brine (15 mL), dried over anhydrous magnesium sulfate and concentrated. The resulting crude residue was purified via silica gel chromatography to afford **16-1** (260 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₁ClN₄O₇: 700.28; found: 700.03.

Step 2. Preparation of **16-2**: To a solution of **16-1** (260 mg, 0.37 mmol) in EtOH (5 mL) were added potassium vinyltrifluoroborate (75 mg, 0.56 mmol), PdCl₂(dppf) (30 mg, 0.037 mmol) and TEA (0.079 mL, 0.56 mmol) sequentially. The reaction was deoxygenated with Ar for 12 min and was heated to 78 °C for 2 h. The reaction was cooled to rt, diluted with ethyl acetate (20 mL), and washed with brine (20 mL). The aqueous layer was extracted with ethyl acetate (10 mL), and the combined organic layers were dried over anhydrous magnesium sulfate and concentrated to afford crude residue. The resulting crude residue was purified via silica gel chromatography to afford **16-2** as a yellow oil (250 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₄N₄O₇: 691.87; found: 691.54.

Step 3. Preparation of **16-3**: To a solution of **16-2** (250 mg, 0.36 mmol) in deoxygenated DCE (0.005 M) was added Zhan 1B catalyst (26 mg, 0.036 mmol,

Strem) and the reaction was deoxygenated for another 10 minutes with Ar. The reaction was heated to 70 °C for 2 h. The reaction mixture was allowed to cool to rt and concentrated. The resulting residue was directly purified by silica gel chromatography to afford **16-3** as a yellow oil (250 mg). LCMS-ESI⁺ (*m/z*):

5 [M+H]⁺ calcd for C₃₇H₅₀N₄O₇: 663.82; found: 663.42.

Step 4. Preparation of **16-4**: To a solution of **16-3** (200 mg, 0.3 mmol) in EtOAc (10 mL) was added Pd/C (10 wt % Pd, 100 mg) under argon. The atmosphere was replaced with hydrogen and the reaction was stirred at rt for 1.5 h. The reaction was filtered over Celite, washed with EtOH and concentrated to
10 give **16-4** as an oil (180 mg) that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₂N₄O₇: 665.83; found: 665.36.

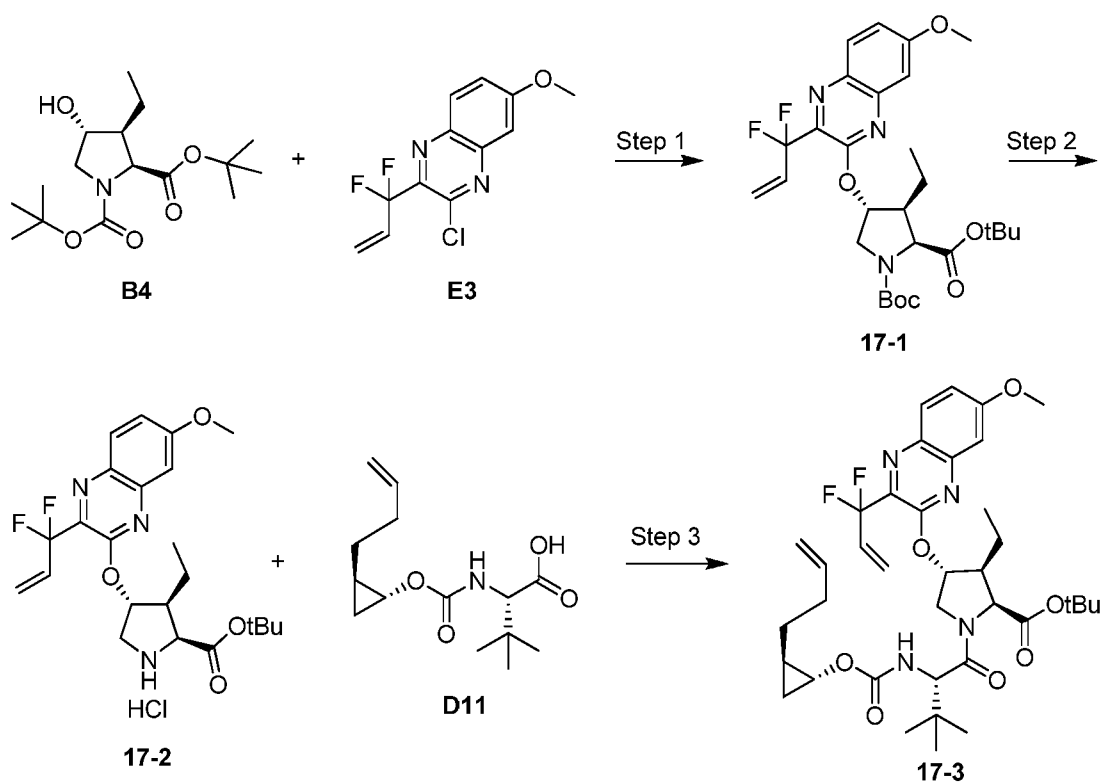
Step 5. Preparation of **16-5**: To a solution of **16-4** (165 mg, 0.25 mmol) in DCM (5 mL) was added TFA (2 mL) and the reaction was stirred at rt for 4 h.
15 The solvent was removed under reduced pressure the reaction was diluted with ethyl acetate (15 mL). The resulting solution was washed with sat. aqueous NaHCO₃ and concentrated to afford **16-5** which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₄N₄O₇: 609.73; found: 609.47

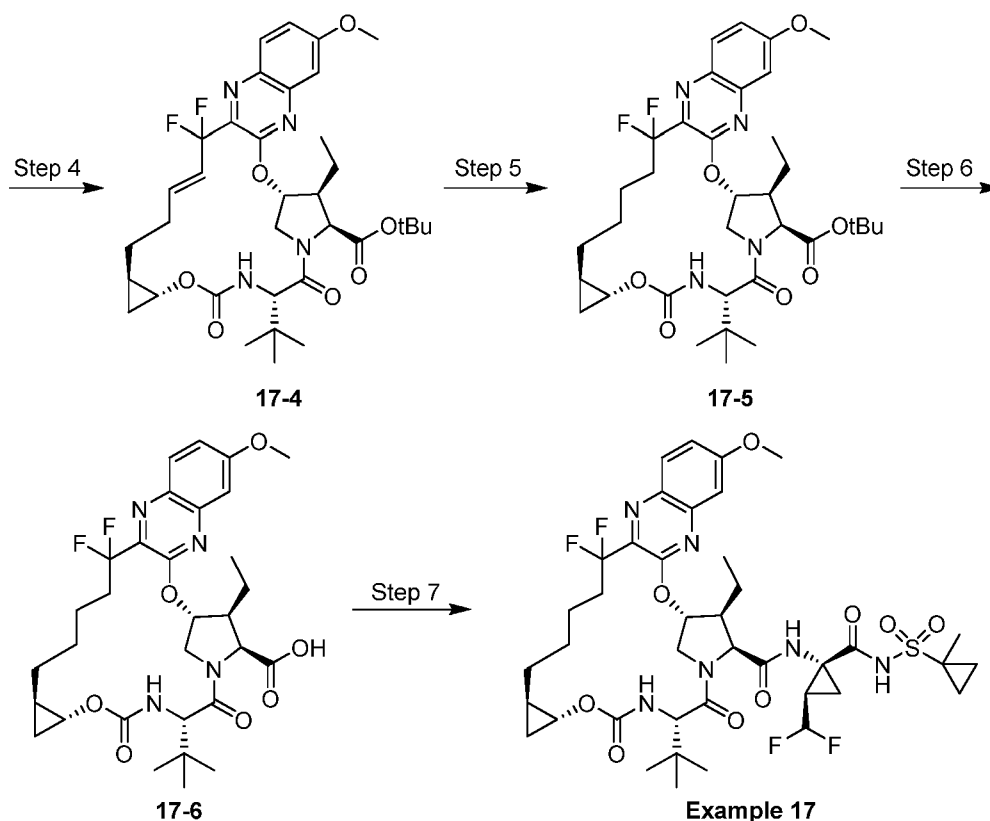
20 Step 6. Preparation of Example **16**: To a solution of **16-5** (70 mg, 0.12 mmol) and Intermediate **A10** (65 mg, 0.21 mmol) in DCM (1 mL) was added DIPEA (0.08 mL, 0.46 mmol) followed by HATU (88 mg, 0.23 mmol). The reaction was stirred at room temperature for 3 h. The reaction was diluted with EtOAc and washed with aqueous NH₄Cl and brine. The crude material was
25 purified by reverse phase HPLC (Gemini column, 58–98 % MeCN/H₂O + 0.1% TFA) and lyophilized to afford Example **16** (40 mg) as a TFA salt. Analytic HPLC RetTime: 9.21 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₆F₂N₆O₉S: 859.99; found: 859.60. ¹H NMR (400 MHz, CD₃OD) δ 9.28 (s, 1H), 7.76 (d, *J* = 9.2 Hz, 1H), 7.18 (d, *J* = 9.2 Hz, 1H), 7.10 (s, 1H), 5.97 – 5.82 (m, 2H), 4.88 (m, 2H),
30 4.51–4.46 (m, 3H), 4.19–4.11 (m, 3H), 3.90 (s, 3H), 3.70–3.29 (m, 6H), 2.97–

2.52 (m, 3H), 2.06 – 1.41 (m, 20H), 1.39 – 1.17 (m, 4H), 1.09 – 0.89 (m, 4H), 0.65 (m, 1H), 0.46 – 0.44 (m, 1H).

Example 17. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 5 [(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

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Steps 1 and 2. Preparation of **17-2**: A mixture of Intermediate **B4** (273 mg, 0.865 mmol), Intermediate **E3** (234 mg, 0.865 mmol), and cesium carbonate (310 mg, 0.952 mmol) in MeCN (2.5 mL) was heated at 85 °C for 36 hours. In an alternative process, DMF was used as the solvent. Water (10 mL) was added and the mixture was extracted with ethyl acetate. The organic phase was dried over sodium sulfate, filtered and concentrated to afford **17-1**, which was used subsequently without further purification or after chromatography purification. The residue was treated with 35 equiv 4 N HCl in dioxane at rt for 2.5 hours. Upon addition of diethyl ether, the hydrochloride salt of **17-2** precipitated. The salt was collected by vacuum filtration and dried under reduced pressure (375 mg). In an alternative process, the deprotection was conducted in the presence of MSA in tBuOAc and DCM. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₃H₃₀F₂N₃O₄: 450.2; found: 450.1.

Step 3. Preparation of **17-3**: A mixture of **17-2** (370 mg, 0.761 mmol), Intermediate **D11** (205 mg, 0.761 mmol), HATU (347 mg, 0.914 mmol) and

DIPEA (0.795 mL, 4.57 mmol) in DMF (3 mL) was stirred at rt overnight. The mixture was diluted with 100 mL water and extracted with dichloromethane. The organic phase was dried over sodium sulfate, filtered and concentrated. The crude product mixture was purified by silica gel chromatography (EtOAc in
5 hexanes: 30%) to give **17-3** (236 mg). In an alternative process, **17-2** and Intermediate **D11** were mixed with EDC and HOBT in the presence of NMM in DMF to give **17-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₁F₂N₄O₇: 701.4; found: 701.3.

Step 4. Preparation of **17-4**: A solution of **17-3** (236 mg, 0.34 mmol) in
10 DCE (67 mL) was deoxygenated with argon for 40 minutes. Zhan 1B catalyst (25 mg, 0.034 mmol, Strem) was added and the reaction was heated in a 100 °C oil bath for 40 minutes. Solvent was removed under reduced pressure and the residue was purified by silica gel chromatography (EtOAc in hexanes: 5% to 65%) to give the **17-4** (229 mg). LCMS-ESI⁺ (*m/z*): [M-F]⁺ calcd for
15 C₃₅H₄₆FN₄O₇: 653.3; found: 653.2.

Step 5. Preparation of **17-5**: A solution of **17-4** (229 mg, 0.34 mmol) in 50 mL ethanol was hydrogenated at 1 atm hydrogen gas over 220 mg of 10% wt Pd/C (wet) for 2.5 hours. Filtration through Celite and concentration under reduced pressure gave a crude residue of **17-5** (184 mg). In an alternative
20 process, **17-4** was hydrogenated at hydrogen gas in the presence of Rh. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉F₂N₄O₇: 675.4; found: 675.3.

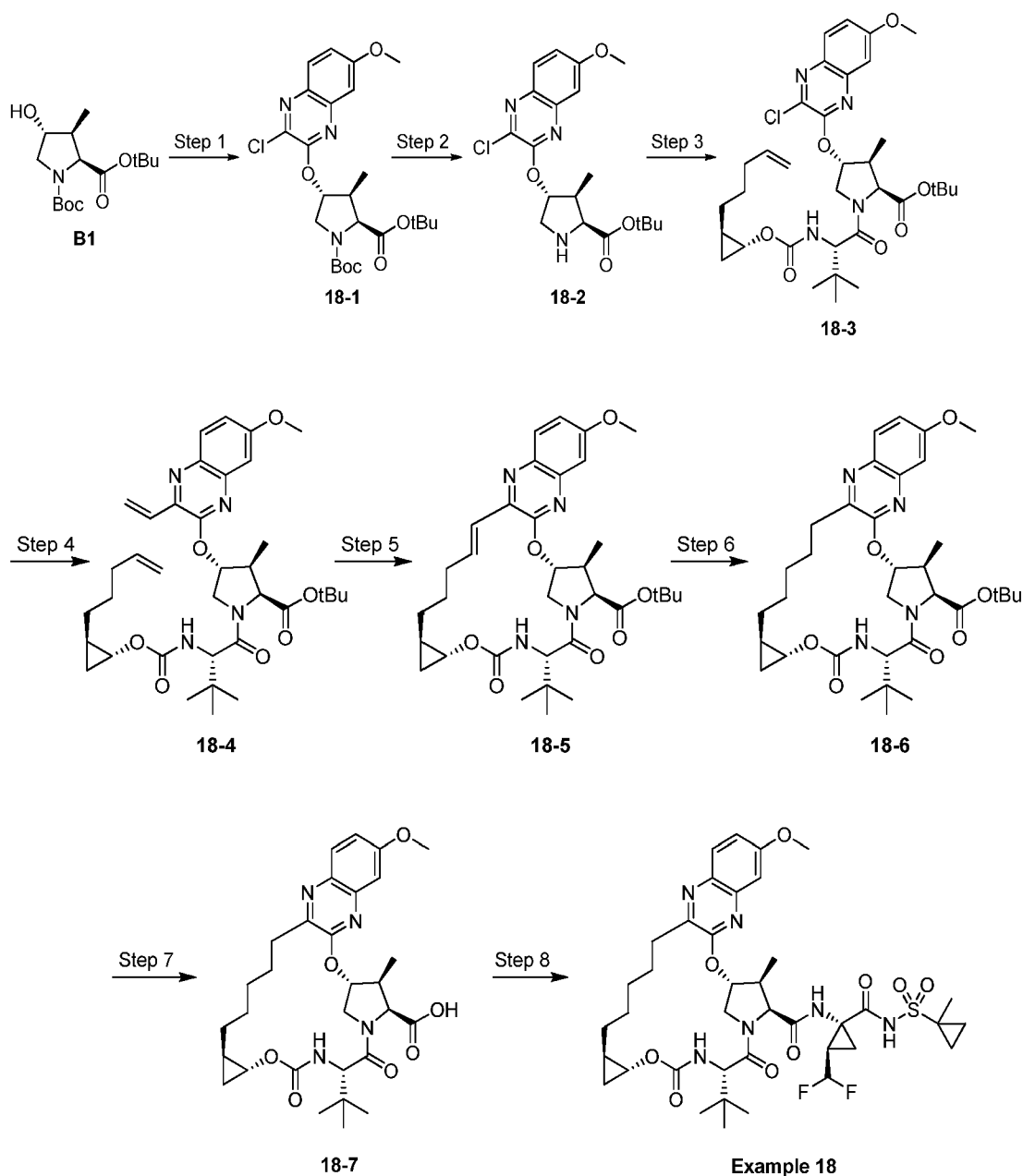
Step 6. Preparation of **17-6**: Ester **17-5** (184 mg, 0.27 mmol) in 2 mL DCM was treated with 1 mL TFA and stirred at rt for 3 h. The reaction mixture was concentrated and then partitioned between water and ethyl acetate. The
25 organic phase was washed with water, dried over anhydrous sodium sulfate, filtered and concentrated to give **17-6** (153 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₄₁F₂N₄O₇: 619.3; found: 619.2.

Step 7. Preparation of Example **17**: A mixture of carboxylic acid **17-6** (153 mg, 0.247 mmol), Intermediate **A10** (90 mg, 0.297 mmol), HATU (113 mg, 0.297
30 mmol), DMAP (45 mg, 0.37 mmol) and DIPEA (0.215 mL, 1.24 mmol) in DMF (1.5 mL) was stirred at rt for 40 minutes. The mixture was diluted with 2 N

aqueous HCl (2 mL) and extracted with dichloromethane. The organic phase was dried over sodium sulfate, filtered and concentrated. The crude product mixture was purified by silica gel chromatography (EtOAc in hexanes: 30% – 95%) to give Example **17** (95 mg). Analytic HPLC RetTime: 8.79 min. LCMS-ESI⁺

5 (m/z): [M+H]⁺ calcd for C₄₀H₅₃F₄N₆O₉S: 869.3; found: 869.2. ¹H NMR (400 MHz, CDCl₃) δ 9.948 (br s, 1H), 7.99 (d, J = 9.2 Hz, 1H), 7.29 (dd, J = 8.8, 2.4 Hz, 1H), 7.09 (d, J = 2.8 Hz, 1H), 6.57 (br s, 1H), 5.97 (td, J_{H-F} = 52 Hz, J = 6.8 Hz, 1H), 5.92 (d, J = 3.6 Hz, 1H), 5.322 (d, J = 9.6 Hz, 1H), 4.42 (ap d, J = 7.2 Hz, 1H), 4.40 (ap s, 1H), 4.34 (ap d, J = 10 Hz, 1H), 4.08 (dd, J = 12.0, 3.6 Hz, 1H), 3.99 –
10 3.94 (m, 1H), 3.96 (s, 3H), 3.67 (m, 1H), 2.52 (m, 2H), 2.06 (m, 1H), 1.93 (m, 2H), 1.77 (m, 2H), 1.63 (m, 3H), 1.50 (s, 3H), 1.56 – 1.42 (m, 4H), 1.25 (m, 1H), 1.19 (t, J = 7.2 Hz, 3H), 1.09 (s, 9H), 1.10–0.93 (m, 2H), 0.85 (m, 2H), 0.69 (m, 1H), 0.49 (m, 1H).

15 Example **18**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
20 b]quinoxaline-8-carboxamide.



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Step 1. Preparation of **18-1**: Intermediate **B1** (1.94 g, 6.44 mmol) was dissolved in MeCN (30 mL) under Ar. Intermediate **E1** (2.02 g, 7.4 mmol) and Cs_2CO_3 (7.5 mmol) were added, and the resulting mixture was stirred for 8 h at
 10 rt. Additional Intermediate **E1** (200 mg, 0.73 mmol) and Cs_2CO_3 (245 mg, 0.75 mmol) were added and the reaction mixture was stirred an additional 15 h. The reaction mixture was filtered through Celite with EtOAc and concentrated. The resulting crude residue was dissolved in CH_2Cl_2 , concentrated onto 12 g silica

gel, and purified by silica gel chromatography (5% to 20% EtOAc in hexanes) to provide **18-1** as a white foam (2.63 g). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₄H₃₃ClN₃O₆: 494.2; found: 494.1.

Step 2. Preparation of **18-2**: Substituted quinoxaline **18-1** (905 mg, 1.84 mmol) was dissolved in tert-butyl acetate (7 mL) and CH₂Cl₂ (1.75 mL). MeSO₃H (600 μL, 9.2 mmol) was added dropwise over 45 s, and the resulting yellow solution was stirred at rt for 50 min. Additional MeSO₃H (100 μL, 1.5 mmol) was added in dropwise fashion and the reaction was stirred an additional 10 min. The reaction mixture was transferred to a stirred mixture of EtOAc (20 mL) and saturated aqueous NaHCO₃ (30 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford amine **18-2** as a colorless residue (680 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₉H₂₅ClN₃O₄: 394.2; found: 394.2.

Step 3. Preparation of **18-3**: Amine **18-2** (680 mg, 1.73 mmol) and Intermediate **D1** (600 mg, 2.1 mmol) were dissolved in DMF (10 mL). DIPEA (925 μL, 5.30 mmol) was added followed by HATU (880 mg, 2.3 mmol). The reaction was stirred 110 min at rt and was diluted with saturated aqueous NaHCO₃ (30 mL) and EtOAc (30 mL). The phases were separated and the organic phase was washed with half-saturated brine (2 x 40 mL), dried over anhydrous Na₂SO₄, filtered and concentrated to a crude residue. Purification by silica gel chromatography (10% to 20% EtOAc in hexanes) provided **18-3** as a colorless residue (703 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₈ClN₄O₇: 659.3; found: 659.4.

Step 4. Preparation of **18-4**: A stirred heterogeneous mixture of **18-3** (703 mg, 1.07 mmol), PdCl₂(dppf)•CH₂Cl₂ (48 mg, 0.059 mmol) and potassium vinyltrifluoroborate (290 mg, 2.16 mmol) in EtOH (11 mL) was sparged with argon for 15 min. Triethylamine (320 μL, 2.3 mmol) was added and the mixture was heated to 75 °C for 70 min. The reaction mixture was cooled to ambient temperature and was diluted with EtOAc (40 mL) and half-saturated brine (30 mL). The phases were separated and the organic phase was dried over Na₂SO₄,

filtered, and concentrated. Purification by silica gel chromatography (10% to 20% to 30% EtOAc in hexanes) provided **18-4** as a yellow residue (490 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.4; found: 651.3.

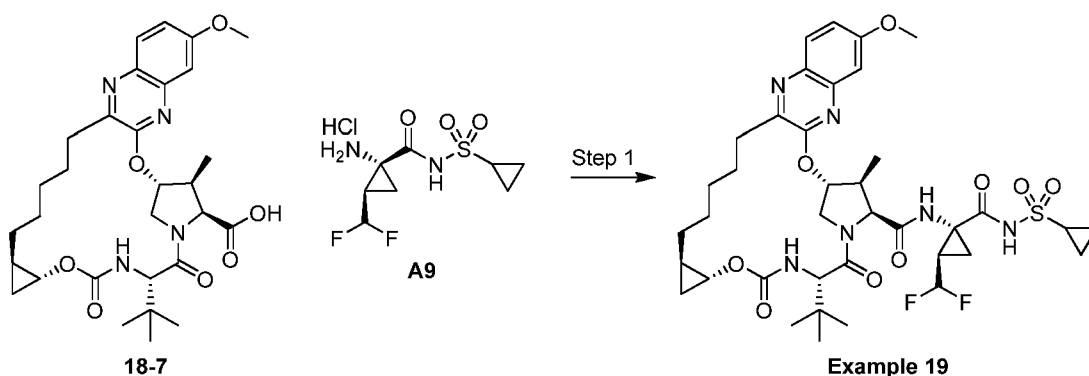
5 Step 5. Preparation of **18-5**: **18-4** (490 mg, 0.179 mmol) was dissolved in DCE (250 mL) and the solution was sparged with Ar for 15 min. Zhan 1B catalyst (66 mg, 0.090 mmol, Strem) was added as a solution in DCE (5 mL) and the resulting solution was stirred at 85 °C under Ar for 105 min. The reaction mixture was cooled to rt and was adsorbed onto silica gel (7.5 g). Purification by silica gel chromatography (10% to 30% EtOAc in hexanes) provided **18-5** as an
10 amorphous residue (290 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.3; found: 623.3.

Step 6: Preparation of **18-6**: Olefin **18-5** (290 mg, 0.072 mmol) was dissolved in EtOAc (5.5 mL) and EtOH (5.5 mL) and the reaction vessel was purged with Ar. Pd/C (10 wt % Pd, 92 mg) was added in a single portion and the
15 reaction vessel was purged twice with H₂. The reaction was stirred at rt under 1 atm H₂ for 1.5 h and was filtered through a pad of Celite and concentrated to afford a crude residue of **18-6** that was used without further purification (LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₉N₄O₇: 625.4; found: 625.0.

Step 7. Preparation of **18-7**: **18-6** (0.466 mmol) was dissolved in CH₂Cl₂
20 (4.3 mL) under Ar. TMSOTf (210 μL, 1.16 mmol) was added dropwise over 30 s. The reaction was stirred 65 min and an additional portion of TMSOTf (50 μL, 0.28 mmol) was added. The reaction was stirred an additional 100 min and an additional portion of TMSOTf (100 μL, 0.55 mmol) was added. The reaction was stirred an additional 105 min and was concentrated *in vacuo*. The resulting crude
25 residue was dissolved in CH₂Cl₂ (20 mL) and 0.2 M aqueous NaOH (10 mL) was added. The mixture was stirred for 5 min and was acidified with 1 M aqueous HCl (20 mL). The phases were separated, and the aqueous phase was extracted with CH₂Cl₂ (2 x 20 mL). The combined organic phase was dried over MgSO₄, filtered, and concentrated to afford **18-7** as a brown solid (273 mg). LCMS-ESI⁺
30 (*m/z*): [M+H]⁺ calcd for C₃₀H₄₁N₄O₇: 569.3; found: 568.9.

Step 8. Preparation of Example **18**: To a suspension of acid **18-7** (28 mg, 0.049 mmol) and Intermediate **A10** (26.5 mg, 0.087 mmol) in MeCN (1.3 mL) was added DIPEA (55 μ L, 0.31 mmol). To the resulting solution was added HATU (30.5 mg, 0.080 mmol). The reaction was stirred at rt for 1 h and an additional portion of Intermediate **A10** (3 mg, 0.01 mmol) was added. After an additional 15 min, the reaction was diluted with EtOAc (30 mL) and 1 M aqueous HCl (20 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography (10% to 40% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **18** as a white amorphous solid (26.4 mg). Analytic HPLC RetTime: 8.42 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₃F₂N₆O₉S: 819.4 ; found: 819.1. ¹H NMR (300 MHz, CDCl₃) δ 9.68 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.08 (d, *J* = 2.6 Hz, 1H), 6.86 (s, 1H), 6.14 – 5.70 (m, 1H), 5.65 (d, *J* = 9.9 Hz, 1H), 5.56 – 5.50 (m, 1H), 4.53 – 4.40 (m, 3H), 4.12 (dd, *J* = 11.9, 4.3 Hz, 1H), 3.93 (s, 3H), 3.81 – 3.74 (m, 1H), 3.06 – 2.64 (m, 4H), 2.10 – 1.35 (m, 13H), 1.13 (d, *J* = 7.5 Hz, 3H), 1.09 (s, 9H), 1.04 – 0.65 (m, 6H), 0.52 – 0.41 (m, 1H).

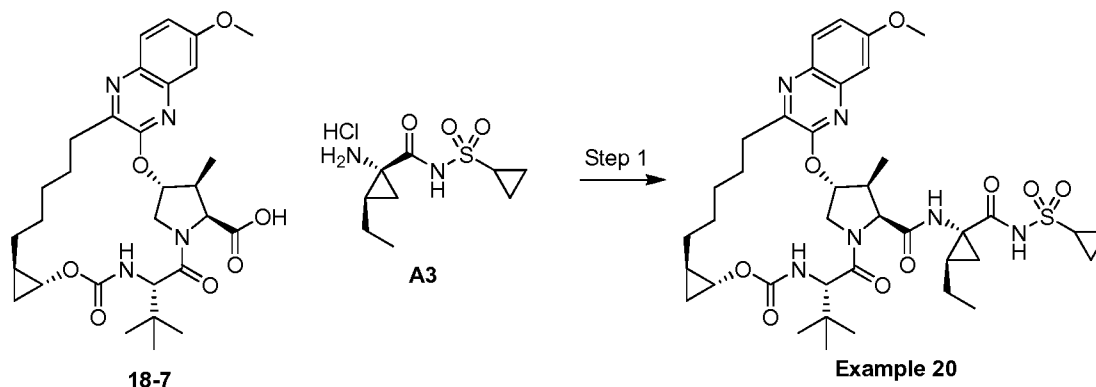
Example **19**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Step 1. Preparation of Example **19**: To a suspension of acid **18-7** (8.8 mg, 0.015 mmol) and Intermediate **A9** (7.4 mg, 0.025 mmol) in MeCN (0.5 mL) was added DIPEA (14 μ L, 0.08 mmol). To the resulting solution was added HATU (9.1 mg, 0.024 mmol). The reaction was stirred at rt for 1 h and an additional portion of Intermediate **A9** (5 mg, 0.02 mmol) and HATU (5 mg, 0.01 mmol) were added. After an additional 1.5 h, the reaction was diluted with EtOAc (30 mL), 0.2 M aqueous HCl (10 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography (10% to 40% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **19** as a white amorphous solid (8.5 mg). Analytic HPLC RetTime: 8.69 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₁F₂N₆O₉S: 805.3 ; found: 805.2. ¹H NMR (300 MHz, CDCl₃) δ 10.12 (s, 1H), 7.83 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.09 (d, *J* = 2.7 Hz, 1H), 6.77 (s, 1H), 6.25 – 5.76 (m, 1H), 5.57 (d, *J* = 3.7 Hz, 1H), 5.51 (d, *J* = 9.9 Hz, 1H), 4.49 – 4.37 (m, 3H), 4.13 (dd, *J* = 12.2, 4.3 Hz, 1H), 3.94 (s, 3H), 3.79 – 3.72 (m, 1H), 3.01 – 2.69 (m, 4H), 2.13 – 2.06 (m, 1H), 2.01 – 1.22 (m, 9H), 1.14 (d, *J* = 7.2 Hz, 3H), 1.09 (s, 9H), 1.06 – 0.82 (m, 6H), 0.76 – 0.62 (m, 1H), 0.54 – 0.41 (m, 1H).

Example **20**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-((1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethylcyclopropyl)-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



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Step 1. Preparation of Example **20**: To a suspension of acid **18-7** (10 mg, 0.018 mmol) and Intermediate **A3** (6.3 mg, 0.023 mmol) in MeCN (0.5 mL) was added DIPEA (15 μ L, 0.086 mmol). To the resulting solution was added HATU (9.0 mg, 0.024 mmol). The reaction was stirred at rt for 2.5 h and an additional

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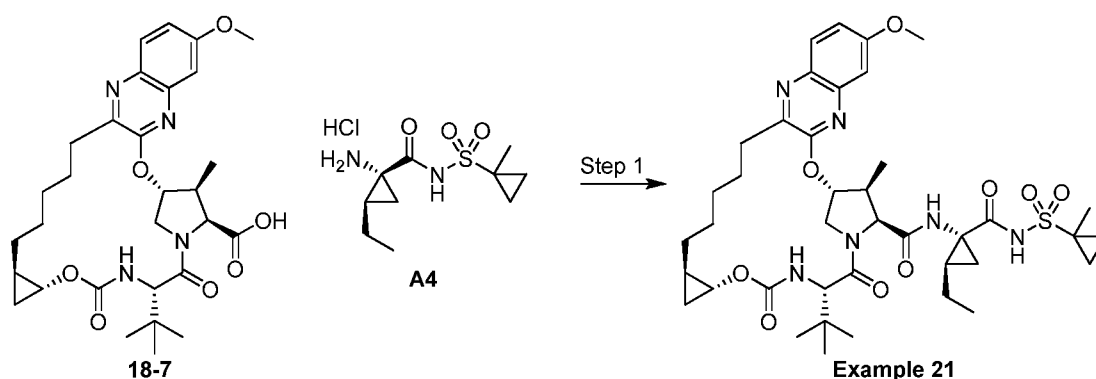
portion of Intermediate **A3** (6.5 mg, 0.024 mmol) was added. After an additional 45 min, the reaction was diluted with EtOAc (2 mL) and 1 M aqueous HCl (1.5 mL). The phases were separated and the aqueous phase was extracted with EtOAc (4 x 1.5 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography (20% to 25% to 30% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **20** as a white amorphous solid (8.0 mg). Analytic HPLC RetTime: 8.40 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₅N₆O₉S: 783.4; found: 783.2. ¹H NMR (300 MHz, CDCl₃) δ 9.98 (s, 1H), 7.83 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.09 (d, *J* = 2.7 Hz, 1H), 6.42 (s, 1H), 5.57 (d, *J* = 3.8 Hz, 1H), 5.36 (d, *J* = 9.9 Hz, 1H), 4.48 – 4.34 (m, 3H), 4.11 (dd, *J* = 11.8, 4.1 Hz, 1H), 3.94 (s, 3H), 3.79 – 3.72 (m, 1H), 2.98 – 2.68 (m, 4H), 1.95 – 0.80 (m, 33H), 0.76 – 0.61 (m, 1H), 0.53 – 0.41 (m, 1H).

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Example **21**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-ethyl-1-[[1-(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

5 methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



10 Step 1. Preparation of Example **21**: To a suspension of acid **18-7** (94.9 mg, 0.167 mmol) and Intermediate **A4** (74.5 mg, 0.263 mmol) in MeCN (2.5 mL) was added DIPEA (180 μ L, 1.0 mmol). To the resulting solution was added HATU (9.0 mg, 0.024 mmol). The reaction was stirred at rt for 110 min and additional portions of Intermediate **A4** (31 mg, 0.11 mmol) and DIPEA (50 μ L,

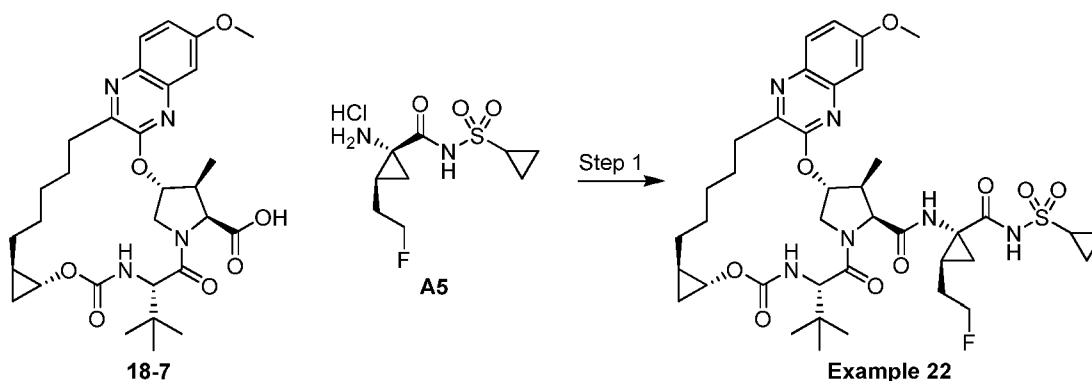
15 0.29 mmol) were added. After an additional 40 min, the reaction was diluted with EtOAc (30 mL), 0.2 M aqueous HCl (20 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography (10% to 40% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **21** as a white amorphous solid (102.1 mg). Analytic HPLC RetTime: 8.83 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₇N₆O₉S: 797.4; found: 797.5. ¹H NMR (400 MHz, CDCl₃) δ 9.76 (s, 1H), 7.80 (d, *J* = 9.1 Hz, 1H), 7.17 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.07 (d, *J* = 2.7 Hz, 1H), 6.92 (s, 1H),

20 5.58 – 5.42 (m, 2H), 4.48 – 4.36 (m, 3H), 4.09 (dd, *J* = 11.8, 4.2 Hz, 1H), 3.92 (s,

3H), 3.79 – 3.74 (m, 1H), 2.97 – 2.66 (m, 4H), 1.80 – 0.88 (m, 33H), 0.84 – 0.77 (m, 1H), 0.77 – 0.61 (m, 2H), 0.52 – 0.40 (m, 1H).

Example **22**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 5 [(1R,2S)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(2-fluoroethyl)cyclopropyl]-14-
 methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-
 tetradecahydro-8H-7,10-
 methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 b]quinoxaline-8-carboxamide.

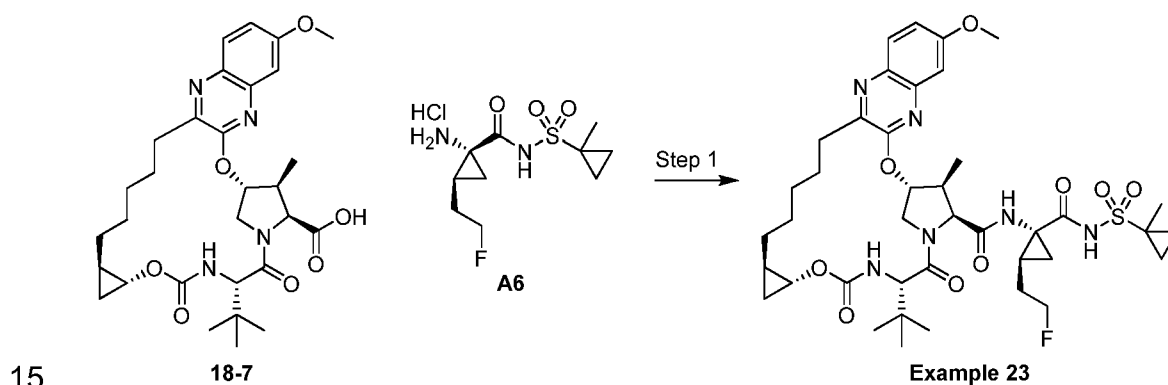
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Step 1. Preparation of Example **22**: To a suspension of acid **18-7** (30.1
 15 mg, 0.0529 mmol) and Intermediate **A5** (35 mg, 0.12 mmol) in MeCN (0.5 mL)
 was added DIPEA (85 μ L, 0.49 mmol). To the resulting solution was added
 HATU (34.5 mg, 0.0907 mmol). The reaction was stirred at rt for 90 min and was
 diluted with EtOAc (30 mL), 0.2 M aqueous HCl (20 mL), and brine (10 mL). The
 phases were separated and the aqueous phase was extracted with EtOAc (30
 20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and
 concentrated to afford a crude residue that was dissolved in CH₂Cl₂ and
 adsorbed onto 2 g silica gel. Purification by silica gel chromatography (15% to
 55% acetone in hexanes) provided a residue that was lyophilized from water and
 MeCN to provide Example **22** as a white amorphous solid (35.5 mg). Analytic
 25 HPLC RetTime: 8.54 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₄FN₆O₉S:

801.4; found: 801.3. ^1H NMR (400 MHz, CDCl_3) δ 9.95 (s, 1H), 7.82 (d, J = 9.1 Hz, 1H), 7.19 (dd, J = 9.1, 2.8 Hz, 1H), 7.08 (d, J = 2.7 Hz, 1H), 6.68 (s, 1H), 5.56 (d, J = 3.9 Hz, 1H), 5.43 (d, J = 9.9 Hz, 1H), 4.57 – 4.29 (m, 5H), 4.12 (dd, J = 11.8, 4.1 Hz, 1H), 3.93 (s, 3H), 3.78 – 3.71 (m, 1H), 2.97 – 2.67 (m, 4H), 2.12 – 1.25 (m, 14H), 1.15 (d, J = 7.4 Hz, 3H), 1.10 (s, 9H), 1.06 – 0.89 (m, 4H), 0.76 – 0.62 (m, 1H), 0.53 – 0.42 (m, 1H).

Example **23**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2S)-2-(2-fluoroethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Step 1. Preparation of Example **23**: To a suspension of acid **18-7** (30.5 mg, 0.0536 mmol) and Intermediate **A6** (24.8 mg, 0.0824 mmol) in MeCN (0.5 mL) was added DIPEA (60 μL , 0.34 mmol). To the resulting solution was added HATU (32.3 mg, 0.0850 mmol). The reaction was stirred at rt for 75 min and an additional portion of Intermediate **A6** (9 mg, 0.03 mmol) was added. After an additional 75 min the reaction was diluted with EtOAc (30 mL), 0.2 M aqueous HCl (20 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was dried over Na_2SO_4 , filtered, and concentrated to afford a crude residue that was

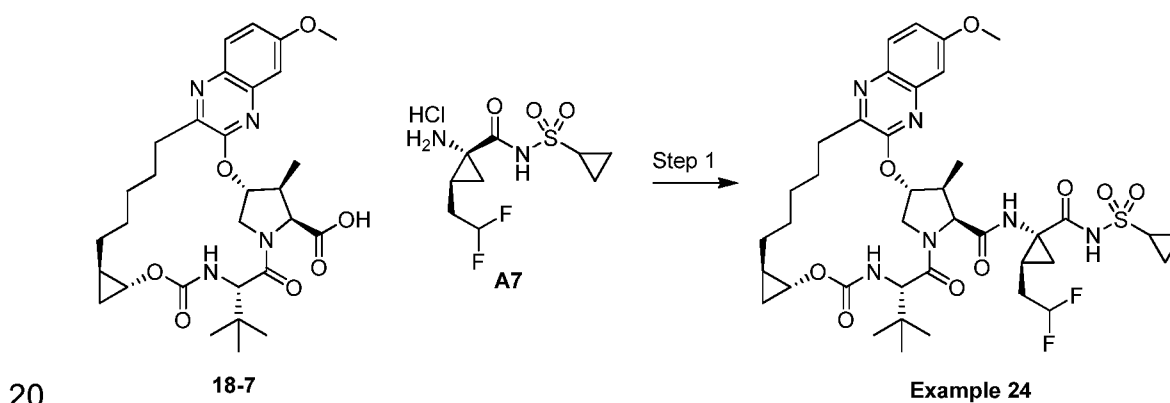
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dissolved in CH₂Cl₂ and adsorbed onto 2 g silica gel. Purification by silica gel chromatography (15% to 55% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **23** as a white amorphous solid (37.1 mg). Analytic HPLC RetTime: 8.64 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺

5 calcd for C₄₀H₅₆FN₆O₉S: 815.4; found: 815.6. ¹H NMR (400 MHz, CDCl₃) δ 9.63 (s, 1H), 7.83 (d, *J* = 9.1 Hz, 1H), 7.20 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.10 (d, *J* = 2.7 Hz, 1H), 6.75 (s, 1H), 5.56 (d, *J* = 3.9 Hz, 1H), 5.50 (d, *J* = 10.0 Hz, 1H), 4.56 – 4.34 (m, 5H), 4.13 (dd, *J* = 11.8, 4.2 Hz, 1H), 3.95 (s, 3H), 3.82 – 3.75 (m, 1H), 2.98 – 2.70 (m, 4H), 2.07 – 2.00 (m, 1H), 2.00 – 1.93 (m, 1H), 1.88 – 1.44 (m, 12H), 1.32 – 1.26 (m, 1H), 1.17 (d, *J* = 7.4 Hz, 3H), 1.12 (d, *J* = 10.6 Hz, 9H), 1.07 – 0.83 (m, 4H), 0.81 – 0.65 (m, 2H), 0.52 – 0.44 (m, 1H).

Example **24**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2S)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(2,2-difluoroethyl)cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



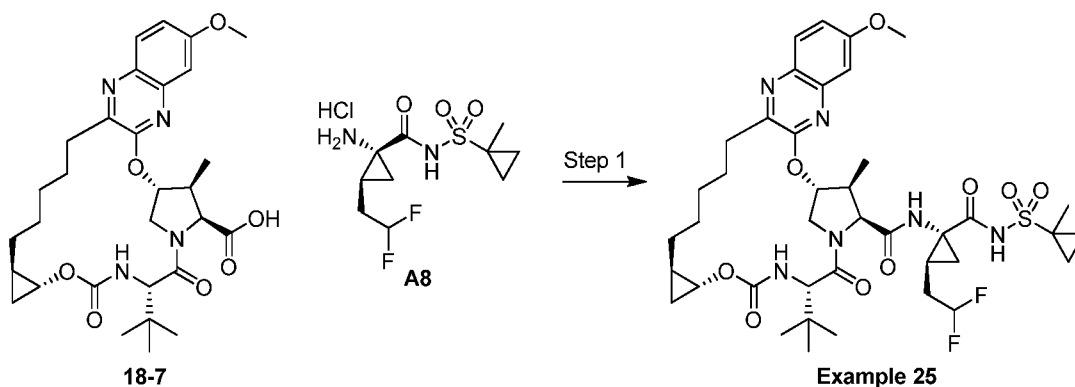
Step 1. Preparation of Example **24**: To a suspension of acid **18-7** (30.2 mg, 0.0531 mmol) and Intermediate **A7** (25.9 mg, 0.0850 mmol) in MeCN (0.5 mL) was added DIPEA (60 μL, 0.34 mmol). To the resulting solution was added HATU (32 mg, 0.084 mmol). The reaction was stirred at rt for 75 min and an

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additional portion of Intermediate **A7** (3.0 mg, 0.0098 mmol) was added. After an additional 30 min the reaction was diluted with EtOAc (30 mL), 0.2 M aqueous HCl (20 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was

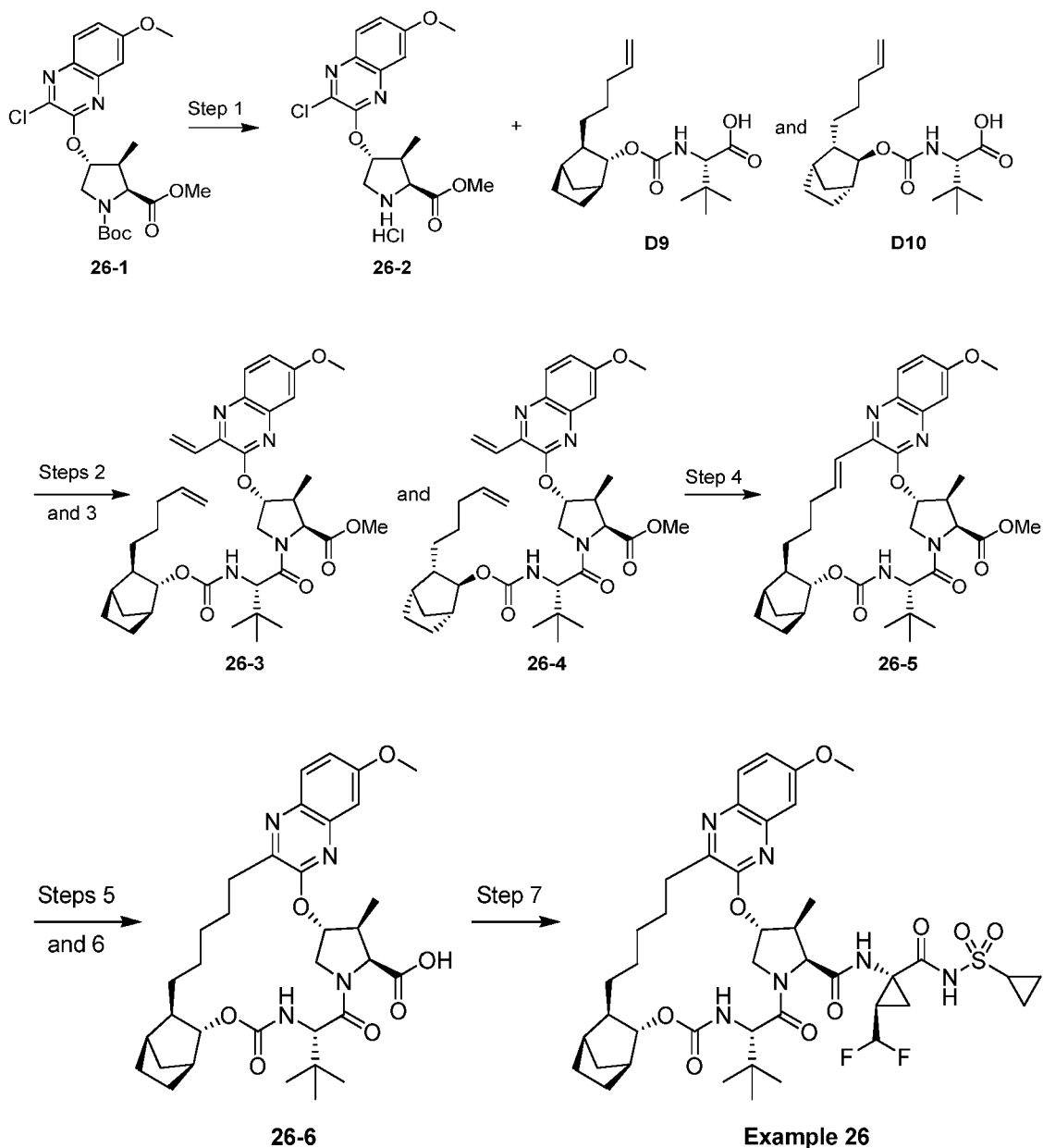
5 dried over Na₂SO₄, filtered, and concentrated to afford a crude residue that was dissolved in CH₂Cl₂ and adsorbed onto 2 g silica gel. Purification by silica gel chromatography (15% to 55% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **24** as a white amorphous solid (35.5 mg). Analytic HPLC RetTime: 8.62 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺
 10 calcd for C₃₉H₅₃F₂N₆O₉S: 819.4; found: 819.2. ¹H NMR (400 MHz, CDCl₃) δ 9.99 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.08 (d, *J* = 2.7 Hz, 1H), 6.69 (s, 1H), 5.99 – 5.64 (m, 1H), 5.56 (d, *J* = 3.9 Hz, 1H), 5.40 (d, *J* = 10.0 Hz, 1H), 4.47 – 4.39 (m, 3H), 4.14 – 4.08 (m, 1H), 3.93 (s, 3H), 3.78 – 3.72 (m, 1H), 2.96 – 2.67 (m, 4H), 2.29 – 2.16 (m, 2H), 1.83 – 1.24 (m, 12H), 1.15 (d, *J* = 7.4 Hz, 3H), 1.09 (s, 9H), 1.05 – 0.82 (m, 4H), 0.74 – 0.63 (m, 1H), 0.53 – 0.42 (m, 1H).

Example **25**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2S)-2-(2,2-difluoroethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Step 1. Preparation of Example **25**: To a suspension of acid **18-7** (30.3 mg, 0.0532 mmol) and Intermediate **A8** (28.3 mg, 0.0887 mmol) in MeCN (0.5 mL) was added DIPEA (60 μ L, 0.34 mmol). To the resulting solution was added
5 HATU (32.4 mg, 0.0852 mmol). The reaction was stirred at rt for 2.5 h and was diluted with EtOAc (30 mL), 0.2 M aqueous HCl (20 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue that was dissolved in CH₂Cl₂ and
10 adsorbed onto 2 g silica gel. Purification by silica gel chromatography (15% to 55% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **25** as a white amorphous solid (33.9 mg). Analytic HPLC RetTime: 8.66 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₅F₂N₆O₉S: 833.4; found: 833.4. ¹H NMR (400 MHz, CDCl₃) δ 9.62 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.18 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.08 (d, *J* = 2.7 Hz, 1H), 6.64 (s, 1H),
15 6.04 – 5.66 (m, 1H), 5.54 (d, *J* = 4.0 Hz, 1H), 5.47 (d, *J* = 10.0 Hz, 1H), 4.50 – 4.38 (m, 3H), 4.11 (dd, *J* = 11.8, 4.2 Hz, 1H), 3.93 (s, 3H), 3.82 – 3.71 (m, 1H), 2.98 – 2.68 (m, 4H), 2.27 – 2.11 (m, 2H), 1.96 – 1.41 (m, 12H), 1.32 (dd, *J* = 9.6, 5.4 Hz, 1H), 1.15 (d, *J* = 7.4 Hz, 3H), 1.10 (s, 9H), 1.05 – 0.64 (m, 6H), 0.51 –
20 0.42 (m, 1H).

Example **26**. Preparation of (1R,4S,4aR,8S,11S,12S,13R,25aR)-8-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-17-methoxy-12-methyl-6,9-dioxo-
25 2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-hexadecahydro-1H,11H-1,4:10,13-dimethanoquinoxalino[2,3-*k*][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide.



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Step 1. Preparation of **26-2**: To a solution of **26-1** (311 mg, 0.710 mmol; prepared similarly to **18-1** of Example **18** substituting Intermediate **B2** for Intermediate **B1** in step 1) in dioxane (1.8 mL) was added 4 M HCl in dioxane (1.8 mL, 7.2 mmol). The reaction was stirred for 15.5 h at rt and was then concentrated under reduced pressure to give **26-2** as a white amorphous solid that was used without further purification in the following step. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₁₉ClN₃O₄: 352.1; found: 352.2.

Steps 2 and 3. Preparation of diastereomeric mixture **26-3** and **26-4**:

Amine hydrochloride **26-2** (0.710 mmol) was dissolved along with 1:1 mixture of Intermediate mixture **D9** and **D10** (266 mg, 0.788 mmol) and DIPEA (600 μ L, 3.4 mmol) in DMF (4.5 mL). HATU (360 mg, 0.95 mmol) was added in one portion.

- 5 The reaction was stirred 1.75 h at rt and was diluted with saturated aqueous NaHCO_3 (20 mL), water (10 mL) and EtOAc (30 mL). The phases were separated and the organic phase was washed twice with a mixture of water (30 mL) and brine (5 mL). The organic phase was dried over anhydrous Na_2SO_4 , filtered and concentrated to a crude residue that was purified by silica gel
- 10 chromatography (10% to 30% EtOAc in hexanes) to provide a colorless residue (380 mg; LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{35}\text{H}_{48}\text{ClN}_4\text{O}_7$: 671.3; found: 671.6). A stirred heterogeneous mixture of this residue, $\text{PdCl}_2(\text{dppf})\cdot\text{CH}_2\text{Cl}_2$ (35 mg, 0.043 mmol) and potassium vinyltrifluoroborate (156 mg, 1.16 mmol) in EtOH (7 mL) was sparged with argon for several minutes. Triethylamine (170 μ L, 1.2
- 15 mmol) was added and the mixture was heated to 70 °C for 55 min. The reaction mixture was cooled to ambient temperature, diluted with EtOAc (40 mL), and washed with water (30 mL). The organics were dried over anhydrous Na_2SO_4 , filtered and concentrated to afford a residue that was purified by silica gel chromatography (15% to 30% EtOAc in hexanes) to afford diastereomeric
- 20 mixture **26-3** and **26-4** as a yellow residue (277 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{37}\text{H}_{51}\text{N}_4\text{O}_7$: 663.4; found: 663.3.

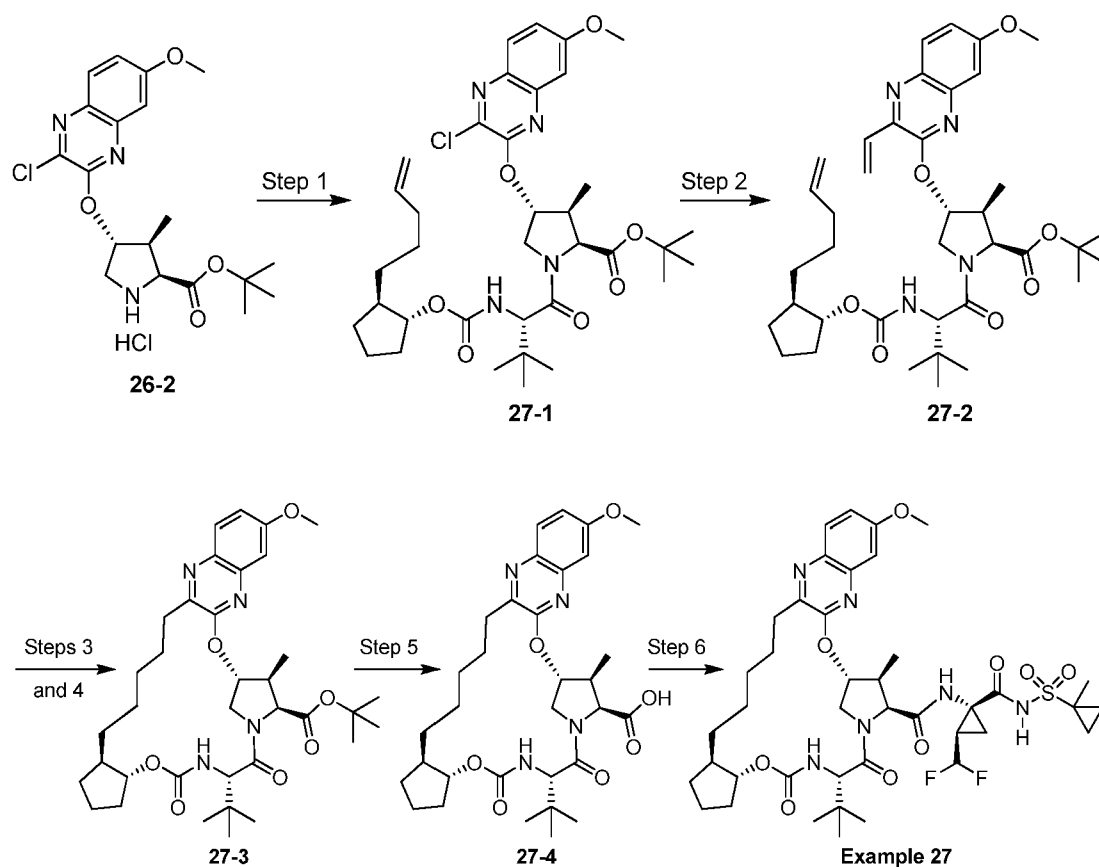
- Step 4. Preparation of **26-5**: Diastereomeric mixture **26-3** and **26-4** (277 mg, 0.419 mmol) was dissolved in DCE (140 mL) and the solution was sparged with Ar for 15 min. Zhan 1B catalyst (37 mg, 0.050 mmol, Strem) was added and
- 25 the resulting solution was stirred at 85 °C under Ar for 1.5 h. The reaction mixture was then concentrated and purified by silica gel chromatography (20% to 50% EtOAc in hexanes) to afford **26-5** as an amorphous residue (105 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{35}\text{H}_{47}\text{N}_4\text{O}_7$: 635.3; found: 635.3.

- Steps 5 and 6. Preparation of **26-6**: To a solution of **26-5** (105 mg, 0.165 mmol) in 1:1 EtOAc:EtOH (4 mL) was added Pd/C (10 wt % Pd, 43 mg). The
- 30 reaction vessel was purged twice with H_2 and was stirred at rt under 1 atm H_2 for

1 h. The reaction mixture was filtered through a pad of Celite and concentrated to afford a crude residue (106 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.4; found: 637.3). This residue was then dissolved in THF (0.8 mL). MeOH (0.4 mL), water (0.4 mL) and LiOH·H₂O (67 mg, 1.6 mmol) were added and the mixture was stirred at 45 °C for 14.5 h. The reaction was quenched dropwise with 1 N aqueous HCl (1.3 mL) and was diluted with CH₂Cl₂ (30 mL) and 1 N aqueous HCl (20 mL). The phases were separated, and the aqueous phase was extracted with CH₂Cl₂ (30 mL). The combined organic phase was dried over MgSO₄, filtered and concentrated to afford **26-6** as a residue (93.8 mg) that was used directly in Step 7. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.3; found: 623.3.

Step 7. Preparation of Example **26**: To a suspension of acid **26-6** (93.8 mg, 0.151 mmol) and Intermediate **A9** (58 mg, 0.20 mmol) in MeCN was added DIPEA (120 µL, 0.69 mmol). To the resulting solution was added HATU (73.5 mg, 0.193 mmol). The reaction was stirred at rt for 100 min and an additional portion of Intermediate **A9** (6 mg, 0.02 mmol) was added. After an additional 30 min, additional Intermediate **A9** (9 mg, 0.03 mmol), HATU (9 mg, 0.02 mmol) and DIPEA (10 µL, 0.06 mmol) were added. The reaction was stirred for an additional 50 min and was diluted with EtOAc (25 mL), 0.2 M aqueous HCl (20 mL) and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (25 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography (25% to 40% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **26** as a white amorphous solid (113 mg). Analytic HPLC RetTime: 9.19 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.4; found: 859.2. ¹H NMR (400 MHz, CDCl₃) δ 10.02 (s, 1H), 7.80 (d, *J* = 9.1 Hz, 1H), 7.21 – 7.15 (m, 2H), 7.07 (d, *J* = 2.7 Hz, 1H), 6.13 – 5.79 (m, 1H), 5.63 (d, *J* = 10.1 Hz, 1H), 5.50 – 5.45 (m, 1H), 4.51 (d, *J* = 10.1 Hz, 1H), 4.44 (d, *J* = 7.4 Hz, 1H), 4.25 (s, 1H), 4.18 – 4.12 (m, 2H), 3.93 (s, 3H), 3.02 – 2.77 (m, 3H), 2.66 – 2.57 (m, 1H), 2.18 – 0.90 (m, 36H).

Example **27**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-16-methoxy-11-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.



Step 1. Preparation of **27-1**: Amine hydrochloride **26-2** (217 mg, 0.504 mmol), was treated with BEP (207 mg, 0.756 mmol), Intermediate **D5** (283 mg, 0.909 mmol), EtOAc (9 mL), NMP (1 mL) and DIPEA (0.44 mL, 2.5 mmol), then heated to 50 °C. After 1.5 h, the reaction mixture was diluted with EtOAc. The organic solution was washed successively with saturated aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (9% to 40% EtOAc/Hex) to

afford amide **27-1** (235 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₂ClN₄O₇: 687.35; found: 688.13.

Step 2. Preparation of **27-2**: Amide **27-1** (235 mg, 0.342 mmol) was treated with potassium vinyltrifluoroborate (69 mg, 0.513 mmol),

- 5 Pd(dppf)Cl₂•DCM (28 mg, 0.0342 mmol), EtOH (3.4 mL) and TEA (0.072 mL, 0.513 mmol), then heated to reflux. After 50 min, the reaction mixture was diluted with EtOAc and washed with H₂O and brine. The organics were dried over MgSO₄, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (9% to 40% EtOAc/Hex) to afford vinyl quinoxaline **27-2** (219 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₅N₄O₇:
10 679.41; found: 679.49.

- Steps 3 and 4. Preparation of **27-3**: Vinyl quinoxaline **27-2** (219 mg, 0.323 mmol) was suspended in DCE (65 mL) and treated with Zhan 1B catalyst (41 mg, 0.065 mmol, Strem). The suspension was deoxygenated with bubbling N₂ for 17
15 min, then heated to reflux for 90 min. The reaction mixture was then filtered over Celite and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (15% to 50% EtOAc/Hex) to afford the desired macrocycle (165 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.38; found: 651.40). The macrocyclic product of step 3 was dissolved in EtOH (10 mL) and EtOAc (2 mL) and treated with 10 wt % Pd/C (95 mg). Hydrogen from a
20 balloon was bubbled through the suspension for 1 min and the mixture was stirred under H₂ (1 atm) for an additional 1.5 h. The reaction mixture was filtered over Celite and concentrated under reduced pressure to afford the desired macrocycle **27-3** which was carried on without further purification. LCMS-ESI⁺
25 (*m/z*): [M+H]⁺ calcd for C₃₆H₅₃N₄O₇: 653.39; found: 653.32.

- Step 5. Preparation of **27-4**: The crude product of step 4 was dissolved in DCM and treated with TMSOTf (0.23 mL, 1.3 mmol). After stirring at rt for 1 h 15 min, the reaction mixture was concentrated under reduced pressure. The residue was redissolved in DCM and added by pipette to a separatory funnel containing 1
30 M aqueous NaOH. The mixture was agitated for 1 min, then acidified to pH 1~2 with 10% aqueous HCl. The aqueous layer was extracted three times with DCM

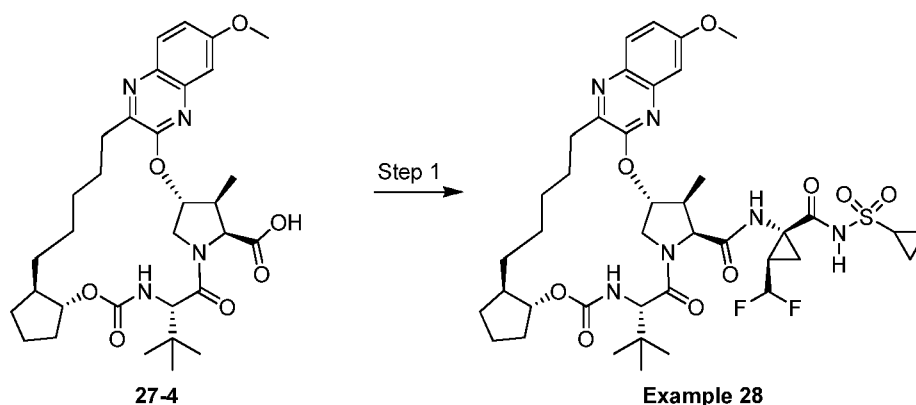
and combined organics dried over MgSO_4 , filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography to afford carboxylic acid **27-4** (119 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{32}\text{H}_{45}\text{N}_4\text{O}_7$: 597.33; found: 597.40.

5 Step 6. Preparation of Example **27**: Carboxylic acid **27-4** (105 mg, 0.177 mmol) and Intermediate **A10** (65 mg, 0.212 mmol) were treated with TBTU (68 mg, 0.212 mmol), DMAP (26 mg, 0.212 mmol), DCM (1.8 mL) and DIPEA (0.31 mL, 1.8 mmol). The reaction mixture was stirred at rt for 30 min, then more amine **A10** (40 mg, 0.131 mmol) was added and the reaction mixture was heated to
10 reflux. After an additional 1.25 h, the mixture was concentrated under reduced pressure. The crude residue was purified by HPLC to afford Example **27** (80 mg) in approximately 90% purity as a TFA salt. Analytic HPLC RetTime: 9.06 min. LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{41}\text{H}_{57}\text{F}_2\text{N}_6\text{O}_9\text{S}$: 847.39; found: 847.69. ¹H NMR (400 MHz, CD_3OD) δ 9.23 (s, 1H), 7.87 – 7.72 (m, 1H), 7.31 – 7.14 (m, 2H), 5.84 (td, J = 55.6, 6.5 Hz, 1H), 5.58 (d, J = 22.6 Hz, 1H), 4.94 – 4.81 (m, 1H), 4.37 (d, J = 15.8 Hz, 1H), 4.29 – 4.10 (m, 2H), 3.94 (s, 3H), 3.01 (ddd, J = 15.1, 9.9, 5.3 Hz, 1H), 2.84 (p, J = 7.4 Hz, 1H), 2.75 (ddd, J = 13.3, 10.2, 6.0 Hz, 1H), 2.03 (d, J = 9.0 Hz, 2H), 1.97 – 1.74 (m, 4H), 1.73 – 1.55 (m, 6H), 1.53 (s, 3H), 1.48 – 1.21 (m, 8H), 1.19 – 1.02 (m, 14H), 0.99 – 0.80 (m, 2H).

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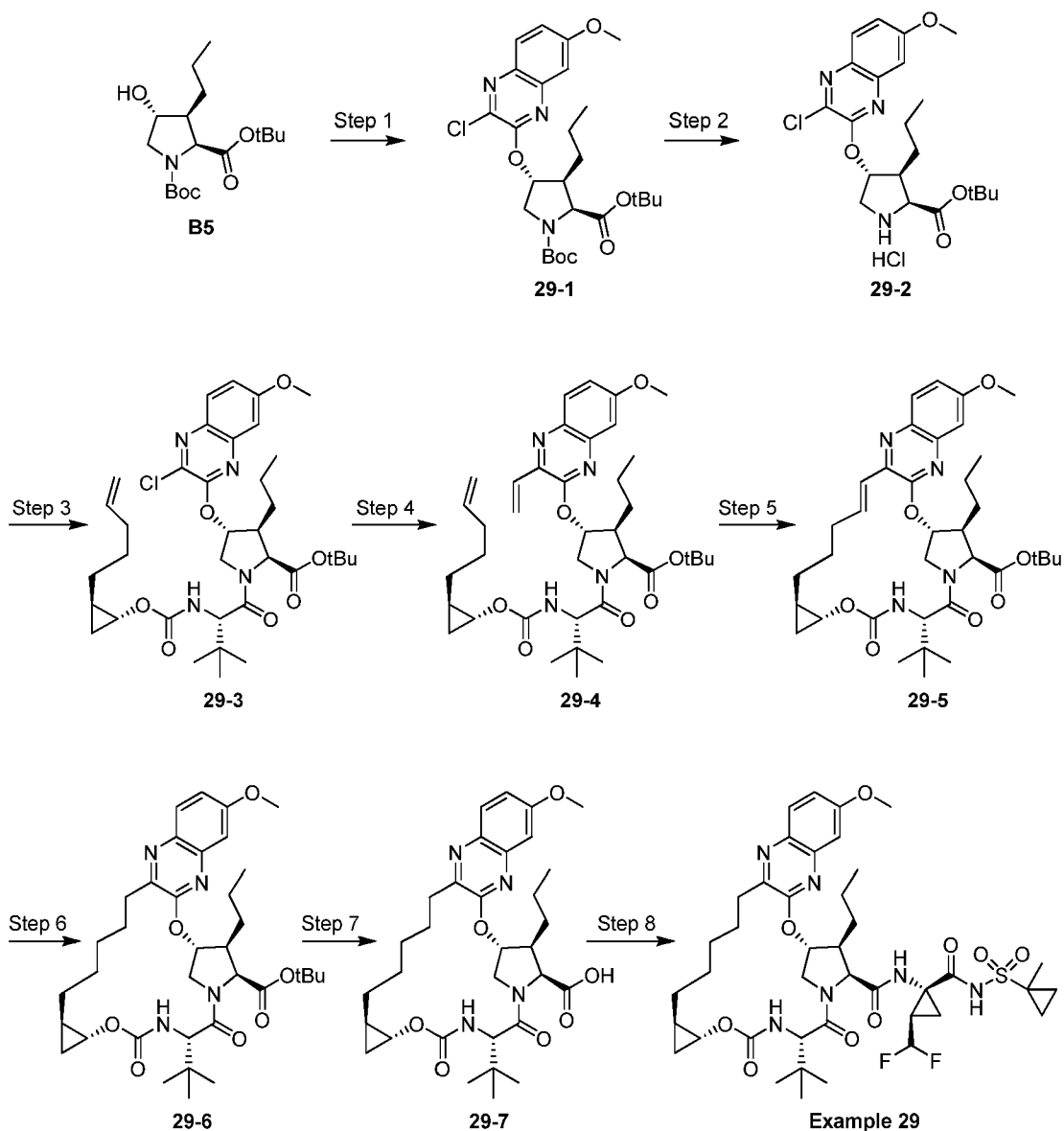
Example **28**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-16-methoxy-11-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.

25



Step 1. Carboxylic acid **27-4** (20 mg, 0.034 mmol) and Intermediate **A9** (35 mg, 0.12 mmol) were treated with TBTU (22 mg, 0.067 mmol), DMAP (8 mg, 0.07 mmol), DCM (1 mL) and DIPEA (0.117 mL, 0.674 mmol). The reaction mixture was stirred at rt for 15 h, then concentrated under reduced pressure. The crude residue was purified by HPLC to afford Example **28** (22 mg) in approximately 90% purity as a TFA salt. Analytic HPLC RetTime: 8.90 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₅F₂N₆O₉S: 833.37; found: 833.61. ¹H NMR (400 MHz, CD₃OD) δ 9.23 (s, 1H), 7.79 (d, *J* = 8.8 Hz, 1H), 7.34 – 7.10 (m, 2H), 5.86 (td, *J* = 55.8, 6.5 Hz, 1H), 5.61 (s, 1H), 4.54 (t, *J* = 9.7 Hz, 1H), 4.36 (d, *J* = 16.5 Hz, 1H), 4.28 – 4.07 (m, 2H), 3.95 (d, *J* = 17.8 Hz, 3H), 3.08 – 2.91 (m, 2H), 2.90 – 2.79 (m, 1H), 2.73 (ddd, *J* = 13.3, 10.3, 6.0 Hz, 1H), 2.04 (s, 2H), 1.97 – 1.74 (m, 4H), 1.64 (ddd, *J* = 18.7, 11.6, 4.0 Hz, 4H), 1.49 – 1.19 (m, 11H), 1.18 – 0.94 (m, 14H), 0.94 – 0.80 (m, 1H).

Example **29**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-3,6-dioxo-9-propyl-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



5

Step 1. Preparation of **29-1**: To a solution of Intermediate **B5** (188 mg, 0.57 mmol) and Intermediate **E1** (233 mg, 0.86 mmol) in MeCN (2.85 mL) was added cesium carbonate (280 mg, 9.18 mmol) at rt under an argon atmosphere. After 19 h, the reaction mixture was then filtered through a pad of Celite and the filtrate concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford substituted quinoxaline **29-1** (240 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₆H₃₇ClN₃O₆: 522.2; found: 522.3.

Step 2. Preparation of **29-2**: To a solution **29-1** (240 mg, 0.46 mmol) in dioxane (1 mL) was added 4 M hydrochloric acid in dioxane (4 mL, 1 mmol) and the reaction stirred at rt. After 15 h, the reaction mixture was concentrated *in vacuo* to afford amine hydrochloride **29-2** (200 mg) as an off white solid, which
5 was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₁H₂₉ClN₃O₄: 422.2; found: 422.2.

Step 3. Preparation of **29-3**: To a solution of **29-2** (200 mg, 0.46 mmol) and Intermediate **D1** (170 mg, 0.51 mmol) in MeCN (2.3 mL) was added HATU (192 mg, 0.51 mmol) followed by DIPEA (400 μL, 2.30 mmol) at rt under and
10 argon atmosphere. After 1.5 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford amide **29-3** (67 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₂ClN₄O₇: 687.3; found: 687.5.

Step 4. Preparation of **29-4**: To a solution of **29-3** (67 mg, 98 μmol), TEA
15 (20 μL, 150 μmol) and potassium vinyltrifluoroborate (19.7 mg, 150 μmol) in EtOH (500 μL) was added PdCl₂(dppf) (8 mg, 9.8 μmol). The reaction mixture was deoxygenated with argon for 10 min and was heated to 78 °C. After 40 min, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl
20 acetate/hexanes gradient) to afford vinyl quinoxaline **29-4** (40.2 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₅N₄O₇: 679.4; found: 679.6.

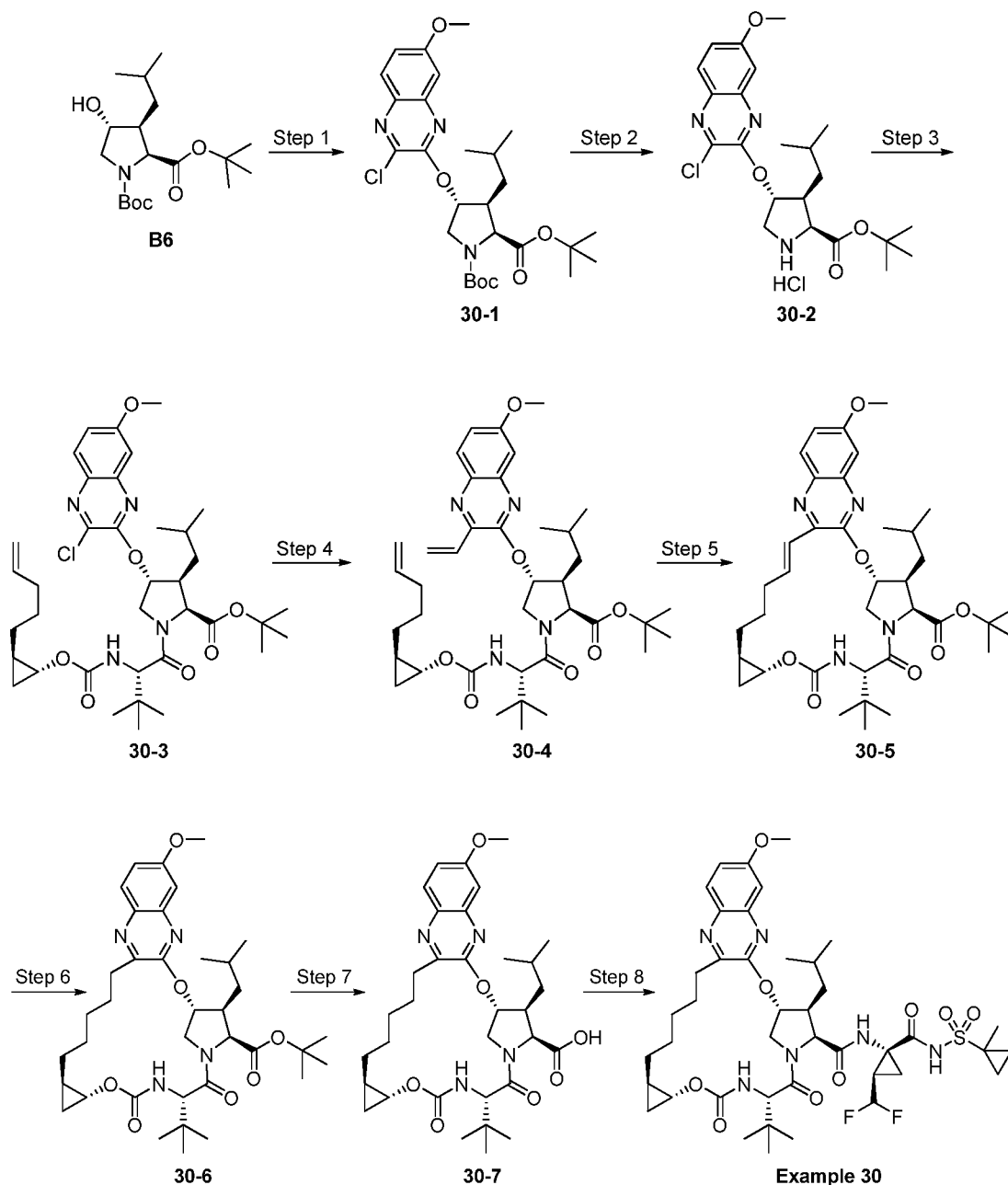
Step 5. Preparation of **29-5**: To a solution of **29-4** (40 mg, 59 μmol) in DCE
25 (11.8 mL) was added Zhan 1B catalyst (4 mg, 6 μmol, Strem) and the reaction mixture was degassed for 10 minutes with argon. The reaction mixture was then heated to 100 °C. After 1 h, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford macrocycle
30 **29-5** (31 mg) as a light yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.4; found: 651.5.

Step 6. Preparation of **29-6**: To a solution of macrocycle **29-5** (31 mg, 47 μmol) in ethanol (500 μL) was added Pd/C (10 wt %, 5 mg, 5 μmol) at rt under an argon atmosphere. The reaction vessel was evacuated and refilled with 1 atm hydrogen gas (3 $\times$) and the reaction mixture was stirred vigorously at rt. After 1 h, the reaction mixture was diluted with ethyl acetate (10 mL) and was filtered through a pad of Celite with ethyl acetate washings (3 $\times$ 5 mL). The filtrate was concentrated *in vacuo* to afford macrocycle **29-6** (31 mg), which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₃N₄O₇: 653.4; found: 653.5.

Step 7. Preparation of **29-7**: To a solution of **29-6** (31 mg, 47 μmol) in DCM (0.5 mL) was added TMSOTf (44 μL , 0.25 mmol) at rt under an argon atmosphere. After 25 min, the reaction mixture was concentrated *in vacuo* and was azeotropically dried from toluene (2 $\times$ 2 mL) to afford carboxylic acid **29-7** (35 mg) as a yellow oil, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₅N₄O₇: 597.3; found: 597.4.

Step 8. Preparation of Example **29**: To a solution of **29-7** (35 mg, 49 μmol) and Intermediate **A10** (22 mg, 74 μmol) in MeCN (245 μL) was added HATU (28 mg, 74 μmol) followed by DIPEA (43 μL , 250 μmol) at rt under an argon atmosphere. After 3 h, the reaction mixture was concentrated *in vacuo*, was purified by preparatory HPLC (Gemini 5u C18 110Å column, 5–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and was lyophilized to afford Example **29** (22.3 mg) as a white powder TFA salt. Analytic HPLC RetTime: 8.81 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₆F₂N₆O₉S: 847.4; found: 847.5. ¹H NMR (400 MHz, CDCl₃) δ 9.83 (d, *J* = 9.4 Hz, 1H), 7.93 (d, *J* = 9.1 Hz, 1H), 7.36 (d, *J* = 9.1 Hz, 1H), 7.21 (d, *J* = 11.0 Hz, 1H), 7.14 (s, 1H), 5.97 (td, *J*_{H-F} = 55 Hz, *J* = 7.2 Hz, 1H), 5.84 (br s, 1H), 5.41 (d, *J* = 9.4 Hz, 1H), 4.66 – 4.34 (m, 3H), 4.13 (app d, *J* = 11.8 Hz, 1H), 4.08 (s, 1H), 3.97 (s, 3H), 3.78 – 3.71 (m, 1H), 3.09 – 2.65 (m, 5H), 2.14 – 2.04 (m, 1H), 1.87 – 1.34 (m, 8H), 1.52 (s, 3H), 1.12 (s, 9H), 1.08 – 0.84 (m, 10H), 0.76 – 0.62 (m, 1H), 0.50 (dd, *J* = 12.6, 6.6 Hz, 1H).

Example 30. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 [(1R,2R)-2-(difluoromethyl)-1-[(1-
 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-(2-
 5 methylpropyl)-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-
 8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 b]quinoxaline-8-carboxamide.



Step 1. Preparation of **30-1**: A mixture of Intermediate **B6** (139 mg, 0.405 mmol), Intermediate **E1** (170 mg, 0.625 mmol), and cesium carbonate (203 mg, 0.623 mmol) in 3.3 mL of acetonitrile was stirred at room temperature under
5 argon overnight. Reaction mixture was filtered over Celite, washing with ethyl acetate, and filtrate was concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to yield **30-1** (170 mg) as a clear film. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₇H₃₉ClN₃O₆: 536.24; found: 536.31.

10 Step 2. Preparation of **30-2**: A solution of hydrogen chloride in dioxane (4.0 M, 0.16 mL, 0.64 mmol) was added to a solution of **30-1** (168 mg, 0.314 mmol) in 3.3 mL of dioxane at room temperature. After thirty minutes, an additional 4 equivalents of HCl was added and mixture was stirred overnight. An additional 25 equivalents of HCl was then added. After thirty minutes, an
15 additional 19 equivalents of HCl was added. After one hour, an additional 29 equivalents of HCl was added. After thirty minutes, reaction mixture was concentrated under reduced pressure to yield **30-2** (148 mg, 85% purity), which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₂H₃₁ClN₃O₄: 436.19; found: 436.25.

20 Step 3. Preparation of **30-3**: HATU (144 mg, 0.379 mmol, Oakwood) and DIPEA (0.28 mL, 1.58 mmol) were added to a mixture of **30-2** (148 mg, 0.315 mmol) and Intermediate **D1** (99 mg, 0.348 mmol) in 3.5 mL of DMF under argon. After stirring overnight, reaction mixture was poured into water and extracted with ethyl acetate (3 x). Combined organics were washed with water and brine, dried
25 (MgSO₄), filtered, and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) to yield **30-3** (136 mg) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₄ClN₄O₇: 701.36; found: 701.47.

30 Step 4. Preparation of **30-4**: Pd(dppf)₂Cl₂•CH₂Cl₂ (35 mg, 0.043 mmol) was added to a degassed mixture of **30-3** (135 mg, 0.193 mmol), potassium vinyltrifluoroborate (41 mg, 0.306 mmol), and triethylamine (0.040 mL, 0.289

mmol) in 2.1 mL of ethanol at room temperature. Reaction mixture was heated at 78 °C under argon for 45 minutes. After cooling to room temperature, reaction mixture was poured into water and extracted with ethyl acetate (three times). Combined organics were washed with water and brine, dried (MgSO₄), filtered, and concentrated under reduced pressure to yield **30-4** (133 mg), which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₇N₄O₇: 693.41; found: 693.48.

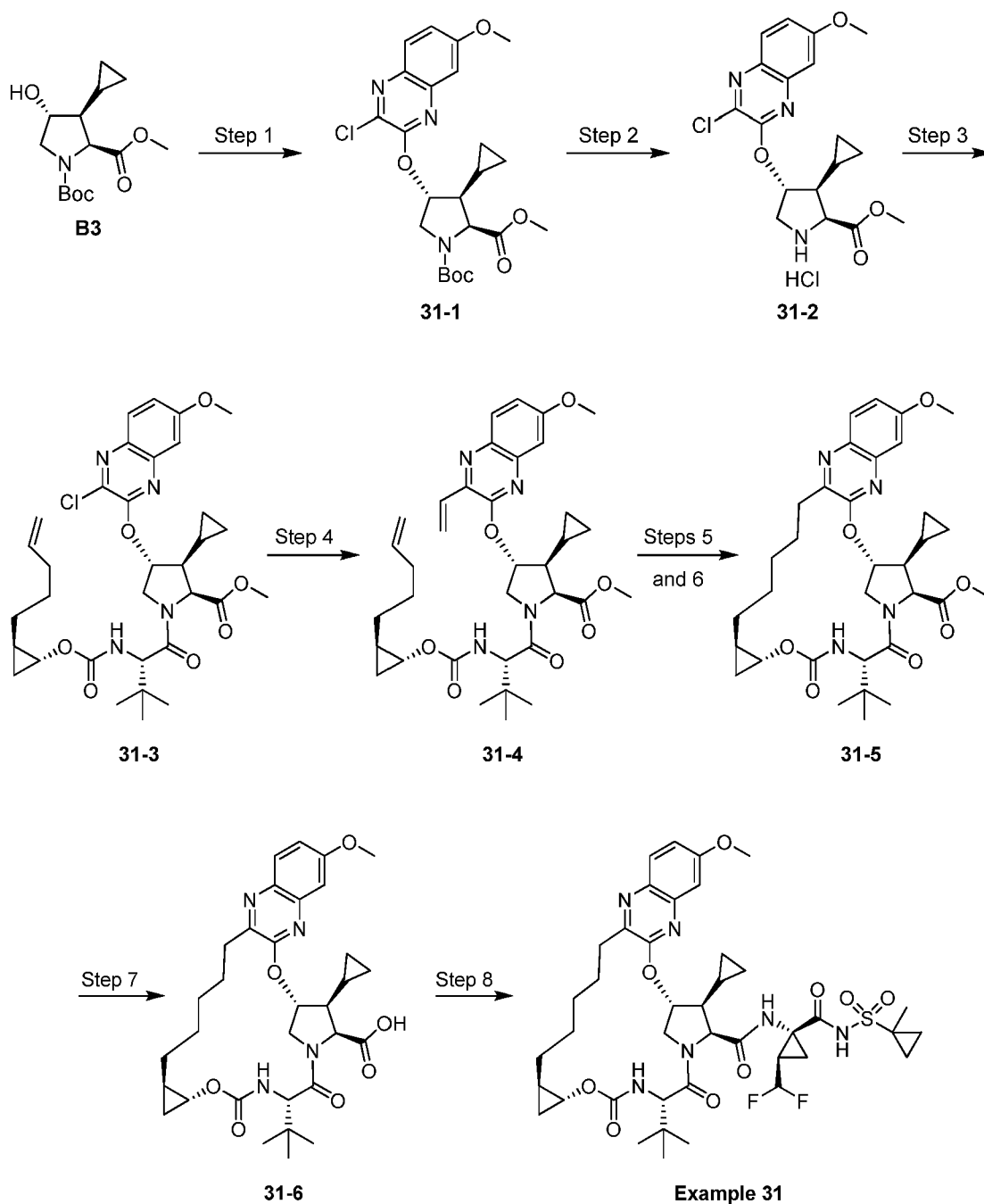
Step 5. Preparation of **30-5**: A mixture of **30-4** (133 mg, 0.192 mmol) and Zhan 1B catalyst (16 mg, 0.022 mmol, Strem) in 38 mL of DCE was deoxygenated under argon for 25 minutes. The mixture was then heated at 95 °C for 50 minutes. After cooling to room temperature, reaction mixture was concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) to yield **30-5** (70 mg) as a light yellow film. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₃N₄O₇: 665.38; found: 665.50.

Step 6. Preparation of **30-6**: Palladium on carbon (10 wt % Pd, 22 mg, 0.0208 mmol) was added to a solution of **30-5** (69 mg, 0.104 mmol) in 3 mL of ethanol. Mixture was then stirred under an atmosphere of hydrogen for 1 hour and then was filtered over Celite, washing with ethyl acetate. Filtrate was concentrated under reduced pressure to yield **30-6** (64 mg) as a light yellow-brown solid film, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₅N₄O₇: 667.40; found: 667.43.

Step 7. Preparation of **30-7**: TMSOTf (0.050 mL, 0.274 mmol) was added dropwise to a solution of **30-6** (30 mg, 0.045 mmol) in 1.2 mL of dichloromethane under argon at room temperature. After 45 minutes, reaction mixture was concentrated under reduced pressure. The resulting film was taken up in 5 mL of toluene and concentrated under reduced pressure. This process was repeated a second time to yield **30-7** (27 mg), which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₇N₄O₇: 611.34; found: 611.41.

Step 8. Preparation of Example **30**: HATU (28 mg, 0.074 mmol, Oakwood) and DIPEA (0.050 mL, 0.281 mmol) were added to a mixture of **30-7** (27 mg, 0.045 mmol) and Intermediate **A10** (22 mg, 0.072 mmol) in 2.2 mL of acetonitrile under argon. After stirring overnight, reaction mixture was poured into water and extracted with ethyl acetate (3 x). Combined organics were washed with water and brine, dried (MgSO₄), filtered, and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (15–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **30** (18 mg) as a light yellow solid, after lyophilization. Analytic HPLC RetTime: 8.96 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₉F₂N₆O₉S: 861.40; found: 861.30. ¹H NMR (400 MHz, CD₃OD): δ 9.17 (s, 1H), 7.80 (d, *J* = 8.8 Hz, 1H), 7.23 (dd, *J* = 8.8, 2.8 Hz, 1H), 7.14 (d, *J* = 2.8 Hz, 1H), 5.81 (td, *J*_{H-F} = 56 Hz, *J* = 7.6 Hz, 1H); 5.77 (d, *J* = 3.2 Hz, 1H), 4.55 (d, *J* = 7.2 Hz, 1H), 4.39 (t, *J* = 5.6 Hz, 2H), 4.16 (dd, *J* = 11.8, 4 Hz, 1H), 3.91 (s, 3H), 3.79–3.71 (m, 1H), 2.98–2.90 (m, 1H), 2.84 (dd, *J* = 12.6, 4.8 Hz, 1H), 2.79–2.72 (m, 1H), 2.06–1.91 (m, 3H), 1.77 (m, 3H), 1.64–1.44 (m, 6H), 1.51 (s, 3H), 1.44–1.32 (m, 3H), 1.15–1.07 (m, 1H), 1.10 (s, 9H), 1.06–0.96 (m, 3H), 1.04–1.01 (m, 6H), 0.93–0.89 (m, 2H), 0.79–0.68 (m, 1H), 0.52–0.47 (m, 1H).

Example **31**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-9-cyclopropyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



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Step 1. Preparation of **31-1**: An unpurified sample of Intermediate **B3** was treated with Intermediate **E1** (217 mg, 0.797 mmol), MeCN (5.7 mL) and Cs₂CO₃ (371 mg, 1.14 mmol). After stirring at rt for 17 h, the reaction mixture was filtered over Celite and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (20% to 40% EtOAc/Hex) to afford

quinoxaline **31-1** (143 mg). LCMS-ESI⁺ (*m/z*): [M-Boc+2H]⁺ calcd for C₁₈H₂₁ClN₃O₄: 378.12; found: 378.59.

Step 2. Preparation of **31-2**: Quinoxaline **31-1** (143 mg, 0.299 mmol) was dissolved in DCM (10 mL) and treated with HCl (4.0 M in dioxane, 5 mL, 20.0 mmol). After stirring for 2 h at rt, the reaction mixture was concentrated and the crude **31-2** was carried on without further purification.

Step 3. Preparation of **31-3**: The crude amine hydrochloride **31-2** was treated with BEP (115 mg, 0.419 mmol), Intermediate **D1** (120 mg, 0.423 mmol), EtOAc (9 mL), NMP (1 mL) and DIPEA (0.37 mL, 2.1 mmol), then heated to 50 °C. After 1.5 h, the reaction mixture was diluted with Et₂O. The organic solution was washed successively with saturated aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (15% to 30% EtOAc/Hex) to afford amide **31-3** (166 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₄ClN₄O₇: 643.29; found: 643.48.

Step 4. Preparation of **31-4**: Amide **31-3** (166 mg, 0.258 mmol) was treated with potassium vinyltrifluoroborate (52 mg, 0.387 mmol), Pd(dppf)Cl₂•DCM (21 mg, 0.0258 mmol), EtOH (2.6 mL) and TEA (0.054 mL), then heated to reflux. After 50 min, the reaction mixture was diluted with EtOAc and washed with H₂O and brine. The organics were dried over MgSO₄, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (15% to 40% EtOAc/Hex) to afford vinyl quinoxaline **31-4** (145 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₇N₄O₇: 635.34; found: 635.58.

Steps 5 and 6. Preparation of **31-5**: Vinyl quinoxaline **31-4** (145 mg, 0.228 mmol) was suspended in DCE (46 mL) and treated with Zhan 1B catalyst (33 mg, 0.0456 mmol, Strem). The suspension was deoxygenated with bubbling N₂ for 22 min, then heated to reflux for 50 min. The reaction mixture was then filtered over Celite and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (25% to 35% EtOAc/Hex) to afford the desired macrocycle (54 mg; LCMS-ESI⁺ (*m/z*): [M +H]⁺ calcd for C₃₃H₄₃N₄O₇: 607.31; found: 607.67). The macrocyclic product of step 5 was dissolved in EtOH (10

mL) and treated with 10% Pd/C (45 mg). Hydrogen from a balloon was bubbled through the suspension for 1 min and hydrogenation (1 atm) was continued for an additional 1.5 h. The reaction mixture was filtered over Celite and concentrated under reduced pressure to afford the desired macrocycle **31-5**

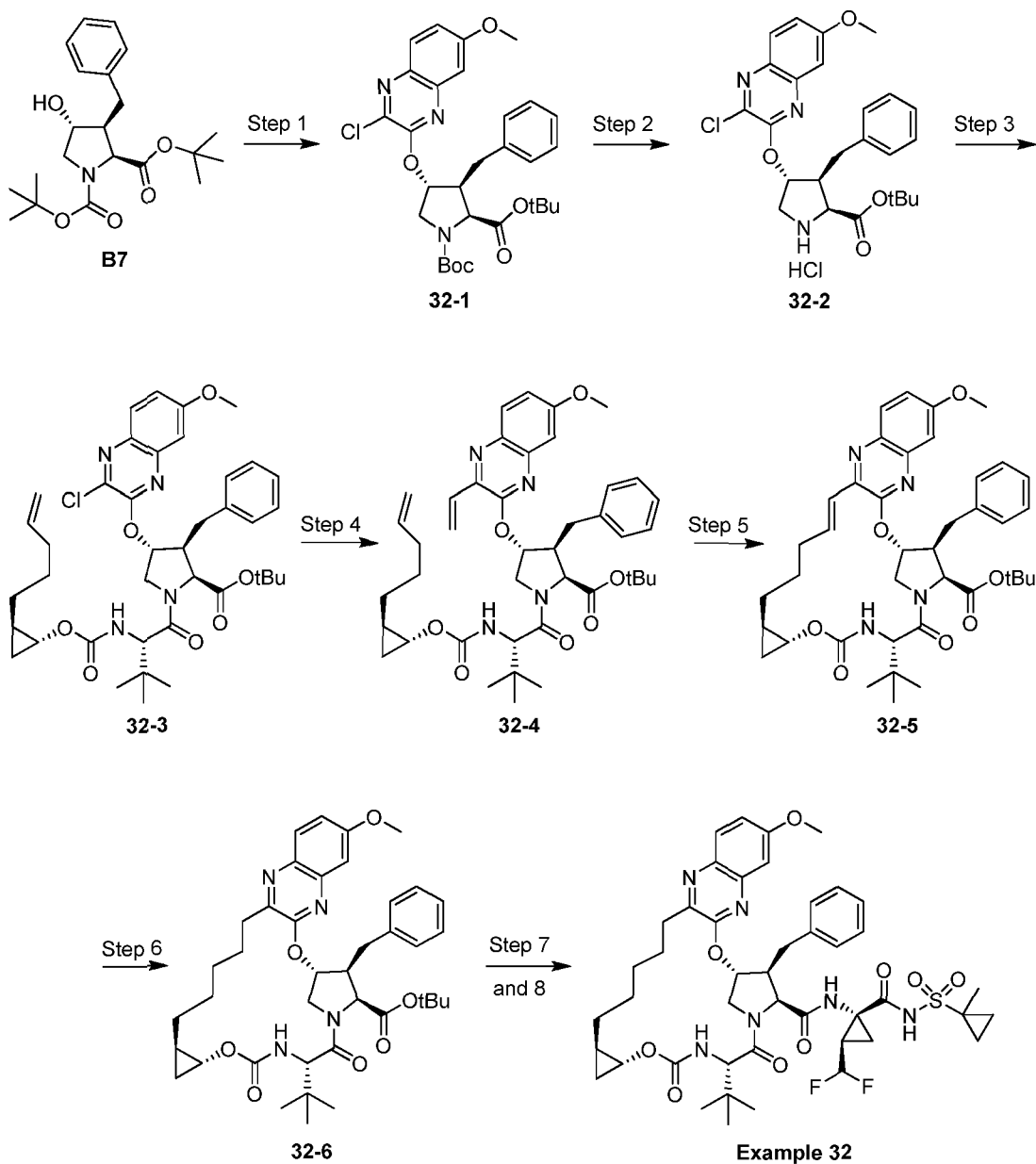
5 which was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₅N₄O₇: 609.33; found: 609.95.

Step 7. Preparation of **31-6**: The crude product **31-5** was dissolved in THF and treated with LiOH (1.0 M in H₂O, 5 mL, 5 mmol). After stirring at rt for 3 d, the reaction mixture was heated to reflux for 20 h. The mixture was then poured into
10 H₂O and acidified to pH ~1–2 with 10% HCl. The aqueous layer was extracted three times with DCM. The combined organics were dried over MgSO₄, filtered and concentrated under reduced pressure. The crude material was purified by silica gel chromatography (80% to 100% EtOAc/Hex) to afford carboxylic acid **31-6** (24 mg). LCMS-ESI⁺ (*m/z*): [M +H]⁺ calcd for C₃₂H₄₃N₄O₇: 595.31; found:
15 595.12.

Step 8. Preparation of Example **31**: Carboxylic acid **31-6** (24 mg, 0.040 mmol) and Intermediate **A10** (25 mg, 0.081 mmol) were treated with TBTU (23 mg, 0.081 mmol), DMAP (10 mg, 0.081 mmol), DCM (2 mL) and DIPEA (0.070 mL, 0.40 mmol). The reaction mixture was stirred at rt for 15 h then concentrated
20 under reduced pressure. The crude residue was purified by HPLC to afford Example **31** (13 mg, 34%) in approximately 90% purity as a TFA salt. Analytic HPLC RetTime: 8.92 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₂N₆O₉S: 845.37; found: 845.67. ¹H NMR (400 MHz, CD₃OD) δ 9.13 (s, 1H), 7.79 (d, *J* = 9.1 Hz, 1H), 7.23 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.13 (d, *J* = 2.7 Hz, 1H), 6.05 – 5.65 (m, 2H), 4.55 (d, *J* = 7.0 Hz, 1H), 4.47 (d, *J* = 11.7 Hz, 2H), 4.27 (dd, *J* = 12.0, 3.7 Hz, 1H), 3.94 (s, 3H), 3.78 (dd, *J* = 6.8, 2.8 Hz, 1H), 2.99 – 2.86 (m, 1H), 2.80 (td, *J* = 13.2, 4.1 Hz, 1H), 1.98 (d, *J* = 28.8 Hz, 2H), 1.92 – 1.67 (m, 4H), 1.65 – 1.41 (m, 10H), 1.33 (d, *J* = 27.7 Hz, 3H), 1.20 – 1.06 (m, 9H), 1.04 – 0.84 (m, 6H), 0.82 – 0.62 (m, 3H), 0.61 – 0.41 (m, 2H), 0.06 (dd, *J* = 9.2, 4.9 Hz, 1H).

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Example **32**. Preparation of (1aR,5S,8S,9S,10R,22aR)-9-benzyl-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Step 1. Preparation of **32-1**: To a solution of Intermediate **B7** (390 mg, 1.00 mmol) and Intermediate **E1** (272 mg, 1.00 mmol) in MeCN (5 mL) was added cesium carbonate (390 mg, 1.00 mmol) at rt under an argon atmosphere. After 24 h, the reaction mixture was diluted with ethyl acetate (50 mL). The resulting mixture was washed with saturated aqueous sodium bicarbonate solution (50 mL) and brine (50 mL), was dried over anhydrous sodium sulfate, and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford quinoxaline **32-1** (550 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₀H₃₇ClN₃O₆: 570.2; found: 570.2.

Step 2. Preparation of **32-2**: To a solution of **32-1** (549 mg, 0.96 mmol) in dioxane (2 mL) was added 4 M hydrochloric acid in dioxane (2 mL, 1 mmol) and the reaction was stirred at rt. After 24 h, the reaction mixture was concentrated *in vacuo* to afford amine hydrochloride **32-2** (461 mg) as an off white solid, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₅H₂₉ClN₃O₄: 470.2; found: 470.2.

Step 3. Preparation of **32-3**: To a solution of **32-2** (461 mg, 0.96 mmol) and Intermediate **D1** (369 mg, 1.10 mmol) in MeCN (5 mL) was added HATU (418 mg, 1.10 mmol) followed by DIPEA (869 μL, 5.00 mmol) at rt under an argon atmosphere. After 24 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **32-3** (202.6 mg) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₂ClN₄O₇: 735.3; found: 735.4.

Step 4. Preparation of **32-4**: To a solution of **32-3** (202 mg, 276 μmol), TEA (56 μL, 414 μmol) and potassium vinyltrifluoroborate (56 mg, 414 μmol) in EtOH (2.76 mL) was added PdCl₂(dppf) (22.5 mg, 27.6 μmol). The reaction mixture was degassed with argon for 10 min and was heated to 78 °C. After 1 h, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **32-4** (163 mg) as a yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₅N₄O₇: 727.4; found: 727.5.

Step 5. Preparation of **32-5**: To a solution of **32-4** (163 mg, 220 μ mol) in DCE (44 mL) was added Zhan 1B catalyst (16 mg, 22 μ mol, Strem) and the reaction mixture was degassed for 10 minutes with argon. The reaction mixture was then heated to 100 °C. After 45 min, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **32-5** (125 mg) as a light yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₁N₄O₇: 699.4; found: 699.4.

Step 6. Preparation of **32-6**: To a solution of macrocycle **32-5** (124 mg, 178 μ mol) in ethanol (890 μ L) was added Pd/C (10 wt % Pd, 19 mg, 18 μ mol) at rt under an argon atmosphere. The reaction vessel was evacuated and refilled with hydrogen gas (3 $\times$) and the reaction mixture was stirred vigorously at rt under 1 atm H₂. After 2.5 h, the reaction mixture was diluted with ethyl acetate (5 mL) and was filtered through a pad of Celite with ethyl acetate washings (3 $\times$ 5 mL). The filtrate was concentrated *in vacuo* to afford **32-6** (139 mg), which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₃N₄O₇: 701.4; found: 701.5.

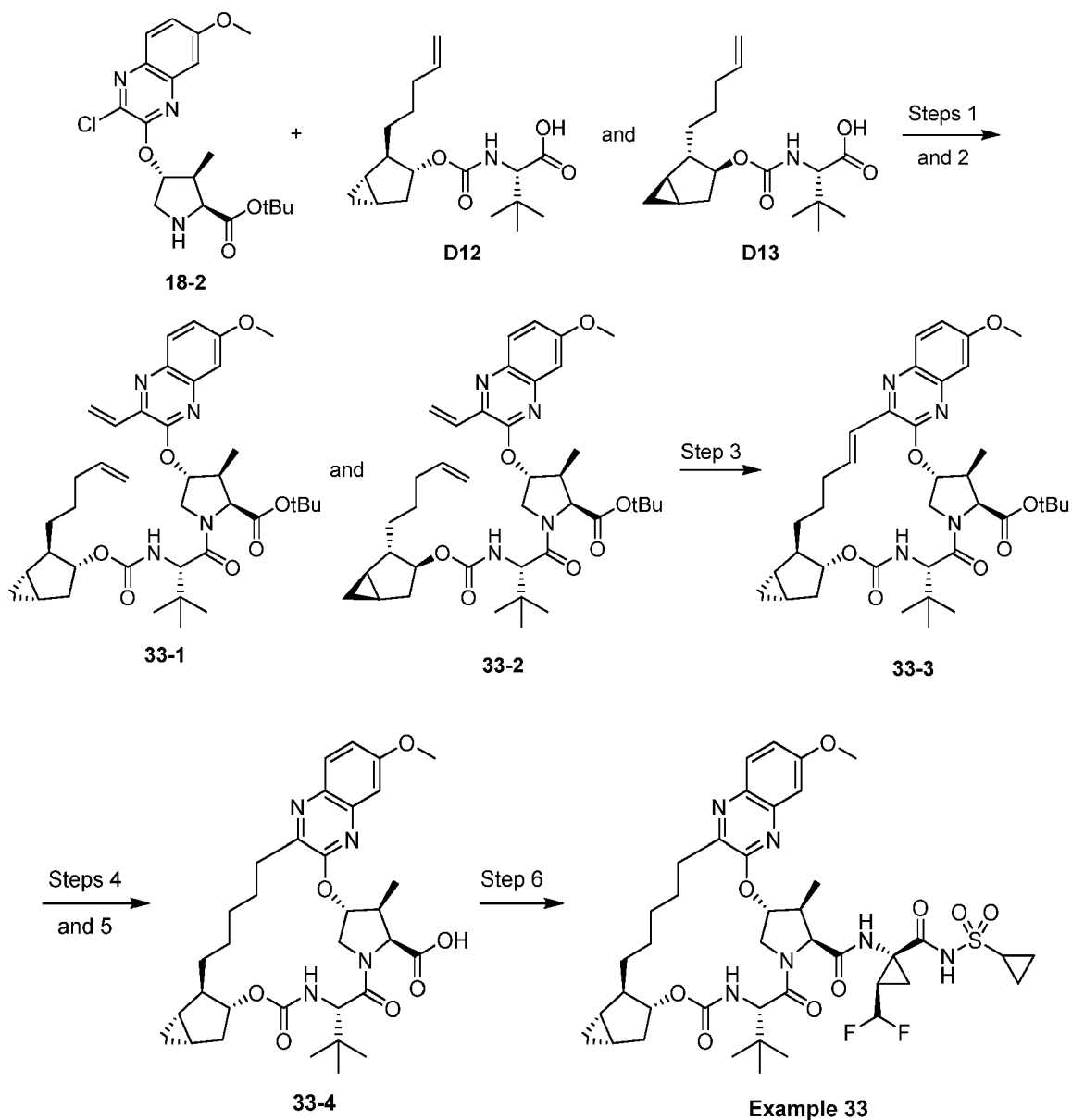
Steps 7 and 8. Preparation of Example **32**: To a solution of **32-6** (124 mg, 178 μ mol) in DCM (3 mL) was added TFA (2 mL) at rt under an argon atmosphere. After 3 h, the reaction mixture was concentrated *in vacuo* and was azeotropically dried from toluene (2 $\times$ 2 mL) to afford the desired carboxylic acid as a yellow oil, which was used directly in the next step without further purification. (126 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₅N₄O₇: 645.3; found: 645.4). To a solution of this carboxylic acid (120 mg, 178 μ mol) and Intermediate **A10** (119 mg, 392 μ mol) in MeCN (1 mL) was added HATU (151 mg, 392 μ mol) followed by DIPEA (155 μ L, 890 μ mol) at rt under an argon atmosphere. After 30 min, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient). The fractions containing the desired product were combined, were repurified by preparatory HPLC (Gemini 5u C18 110Å column, 5–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and were lyophilized to

afford the TFA salt of Example **32** (23 mg) as a white powder. Analytic HPLC RetTime: 8.81 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₅H₅₇F₂N₆O₉S: 895.4; found: 895.6. ¹H NMR (400 MHz, CD₃OD) δ 9.24 (s, 1H), 7.73 (d, *J* = 9.1 Hz, 1H), 7.47 – 7.27 (m, 4H), 7.21 – 7.12 (m, 1H), 6.65 (d, *J* = 2.9 Hz, 1H), 5.83 (td, *J*_{H-F} = 55 Hz, *J* = 7.2 Hz, 1H), 5.77 (br s, 1H), 4.63 (d, *J* = 6.9 Hz, 2H), 4.50 – 4.28 (m, 3H), 3.93 (s, 2H), 3.79 – 3.71 (m, 1H), 3.11 – 2.99 (m, 1H), 2.97 – 2.85 (m, 1H), 2.82 – 2.61 (m, 3H), 1.92 (br s, 2H), 1.82 – 1.70 (m, 2H), 1.63 – 1.44 (m, 4H), 1.52 (s, 3H), 1.15 (s, 9H), 1.04 (br s, 2H), 1.02 – 0.96 (m, 2H), 0.95 – 0.88 (m, 4H), 0.78 – 0.66 (m, 1H), 0.56 – 0.46 (m, 1H).

10

Example **33**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1S,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.

15



5

Steps 1 and 2. Preparation of diastereomeric mixture **33-1** and **33-2**:

Quinoxaline **18-2** (220 mg, 0.56 mmol) was dissolved along with 1:1 diastereomer Intermediate mixture **D12** and **D13** (208 mg, 0.643 mmol) in MeCN (5 mL). DIPEA (280 μ L, 1.6 mmol) and HATU (360 mg, 0.95 mmol) were added, and the reaction was stirred for 1.25 h at rt. The reaction was then diluted with EtOAc (30 mL), saturated aqueous NaHCO₃ (15 mL), H₂O (10 mL), and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The organic phase was dried over anhydrous Na₂SO₄, filtered

10

and concentrated to a crude residue that was dissolved in CH_2Cl_2 and adsorbed onto silica gel (5 g). Purification by silica gel chromatography (10% to 30% EtOAc in hexanes) provided a white foam (352 mg; LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{37}\text{H}_{52}\text{ClN}_4\text{O}_7$: 699.4; found: 699.1). A stirred heterogeneous mixture of
5 this residue, $\text{PdCl}_2(\text{dppf})\cdot\text{CH}_2\text{Cl}_2$ (30.7 mg, 0.0376 mmol) and potassium vinyltrifluoroborate (135 mg, 1.01 mmol) in EtOH (5 mL) was sparged with argon for several minutes. Triethylamine (160 μL , 1.1 mmol) was added and the mixture was heated to 75 °C for 1 h. The reaction mixture was cooled to ambient temperature and was diluted with EtOAc (30 mL), H_2O (15 mL) and brine (15
10 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (30 mL). The organics were dried over anhydrous Na_2SO_4 , filtered and concentrated to afford a crude residue that was dissolved in CH_2Cl_2 and adsorbed onto silica gel (3 g). Purification by silica gel chromatography (10% to 40% EtOAc in hexanes) produced inseparable mixture of **33-1** and **33-2** as a
15 yellow residue (258 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{39}\text{H}_{55}\text{N}_4\text{O}_7$: 691.4; found: 691.7.

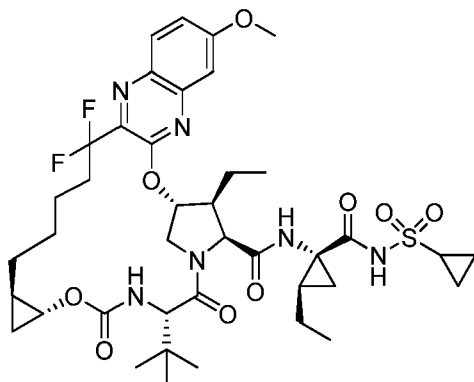
Step 3: Preparation of **33-3**: Diastereomeric mixture **33-1** and **33-2** (258 mg, 0.373 mmol) was dissolved in DCE (125 mL) and the solution was sparged with Ar for 10 min. Zhan 1B catalyst (41 mg, 0.056 mmol, Strem) was added as a
20 solution in DCE (3.3 mL) and the resulting solution was stirred at 85 °C under Ar for 105 min. The reaction mixture was then concentrated onto 5 g silica gel and was purified by silica gel chromatography (0% to 25% EtOAc in hexanes) to afford macrocycle **33-3** as an amorphous residue (81.9 mg). LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{37}\text{H}_{51}\text{N}_4\text{O}_7$: 663.4; found: 663.3.

25 Steps 4 and 5: Preparation of **33-4**: To a solution of **33-3** (81.9 mg, 0.124 mmol) in 1:1 EtOAc:EtOH (4 mL) was added Pd/C (10 wt % Pd, 19 mg). The reaction vessel was purged twice with H_2 and was stirred at rt under 1 atm H_2 for 2.5 h. The reaction mixture was filtered through a pad of Celite and concentrated to afford a crude residue. This residue was dissolved in CH_2Cl_2 (1.2 mL) and
30 TMSOTf (90 μL , 0.50 mmol) was added. The mixture was stirred at rt for 4.5 h. The reaction was then concentrated *in vacuo* and dissolved in CH_2Cl_2 (5 mL). 0.2

M aqueous NaOH (5 mL) was added and the biphasic mixture was stirred at rt for 5 min. The mixture was then acidified with 1 M aqueous HCl (20 mL) and was diluted with CH₂Cl₂ (20 mL). The phases were separated and the aqueous phase was extracted with CH₂Cl₂ (2 x 20 mL). The combined organic phase was dried
5 over MgSO₄, filtered, and concentrated to afford **33-4** as a crude residue (76.1 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₅N₄O₇: 609.3; found: 608.9.

Step 6: Preparation of Example **33**: To a suspension of acid **33-4** (43 mg, 0.072 mmol) and Intermediate **A9** (40.9 mg, 0.14 mmol) in MeCN (800 µL) was added DIPEA (100 µL, 0.57 mmol). HATU (37 mg, 0.097 mmol) was added to the
10 resulting solution, and the reaction was stirred at rt for 15 h. The reaction was then diluted with EtOAc (20 mL), 0.2 M aqueous HCl (10 mL) and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and
15 was concentrated onto 2 g silica gel. Purification by silica gel chromatography (15% to 55% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **33** as a white amorphous solid (29.6 mg). Analytic HPLC RetTime: 9.07 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₂N₆O₉S: 845.4; found: 845.2. ¹H NMR (400 MHz, CDCl₃) δ
20 10.21 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.09 (d, *J* = 2.7 Hz, 1H), 6.79 (s, 1H), 6.21 – 5.76 (m, 1H), 5.65 (d, *J* = 3.9 Hz, 1H), 5.29 (d, *J* = 9.7 Hz, 1H), 4.99 (d, *J* = 7.5 Hz, 1H), 4.47 – 4.29 (m, 4H), 4.16 – 4.09 (m, 1H), 3.93 (s, 3H), 2.99 – 2.85 (m, 2H), 2.80 – 2.64 (m, 2H), 2.24 – 2.16 (m, 1H), 2.13 – 2.05 (m, 1H), 2.01 – 0.95 (m, 29H), 0.56 – 0.45 (m, 1H), 0.45 – 0.35 (m, 1H).

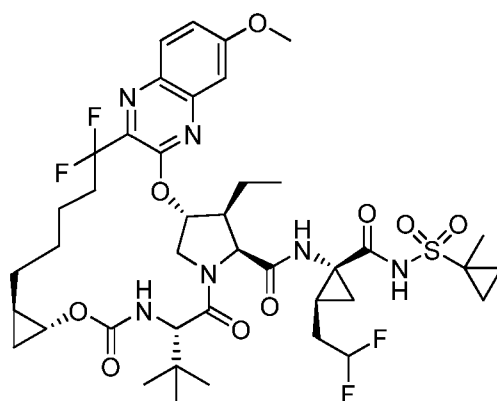
25 Example **34**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
{(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethylcyclopropyl}-9-ethyl-18,18-
difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-
tetradecahydro-8H-7,10-
30 methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
b]quinoxaline-8-carboxamide.



Example 34

Example **34** was prepared in a similar fashion to Example **17**, substituting
 5 Intermediate **A3** for Intermediate **A10** in Step 7. Example **34** was isolated (5.7
 mg) in approximately 95% purity. Analytic HPLC RetTime: 8.81 min. LCMS-ESI⁺
 (*m/z*): [M+H]⁺ calcd for C₄₀H₅₅F₂N₆O₉S: 833.4; found: 833.25. ¹H NMR (400
 MHz, CDCl₃) δ 10.027 (br s, 1H), 7.98 (d, J = 8.8 Hz, 1H), 7.29 (dd, J = 9.2, 2.8
 Hz, 1H), 7.09 (d, J = 2.8 Hz, 1H), 6.32 (br s, 1H), 5.92 (d, J = 3.6 Hz, 1H), 5.30
 10 (d, J = 10.0 Hz, 1H), 4.42 – 4.33 (m, 3H), 4.08 (dd, J = 11.6, 4.0 Hz, 1H), 3.96 (s,
 3H), 3.65 (m, 1H), 2.93 (m, 1H), 2.51 (m, 2H), 2.02 (m, 1H), 1.86 – 1.40 (m, 11H)
 1.34 – 1.14 (m, 7H), 1.09 (s, 9H), 1.10 – 0.82 (m, 6H), 0.72 (m, 1H), 0.48 (m,
 1H).

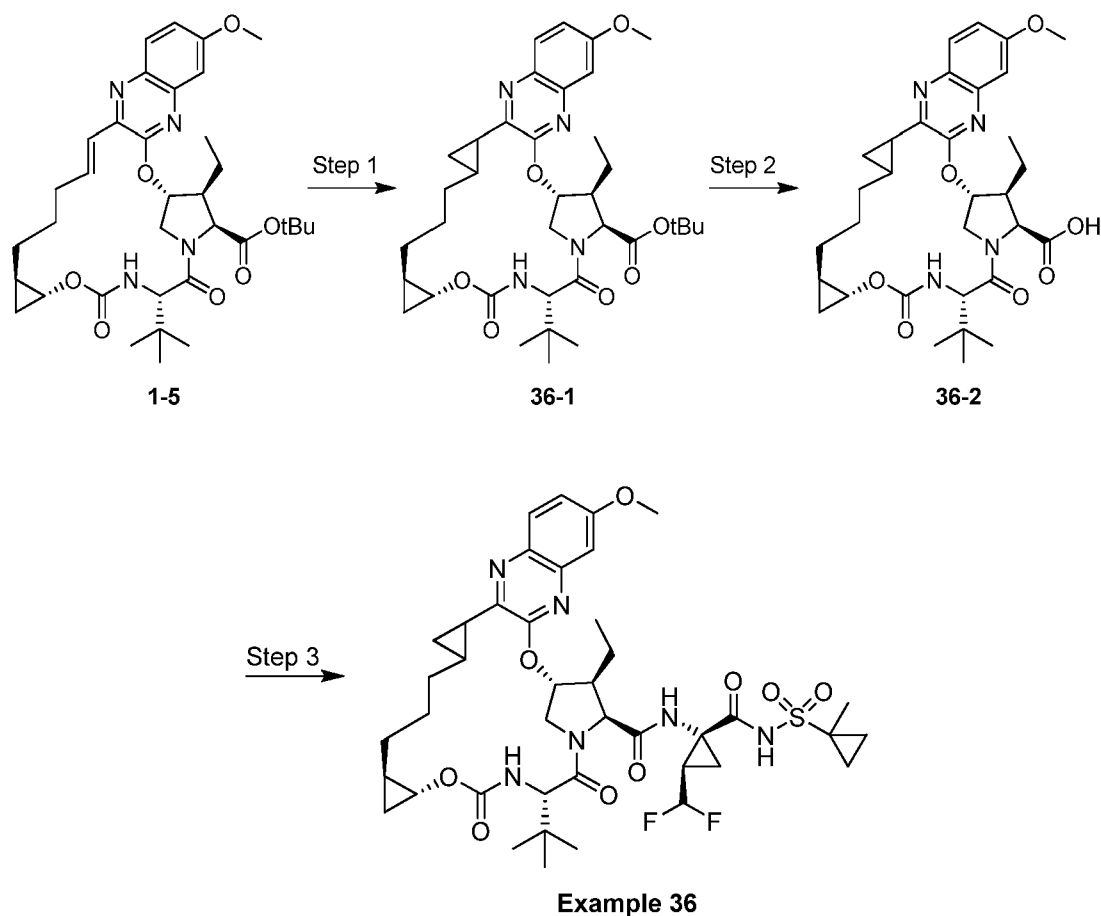
15 Example **35**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 [(1R,2S)-2-(2,2-difluoroethyl)-1-[(1-
 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-14-
 methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-
 7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 20 b]quinoxaline-8-carboxamide.



Example 35

Example **35** was prepared in a similar fashion to Example **17**, substituting Intermediate **A8** for Intermediate **A10** in Step 7. Example **35** was isolated (12.8 mg) in approximately 90% purity. Analytic HPLC RetTime: 8.78 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₄N₆O₉S: 883.4; found: 883.2. ¹H NMR (400 MHz, CDCl₃) δ 9.69 (br s, 1H), 7.98 (d, J = 9.2 Hz, 1H), 7.29 (dd, J = 9.2, 2.8 Hz, 1H), 7.09 (d, J = 2.8 Hz, 1H), 6.53 (br s, 1H), 5.91 (d, J = 4.0 Hz, 1H), 5.84 (tt, J_{H-F} = 56 Hz, J = 3.6 Hz, 1H), 5.33 (d, J = 6.4 Hz, 1H), 4.43 (m, 2H), 4.34 (ap d, J = 9.6 Hz, 1H), 4.08 (dd, J = 11.6, 4.0 Hz, 1H), 3.96 (s, 3H), 3.99 – 3.94 (m, 1H), 3.68 (m, 1H), 2.58 – 2.52 (m, 3H), 2.20 (m, 2H), 1.82 – 1.58 (m, 7H) 1.54 – 1.40 (m, 5H), 1.36 – 1.18 (m, 6H), 1.09 (s, 9H), 1.10 – 1.00 (m, 1H), 0.85 (m, 2H), 0.69 (m, 1H), 0.49 (m, 1H).

Example **36**. Preparation of (1aR,5S,8S,9S,10R,21aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1a,3,4,5,6,9,10,17b,18,18a,19,20,21,21a-tetradecahydro-1H,8H-7,10-methanodicyclopropa[13,14:18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



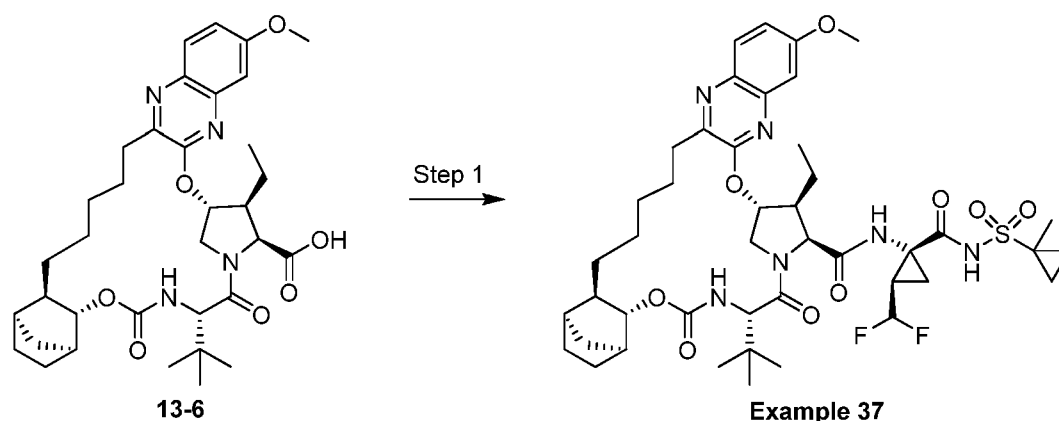
5 Step 1. Preparation of **36-1**: To a solution of trimethylsulfoxonium iodide (72 mg, 0.32 mmol) in DMSO/THF (1:1, 2 mL) was added sodium hydride (60%, 12 mg, 0.32 mmol) and stirred at rt for 2 h. Macrocycle **1-5** (103 mg, 0.16 mmol) was added dropwise in THF (3 mL). The mixture was heated to 65 °C and stirred for 16 h. After cooling to rt, the mixture was diluted with EtOAc/H₂O, extracted
 10 with EtOAc, dried over anhydrous MgSO₄, and concentrated *in vacuo*. The residue was purified by silica gel chromatography (0–25% EtOAc/hexanes) to give **36-1** (27 mg) as a residue. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.38; found: 651.52.

15 Step 2. Preparation of **36-2**: To a solution of **36-1** (26 mg, 0.04 mmol) in DCM (1 mL) was added TMSOTf (0.036 mL, 0.2 mmol) and stirred at rt for 2 h. The reaction was pipetted into stirring 1 N NaOH (2 mL). After 10 min, the mixture was diluted with DCM and acidified to pH 3 with 1 N aqueous HCl.

Following extraction of the aqueous layer with DCM, the combined organics were dried over anhydrous MgSO_4 and concentrated *in vacuo*. The residue was purified by silica gel chromatography (0–10% EtOAc/MeOH) to give **36-2** (24 mg) as a residue that was used without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{32}\text{H}_{43}\text{N}_4\text{O}_7$: 595.31; found: 595.43.

Step 3. Preparation of Example **36**: To a solution of **36-2** (24 mg, 0.041 mmol), Intermediate **A10** (16 mg, 0.053 mmol), TBTU (19 mg, 0.06 mmol) and DMAP (8 mg, 0.06 mmol) in DCM (2 mL) was added DIPEA (0.021 mL, 0.12 mmol) and the reaction was stirred at rt for 16 h. Additional Intermediate **A10** (16 mg, 0.053 mmol), TBTU (19 mg, 0.06 mmol), DMAP (8 mg, 0.06 mmol), and DIPEA (0.021 mL, 0.12 mmol) were added and the reaction was stirred at rt for 4 h. The reaction was quenched with water, diluted with EtOAc, washed with sat. aqueous NaHCO_3 , brine, dried over anhydrous MgSO_4 and concentrated *in vacuo*. The crude material was purified by reverse phase HPLC (Gemini, 45–85% MeCN/ H_2O + 0.1% TFA) and lyophilized to give Example **36** (3 mg) as a TFA salt. Analytic HPLC RetTime: 9.06 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{41}\text{H}_{55}\text{F}_2\text{N}_6\text{O}_9\text{S}$: 845.37; found: 845.43. ¹H NMR (400 MHz, CD_3OD) δ 9.31 (s, 1H), 7.72 (d, *J* = 10 Hz, 1H), 7.20 – 7.17 (m, 2H), 5.60 – 5.82 (m, 2H), 5.51 (s, 1H), 4.72 (d, *J* = 7.2 Hz, 1H), 4.43 (d, *J* = 11.6 Hz, 1H), 4.31 (s, 1H), 4.26 – 4.22 (dd, *J* = 11.6, 4 Hz, 1H), 3.94 (s, 3H), 3.78 (m, 1H), 2.60 (m, 1H), 2.27 (m, 1H), 2.04 (s, 3H), 1.68 (m, 3H), 1.59 (m, 2H), 1.54 – 1.15 (m, 11H), 1.09 (s, 9H), 0.95 – 0.86 (m, 8H), 0.47 (m, 1H).

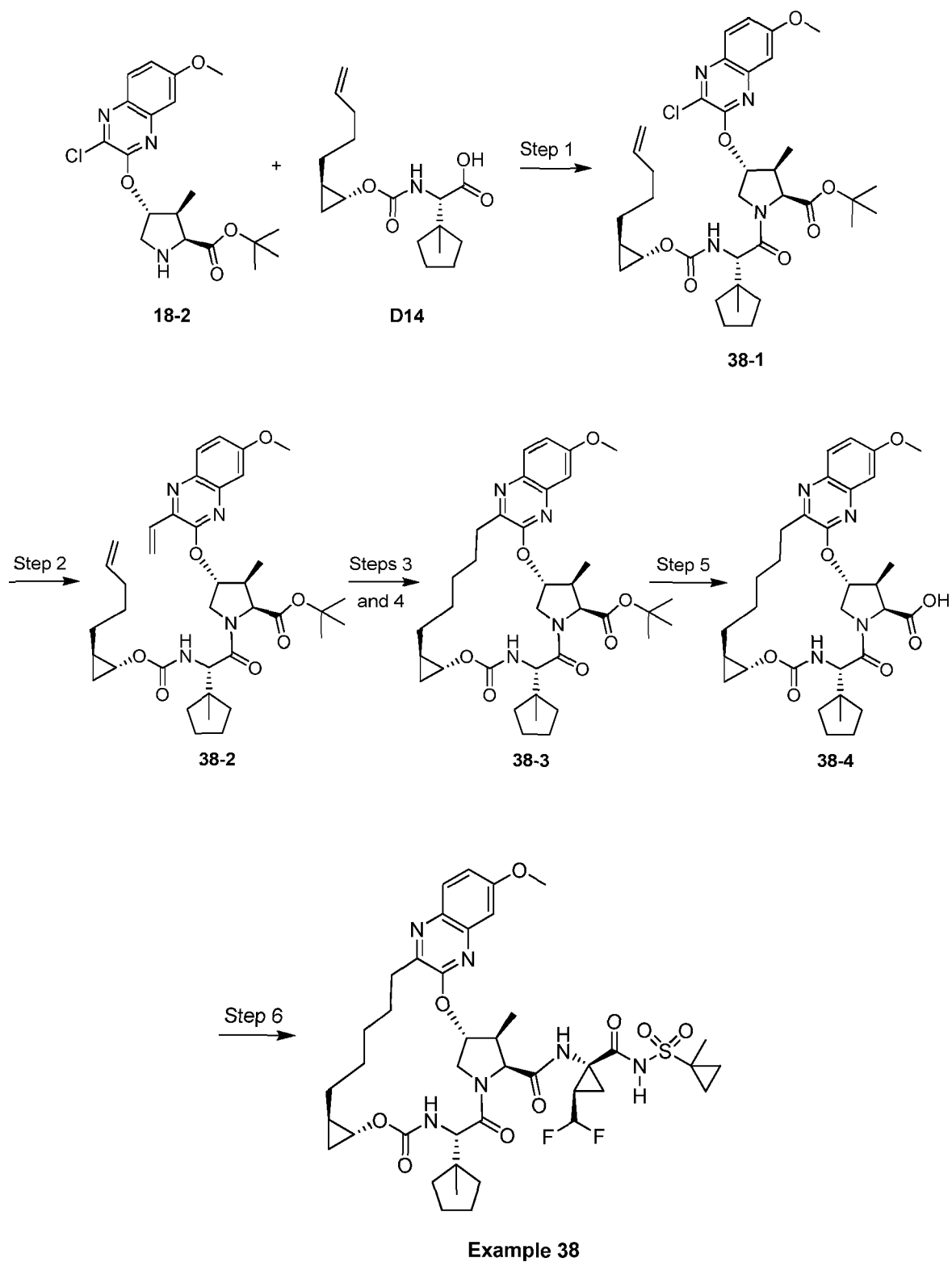
Example **37**. Preparation of (1R,4S,4aR,8S,11S,12S,13R,25aR)-8-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-12-ethyl-17-methoxy-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-hexadecahydro-1H,11H-1,4:10,13-dimethanoquinoxalino[2,3-k][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide.



Step 1. Preparation of Example **37**: To a solution of **13-6** (76 mg, 0.12 mmol), Intermediate **A10** (44 mg, 0.14 mmol), HATU (55 mg, 0.14 mmol) and DMAP (21 mg, 0.18 mmol) in DMF (2 mL) was added DIPEA (0.11 mL, 0.6 mmol) and the reaction was stirred at rt for 16 h. Additional Intermediate **A10** (44 mg, 0.14 mmol), HATU (55 mg, 0.14 mmol), DMAP (21 mg, 0.18 mmol), followed by DIPEA (0.11 mL, 0.6 mmol) was added and the reaction was stirred at 40 °C for 50 h. The reaction was quenched with water, diluted with EtOAc, washed with sat. aqueous NaHCO₃, brine, dried over anhydrous MgSO₄ and concentrated *in vacuo*. The crude material was purified by reverse phase HPLC (Gemini, 45–85% MeCN/H₂O + 0.1% TFA) and lyophilized to give Example **37** (30 mg) as a TFA salt. Analytic HPLC RetTime: 9.44 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₄H₆₁F₂N₆O₉S: 887.42; found: 887.50. ¹H NMR (400 MHz, CD₃OD) δ 9.24 (s, 1H), 7.76 (d, J = 9.2 Hz, 1H), 7.20 (dd, J = 8.8, 2.4 Hz, 1H), 7.12 (m, 1H), 5.95 – 5.66 (m, 2H), 5.43 (s, 1H), 4.51 (d, J = 7.6 Hz, 1H), 4.41 (s, 1H), 4.20 – 4.10 (m, 2H), 3.88 (s, 3H), 2.94 – 2.88 (m, 1H), 2.73 – 2.63 (m, 2H), 2.11 (br, 2H), 2.02 – 0.83 (m, 41H).

Example **38**. Preparation of (1aR,5S,8S,9S,10R,22aR)-N-[(1R,2R)-2-(difluoromethyl)-1-[[[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-9-methyl-5-(1-methylcyclopentyl)-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide



Step 1. Preparation of **38-1**: Amine **18-2** (192 mg, 0.487 mmol) was treated with BEP (246 mg, 0.898 mmol), Intermediate **D14** (278 mg, 0.898 mmol), EtOAc (9 mL), NMP (1 mL) and DIPEA (0.42 mL, 2.4 mmol), then heated to 50 °C. After 1 h, the reaction mixture was diluted with EtOAc. The organic solution was washed successively with sat. aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography (15% to 35% EtOAc/Hex) to afford amide **38-1** (264 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₀ClN₄O₇: 685.34; found: 685.82.

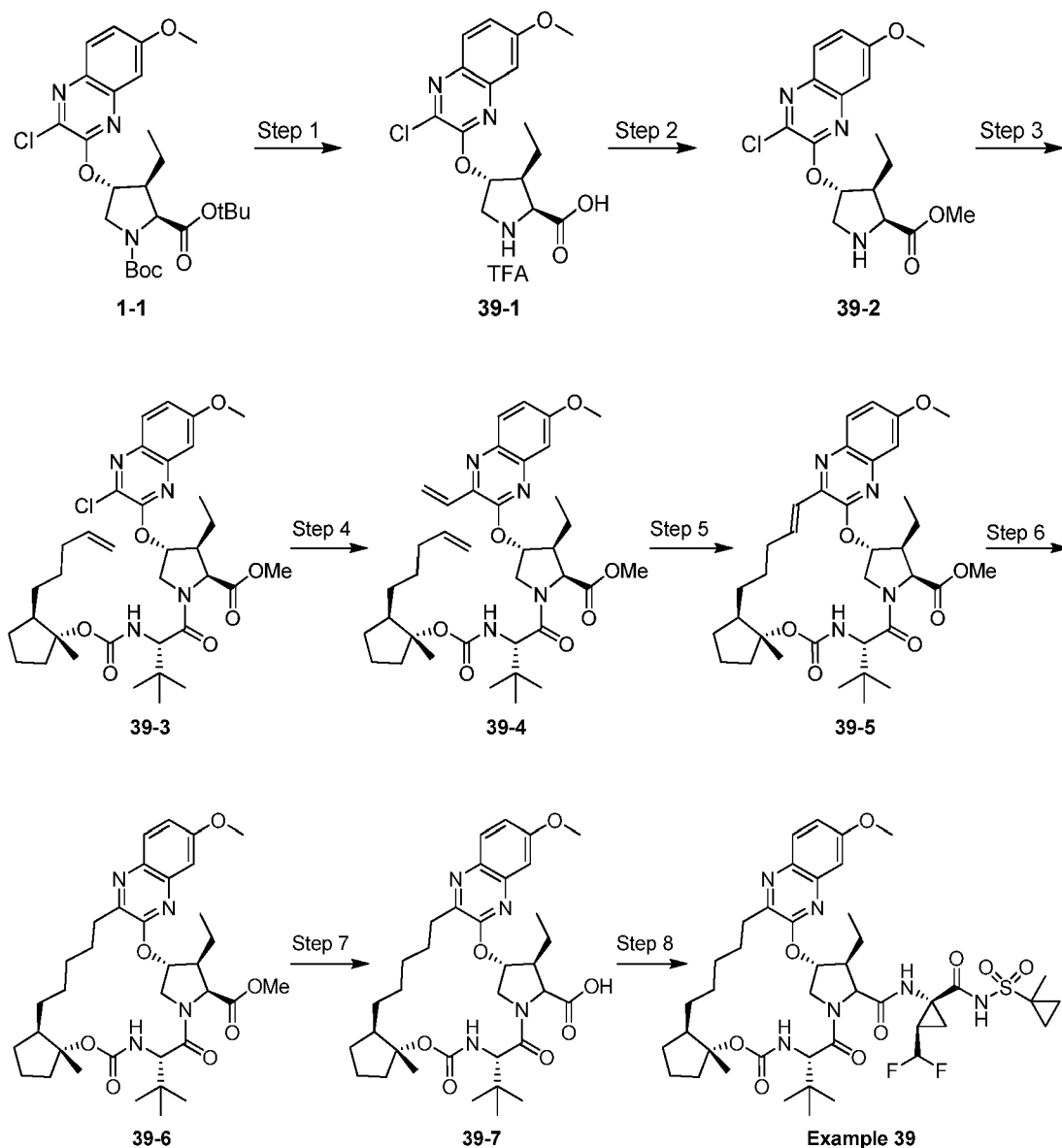
Step 2. Preparation of **38-2**: Amide **38-1** (264 mg, 0.385 mmol) was treated with potassium vinyltrifluoroborate (82 mg, 0.615 mmol), Pd(dppf)Cl₂•DCM (33 mg, 0.041 mmol), EtOH (4.0 mL) and TEA (0.086 mL, 0.62 mmol), then heated to reflux. After 55 min, the reaction mixture was diluted with EtOAc and washed with H₂O and brine. The organics were dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography (15% to 30% EtOAc/Hex) to afford vinyl quinoxaline **38-2** (168 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₃N₄O₇: 677.39; found: 677.38.

Steps 3 and 4. Preparation of **38-3**: Vinyl quinoxaline **38-2** (225 mg, 0.332 mmol) was suspended in DCE (66 mL) and treated with Zhan 1B catalyst (42 mg, 0.067 mmol, Strem). The suspension was degassed with bubbling N₂ for 28 min, then heated to reflux for 90 min. The reaction mixture was then filtered over Celite and concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (15% to 30% EtOAc/Hex) to afford the desired macrocycle (168 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉N₄O₇: 649.36; found: 649.33). The macrocycle was dissolved in EtOH (25 mL) and EtOAc (5 mL) and treated with Pd/C (10 wt% Pd, 95 mg). Hydrogen from a balloon was bubbled through the suspension for 1 min the reaction was stirred under an H₂ atmosphere for an additional 1.5 h. Upon completion, the reaction mixture was filtered over Celite and concentrated *in vacuo* to afford the desired macrocycle **38-3** which was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.38; found: 651.42.

Step 5. Preparation of **38-4**: Unpurified **38-3** from the previous step was dissolved in DCM (10 mL) and treated with TMSOTf (0.23 mL, 1.3 mmol). After stirring at rt for 1 h 15 min, the reaction mixture was concentrated *in vacuo*. The residue was redissolved in DCM and pipetted into 1 M aqueous NaOH. The mixture was agitated for 1 min, then acidified to pH ~ 1–2 with 10% aqueous HCl. The aqueous layer was extracted three times with DCM and combined organics dried over anhydrous MgSO₄, filtered and concentrated *in vacuo*. The crude material was purified by silica gel chromatography (0% to 20% MeOH/EtOAc) to afford carboxylic acid **38-4** (131 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₃N₄O₇: 595.31; found: 595.29.

Step 6. Preparation of Example **38**: Carboxylic acid **38-4** (131 mg, 0.220 mmol) and Intermediate **A10** (81 mg, 0.264 mmol) were treated with TBTU (85 mg, 0.264 mmol), DMAP (32 mg, 0.264 mmol), DCM (2.6 mL) and DIPEA (0.38 mL, 2.2 mmol). The reaction mixture was stirred at rt for 14 h, then concentrated under reduced pressure. The crude residue was purified by HPLC to afford Example **38** (74 mg) in approximately 90% purity as a TFA salt. Analytic HPLC RetTime: 8.93 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₂N₆O₉S: 845.37; found: 845.57. ¹H NMR (400 MHz, CD₃OD) δ 9.12 (s, 1H), 7.77 (d, *J* = 9.2 Hz, 1H), 7.20 (dd, *J* = 9.0 Hz, 2.7 Hz, 1H), 7.16 (d, *J* = 2.8 Hz, 1H), 5.81 (td, *J* = 55.9, 6.6 Hz, 1H), 5.59 (d, *J* = 3.5 Hz, 1H), 4.52 (d, *J* = 6.8 Hz, 1H), 4.50 (s, 1H), 4.40 (d, *J* = 12.0 Hz, 1H), 4.18 (dd, *J* = 11.9 Hz, 3.9 Hz, 1H), 3.93 (s, 3H), 3.74 (m, 1H), 2.97–2.90 (m, 1H), 2.85–2.75 (m, 2H), 2.01 (m, 2H), 1.85–1.41 (m, 21H), 1.12 (s, 3H), 1.08 (d, *J* = 7.4 Hz, 3H), 0.96 (m, 2H), 0.91 (t, *J* = 4.3 Hz, 2H), 0.70 (m, 1H), 0.48 (m, 1H).

Example **39**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-11-ethyl-16-methoxy-3a-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.



5

Step 1. Preparation of **39-1**: Quinoxaline ether **1-1** (588.7 mg, 1.159 mmol) was dissolved in TFA (5 mL). The solution was stirred at room temperature for 3 h. The TFA was removed *in vacuo* to give the TFA salt of **39-1** (631.2 mg) as a colorless powder. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₆H₁₉ClN₃O₄: 352.1; found: 352.1.

Step 2. Preparation of **39-2**: The TFA salt of **39-1** (631.2 mg, 1.159 mmol) was dissolved in CH₂Cl₂/MeOH (3 mL/3 mL). To the solution was added a

solution of TMSCHN₂ (2 M hexane, 3 mL, 5.177 mmol) at rt. The solution was stirred for 30 min to produce a suspension that was filtered through a fritted glass funnel to remove solids. The filtrate was concentrated *in vacuo* to afford a residue that was purified by silica gel chromatography (100% ethyl acetate) to produce methyl ester **39-2** (213.0 mg) as colorless crystals. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₇H₂₁ClN₃O₄: 366.1; found: 366.1.

Step 3. Preparation of **39-3**: Intermediate **D7** (191.2 mg, 0.587 mmol) and methyl ester **39-2** (414.1 mg, 1.132 mmol) were treated with HATU (860.0 mg, 2.264 mmol) and DIPEA (0.59 mL, 3.396 mmol) in DMF (8 mL) at rt for 4 h. The reaction was quenched with H₂O (50 mL) and extracted with EtOAc (50 mL three times). The combined organics were washed with brine (50 mL) and dried over anhydrous Na₂SO₄. After removal of drying agent by filtration, the solvent was removed *in vacuo*. The residue was purified by silica gel chromatography (20% ethyl acetate in hexanes) to give the desired amide **39-3** (573.9 mg) as colorless oil. LCMS-ESI⁺ (*m/z*): [M+Na]⁺ calcd for C₃₃H₄₉ClN₄NaO₇: 695.3; found: 695.3.

Step 4. Preparation of **39-4**: Amide **39-3** (573.9 mg, 0.8524 mmol), potassium trifluorovinylborate (171.3 mg, 1.279 mmol) and PdCl₂dppf•CH₂Cl₂ (62.4 mg, 0.085 mmol) were treated with Et₃N (0.18 mL, 1.279 mmol) in EtOH (8 mL) under a nitrogen atmosphere and gently refluxed for 30 min. The reaction was diluted with PhMe (30 mL) and the solvent was removed *in vacuo*. The residue was purified by silica gel chromatography (20% ethyl acetate in hexanes) to give the desired vinyl quinoxaline **39-4** (542.0 mg, 0.8152 mmol) as an orange foam. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₂N₄NaO₇: 687.4; found: 687.3.

Step 5. Preparation of **39-5**: The vinyl quinoxaline **39-4** (542.0 mg, 0.8152 mmol) was treated with Zhan 1b catalyst (59.8 mg, 0.08 mmol, Strem) in DCE (41 mL). The mixture was heated at 80 °C for 1 h. Additional Zhan 1b catalyst (59.8 mg, 0.08 mmol, Strem) was added and the mixture to heat at 80 °C for an additional 30 min. The solvent was removed *in vacuo* and the residue purified by silica gel chromatography (20% ethyl acetate in hexanes) to produce macrocycle **39-5** (401.0 mg, 0.6297 mmol) as an orange oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.4; found: 637.3.

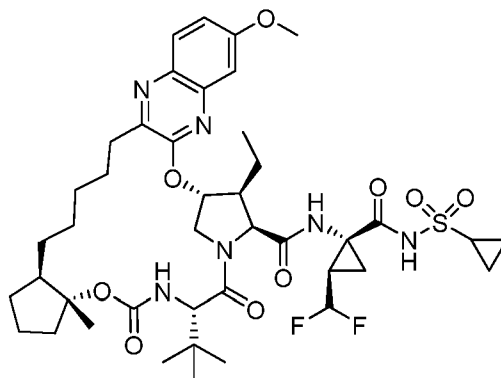
Step 6. Preparation of **39-6**: Macrocycle **39-5** (401.0 mg, 0.6297 mmol) was taken up in 1,4-dioxane (15 mL) and treated with Pd/C (10% wt Pd, 200.0 mg) and MgO (200.0 mg) stirred under an atmosphere of hydrogen. The mixture was stirred at rt for 1 h. The reaction mixture was filtered through Celite (5 g) using EtOAc (80 mL). The solvent was removed *in vacuo* to give macrocycle **39-6** (425.3 mg) as a pale orange oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₅₁N₄O₇: 639.4; found: 639.3.

Step 7. Preparation of **39-7**: Macrocycle **39-6** (74.8 mg, 0.110 mmol) was treated with 2 M aqueous LiOH aqueous solution (1.6 mL, 3.15 mmol) in MeOH/THF (4 mL /4 mL) at rt for 8 h, 50 °C for 2 h and then 60 °C for 3 h. The mixture was cooled to 0 °C using ice-water bath. To the mixture was added brine (30 mL). The whole was extracted with CH₂Cl₂ (30 mL three times). The organic layer was washed with brine (30 mL) and dried over anhydrous Na₂SO₄. After removal of the drying agent by filtration, the solvent was removed *in vacuo* to give carboxylic acid **39-7** (370.6 mg, 0.5932 mmol) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₉N₄O₇: 625.4; found: 625.3.

Step 8. Preparation of Example **39**: Carboxylic acid **39-7** (100.0 mg, 0.1601 mmol) and Intermediate **A10** (73.2 mg, 0.2401 mmol) were treated with HATU (91.3 mg, 0.2401 mmol) and DIPEA (0.14 mL, 0.8005 mmol) in DMF (3 mL) at rt for 5 h. The reaction was quenched with H₂O (30 mL) and extracted with EtOAc (30 mL three times). The organic layer was washed with brine (30 mL) and dried over anhydrous Na₂SO₄. After removal of the drying agent by filtration, the solvent was removed *in vacuo*. The residue was purified by silica gel chromatography (25 to 100% ethyl acetate in hexanes). Fractions containing desired product were concentrated *in vacuo* and the residue further purified by super critical fluid column chromatography (DAICEL Chiralpak IC 10x250 mm, 18.9 mL/min, 35% MeOH, 15 atm, 40 °C) to give Example **39** (80.5 mg, 0.0920 mmol, 57%) as a colorless powder. Analytic HPLC RetTime: 9.35 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₆₁F₂N₆O₉S: 875.4; found: 875.4. ¹H NMR (300 MHz, CD₃OD) δ 7.81 (d, *J* = 9.6 Hz, 1H), 7.27 (s, 1H), 7.24 (d, *J* = 9.6 Hz, 1H), 6.68 (d, *J* = 9.6 Hz, 1H), 5.74–6.30 (m, 3H), 4.73 (d, *J* = 7.2 Hz, 1H), 4.73 (d, *J* =

7.2 Hz, 1H), 4.40–4.60 (m, 1H), 4.22 (d, $J = 9.6$ Hz, 1H), 3.95 (s, 3H), 3.61 (q, $J = 7.2$ Hz, 2H), 3.16–3.30 (m, 1H), 2.50–2.77 (m, 2H), 2.20–0.60 (m, 21H), 1.35 (s, 3H) 1.12 (t, $J = 7.2$ Hz, 3H), 1.18 (s, 3H), 1.02 (s, 9H).

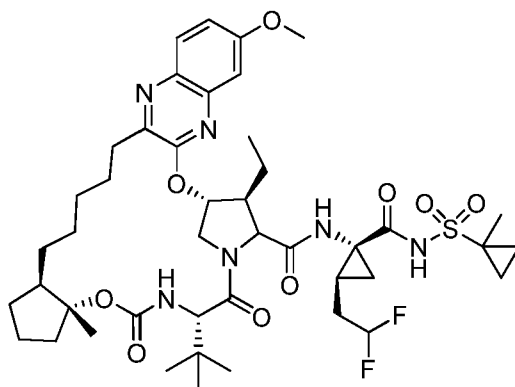
- 5 Example **40**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-11-ethyl-16-methoxy-3a-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide



Example 40

- Example **40** was prepared in a similar fashion to Example **39**, substituting Intermediate **A9** for Intermediate **A10** in Step 8. Example **40** was isolated (70.9 mg) in approximately 92% purity. Analytic HPLC RetTime: 9.24 min. LCMS-ESI⁺ (m/z): $[M+H]^+$ calcd for C₄₂H₅₉F₂N₆O₉S: 861.4; found: 861.4. ¹H NMR (300 MHz, CD₃OD) δ 7.80 (d, $J = 9.6$ Hz, 1H), 7.25 (s, 1H), 7.23 (d, $J = 9.6$ Hz, 1H), 6.70 (d, $J = 9.6$ Hz, 1H), 5.60–6.10 (m, 3H), 4.69 (d, $J = 7.2$ Hz, 1H), 4.39 (dd, $J = 12.0$, 6.0 Hz, 1H), 4.2 (d, $J = 9.6$ Hz, 1H), 4.03–4.10 (m, 1H), 3.94 (s, 3H), 3.12–3.28 (m, 1H), 2.89–3.05 (m, 1H), 2.50–2.76 (m, 2H), 2.30–0.80 (m, 19H), 1.36 (s, 3H) 1.25 (t, $J = 7.2$ Hz, 3H), 1.10 (s, 3H), 1.04 (s, 9H).

Example **41**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-[(1R,2S)-2-(2,2-difluoroethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-11-ethyl-16-methoxy-3a-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.

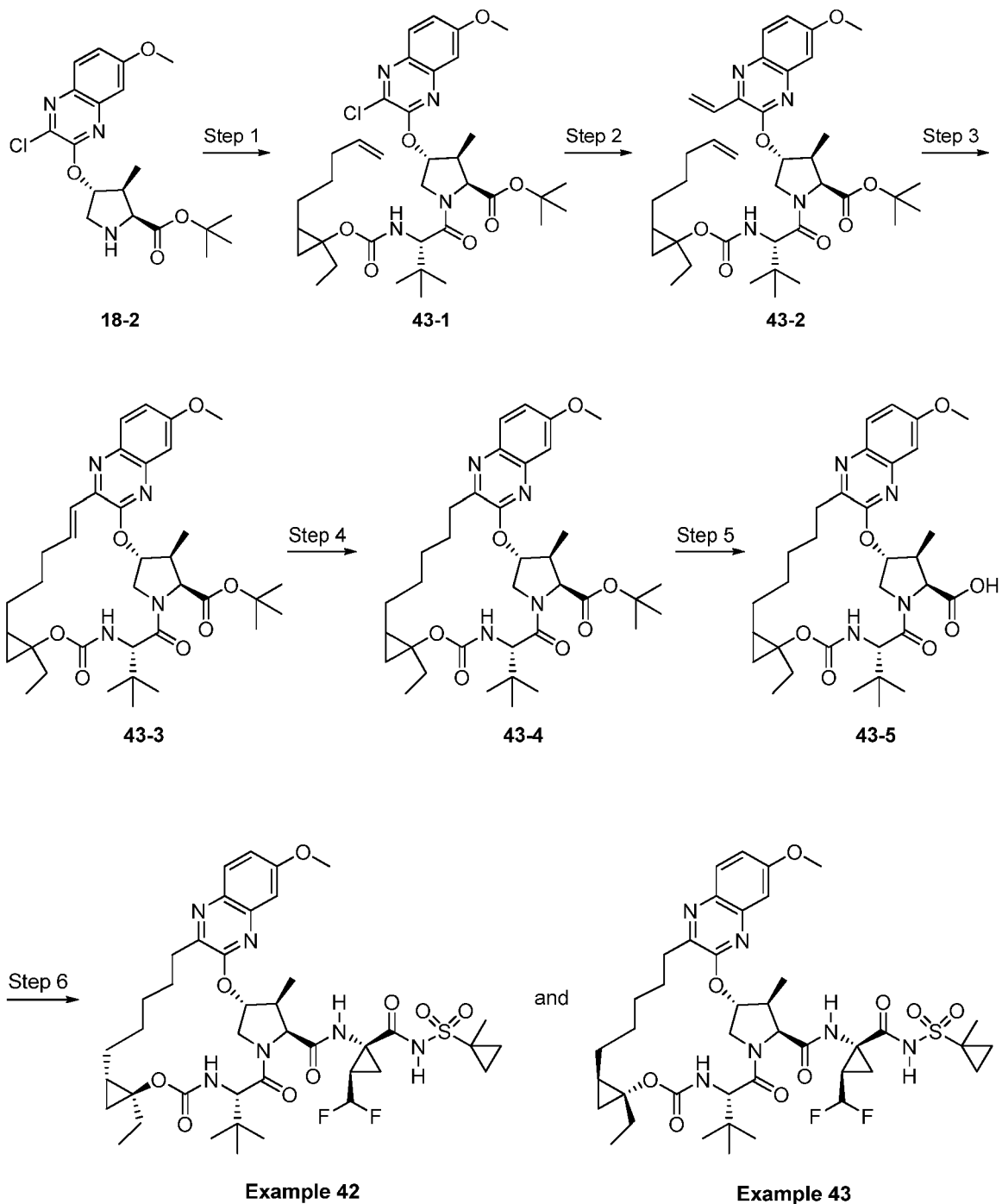


Example **41**

Example **41** was prepared in a similar fashion to Example **39**, substituting Intermediate **A8** for Intermediate **A10** in Step 8. Example **41** was isolated (4.3 mg) in approximately 92% purity. Analytic HPLC RetTime: 9.36 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₉F₂N₆O₉S: 889.4; found: 889.5. ¹H NMR (300 MHz, CD₃COCD₃) δ 7.83 (d, *J* = 7.83 Hz, 1H), 7.19–7.30 (m, 1H), 5.74–6.30 (m, 3H), 4.70 (d, *J* = 7.2 Hz, 1H), 4.19 (dd, *J* = 12.0, 6.0 Hz, 1H), 4.24 (d, *J* = 9.6 Hz, 1H), 4.12 (d, *J* = 12.0, 9.6 Hz, 1H), 3.96 (s, 3H), 3.10–3.26 (m, 1H), 2.56–2.80 (m, 2H), 2.30–0.80 (m, 25H), 1.54 (s, 3H), 1.42 (s, 3H), 1.12 (t, *J* = 7.2 Hz, 3H), 1.06 (s, 9H).

Example **42** and Example **43**. Preparation of (1aS,5S,8S,9S,10R,22aS)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-1a-ethyl-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-

- b]quinoxaline-8-carboxamide and (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-1a-ethyl-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide



Step 1. Preparation of **43-1**: To a solution of Intermediate mixture **D15** (281 mg, 0.81 mmol) and Intermediate **18-2** (290 mg, 0.74 mmol) in MeCN (3.7 mL) was added HATU (308 mg, 0.81 mmol) followed by DIPEA (640 μ L, 3.68 mmol) at rt under an argon atmosphere. After 17 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **43-1** (121 mg, 1:1 diastereomeric mixture) as a colorless oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₂ClN₄O₇: 687.3; found: 687.5.

Step 2. Preparation of **43-2**: To a solution of diastereomeric mixture **43-1** (121 mg, 176 μ mol), TEA (38 μ L, 264 μ mol) and potassium vinyltrifluoroborate (35.4 mg, 264 μ mol) in EtOH (0.88 mL) was added PdCl₂(dppf) (14.4 mg, 17.6 μ mol). The reaction mixture was degassed with argon for 10 min and heated to 78 °C. After 25 min, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **43-2** (105 mg, 1:1 diastereomeric mixture) as a yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₅N₄O₇: 679.4; found: 679.5.

Step 3. Preparation of **43-3**: To a solution of diastereomeric mixture **43-2** (105 mg, 155 μ mol) in DCE (31 mL) was added Zhan 1B catalyst (11.3 mg, 15.5 μ mol, Strem) and the reaction mixture was degassed for 10 minutes with argon. The reaction mixture was then heated to 100 °C. After 15 min, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes) to afford **43-3** (52.3 mg, 1:1 diastereomeric mixture) as a light yellow oil. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.4; found: 651.5.

Step 4. Preparation of **43-4**: To a solution of diastereomeric mixture **43-3** (52 mg, 80 μ mol) in ethanol (0.4 mL) was added Pd/C (10 wt % Pd, 9 mg, 8 μ mol) at rt under an argon atmosphere. The atmosphere was replaced with hydrogen and the reaction mixture was stirred vigorously at rt. After 45 min, the reaction mixture was diluted with ethyl acetate (1 mL) and was filtered through a

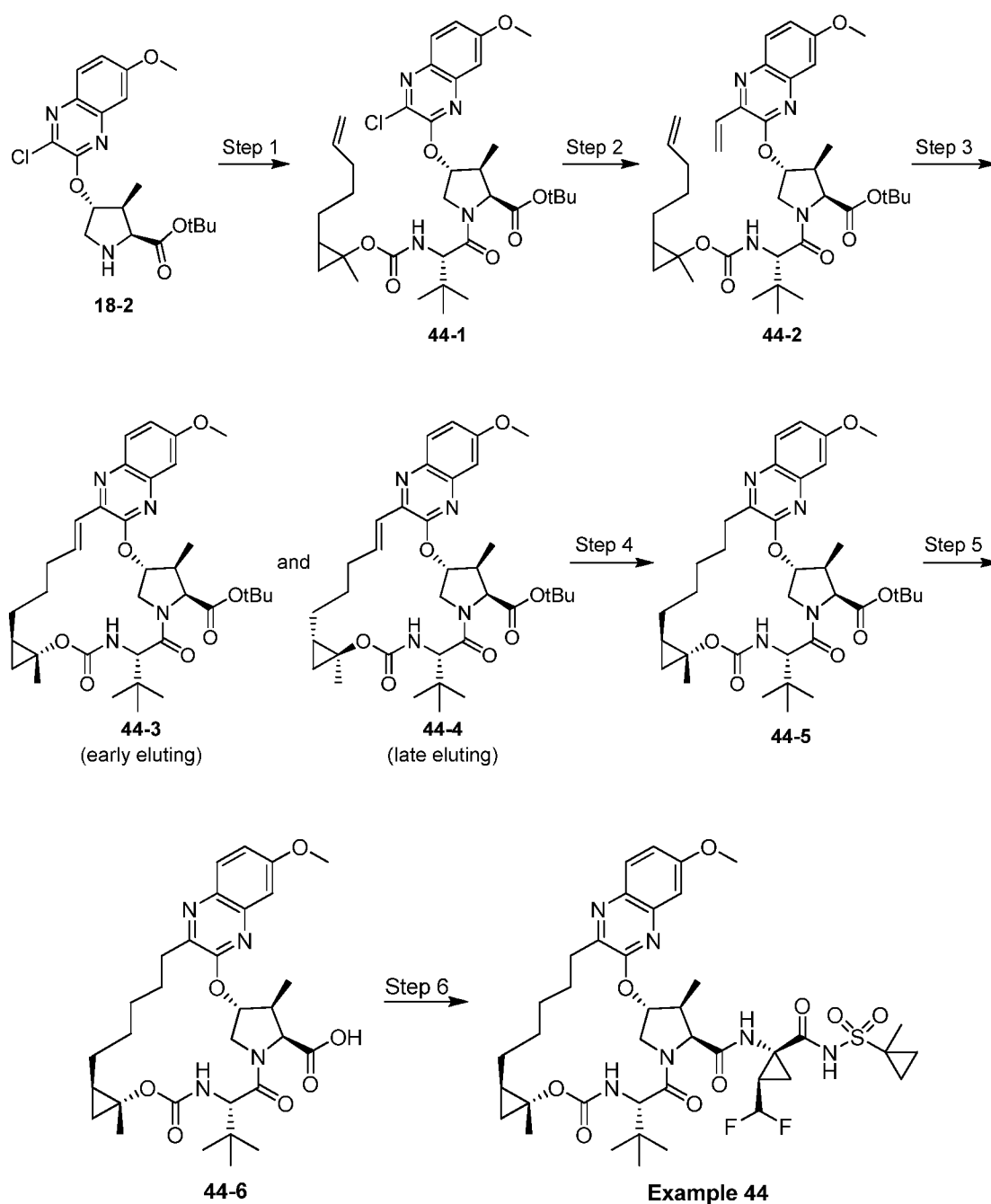
pad of Celite with ethyl acetate washings (3 × 1 mL). The filtrate was concentrated *in vacuo* to afford **43-4** (49 mg, 1:1 diastereomeric mixture), which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₂N₄O₇: 653.4; found: 653.6.

5 Step 5. Preparation of **43-5**: To a solution of diastereomeric mixture **43-4** (49 mg, 67 μmol) in DCM (0.5 mL) was added TMSOTf (60 μL, 0.34 mmol) at rt under an argon atmosphere. After 3 h, the reaction mixture was added slowly to a 0.25 N aqueous NaOH solution (precooled to 0 °C, 1 mL). The resulting mixture was diluted with 1 N aqueous HCl solution (5 mL), and was extracted
10 with DCM (3 × 5 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated to afford **43-5** (71 mg, 1:1 diastereomeric mixture) as a tan solid, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₅N₄O₇: 597.3; found: 597.5.

15 Step 6. Preparation of Examples **42** and **43**: To a solution of diastereomeric mixture **43-5** (71 mg, ~67 μmol) and Intermediate **A10** (54 mg, 178 μmol) in MeCN (1.00 mL) was added HATU (69 mg, 178 μmol) followed by DIPEA (155 μL, 0.89 mmol) at rt under an argon atmosphere. After 1 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified
20 by silica gel chromatography (0–100% ethyl acetate/hexanes). The fractions containing the desired product were combined and repurified by preparatory HPLC (Gemini 5u C18 110Å column, 50–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and were lyophilized to afford Example **42** (10 mg) and Example **43** (10 mg) as off white powders. Example **42**: Analytic HPLC RetTime: 9.04 min.
25 [M+H]⁺ calcd for C₄₁H₅₇F₂N₆O₉S: 847.4; found: 847.6. ¹H NMR (400 MHz, CD₃OD) δ 8.98 (s, 1H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.20 – 7.13 (m, 2H), 5.70 (td, *J* = 55.8, 6.4 Hz, 1H), 5.65 (d, *J* = 3.7 Hz, 1H), 5.44 (br s, 1H), 4.55 – 4.42 (m, 1H), 4.20 – 4.03 (m, 1H), 3.87 (s, 3H), 3.17 – 3.08 (m, 1H), 2.85 – 2.72 (m, 1H), 2.71 – 2.59 (m, 1H), 2.18 – 2.06 (m, 1H), 2.03 – 1.83 (m, 4H), 1.80 – 1.53 (m, 5H),
30 1.50 (br s, 3H), 1.46 (s, 3H), 1.40 – 1.31 (m, 1H), 1.33 – 1.09 (m, 5H), 1.06 (s, 9H), 1.05 – 0.95 (m, 6H), 0.92 – 0.73 (m, 3H). Example **43**: Analytic HPLC

RetTime: 9.17 min. $[M+H]^+$ calcd for $C_{41}H_{57}F_2N_6O_9S$: 847.4; found: 847.6. ^1H NMR (400 MHz, CD_3OD) δ 9.03 (s, 1H), 7.68 (d, $J = 9.5$ Hz, 1H), 7.14 – 7.09 (m, 2H), 5.68 (td, $J_{H-F} = 55.5, 6.7$ Hz, 1H), 5.59 (d, $J = 3.7$ Hz, 1H), 4.45 (d, $J = 6.8$ Hz, 1H), 4.29 (d, $J = 12.1$ Hz, 1H), 4.12 (s, 1H), 4.08 (dd, $J = 12.1, 4.3$ Hz, 1H), 3.82 (s, 3H), 2.90 – 2.79 (m, 1H), 2.79 – 2.70 (m, 1H), 2.66 – 2.56 (m, 1H), 2.43 – 2.31 (m, 1H), 1.95 – 1.85 (m, 2H), 1.75 – 1.62 (m, 1H), 1.61 – 1.42 (m, 5H), 1.44 (br s, 3H), 1.40 (s, 3H), 1.34 – 1.02 (m, 8H), 1.00 (s, 9H), 0.99 – 0.89 (m, 5H), 0.85 – 0.74 (m, 3H).

- 10 Example **44**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
[(1R,2R)-2-(difluoromethyl)-1-[(1-
methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-1a,9-dimethyl-
3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-
methanocyclopropano[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
15 b]quinoxaline-8-carboxamide.



5

Step 1. Preparation of **44-1**: HATU (544 mg, 1.43 mmol, Oakwood) and DIPEA (0.83 mL, 4.76 mmol) were added to a mixture of **18-2** (429 mg, 1.09 mmol) and an Intermediate mixture **D6** (395 mg, 1.33 mmol) in 12 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was concentrated under reduced pressure and the resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to produce **44-1**

(545 mg; 1:1 mixture of diastereomers) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₅₀ClN₄O₇: 673.33; found: 673.47.

Step 2. Preparation of **44-2**: Pd(dppf)Cl₂•CH₂Cl₂ (74 mg, 0.091 mmol, Strem) was added to a deoxygenated mixture of **44-1** (542 mg, 0.805 mmol),
5 potassium vinyltrifluoroborate (168 mg, 1.25 mmol), and triethylamine (0.170 mL, 1.21 mmol) in 9 mL of EtOH at room temperature. Reaction mixture was heated at 78 °C under argon for 75 minutes. After cooling to rt, 6 mL of toluene was added and reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–35% ethyl acetate in hexanes) to
10 yield **44-2** (438 mg; 1:1 mixture of diastereomers) as a yellow film. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₃N₄O₇: 665.38; found: 665.55.

Step 3. Preparation of **44-3** and **44-4**: A diastereomeric mixture **44-2** (437 mg, 0.658 mmol) and Zhan 1B catalyst (81 mg, 0.072 mmol, Strem) in 131 mL of DCE was deoxygenated under argon for 25 minutes. The mixture was then
15 heated at 95 °C for 50 minutes. An additional 7 mg of Zhan 1B catalyst was added and reaction mixture was heated at 95 °C for 10 minutes. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–40% ethyl acetate in hexanes) to yield single diastereomers **44-3** (143 mg, early eluting component)
20 as a light yellow film and **44-4** (118 mg, late eluting component) as a light yellow solid. Early eluting **44-3**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.35; found: 637.45. Late eluting **44-4**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉N₄O₇: 637.35; found: 637.59.

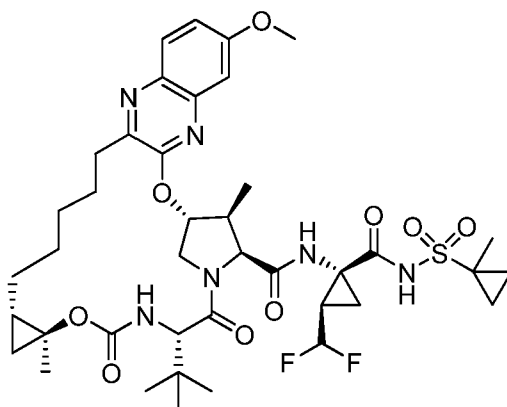
Step 4. Preparation of **44-5**: Palladium on carbon (10 wt % Pd, 48 mg, 0.045 mmol) was added to a solution of **44-3** (143 mg, 0.225 mmol) in 6 mL of ethanol. The atmosphere was replaced with hydrogen and the reaction stirred
25 for 90 minutes. The reaction mixture was filtered over Celite and washed with ethyl acetate. Filtrate was concentrated *in vacuo* to yield **44-5** (130 mg) as brown solid film, which was used in the next step without further purification.
30 LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₅₁N₄O₇: 639.37; found: 639.53.

Step 5. Preparation of **44-6**: TMSOTf (0.53 mL, 2.91 mmol) was added dropwise to a solution of **44-5** (130 mg, 1.27 mmol) in 3.8 mL of dichloromethane under argon at room temperature. After one hour, an additional 0.22 mL of TMSOTf was added. After an additional hour, 0.20 mL of TMSOTf was added.

- 5 After 40 minutes, 0.25 mL of TMSOTf was added. After one hour, reaction mixture was taken up in 10 mL of dichloromethane and quenched by addition of 20 mL of 1 N aqueous HCl with stirring. Layers were separated and aqueous was extracted with dichloromethane (3 x 30 mL). Combined organics were washed with brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo* to yield **44-6** (113 mg) as an off white solid, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₄₃N₄O₇: 583.31; found: 583.45.

- Step 6. Preparation of Example **44**: HATU (53 mg, 0.139 mmol) and DIPEA (0.080 mL, 0.459 mmol) were added to a mixture of **44-6** (51 mg, 0.088 mmol) and Intermediate **A10** (49 mg, 0.161 mmol) in 1.5 mL of MeCN under argon. After stirring for overnight, an additional 13 mg of Intermediate **A10** was added. After one hour, reaction mixture was taken up in 15 mL of ethyl acetate and poured into 20 mL of 1 N aqueous HCl. Layers were separated and aqueous was extracted three times with ethyl acetate. Combined organics were washed with water and brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–40% ethyl acetate in hexanes) to yield Example **44** (41 mg) as an off white solid. Analytic HPLC RetTime: 8.86 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₅F₂N₆O₉S: 833.36; found: 833.51. ¹H NMR (400 MHz, CD₃OD): 7.79 (d, J = 10 Hz, 1H), 7.28–7.21 (m, 2H), 6.77 (d, J = 8.4 Hz, 1H), 5.81 (td, J_{H-F} = 56 Hz, J = 6.4 Hz, 1H), 5.73–5.70 (m, 1H), 4.56 (d, J = 7.2 Hz, 1H), 4.40 (d, J = 11.6 Hz, 1H), 4.26–4.16 (m, 2H), 3.93 (s, 3H), 3.05–2.91 (m, 1H), 2.90–2.82 (m, 1H), 2.77–2.68 (m, 1H), 2.06–1.94 (m, 2H), 1.88–1.74 (m, 1H), 1.72–1.58 (m, 3H), 1.58–1.44 (m, 4H), 1.53 (s, 3H), 1.51 (s, 3H), 1.43–1.36 (m, 1H), 1.12–1.02 (m, 2H), 1.09 (s, 9H), 1.07 (d, J = 4 Hz, 3H), 1.00–0.94 (m, 2H), 0.92–0.84 (m, 3H), 0.16–0.11 (m, 1H).

Example **45**. Preparation of (1aS,5S,8S,9S,10R,22aS)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-1a,9-dimethyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Example **45**

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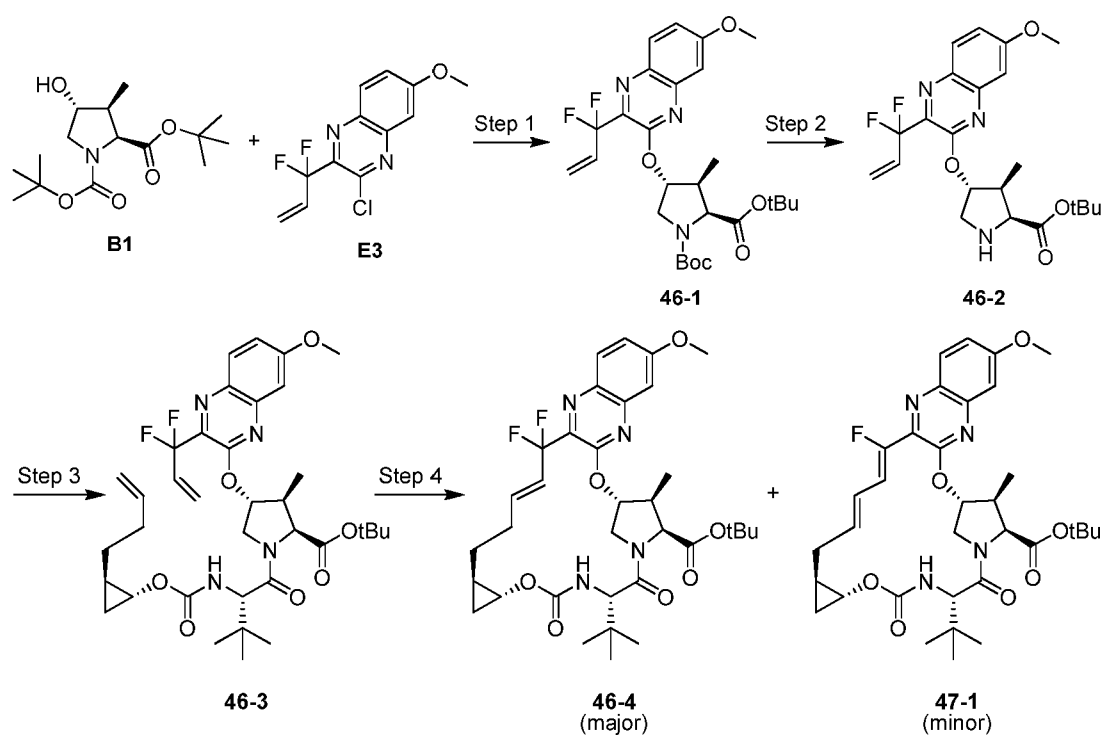
Example **45** was prepared in a similar fashion to Example **44**, substituting late eluting **44-4** for early eluting **44-3** in step 4. Example **45** was isolated (23 mg) as an off white solid. Analytic HPLC RetTime: 8.92 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₅F₂N₆O₉S: 833.36; found: 833.54. ¹H NMR (400 MHz, CD₃OD): 7.79 (d, *J* = 9.2 Hz, 1H), 7.25–7.19 (m, 2H), 6.55 (d, *J* = 5.2 Hz, 1H), 5.78 (td, *J*_{H-F} = 61 Hz, *J* = 6 Hz, 1H), 5.52–5.48 (m, 1H), 4.58 (d, *J* = 6.4 Hz, 1H), 4.52 (d, *J* = 12 Hz, 1H), 4.17–4.10 (m, 1H), 4.04 (d, *J* = 6.4 Hz, 1H), 3.93 (s, 3H), 3.22–3.14 (m, 1H), 2.88–2.80 (m, 1H), 2.78–2.66 (m, 1H), 2.08–1.90 (m, 2H), 1.76–1.64 (m, 1H), 1.63–1.50 (m, 7H), 1.51 (s, 3H), 1.47–1.36 (m, 2H), 1.46 (s, 3H), 1.18–1.06 (m, 1H), 1.12 (s, 9H), 1.07 (m, 3H), 1.00–0.80 (m, 4H), 0.10–0.04 (m, 1H).

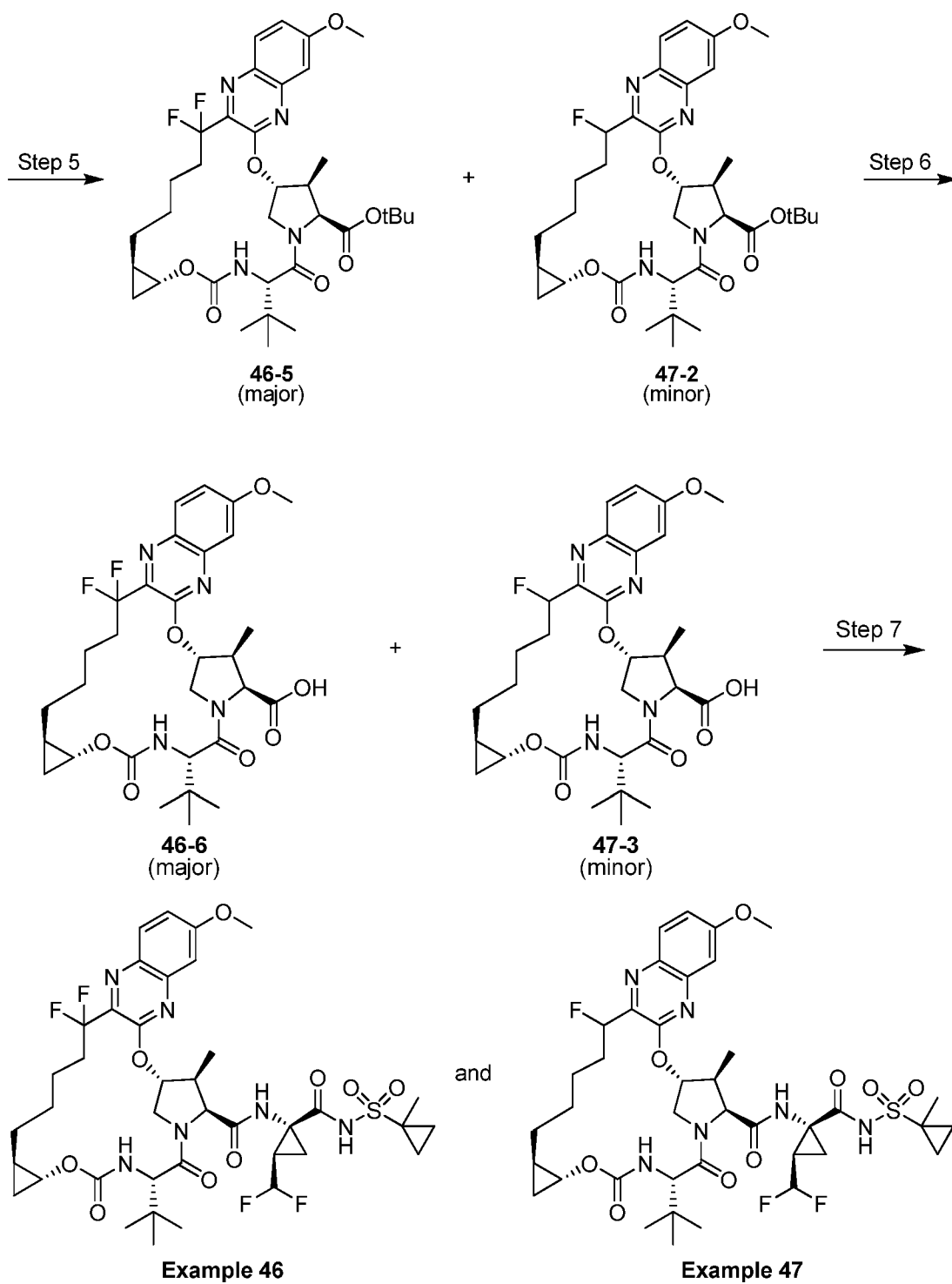
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Example **46** and **47**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-

methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide and (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18-fluoro-14-methoxy-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

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Step 1. Preparation of **46-1**: A mixture of Intermediate **B1** (627 mg, 2.08 mmol), Intermediate **E3** (548 mg, 1.91 mmol) and cesium carbonate (744 mg, 2.28 mmol) in 7 mL of DMF was stirred at 85 °C under argon for 36 hours.

Reaction mixture was cooled to room temperature and poured into 30 mL of water and aqueous was extracted with ethyl acetate (3 x 30 mL). Combined organics were washed with water, brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to yield **46-1** (891 mg) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₇H₃₆F₂N₃O₆: 536.25; found: 536.35.

Step 2. Preparation of **46-2**: Quinoxaline ether **46-1** (478 mg, 0.893 mmol) was dissolved in 4.2 mL of tert-butyl acetate and 1.1 mL of dichloromethane at room temperature. MeSO₃H (0.30 mL, 4.67 mmol) was added dropwise and reaction mixture stirred at rt for 2 h. The reaction mixture was transferred to a stirred mixture of EtOAc (20 mL) and saturated aqueous NaHCO₃ (30 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (2 x 20 mL). The combined organic phase was dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo* to afford amine **46-2** as a yellow solid film (346 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₂H₂₈F₂N₃O₄: 436.20; found: 436.29.

Step 3. Preparation of **46-3**: HATU (396 mg, 1.04 mmol, Oakwood) and DIPEA (0.57 mL, 3.29 mmol) were added to a mixture of **46-2** (345 mg, 0.793 mmol) and Intermediate **D11** (260 mg, 0.965 mmol) in 9 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was concentrated under reduced pressure and the resulting residue was purified by silica gel chromatography (0–40% ethyl acetate in hexanes) to yield **46-3** (545 mg) as a clear solid film. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉F₂N₄O₇: 687.35; found: 687.57.

Step 4. Preparation of **46-4**: A mixture of **46-3** (480 mg, 0.699 mmol) and Zhan 1B catalyst (61 mg, 0.083 mmol, Strem) in 140 mL of DCE was deoxygenated with argon for 18 minutes. The mixture was then heated at 95 °C for 70 minutes. An additional 20 mg of Zhan 1B catalyst was added and mixture stirred at 95 °C for one hour. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel

chromatography (0–35% ethyl acetate in hexanes) to yield an inseparable mixture of **46-4** (major), and approximately 15% of **47-1** (minor; 233 mg total) as an off white solid. Major component **46-4**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₅F₂N₄O₇: 665.38; found: 665.50. Minor component **47-1**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₄FN₄O₇: 639.31; found: 639.49.

Step 5. Preparation of mixture of **46-5** and **47-2**: Palladium on carbon (10 wt % Pd, 70 mg, 0.066 mmol) was added to a solution of the mixture of **46-4** and **47-1** (232 mg, 0.353 mmol) from the previous step in 9 mL of ethanol. The atmosphere was replaced with hydrogen and stirred for 7 h. The reaction was filtered over Celite, washing with ethanol. Filtrate was concentrated *in vacuo* to yield a mixture of **46-5** (major) and **47-2** (minor; 216 mg total) as an off white solid, which was used in the next step without further purification. Major component **46-5**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇F₂N₄O₇: 661.33; found: 661.52. Minor component **47-2**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₈FN₄O₇: 643.34; found: 643.57.

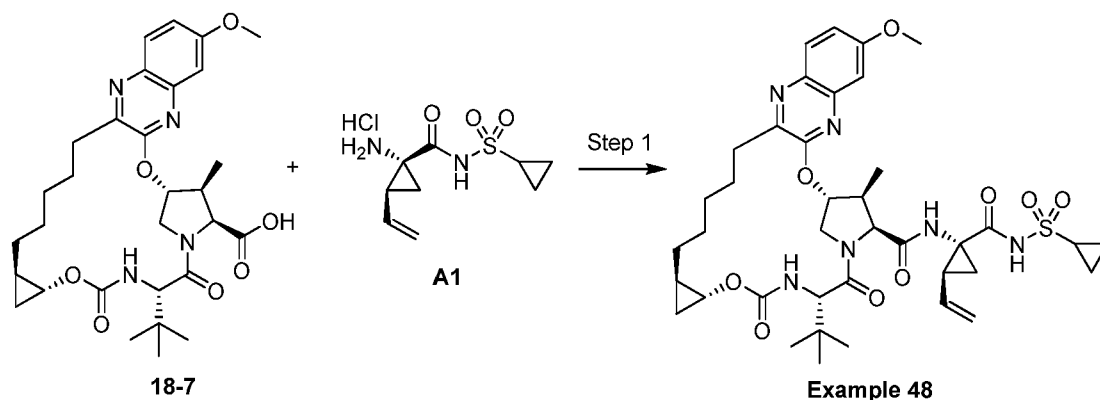
Step 6. Preparation of mixture of **46-6** and **47-3**: TMSOTf (0.35 mL, 1.90 mmol) was added dropwise to a solution of a mixture of **46-5** and **47-2** (215 mg, 0.326 mmol) from the previous step in 6.5 mL of dichloromethane under argon at rt. After 1 h, an additional 0.18 mL of TMSOTf was added. After an additional hour, 0.30 mL of TMSOTf was added. After 2 h, 0.18 mL of TMSOTf was added. After 1 h, an additional 0.18 mL of TMSOTf was added. After 45 minutes, reaction mixture was taken up in 25 mL of dichloromethane and quenched by addition of 30 mL of 1 N aqueous HCl with stirring. The aqueous layer was extracted with dichloromethane (3 x 40 mL). Combined organics were washed with brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo* to yield an inseparable mixture of **46-6** (major) and **47-3** (minor; 187 mg total), which was used in the next step without further purification. Major component **46-6**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₀H₃₉F₂N₄O₇: 605.27; found: 605.44. Minor component **47-3**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₀H₃₉FN₄O₇: 587.28; found: 587.38.

Step 7. Preparation of Example **46** and Example **47**: HATU (160 mg, 0.421 mmol, Oakwood) and DIPEA (0.25 mL, 1.44 mmol) were added to a mixture of **46-6** and **47-3** (150 mg, 0.248 mmol) from the previous step and Intermediate **A10** (150 mg, 0.496 mmol) in 6.5 mL of acetonitrile under argon.

- 5 After stirring for overnight, reaction mixture was taken up in 30 mL of ethyl acetate and poured into 30 mL of 1 N aqueous HCl. The aqueous layer was extracted three times with ethyl acetate. Combined organics were washed with water and brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **46** (107 mg) as a light yellow solid and the trifluoroacetic acid salt of the 1:1 mixture of diastereomers of Example **47** (12 mg) as a light yellow solid.

Example **46**: Analytic HPLC RetTime: 8.60 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₁F₄N₆O₉S: 855.33; found: 855.63. ¹H NMR (400 MHz, CD₃OD): δ 9.23 (s, 1H), 7.94 (d, J = 9.2 Hz, 1H), 7.31 (dd, J = 9.2, 2.8 Hz, 1H), 7.28 (d, J = 2.8 Hz, 1H), 5.78 (td, J_{H-F} = 66 Hz, J = 6.8 Hz, 1H), 5.68–5.66 (m, 1H), 4.57 (d, J = 6.4 Hz, 1H), 4.41 (d, J = 12 Hz, 1H), 4.35 (s, 1H), 4.22–4.16 (dd, J = 12, 4 Hz, 1H), 3.97 (s, 3H), 3.72–3.66 (m, 1H), 2.86–2.76 (m, 1H), 2.64–2.48 (m, 1H), 2.11–1.94 (m, 3H), 1.86–1.74 (m, 3H), 1.73–1.62 (m, 1H), 1.58–1.54 (m, 2H), 1.50 (s, 3H), 1.49–1.44 (m, 1H), 1.42–1.38 (m, 1H), 1.11–1.04 (m, 4H), 1.09 (s, 9H), 1.02–0.94 (m, 2H), 0.93–0.86 (m, 2H), 0.78–0.66 (m, 1H), 0.54–0.46 (m, 1H). Example **47** (1:1 mixture of diastereomers): Analytic HPLC RetTime: 8.45 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₂F₃N₆O₉S: 837.34; found: 837.63. ¹H NMR (400 MHz, CD₃OD): δ 9.13 (s, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.27 (dd, J = 9.2, 2.8 Hz, 1H), 7.24 (d, J = 2.8 Hz, 1H), 5.99–5.43 (m, 1H), 5.79 (td, J_{H-F} = 55 Hz, J = 6.8 Hz, 1H), 5.53–5.50 (m, 1H), 4.57–4.44 (m, 2H), 4.11 (s, 1H), 4.35 (s, 1H), 4.22–4.13 (dd, J = 12.4, 4 Hz, 1H), 3.95 (s, 3H), 3.83–3.79 (m, 1H), 2.94–2.80 (m, 2H), 2.28–2.14 (m, 1H), 2.06–1.96 (m, 2H), 1.88–1.69 (m, 4H), 1.58–1.54 (m, 2H), 1.51 (s, 3H), 1.44–1.36 (m, 1H), 1.32–1.26 (m, 1H), 1.14–1.04 (m, 4H), 1.10 (s, 9H), 1.02–0.86 (m, 4H), 0.74–0.64 (m, 1H), 0.58–0.48 (m, 1H).

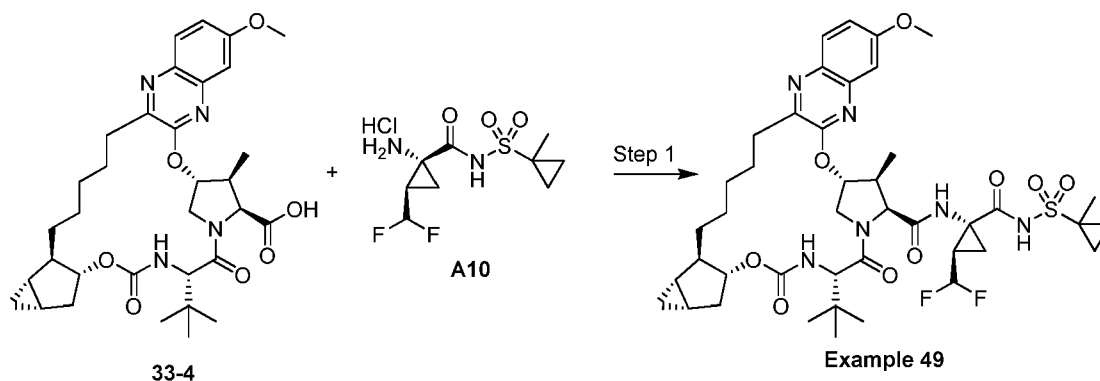
Example **48**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 {(1R,2S)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethenylcyclopropyl}-14-methoxy-9-
 methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-
 5 methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 b]quinoxaline-8-carboxamide.



Step 1: Preparation of Example **48**: To a suspension of acid **18-7** (9.7 mg, 0.017 mmol) and Intermediate **A1** (13 mg, 0.049 mmol) in MeCN (0.4 mL) was added DIPEA (40 μ L, 0.23 mmol). To the resulting solution was added HATU (12.5 mg, 0.033 mmol). The reaction was stirred at rt for 1 h and was diluted with EtOAc (2 mL), 0.2 M aqueous HCl (1 mL), and brine (1 mL). The phases were separated and the aqueous phase was extracted with EtOAc (3 x 2 mL). The combined organic phase was dried over anhydrous Na_2SO_4 , filtered, and concentrated to afford a crude residue that was dissolved in CH_2Cl_2 and adsorbed onto 1 g silica gel. Purification by silica gel chromatography (10% to 50% acetone in hexanes) provided a residue that was lyophilized from water and MeCN to provide Example **48** as a white amorphous solid (8.4 mg). Analytic HPLC RetTime: 8.52 min. LCMS-ESI⁺ (m/z): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{39}\text{H}_{53}\text{N}_6\text{O}_9\text{S}$: 781.4; found: 781.2. ¹H NMR (400 MHz, CDCl_3) δ 9.91 (s, 1H), 7.83 (d, J = 9.1 Hz, 1H), 7.19 (dd, J = 9.1, 2.7 Hz, 1H), 7.10 (d, J = 2.7 Hz, 1H), 6.73 (s, 1H), 5.86 – 5.72 (m, 1H), 5.57 (d, J = 3.8 Hz, 1H), 5.48 (d, J = 9.9 Hz, 1H), 5.27 – 5.15 (m, 1H), 5.15 – 5.07 (m, 1H), 4.48 – 4.35 (m, 3H), 4.12 (dd, J = 11.8, 4.1 Hz,

1H), 3.94 (s, 3H), 3.81 – 3.71 (m, 1H), 2.98 – 2.75 (m, 4H), 2.16 – 2.09 (m, 1H), 1.94 (dd, $J = 8.2, 5.8$ Hz, 1H), 1.87 – 1.24 (m, 9H), 1.17 (d, $J = 7.4$ Hz, 3H), 1.09 (s, 9H), 1.04 – 0.91 (m, 5H), 0.75 – 0.65 (m, 1H), 0.52 – 0.42 (m, $J = 6.0$ Hz, 1H).

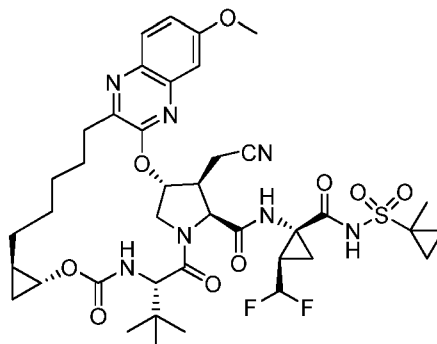
5 Example **49**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-{[(1-methylcyclopropyl)sulfonyl]carbamoyl}cyclopropyl]-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.



Step 1: Preparation of Example **49**: To a suspension of acid **33-4** (30 mg, 0.049 mmol) and Intermediate **A10** (31 mg, 0.10 mmol) in MeCN (700 μ L) was added DIPEA (70 μ L, 0.40 mmol). HATU (32 mg, 0.084 mmol) was added to the resulting solution, and the reaction was stirred at rt for 1.5 h. An additional portion of Intermediate **A10** (6 mg, 0.02 mmol) was then added. The reaction was stirred an additional 30 min and was then diluted with EtOAc (30 mL), 0.2 M aqueous HCl (15 mL) and brine (15 mL). The phases were separated and the aqueous phase was extracted with EtOAc (30 mL). The combined organic phase was dried over anhydrous Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and adsorbed onto 2 g silica gel. Purification by silica gel chromatography (10% to 50% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to

provide Example **49** as a white amorphous solid (30.5 mg). Analytic HPLC RetTime: 9.15 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.4; found: 859.2. ¹H NMR (400 MHz, CDCl₃) δ 9.86 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.45 (s, 1H), 7.18 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.08 (d, *J* = 2.7 Hz, 1H), 6.14 – 5.71 (m, 1H), 5.61 (d, *J* = 3.7 Hz, 1H), 5.28 (d, *J* = 9.8 Hz, 1H), 5.00 (d, *J* = 7.4 Hz, 1H), 4.49 (d, *J* = 7.0 Hz, 1H), 4.42 – 4.31 (m, 2H), 4.12 (dd, *J* = 11.6, 4.0 Hz, 1H), 3.93 (s, 3H), 3.00 – 2.63 (m, 4H), 2.25 – 2.16 (m, 1H), 2.09 – 1.90 (m, 4H), 1.81 – 0.95 (m, 26H), 0.92 – 0.75 (m, 3H), 0.57 – 0.45 (m, 1H), 0.44 – 0.36 (m, 1H).

Example **50**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-9-(cyanomethyl)-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



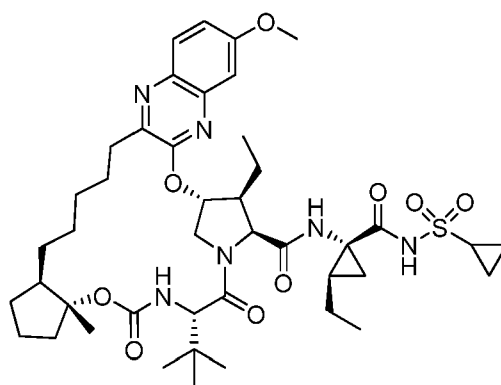
Example 50

Example **50** was prepared in a similar fashion to Example **1**, substituting Intermediate **B8** for Intermediate **B4** in step 1. Example **50** was purified by reverse phase HPLC (Gemini column, 58–98 % ACN/H₂O + 0.1% TFA) and lyophilized to afford solid (5 mg) as a TFA salt. Analytic HPLC RetTime: 8.29 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₁F₂N₇O₉S: 844.94; found: 844.58. ¹H NMR (400 MHz, CD₃OD) δ 9.71 (s, 1H), 7.79 (d, *J* = 8.8 Hz, 1H), 7.22 (m, 2H), 6.25 (m, 1H), 6.08 – 5.80 (m, 1H), 4.39 (m, 1H), 4.29 (m, 2H), 4.13 (m, 1H),

3.92 (s, 3H), 3.65 (m, 1H), 3.06 – 2.83 (m, 4H), 2.55 (m, 1H), 2.14 – 1.47 (m, 17H), 1.03(s, 9H), 0.92 (m, 4H), 0.65 (m, 1H), 0.45 – 0.43 (m, 1H).

Example **51**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-N-
 5 {(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethylcyclopropyl}-11-ethyl-16-
 methoxy-3a-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-
 hexadecahydro-10H-9,12-
 methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
 b]quinoxaline-10-carboxamide.

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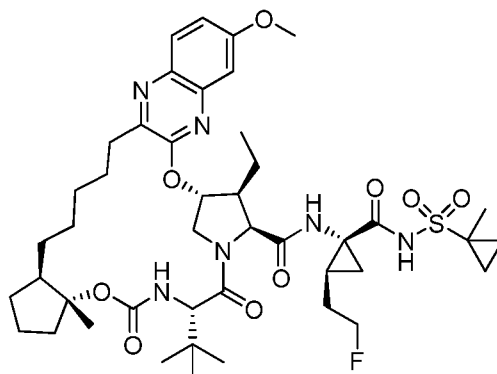


Example 51

Example **51** was prepared in a similar fashion to Example **39**, substituting
 Intermediate **A3** for Intermediate **A10** in step 8. Example **51** was isolated (12.3
 15 mg) in approximately 96.5% purity. Analytic HPLC RetTime: 9.38 min. LCMS-
 ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₆₃N₆O₉S: 839.4; found: 839.5. ¹H NMR (300
 MHz, CD₃OD) δ 7.60 (d, *J* = 8.4 Hz, 1H), 6.98-7.08 (m, 2H), 6.53 (d, *J* = 9.6 Hz,
 1H), 5.57-5.83 (m, 2H), 4.52 (d, *J* = 8.4 Hz, 2H), 4.24 (dd, *J* = 10.8, 6.0 Hz, 1H),
 4.02 (d, *J* = 9.6 Hz, 1H), 3.82 (dd, *J* = 10.8, 2.4 Hz, 1H), 3.73 (s, 3H), 2.93-3.10
 20 (m, 1H), 2.80-2.90 (m, 2H), 2.30-2.58 (m, 2H), 0.60-2.10 (m, 32H), 0.84 (s, 9H).

Example **52**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-11-
 ethyl-N-[(1R,2S)-2-(2-fluoroethyl)-1-[(1-
 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-16-methoxy-3a-methyl-5,8-

dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide.



Example 52

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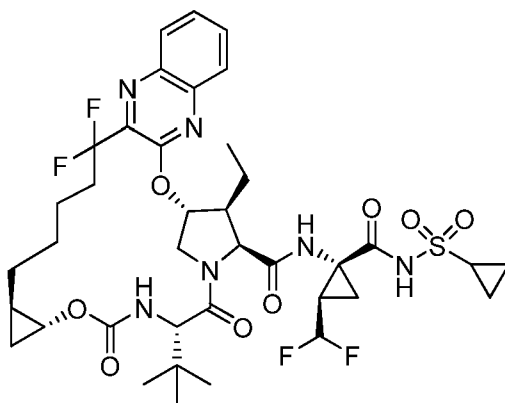
Example **52** was prepared in a similar fashion to Example **39**, substituting Intermediate **A6** for Intermediate **A10** in step 8. Example **52** was isolated (12.3 mg) in approximately 96.5% purity. Analytic HPLC RetTime: 8.60 min. Analytic HPLC RetTime: 9.31 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₄H₆₄FN₆O₉S: 871.4; found: 871.5. ¹H NMR (300 MHz, CD₃OD) δ 7.81 (d, *J* = 8.4 Hz, 1H), 7.20-7.30 (m, 2H), 6.73 (d, *J* = 9.6 Hz, 1H), 5.75-6.02 (m, 2H), 4.74 (d, *J* = 8.4 Hz, 2H), 4.54 (t, *J* = 6.0 Hz, 2H), 4.36-4.49 (m, 1H), 4.23 (d, *J* = 9.6 Hz, 1H), 4.04 (dd, *J* = 12.0, 2.4 Hz, 1H), 3.75 (s, 3H), 3.28-3.16 (m, 1H), 2.50-2.70 (m, 2H), 2.30-0.80 (m, 35H), 1.04 (s, 9H).

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Example **53**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

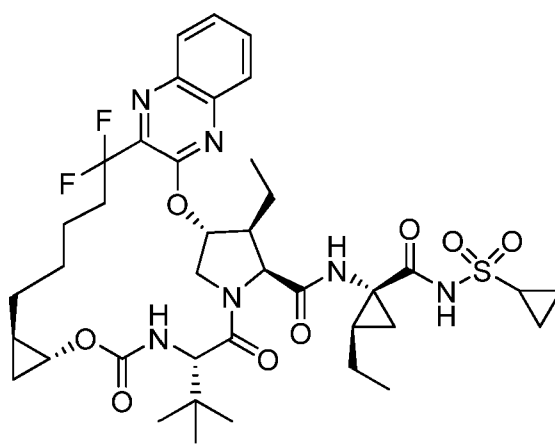
20

**Example 53**

Example **53** was prepared similarly to Example **17** substituting Intermediate **E4** for Intermediate **E3** in Step 1 and Intermediate **A9** for

- 5 Intermediate **A10** in Step 7. Example **53** was isolated (8.8 mg) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₄₈F₄N₆O₈S: 825.32; found: 825.75. ¹H NMR (400 MHz, CDCl₃) δ 10.13 (s, 1H), 8.15 (d, *J* = 8.2 Hz, 1H), 7.91 – 7.74 (m, 2H), 7.69 (t, *J* = 7.6 Hz, 1H), 6.92 (s, 1H), 5.47 (d, *J* = 9.6 Hz, 1H), 4.48 (t, *J* = 10.3 Hz, 2H), 4.36 (d, *J* = 9.4 Hz, 1H), 4.12 (dd, *J* = 12.1, 3.6 Hz, 1H), 3.70 – 3.59 (m, 1H), 3.08 – 2.75 (m, 1H), 2.58 – 2.38 (m, 1H), 2.14 (t, *J* = 6.8 Hz, 1H), 1.95 – 1.67 (m, 4H), 1.47 (tt, *J* = 13.9, 7.1 Hz, 4H), 1.35 (s, 2H), 1.20 (t, *J* = 7.3 Hz, 3H), 1.15 – 0.64 (m, 19H), 0.51 (q, *J* = 6.4 Hz, 1H).

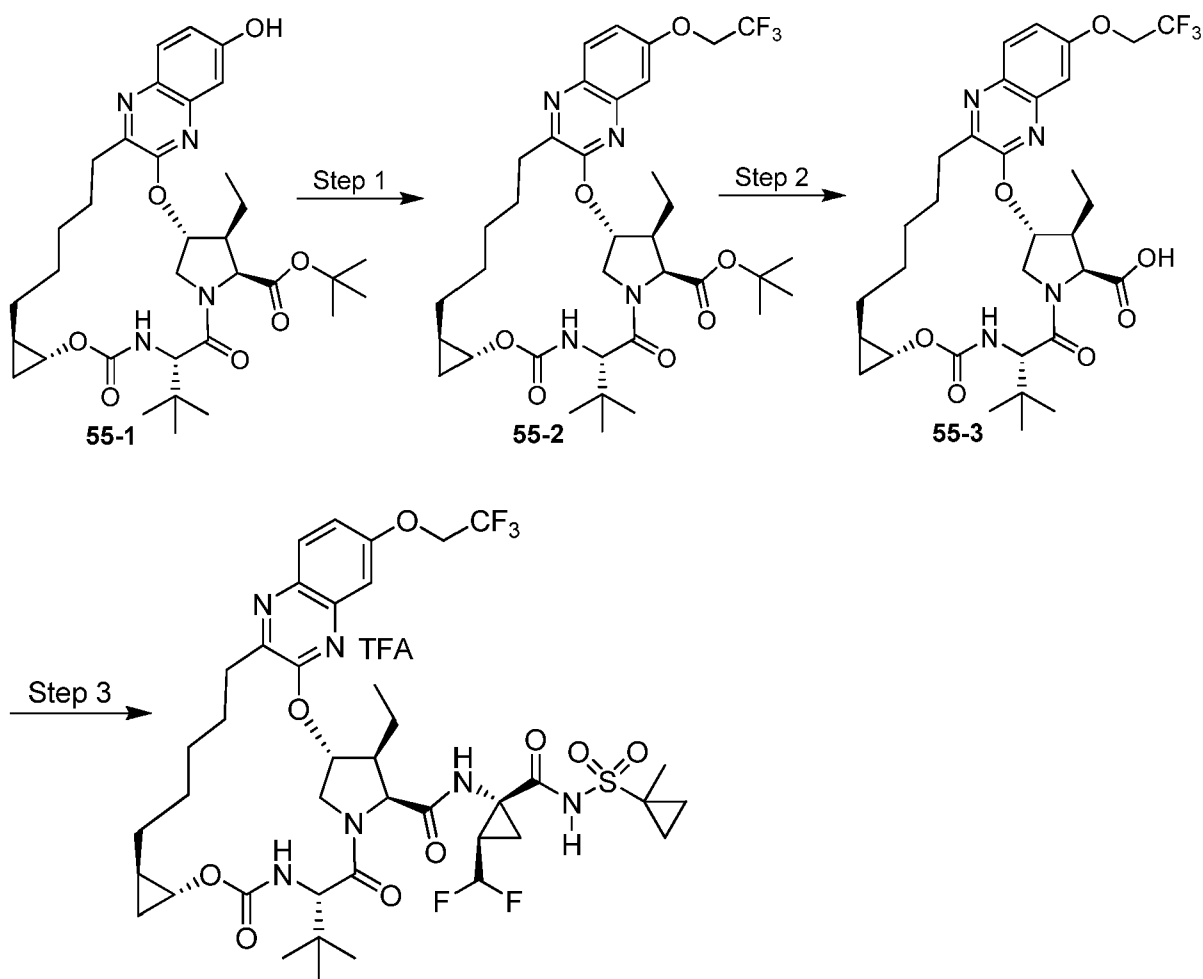
- 15 Example **54**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-{{(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethylcyclopropyl}-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

**Example 54**

Example **54** was prepared similarly to Example **53** replacing Intermediate **A9** with Intermediate **A3**. Example **54** was isolated (10.0 mg) as a white solid.

- 5 LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₂F₂N₆O₈S: 803.35; found: 803.79. ¹H NMR (400 MHz, CDCl₃) δ 9.88 (s, 1H), 8.12 (d, *J* = 8.2 Hz, 1H), 7.88 – 7.69 (m, 2H), 7.66 (t, *J* = 7.6 Hz, 1H), 6.68 (s, 1H), 5.95 (d, *J* = 3.4 Hz, 1H), 5.46 (d, *J* = 9.4 Hz, 1H), 4.45 (dd, *J* = 13.8, 9.7 Hz, 2H), 4.09 (dd, *J* = 12.0, 3.6 Hz, 2H), 3.71 – 3.57 (m, 1H), 2.53 (dd, *J* = 21.4, 14.6 Hz, 1H), 1.85 – 1.39 (m, 10H), 1.38 – 10 0.96 (m, 20H), 1.01 (dd, *J* = 17.2, 9.5 Hz, 3H), 1.04 – 0.78 (m, 6H), 0.70 (s, 1H), 0.49 (dd, *J* = 12.7, 6.3 Hz, 1H).

- Example **55**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[[1-
15 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-3,6-dioxo-14-(2,2,2-trifluoroethoxy)-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Example 55

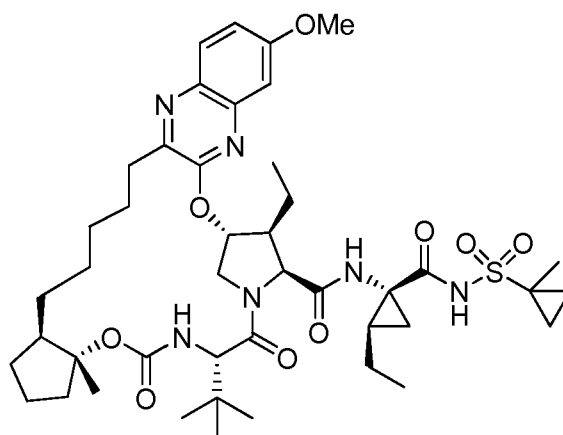
Intermediate **55-1** was prepared by following Steps 1 through 6 of Example 1, substituting for Intermediate **E2** for Intermediate **E1** in Step 1. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₉N₄O₇: 625.36; found: 625.25.

Step 1. Preparation of **55-2**. Quinoxalinol **55-1** (24 mg, 0.038 mmol) was suspended in DMF (2 mL) and treated with Cs₂CO₃ (63 mg, 0.19 mmol) and 2,2,2-trifluoroethyl trifluoromethanesulfonate (0.055 mL, 0.38 mmol). The reaction mixture was stirred at RT for 5 h, then diluted with EtOAc. The organic layer was washed with H₂O and brine, dried over MgSO₄, filtered and concentrated under reduced pressure to afford **55-2**, which was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₀F₃N₄O₇: 707.36; found: 707.38.

Step 2. Preparation of **55-3**. Trifluoroethyl ether **55-2** (0.038 mmol theoretical) was treated with DCM (4 mL) and TMSOTf (0.14 mL, 0.77 mmol) at RT. After 1 h, the reaction was quenched by addition of 1M NaOH (2 mL). After stirring vigorously for 5 min, the mixture was poured into a separatory funnel followed by 10% HCl (20 mL). The aqueous layer was extracted 3x with DCM. The combined organics were dried over MgSO₄, filtered and concentrated under reduced pressure to afford **55-3**, which was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₂F₃N₄O₇: 651.30; found: 651.18.

Step 3. Preparation of Example **55**. Carboxylic acid **55-3** (0.038 mmol theoretical) was treated with intermediate **A10** (23 mg, 0.077 mmol), TBTU (25 mg, 0.077 mmol), DMAP (9 mg, 0.077 mmol), DCM (1 mL) and DIPEA (0.134 mL, 0.768 mmol). The reaction mixture was stirred at RT for 20 h, then concentrated under reduced pressure and purified by reverse phase HPLC to afford Example **55** as a TFA salt (7 mg, 18% over 3 steps). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₄F₅N₆O₉S: 901.36; found: 902.08. ¹H NMR (400 MHz, CD₃OD) δ 9.18 (s, 1H), 7.86 (d, *J* = 9.1 Hz, 1H), 7.32 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.25 (d, *J* = 2.7 Hz, 1H), 6.02 – 5.63 (m, 2H), 4.76 – 4.62 (m, 2H), 4.56 (d, *J* = 7.1 Hz, 1H), 4.39 (t, *J* = 6.0 Hz, 2H), 4.15 (dt, *J* = 17.2, 8.6 Hz, 1H), 3.74 (dd, *J* = 6.7, 2.8 Hz, 1H), 3.05 – 2.89 (m, 1H), 2.82 (td, *J* = 13.2, 4.2 Hz, 1H), 2.65 – 2.50 (m, 1H), 2.02 (d, *J* = 10.4 Hz, 2H), 1.78 (dt, *J* = 23.5, 10.7 Hz, 3H), 1.68 – 1.26 (m, 14H), 1.22 (t, *J* = 7.3 Hz, 3H), 1.10 (s, 9H), 0.97 (d, *J* = 2.5 Hz, 2H), 0.95 – 0.84 (m, 2H), 0.71 (s, 1H), 0.51 (t, *J* = 9.8 Hz, 1H).

Example **56**. Preparation of (3aR,7S,10S,11S,12R,24aR)-7-tert-butyl-11-ethyl-N-[(1R,2R)-2-ethyl-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-16-methoxy-3a-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanocyclopenta[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-10-carboxamide

**Example 56**

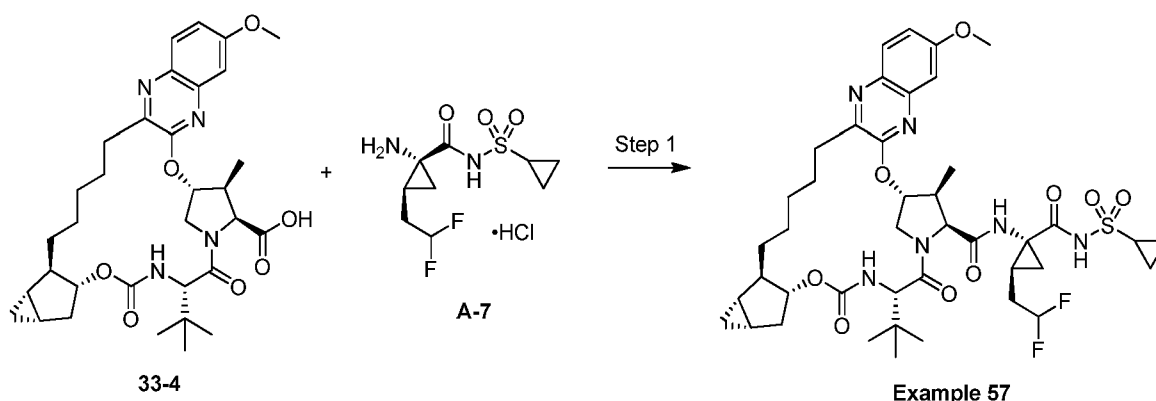
Example **56** was prepared in a similar fashion to Example **39**, substituting Intermediate **A9** for Intermediate **A3** in Step 8. Example **56** was isolated (8.8 mg, 0.0103 mmol, 53.7%). Analytic HPLC RetTime: 9.56 min. LCMS-ESI⁺ (*m/z*):

5 [M+H]⁺ calcd for C₄₄H₆₅N₆O₉S: 853.45; found: 853.5. ¹H NMR (300 MHz, CD₃OD) δ 7.81 (d, *J* = 9.6 Hz, 1H), 7.20-7.30 (m, 2H), 6.73 (d, *J* = 9.6 Hz, 1H), 5.76-6.01 (m, 2H), 4.75 (d, *J* = 8.4 Hz, 1H), 4.46 (dd, *J* = 12.0, 6.0 Hz, 1H), 4.23 (d, *J* = 9.6 Hz, 1H), 4.00-4.08 (m, 1H), 3.95 (s, 3H), 2.50-2.78 (m, 3H), 0.80-2.30 (m, 30H), 1.54 (s, 3H), 1.35 (s, 3H), 1.05 (s, 9H).

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Example **57**. Preparation of (1a*S*,2a*R*,6*S*,9*S*,10*S*,11*R*,23a*R*,23b*S*)-6-tert-butyl-N-[(1*R*,2*S*)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(2,2-difluoroethyl)cyclopropyl]-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1*H*,9*H*-8,11-

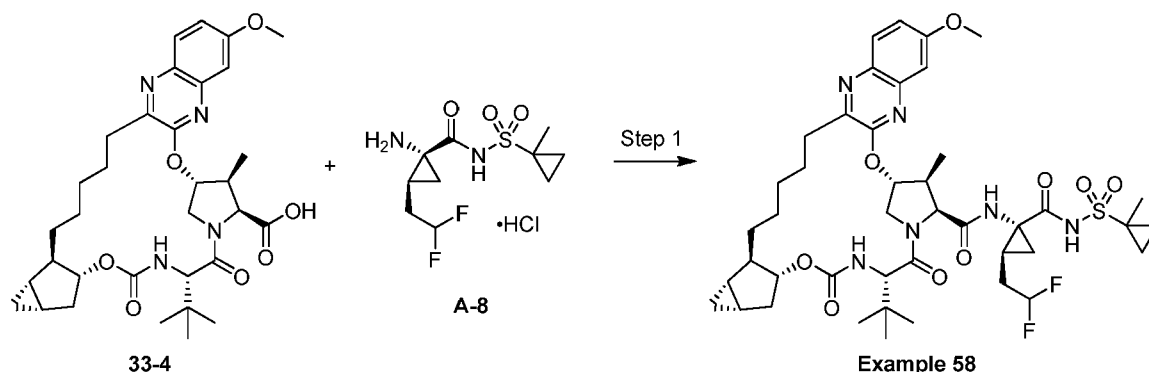
15 methanocyclopropana[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-*b*]quinoxaline-9-carboxamide.



Step 1. Preparation of Example **57**. To a suspension of acid **33-4** (14.9 mg, 0.0245 mmol) and amine hydrochloride **A-7** (16.3 mg, 0.0535 mmol) in MeCN (500 μ L) was added DIPEA (40 μ L, 0.23 mmol). HATU (15.5 mg, 0.0408 mmol) was added to the resulting solution, and the reaction was stirred at rt for 17 h. The reaction was then diluted with EtOAc (2 mL), 0.2 M aqueous HCl (1.5 mL) and brine (1.5 mL). The phases were separated and the aqueous phase was extracted with EtOAc (4 x 1.5 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and was concentrated onto 1.5 g silica gel. Purification by silica gel chromatography (10% to 40% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **57**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.4; found: 859.0. ¹H NMR (300 MHz, CDCl₃) δ 10.00 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.09 (d, *J* = 2.6 Hz, 1H), 6.75 (s, 1H), 6.07 – 5.57 (m, 2H), 5.26 (d, *J* = 9.8 Hz, 1H), 5.01 (d, *J* = 7.4 Hz, 1H), 4.50 – 4.29 (m, 3H), 4.12 (dd, *J* = 11.7, 3.9 Hz, 1H), 3.93 (s, 3H), 3.00 – 2.62 (m, 4H), 2.34 – 0.96 (m, 33H), 0.95 – 0.78 (m, 1H), 0.51 (dd, *J* = 13.0, 7.9 Hz, 1H), 0.39 (d, *J* = 4.2 Hz, 1H).

Example **58**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2S)-2-(2,2-difluoroethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-

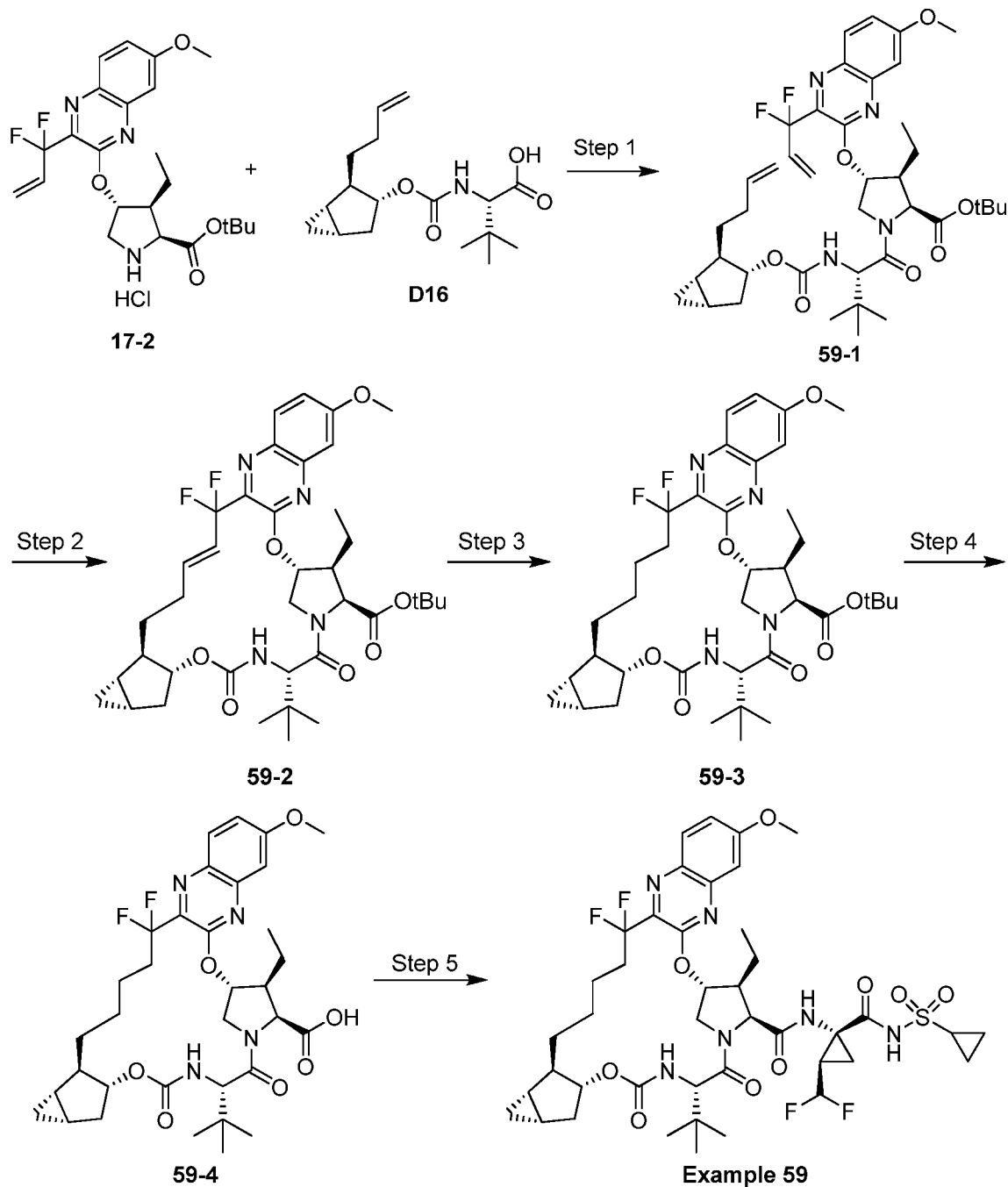
methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide



- 5 Step 1. Preparation of Example **58**. To a suspension of acid **33-4** (14.5 mg, 0.0238 mmol) and amine hydrochloride **A-8** (16.0 mg, 0.0502 mmol) in MeCN (500 μ L) was added DIPEA (40 μ L, 0.23 mmol). HATU (15.5 mg, 0.0408 mmol) was added to the resulting solution, and the reaction was stirred at rt for 17 h. The reaction was then diluted with EtOAc (2 mL), 0.2 M aqueous HCl (1.5 mL) and brine (1.5 mL). The phases were separated and the aqueous phase was extracted with EtOAc (4 x 1.5 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and was concentrated onto 1.5 g silica gel. Purification by silica gel chromatography (10% to 40% acetone in hexanes) provided an
- 10 amorphous residue that was lyophilized from water and MeCN to provide Example **58**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₉F₂N₆O₉S: 873.4; found: 873.3. ¹H NMR (300 MHz, CDCl₃) δ 9.72 (s, 1H), 7.82 (d, *J* = 9.1 Hz, 1H), 7.19 (dd, *J* = 9.1, 2.7 Hz, 1H), 7.09 (d, *J* = 2.7 Hz, 1H), 6.82 (s, 1H), 6.12 – 5.54 (m, 2H), 5.25 (d, *J* = 9.8 Hz, 1H), 5.01 (d, *J* = 7.2 Hz, 1H), 4.50 – 4.30 (m, 3H), 4.13
- 15 (dd, *J* = 11.7, 4.2 Hz, 1H), 3.93 (s, 3H), 3.03 – 2.65 (m, 4H), 2.34 – 0.97 (m, 33H), 0.94 – 0.76 (m, 3H), 0.60 – 0.45 (m, 1H), 0.45 – 0.34 (m, 1H).
- 20

- Example **59**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-10-ethyl-19,19-difluoro-15-methoxy-4,7-dioxo-
- 25

1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.



Step 1. Preparation of **59-1**. A solution of Intermediate **D16** (0.50 g, 1.6 mmol) in DMF (7 mL) was treated subsequently with COMU (0.80 g, 1.9 mmol),

DIPEA (1.2 mL, 6.7 mmol) and Intermediate **17-2** (0.65 g, 1.3 mmol) and stirred overnight at rt. The reaction was quenched with 1 M citric acid solution (5 mL) and extracted with EA. The combined organics were washed with brine, dried over anhydrous MgSO_4 and concentrated *in vacuo*. The resulting residue was
5 purified by silica gel chromatography (15-100% EA/hex) to afford **59-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{40}\text{H}_{55}\text{F}_2\text{N}_4\text{O}_7$: 741.88; found: 741.51.

Step 2. Preparation of **59-2**. A solution of **59-1** (0.51 g, 0.69 mmol) in DCE (140 mL) is sparged with argon for 30 min prior to addition of Zhan 1B catalyst (0.051 g, 0.07 mmol). The reaction was heated to 85 °C for 45 min, and
10 another portion of Zhan 1B catalyst was added. After an additional 30 min, the reaction was cooled to rt, concentrated *in vacuo* and purified by silica gel chromatography (5-100% EA/hex) to produce **59-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{38}\text{H}_{51}\text{F}_2\text{N}_4\text{O}_7$: 713.83; found: 713.54.

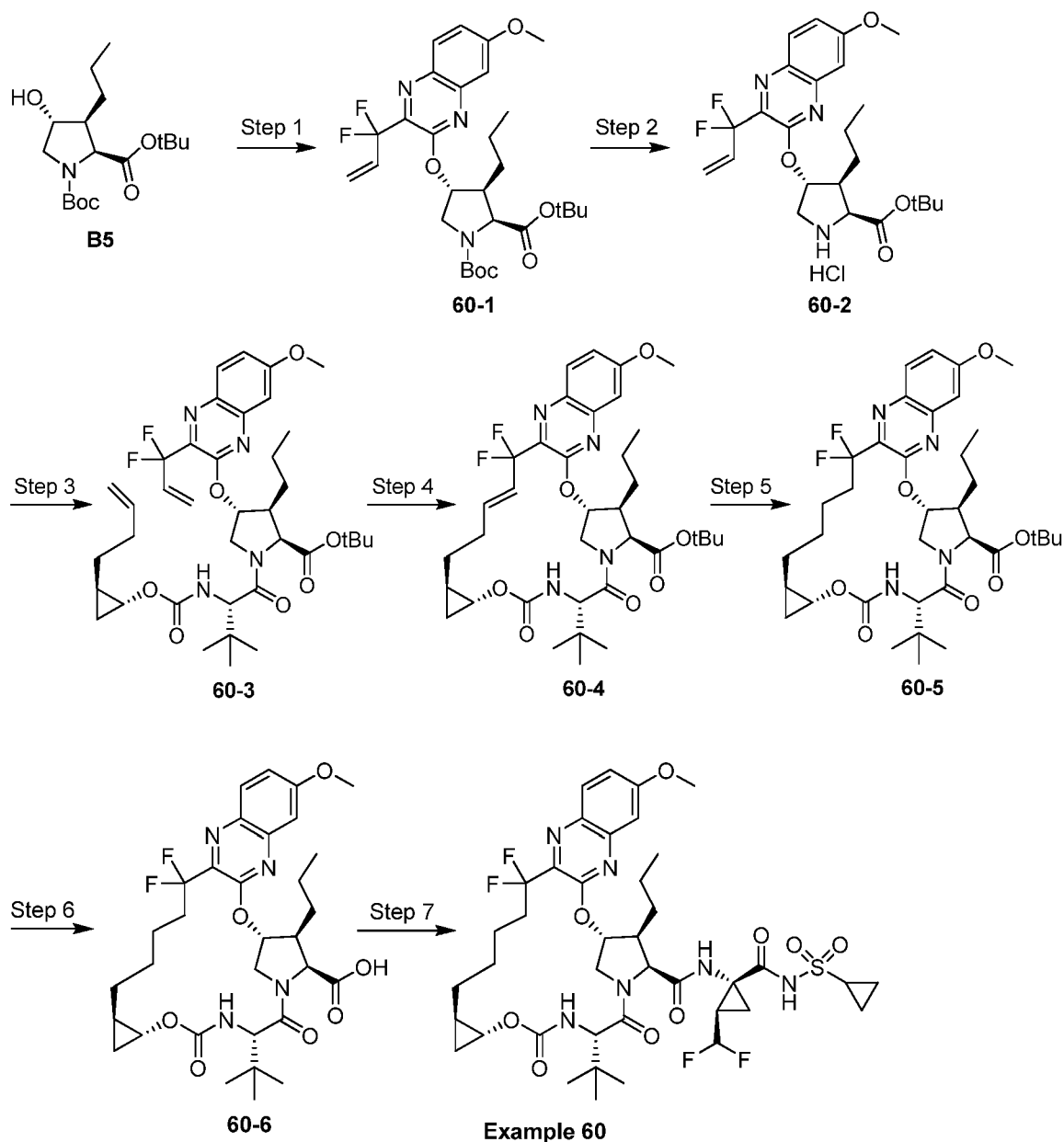
Step 3. Preparation of **59-3**. A solution of **59-2** was taken up in EtOH (8
15 mL). Pd/C (0.072 g, 10% w/w) was added and the atmosphere replaced with H_2 . After 1 h, additional catalyst was added. After 4 h, EA and additional catalyst was added. After an additional 3 h, the reaction was filtered, concentrated *in vacuo*, and the residue taken up in EtOH (8 mL) and treated with 0.5 g Pd/C (10% w/w) and the atmosphere replaced with H_2 . The reaction was stirred
20 overnight, and then worked up again as previously described to produce of **59-3** that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{38}\text{H}_{53}\text{F}_2\text{N}_4\text{O}_7$: 715.85; found: 715.52.

Step 4. Preparation of **59-4**. A solution of **59-3** (0.40 g, 0.56 mmol) in DCM (1.5 mL) was treated with 2.5 mL TFA at rt. After 1.5 h, the reaction was
25 concentrated *in vacuo*. The residue was taken up in EA, washed with saturated aqueous NaHCO_3 , brine and then dried over anhydrous MgSO_4 . Concentration *in vacuo* produced **59-4** that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{34}\text{H}_{45}\text{F}_2\text{N}_4\text{O}_7$: 659.74; found: 659.56.

Step 5. Preparation of Example **59**: A solution of **59-4** (0.20 g, 0.30
30 mmol) in DMF (2 mL) was treated subsequently with HATU (0.21 g, 0.55 mmol), DIPEA (0.27 mL, 1.5 mmol), DMAP (0.056 g, 0.46 mmol), and Intermediate **A9**

(0.13 g, 0.46 mmol) and stirred for 5 h at rt. The reaction mixture is purified by preparatory HPLC to produce the TFA salt of Example **59**. Analytic HPLC RetTime: 9.20 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₅F₄N₆O₉S: 895.98; found: 895.60. ¹H NMR (400 MHz, CD₃OD) δ 9.31 (s, 1H); 7.94 (d, J = 9.2 Hz, 1H); 7.32 (dd, J = 9.2, 2.4 Hz, 1H); 7.21 (d, J = 2.4 Hz, 1H); 5.98 (br s, 1H); 5.85 (td, J_{H-F} = 55.2 Hz, J = 6 Hz, 1H); 4.94 (d, J = 7.6 Hz, 1H); 4.58 (d, J = 7.2 Hz, 1H); 4.35 (d, J = 7.2 Hz, 1H); 4.33 (br s, 1H); 4.18 (dd, J = 12, 3.6 Hz, 1H); 3.97 (br s, 3H); 2.98 (m, 1H); 2.64-2.41 (m, 2H); 2.22 (m, 1H); 2.15-1.92 (m, 4H); 1.84-1.22 (m, 14H); 1.18 (t, J = 7.2 Hz, 3H); 1.14-0.98 (m, 2H); 1.08 (s, 9H); 0.60-0.48 (m, 2H).

Example **60**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-18,18-difluoro-14-methoxy-3,6-dioxo-9-propyl-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropano[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



- 5 Step 1. Preparation of **60-1**: To a solution of Intermediate **B5** (160 mg, 0.590 mmol) and Intermediate **E3** (194 mg, 0.590 mmol) in MeCN (2.95 mL) was added cesium carbonate (192 mg, 0.590 mmol) at rt under an argon atmosphere. After 24 h, the reaction mixture was then filtered through a pad of Celite and the filtrate concentrated *in vacuo*. The crude residue was purified by silica gel
- 10 chromatography (0–100% ethyl acetate/hexanes gradient) to afford substituted quinoxaline **60-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₉H₄₀F₂N₃O₆: 564.28; found: 564.44.

Step 2. Preparation of **60-2**: To a solution **60-1** (193 mg, 0.343 mmol) in *tert*-butyl acetate (1.36 mL) was added a solution of methanesulfonic acid (111 μ L, 1.72 mmol) in dichloromethane (0.34 mL) and the reaction was stirred at rt. After 2 h, the reaction mixture was diluted with saturated sodium bicarbonate solution (20 mL) and the resulting mixture was extracted with ethyl acetate (2 $\times$ 20 mL). The combine organics were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford amine hydrochloride **60-2**, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₄H₃₂F₂N₃O₄: 464.23; found: 464.35.

Step 3. Preparation of **60-3**: To a solution of **60-2** (133 mg, 0.289 mmol) and Intermediate **D11** (133 mg, 0.412 mmol) in MeCN (1.7 mL) was added HATU (157 mg, 0.412 mmol) followed by DIPEA (298 μ L, 1.72 mmol) at rt under and argon atmosphere. After 1 h, the reaction mixture was concentrated *in vacuo*, and the crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford amide **60-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₃F₂N₄O₇: 715.38; found: 715.55.

Step 4. Preparation of **60-4**: To a solution of **60-3** (188 mg, 264 μ mol) in DCE (52.8 mL) was added Zhan 1B catalyst (19.4 mg, 26.4 μ mol) and the reaction mixture was degassed for 10 minutes with argon. The reaction mixture was then heated to 100 °C. After 1 h, the reaction mixture was allowed to cool to rt and was concentrated *in vacuo*. The crude residue was purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford macrocycle **60-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉F₂N₄O₇: 687.35; found: 687.54.

Step 5. Preparation of **60-5**: To a solution of macrocycle **60-4** (119 mg, 173 μ mol) in ethanol (1.0 mL) was added Pd/C (10 wt %, 18.4 mg, 17.3 μ mol) at rt under an argon atmosphere. The reaction vessel was evacuated and refilled with 1 atm hydrogen gas (3 $\times$) and the reaction mixture was stirred vigorously at rt. After 1 h, the reaction mixture was filtered through a pad of Celite with ethyl acetate washings (3 $\times$ 2 mL). The filtrate was concentrated *in vacuo* to afford macrocycle **60-5**, which was used directly in the next step without further

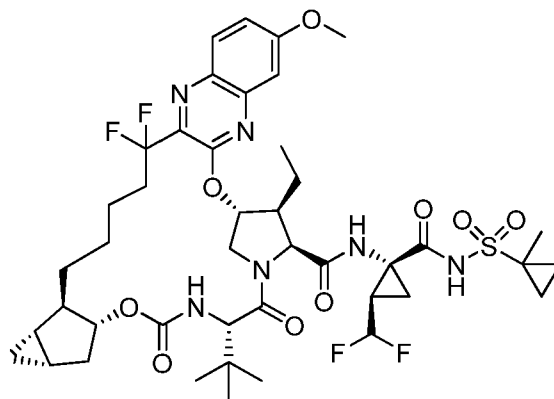
purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁F₂N₄O₇: 689.36; found: 689.56.

Step 6. Preparation of **60-6**: To a solution of **60-5** (150 mg, 218 μmol) in DCM (1.1 mL) was added TMSOTf (197 μL, 1.09 mmol) at rt under an argon atmosphere. After 2 h, the reaction mixture was transferred to a solution of 0.5 N NaOH solution (5 mL) precooled to 0 °C. The resulting mixture was acidified with 1N HCl solution to pH = 2 and was extracted with dichloromethane (3 × 5 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo* to afford carboxylic acid **60-6**, which was used directly in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₃F₂N₄O₇: 633.30; found: 633.49.

Step 7. Preparation of Example **60**: To a solution of **60-6** (100 mg, 158 μmol) and Intermediate **A9** (69.0 mg, 237 μmol) in MeCN (790 μL) was added HATU (91.5 mg, 237 μmol) followed by DIPEA (137 μL, 790 μmol) at rt under an argon atmosphere. After 3 h, the reaction mixture was concentrated *in vacuo*, was purified by preparatory HPLC (Gemini 5u C18 110Å column, 5–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and was lyophilized to afford Example **60** as a TFA salt. Analytic HPLC RetTime: 8.89 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₃F₄N₆O₉S: 869.35; found: 859.66. ¹H NMR (400 MHz, CD₃OD) δ 9.29 (br s, 1H), 7.94 (d, *J* = 9.2 Hz, 1H), 7.31 (d, *J* = 9.2 Hz, 1H), 7.19 (br s, 1H), 5.87 (br s, 1H), 5.84 (td, *J*_{H-F} = 55.8 Hz, *J* = 5.4 Hz, 1H), 4.56 (d, *J* = 6.9 Hz, 1H), 4.40 (d, *J* = 12.6 Hz, 1H), 4.36 (s, 1H), 4.17 (dd, *J* = 11.9, 3.4 Hz, 1H), 3.96 (br s, 4H), 3.68 (br s, 1H), 3.01 – 2.91 (m, 1H), 2.71 – 2.61 (m, 1H), 2.61 – 2.43 (m, 1H), 2.02 (br s, 4H), 1.88 – 1.59 (m, 4H), 1.59 – 1.35 (m, 4H), 1.33 – 1.20 (m, 3H), 1.09 (s, 9H), 1.04 – 0.95 (app t, *J* = 7.0 Hz, 5H), 0.79 – 0.65 (m, 1H), 0.49 (d, *J* = 6.5 Hz, 1H).

Example **61**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-10-ethyl-19,19-difluoro-15-methoxy-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-

hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.



Example 61

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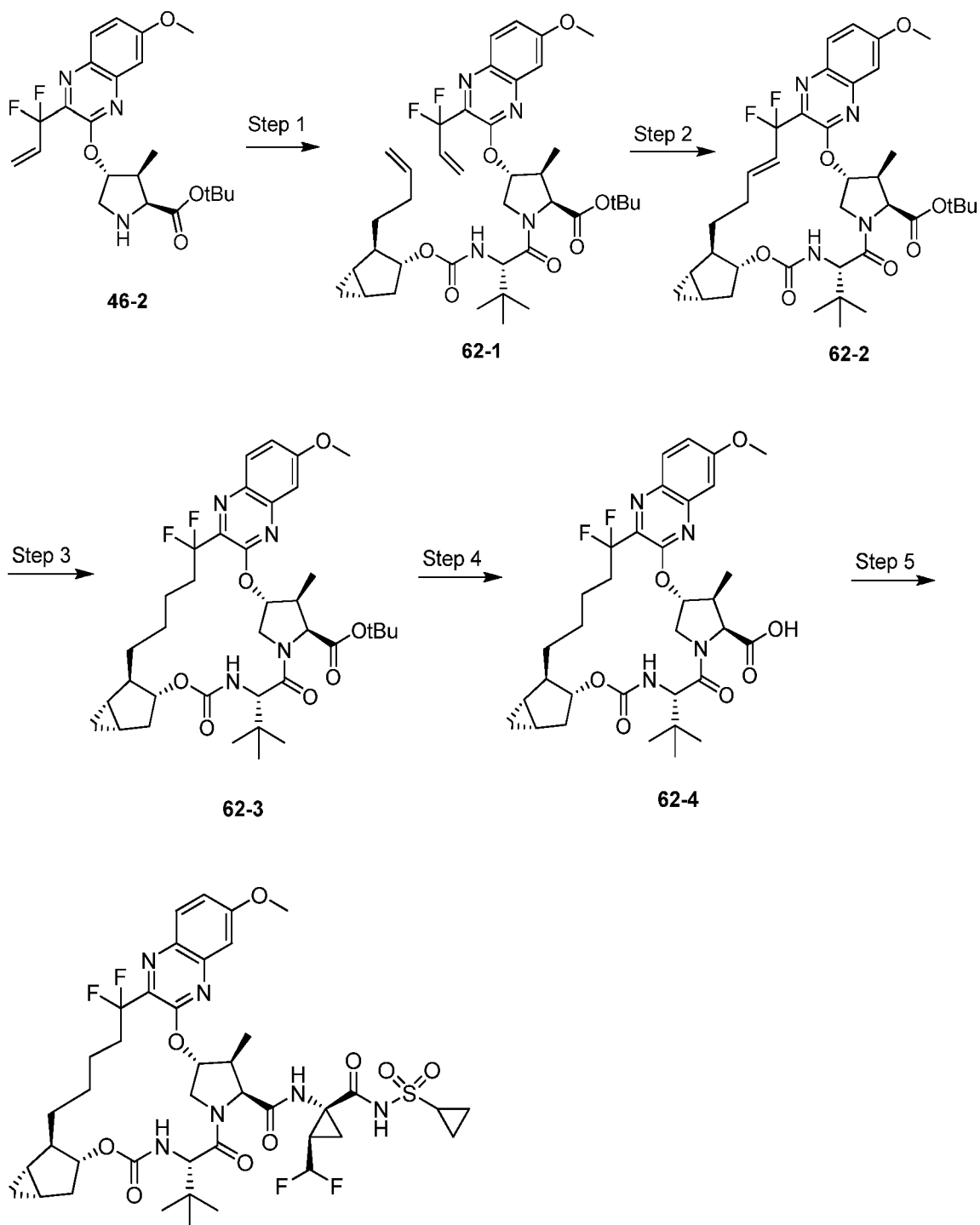
Example **61** was prepared similarly to Example **59** substituting Intermediate **A10** for Intermediate **A9** in Step 5. The TFA salt of Example **61** was isolated. Analytic HPLC RetTime: 9.28 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₇F₄N₆O₉S: 909.38; found: 909.59. ¹H NMR (400 MHz, CD₃OD) δ 9.28 (s, 1H); 7.95 (d, *J* = 9.2 Hz, 1H); 7.33 (dd, *J* = 9.2, 2.4 Hz, 1H); 7.23 (d, *J* = 2.4 Hz, 1H); 6.0 (br s, 1H); 5.83 (br s, 1H); 5.83 (td, *J*_{H-F} = 55 Hz, *J* = 6 Hz, 1H); 4.94 (d, *J* = 7.6 Hz, 1H); 4.61 (d, *J* = 7.6 Hz, 1H); 4.34 (d, *J* = 7.6 Hz, 1H); 4.32 (br s, 1H); 4.18 (m, 1H); 3.97 (s, 3H); 2.63-2.47 (m, 2H); 2.28-2.17 (m, 1H); 2.12-1.96 (m, 4H); 1.83-1.26 (m, 14H); 1.53 (s, 3H); 1.19 (t, *J* = 7.2 Hz, 3H); 1.08 (s, 9H); 0.94-0.88 (m, 2H); 0.62-0.48 (m, 2H).

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Example **62**. Preparation of (1a*S*,2a*R*,6*S*,9*S*,10*S*,11*R*,23a*R*,23b*S*)-6-tert-butyl-N-[(1*R*,2*R*)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-19,19-difluoro-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide

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Example 62

Step 1. Preparation of **Example 62-1**: HATU (214 mg, 0.563 mmol, Oakwood) and DIPEA (0.30 mL, 1.72 mmol) were added to a mixture of **46-2** (186 mg, 0.428 mmol) and Intermediate **D16** (157 mg, 0.508 mmol) in 10 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was

concentrated under reduced pressure and the resulting residue was purified by silica gel chromatography (0–30% ethyl acetate in hexanes) to yield Intermediate **62-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₃F₂N₄O₇: 727.38; found: 727.51.

Step 2. Preparation of **62-2**: A mixture of **62-1** (275 mg, 0.378 mmol) and
5 Zhan 1B catalyst (34 mg, 0.046 mmol, Strem) in 75 mL of DCE was deoxygenated with argon for 17 minutes. The mixture was then heated at reflux for 80 minutes. An additional 8 mg of Zhan 1B catalyst was added and mixture stirred at reflux for twenty minutes. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica
10 gel chromatography (0–25% ethyl acetate in hexanes) to yield intermediate **62-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₄₉F₂N₄O₇: 699.35; found: 669.50.

Step 3. Preparation of mixture of **62-3**: Palladium on carbon (10 wt % Pd, 60 mg, 0.057 mmol) was added to a solution of **62-2** (207 mg, 0.297 mmol) in 7 mL of ethanol. The atmosphere was replaced with hydrogen and mixture was
15 stirred overnight. The reaction was filtered over Celite, washing with ethanol. Filtrate was concentrated *in vacuo* to yield intermediate **62-3**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₁F₂N₄O₇: 701.36; found: 701.65.

Step 4. Preparation of **62-4**: TFA (1.6 mL, 20.9 mmol) was added slowly
20 to a solution of **62-3** (202 mg, 0.289 mmol) in 4.5 mL of dichloromethane. After 3.5 hours, mixture was concentrated under reduced pressure to near dryness. Resulting residue was taken up in 30 mL of ethyl acetate, washed with 20 mL of water, 20 mL of sat. NaHCO₃ (aq), and separated. Aqueous layers were extracted with ethyl acetate (3 x 20 mL). Combined organics were washed with
25 30 mL of brine, dried over anhydrous MgSO₄, filtered, and concentrated *in vacuo* to yield intermediate **62-4**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₃F₂N₄O₇: 645.30; found: 645.53.

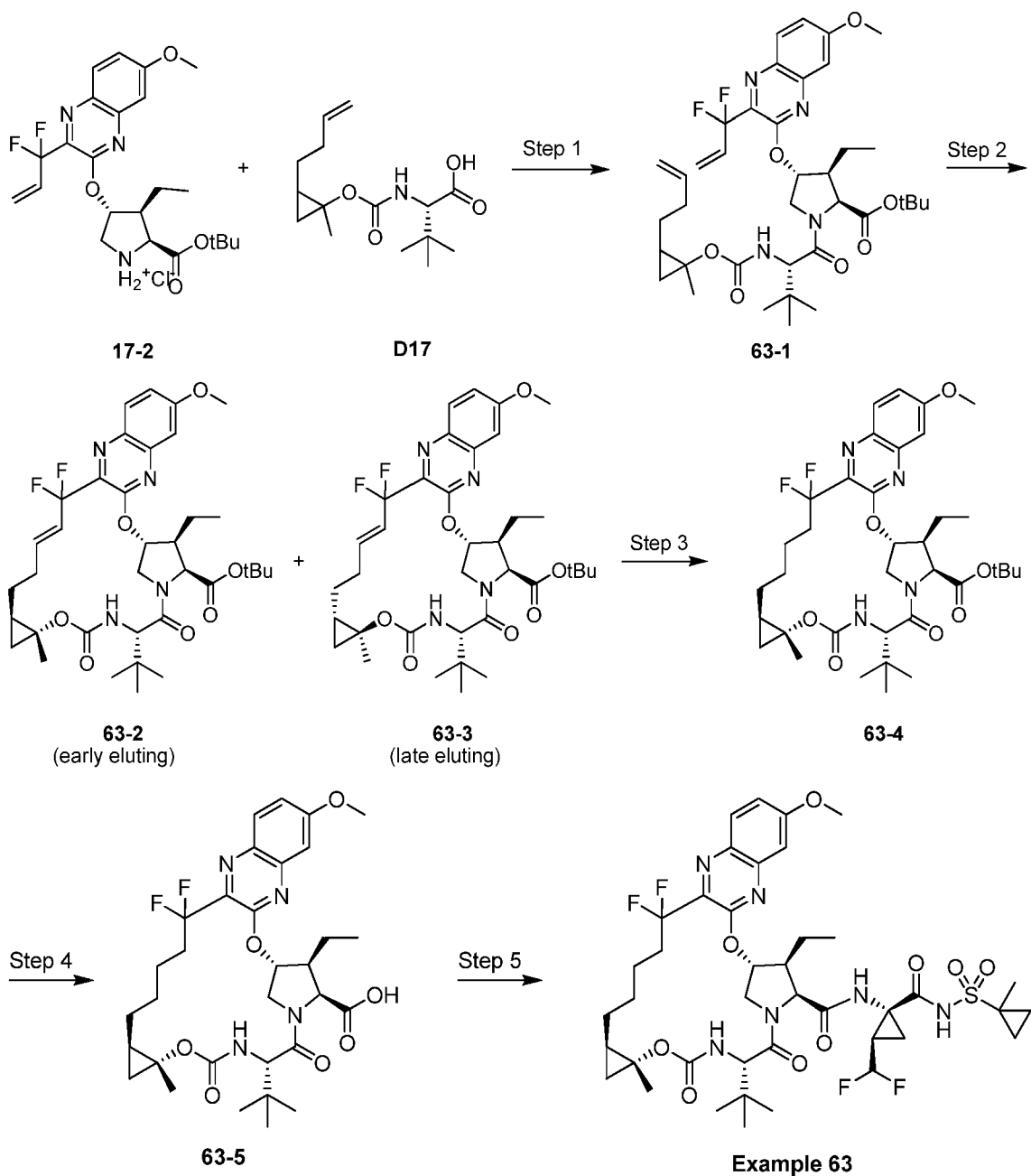
Step 5. Preparation of Example **62**: HATU (113 mg, 0.297 mmol,
30 Oakwood) and DIPEA (0.17 mL, 0.978 mmol) were added to a mixture of **62-4** (120 mg, 0.186 mmol) and Intermediate **A9** (110 mg, 0.379 mmol) in 6 mL of

acetonitrile under argon. After stirring for overnight, reaction mixture was taken up in 30 mL of ethyl acetate and washed with 20 mL of 1 N aqueous HCl. The aqueous layer was extracted three times with ethyl acetate. Combined organics were washed with 50% brine, dried over anhydrous Na₂SO₄, filtered, and

- 5 concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **62**. Analytic HPLC RetTime: 9.03 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₃F₄N₆O₉S: 881.35; found: 881.57.
- 10 ¹H NMR (400 MHz, CD₃OD): δ 9.27 (s, 1H), 7.94 (d, *J* = 8.8 Hz, 1H), 7.33 (dd, *J* = 9.2, 2.8 Hz, 1H), 7.27 (d, *J* = 2.8 Hz, 1H), 5.84 (td, *J*_{H-F} = 56 Hz, *J* = 6.8 Hz, 1H), 5.75 (d, *J* = 3.6 Hz, 1H), 4.94 (d, *J* = 7.2 Hz, 1H), 4.55 (d, *J* = 7.2 Hz, 1H), 4.35 (d, *J* = 12 Hz, 1H), 4.32 (s, 1H), 4.22–4.16 (dd, *J* = 12, 4 Hz, 1H), 3.97 (s, 3H), 3.01–2.94 (m, 1H), 2.81–2.72 (m, 1H), 2.66–2.40 (m, 1H), 2.36–2.28 (m, 1H),
- 15 2.10–1.94 (m, 4H), 1.82–1.72 (m, 2H), 1.70–1.22 (m, 10H), 1.14–1.02 (m, 7H), 1.10 (s, 9H), 0.61–0.49 (m, 2H).

Example **63**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-14-methoxy-1a-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide

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Step 1. Preparation of **63-1**: Amine hydrochloride **17-2** (500 mg, 1.03 mmol) was combined with intermediate mixture **D17** (378.5 mg, 1.34 mmol), DIPEA (1.8 mL, 10.3 mmol) and DMF (3 mL). HATU (587.1 mg, 1.55 mmol) was then added to the reaction mixture, which was stirred at room temperature for 18 hrs. Reaction mixture was then diluted with water (20 mL) and 1N HCl (10.5 mL) and taken up into methylene chloride (20 mL). Organics were separated and aqueous layer was extracted three times with methylene chloride (10 mL).

Combined organics were then washed with brine, dried over MgSO_4 , filtered, and concentrated *in vacuo*. Crude residue was then purified via silica gel chromatography to give **63-1** as a 1:1 diastereomeric mixture. LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{38}\text{H}_{53}\text{F}_2\text{N}_4\text{O}_7$: 715.4; found: 715.4.

5 Step 2. Preparation of **63-2** and **63-3**: Diastereomeric mixture **63-1** (496 mg, 0.695 mmol) and Zhan 1B catalyst (53.8 mg, 0.0695 mmol, Strem) were dissolved in 140 mL of anhydrous DCE and sparged with N_2 for 30 minutes. The mixture was then heated to 100 °C for 90 minutes, and an additional portion of Zhan 1B catalyst was added (54 mg, 0.695 mmol, Strem). Reaction was then
10 cooled to room temperature and concentrated *in vacuo*. The resulting residue was purified via silica gel chromatography (0% to 40% ethyl acetate in hexanes) to yield single diastereomers **63-2** (early eluting fraction) and **63-3** (late eluting fraction). Early eluting fraction: LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{36}\text{H}_{49}\text{F}_2\text{N}_4\text{O}_7$: 687.4; found: 687.2. Late eluting fraction: LCMS-ESI⁺ (*m/z*):
15 $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{36}\text{H}_{49}\text{F}_2\text{N}_4\text{O}_7$: 687.4; found: 687.3.

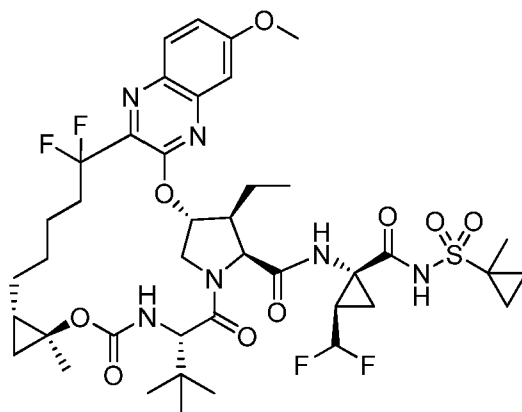
 Step 3. Preparation of **63-4**: Palladium on carbon (10% w/w, 155 mg) was added to a solution of **63-2** (155 mg, 0.226 mmol) in ethanol (3 mL). Mixture was stirred under an atmosphere of hydrogen for 1 hr and was then filtered through a plug of Celite, and washed with ethyl acetate. Filtrate was
20 concentrated under reduced pressure to yield **63-4**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{36}\text{H}_{51}\text{F}_2\text{N}_4\text{O}_7$: 689.4; found: 689.3.

 Step 6. Preparation of **63-5**: Intermediate **63-4** (153.5 mg, 0.222 mmol) was dissolved in a mixture of 1:1 TFA:DCM (6 mL) and stirred at room
25 temperature for 3 hrs. Reaction mixture was then concentrated *in vacuo* to give **63-5**, which was used in the subsequent step without further purification. LCMS-ESI⁺ (*m/z*): $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{32}\text{H}_{44}\text{N}_4\text{O}_7$: 633.3; found: 633.2.

 Step 7. Preparation of Example **63**: HATU (99.2 mg, 0.261 mmol) and DIPEA (271 μL , 2.1 mmol) were added to a mixture of **63-5** (140.5 mg, 0.222 mmol) and
30 **A10** (100 mg, 0.316 mmol) in 1 mL of DMF. After stirring overnight at room

temperature, reaction mixture was poured into water, acidified to pH 1 with 1 N aqueous HCl, and extracted three times with methylene chloride (15 mL). Combined organics were washed with water, brine, dried over MgSO₄, filtered, and concentrated under reduced pressure. The resulting residue was purified by reverse phase prep HPLC (5–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to afford Example **63**. Analytic HPLC RetTime: 8.951 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₄N₆O₉S: 883.4; found: 883.2. ¹H NMR (400 MHz, CD₃OD) δ 7.96 (d, *J* = 9.2 Hz, 1H), 7.33 (dd, *J* = 9.2, 2.8 Hz, 1H), 7.23 (d, *J* = 2.7 Hz, 1H), 6.03 (d, *J* = 3.9 Hz, 1H), 5.80 (td, *J* = 55.8, 6.7 Hz, 1H), 4.61 (d, *J* = 6.9 Hz, 1H), 4.46 (d, *J* = 12.2 Hz, 1H), 4.26 – 4.14 (m, 2H), 4.01 – 3.91 (m, 3H), 2.65 – 2.47 (m, 2H), 2.11 – 1.85 (m, 5H), 1.84 – 1.61 (m, 3H), 1.61 – 1.46 (m, 10H), 1.46 – 1.32 (m, 3H), 1.33 – 1.17 (m, 4H), 1.09 (d, *J* = 15.9 Hz, 10H), 1.04 – 0.95 (m, 1H), 0.94 – 0.84 (m, 2H), 0.21 – 0.12 (m, 1H).

Example **64**. Preparation of (1aS,5S,8S,9S,10R,22aS)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-14-methoxy-1a-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide



Example 64

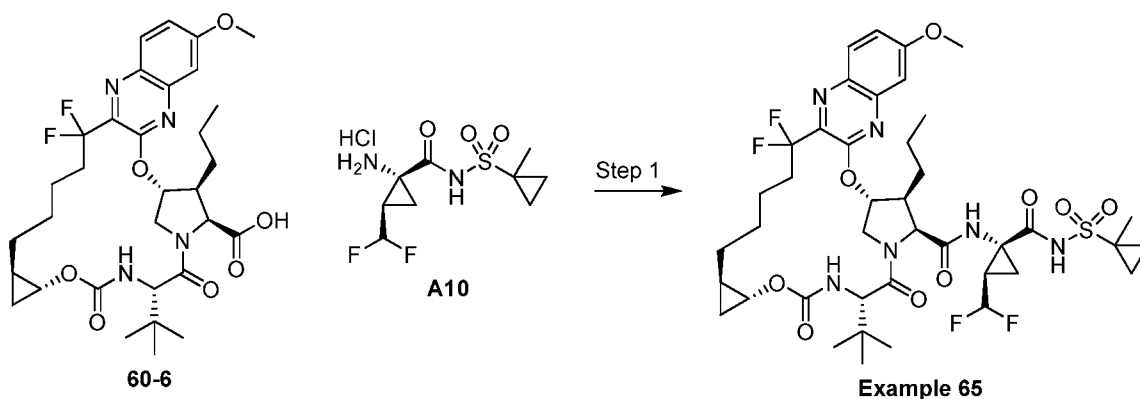
Example **64** was prepared in a similar fashion to Example **63**, substituting late eluting **63-3** for early eluting **63-2** in Step 3. Example **64** was then isolated.

Analytic HPLC RetTime: 8.535 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

C₄₁H₅₇F₂N₆O₉S: 883.4; found: 883.3. ¹H NMR (400 MHz, CD₃OD) δ 7.97 (d, *J* =

5 8.9 Hz, 1H), 7.45 – 7.16 (m, 2H), 5.97 – 5.52 (m, 2H), 4.74 (d, *J* = 7.6 Hz, 1H), 4.50 – 4.16 (m, 1H), 4.06 – 3.86 (m, 5H), 2.77 – 2.57 (m, 1H), 2.51 – 2.18 (m, 2H), 2.16 – 1.86 (m, 5H), 1.75 – 1.32 (m, 16H), 1.33 – 1.03 (m, 14H), 1.02 – 0.76 (m, 2H), 0.42 – -0.09 (m, 1H).

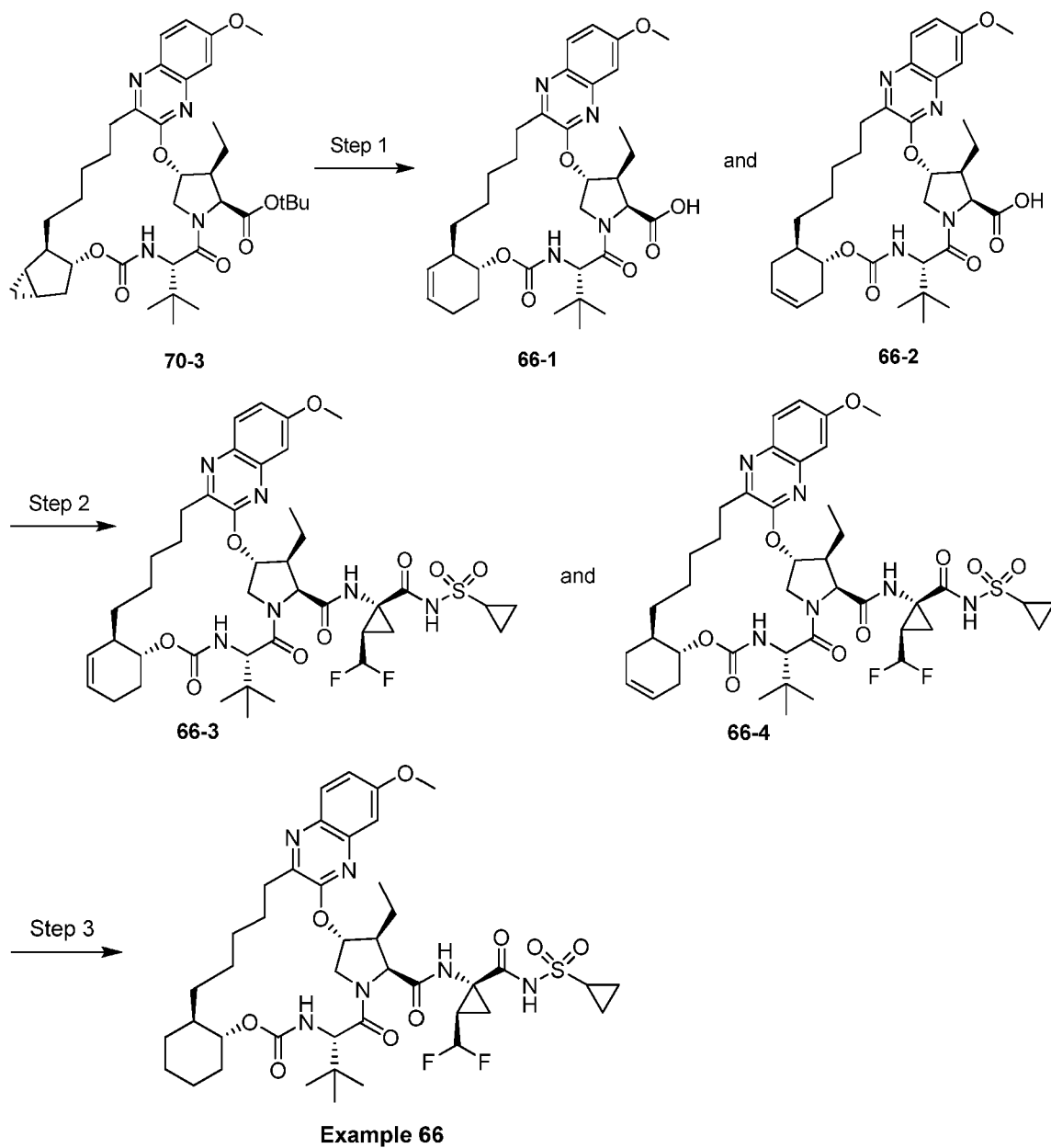
Example **65**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
10 [(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-14-methoxy-
3,6-dioxo-9-propyl-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-
7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
b]quinoxaline-8-carboxamide



Step 1. Preparation of Example **65**: To a solution of **60-6** (52 mg, 82 μmol) and Intermediate **A10** (37.5 mg, 123 μmol) in MeCN (411 μL) was added HATU (47.5 mg, 123 μmol) followed by DIPEA (73 μL, 411 μmol) at rt under an argon atmosphere. After 20 h, the reaction mixture was concentrated *in vacuo*,
20 was purified by preparatory HPLC (Gemini 5u C18 110Å column, 5–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and was lyophilized to afford Example **65** as a TFA salt. Analytic HPLC RetTime: 8.99 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₄N₆O₉S: 883.36; found: 883.60. ¹H NMR (400 MHz, CD₃OD) δ 9.26 (s, 1H), 7.95 (d, *J* = 9.1 Hz, 1H), 7.33 (dd, *J* = 9.2, 2.8 Hz, 1H),

7.22 (d, $J = 2.8$ Hz, 1H), 5.89 (d, $J = 3.2$ Hz, 1H), 5.81 (td, $J_{\text{H-F}} = 55.5$ Hz, $J = 6.5$ Hz, 1H), 4.59 (d, $J = 7.0$ Hz, 1H), 4.40 (d, $J = 12.5$ Hz, 1H), 4.36 (s, 1H), 4.17 (dd, $J = 12.2, 3.8$ Hz, 1H), 3.97 (s, 3H), 3.73 – 3.66 (m, 1H), 2.73 – 2.64 (m, 1H), 2.63 – 2.45 (m, 1H), 2.01 (br s, 3H), 1.85 – 1.62 (m, 4H), 1.62 – 1.53 (m, 3H),
5 1.51 (s, 3H), 1.48 – 1.22 (m, 5H), 1.08 (s, 9H), 1.01 (app t, $J = 7.3$ Hz, 4H), 0.94 – 0.87 (m, 2H), 0.80 – 0.69 (m, 1H), 0.50 (d, $J = 7.1$ Hz, 1H).

Example 66. Preparation of (4aR,8S,11S,12S,13R,25aR)-8-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-12-ethyl-17-methoxy-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-
10 hexadecahydro-1H,11H-10,13-methanoquinoxalino[2,3-k][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide.



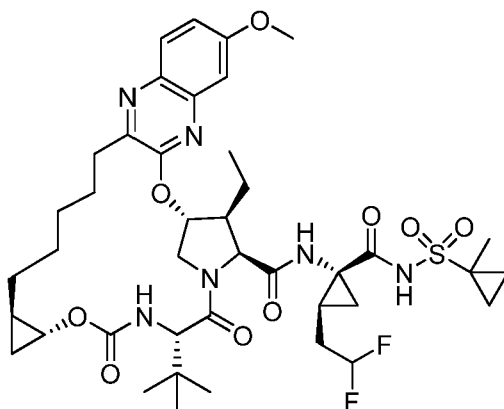
- 5 Step 1. Preparation of **66-1** and **66-2**. To a solution of Intermediate **70-3** (283 mg, 0.42 mmol) in CH_2Cl_2 (5 mL) was added TMSOTf (380 μL , 2.1 mmol). After stirring for 2 h, the reaction mixture was poured into stirring 1 N NaOH (12 mL). The mixture was transferred to a separatory funnel, acidified to pH 3 with 1N HCl, extracted with CH_2Cl_2 , dried over magnesium sulfate, and concentrated.
- 10 The crude residue was purified by silica gel chromatography (0-10%

MeOH/EtOAc) to yield a mixture of **66-1** and **66-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.34; found: 623.66.

Step 2. Preparation of **66-3** and **66-4**. To a solution of **66-1** and **66-2** (58 mg, 0.09 mmol), intermediate **A9** (32 mg, 0.11 mmol), TBTU (42 mg, 0.13 mmol) and DMAP (16 mg, 0.14 mmol) in DMF (3 mL) was added DIPEA (47 μ L, 0.27 mmol) and the reaction was stirred at rt for 23 h. The reaction was quenched with water, diluted with EtOAc, washed with sat. NaHCO₃, brine, dried over magnesium sulfate, and concentrated. The crude material was purified by reverse phase HPLC (Gemini, 30-85% ACN/H₂O + 0.1% TFA) and lyophilized to give the TFA salt of Intermediate **66-3** and **66-4** mixture. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.39; found: 859.65.

Step 3. Preparation of Example **66**: To **66-3** and **66-4** (5 mg, 0.005 mmol) that was taken up in EtOH (2 mL) and treated with Pd/C (10%, 5 mg). The atmosphere was replaced with hydrogen and stirred at rt for 2.5 h. The reaction was filtered over Celite, washed with EtOAc and concentrated. The residue was purified by silica gel chromatography (0-10% MeOH/EtOAc) and lyophilized to give the parent compound. Analytical HPLC RetTime: 9.15 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₉F₂N₆O₉S: 862.01; found: 862.37. ¹H NMR (400 MHz, CD₃OD) δ 7.94 – 7.73 (m, 1H), 7.25 (m, 1H), 6.87 (d, *J* = 9.8 Hz, 1H), 6.05 (m, 2H), 4.83 – 4.74 (m, 1H), 4.70 (d, *J* = 7.6 Hz, 1H), 4.52 – 4.28 (m, 2H), 4.16 (m, 2H), 4.05 – 3.86 (m, 4H), 3.86 – 3.45 (m, 4H), 3.22 – 3.00 (m, 1H), 2.89 (s, 1H), 2.77 – 2.55 (m, 1H), 2.25 (t, *J* = 7.3 Hz, 1H), 2.09 – 0.81 (m, 35H).

Example **67**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2S)-2-(2,2-difluoroethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

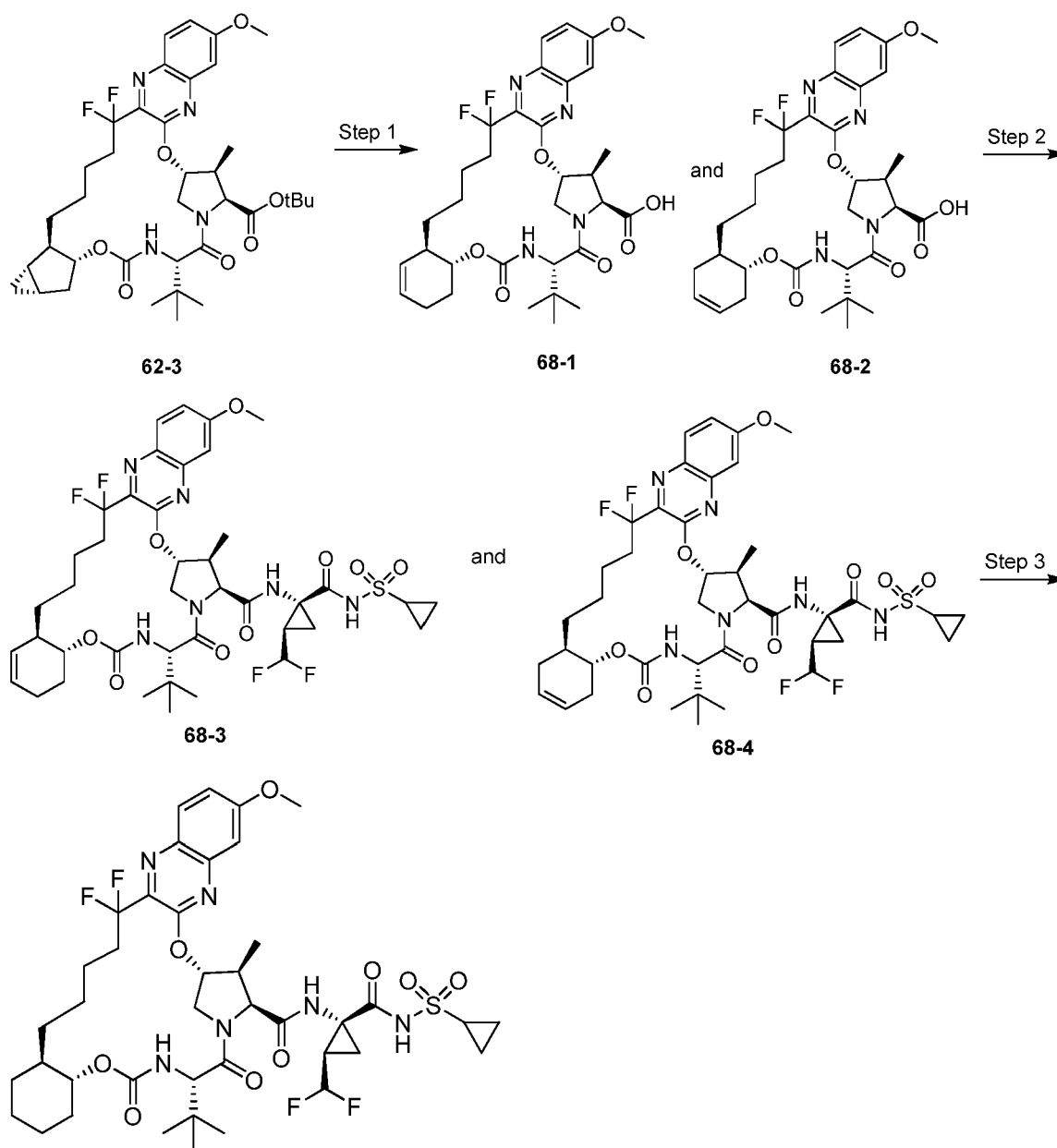


Example 67

Example **67** was prepared similarly to Example **1** substituting Intermediate **A8** for Intermediate **A10** in Step 8. The TFA salt of Example **67** was isolated.

- 5 Analytic HPLC RetTime: 8.85 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₇F₂N₆O₉S: 847.99; found: 847.64. ¹H NMR (400 MHz, CD₃OD) δ 9.00 (s, 1H); 7.79 (d, *J* = 9.2 Hz, 1H); 7.23 (dd, *J* = 9.2, 2.4 Hz, 1H); 7.15 (d, *J* = 2.4 Hz, 1H); 5.89 (tt, *J*_{H-F} = 54 Hz, *J* = 4.4 Hz, 1H); 5.89 (br s, 1H); 4.61 (d, *J* = 7.2 Hz, 1H); 4.39 (br s, 1H); 4.37 (d, *J* = 9.2 Hz, 1H); 4.16 (dd, *J* = 9.2 Hz, 7.2 Hz, 1H);
- 10 3.92 (s, 3H); 3.78-3.72 (m, 1H); 3.10-2.88 (m, 1H); 2.86-2.74 (td, *J* = 12, 4.4 Hz, 1H); 2.62-2.53 (m, 1H); 2.18-2.04 (m, 1H); 1.88-1.46 (m, 14H); 1.53 (s, 3H); 1.28-1.20 (m, 4H); 1.10 (s, 9H); 1.02-0.96 (m, 2H); 0.96-0.86 (m, 2H); 0.78-0.67 (m, 1H); 0.54-0.47 (m, 1H).

- 15 Example **68**. Preparation of (4aR,8S,11S,12S,13R,25aS)-8-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-21,21-difluoro-17-methoxy-12-methyl-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-hexadecahydro-1H,11H-10,13-methanoquinoxalino[2,3-*k*][1,10,3,6]benzodioxadiazacyclononadecine-11-
- 20 carboxamide

**Example 68**

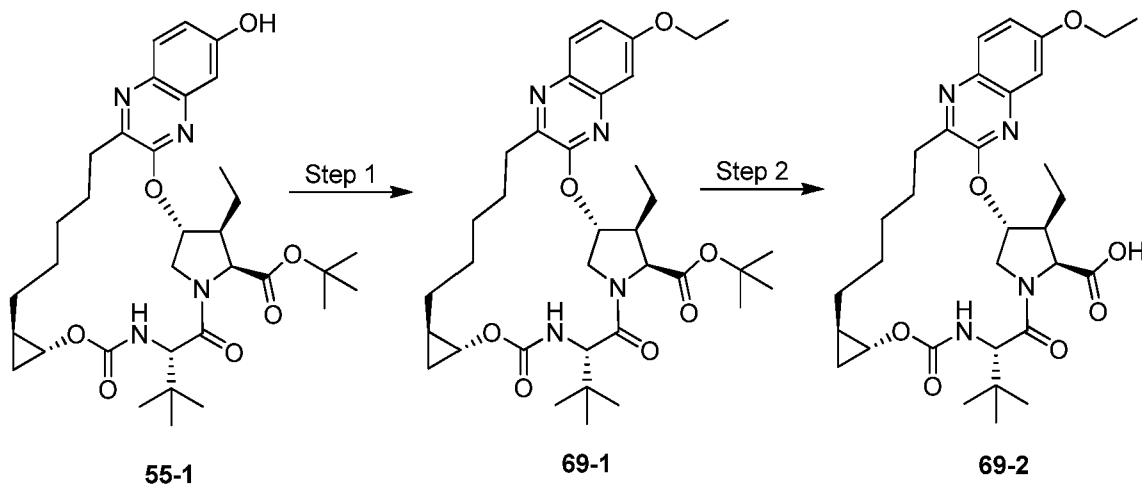
Step 1. Preparation of **68-1** and **68-2** (mixture): TMSOTf (0.6 mL, 3.3 mmol) was added to a solution of intermediate **62-3** (424 mg, 0.606 mmol) in 7 mL of dichloromethane at room temperature. After 1 hour, an additional 0.2 mL of TMSOTf was added. After a total of three hours, reaction mixture was concentrated to yield a mixture of **68-1** and **68-2** isomers, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₃F₂N₄O₇: 645.30; found: 645.49.

Step 2. Preparation of **68-3** and **68-4** (mixture): HATU (209 mg, 0.550 mmol, Oakwood) and DIPEA (0.25 mL, 1.43 mmol) were added to the mixture of **68-1** and **68-2** from the previous step (176 mg, 0.273 mmol) and Intermediate **A9** (161 mg, 0.555 mmol) in 4 mL of acetonitrile and 2 mL of DMF under argon. After one hour, an additional 100 mg of Intermediate **A9** was added. After two hours, reaction mixture was taken up in 30 mL of ethyl acetate and washed with 20 mL of 1 N aqueous HCl. The aqueous layer was extracted three times with ethyl acetate. Combined organics were washed with 50% brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salts of a mixture of **68-3** and **68-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₃F₄N₆O₉S: 881.35; found: 881.50.

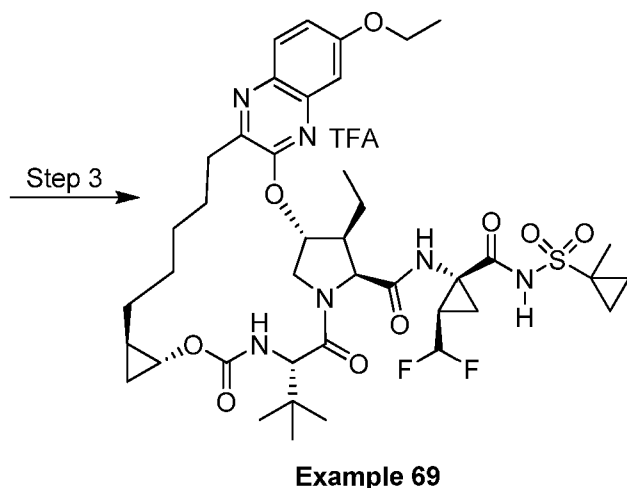
Step 3. Preparation of Example **68**: Palladium on carbon (10 wt % Pd, 2 mg, 0.0019 mmol) was added to a solution of the mixture of **68-3** and **68-4** from the previous step (4.5 mg, 0.0045 mmol) in 1 mL of ethanol. The atmosphere was replaced with hydrogen and mixture was stirred for two hours. The reaction was filtered over Celite, washing with ethanol. Filtrate was concentrated *in vacuo* to yield Example **68**. Analytic HPLC RetTime: 8.81 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₅F₄N₆O₉S: 883.36; found: 883.64. ¹H NMR (400 MHz, CD₃OD): δ 7.94 (d, J = 10.4 Hz, 1H), 7.34–7.30 (m, 2H), 6.13 (td, J_{H-F} = 57 Hz, J = 6.8 Hz, 1H), 5.88–5.84 (m, 1H), 4.62 (d, J = 7.6 Hz, 1H), 4.38–4.30 (m, 2H), 4.20–4.05 (m, 2H), 3.98 (s, 3H), 2.87–2.76 (m, 2H), 2.34–2.16 (m, 2H), 1.92–1.54 (m, 6H), 1.46–1.36 (m, 3H), 1.34–1.12 (m, 8H), 1.20 (d, J = 7.6 Hz, 3H), 1.08–0.96 (m, 4H), 1.04 (s, 9H), 0.93–0.78 (m, 4H).

Example **69**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-14-ethoxy-9-ethyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide



5



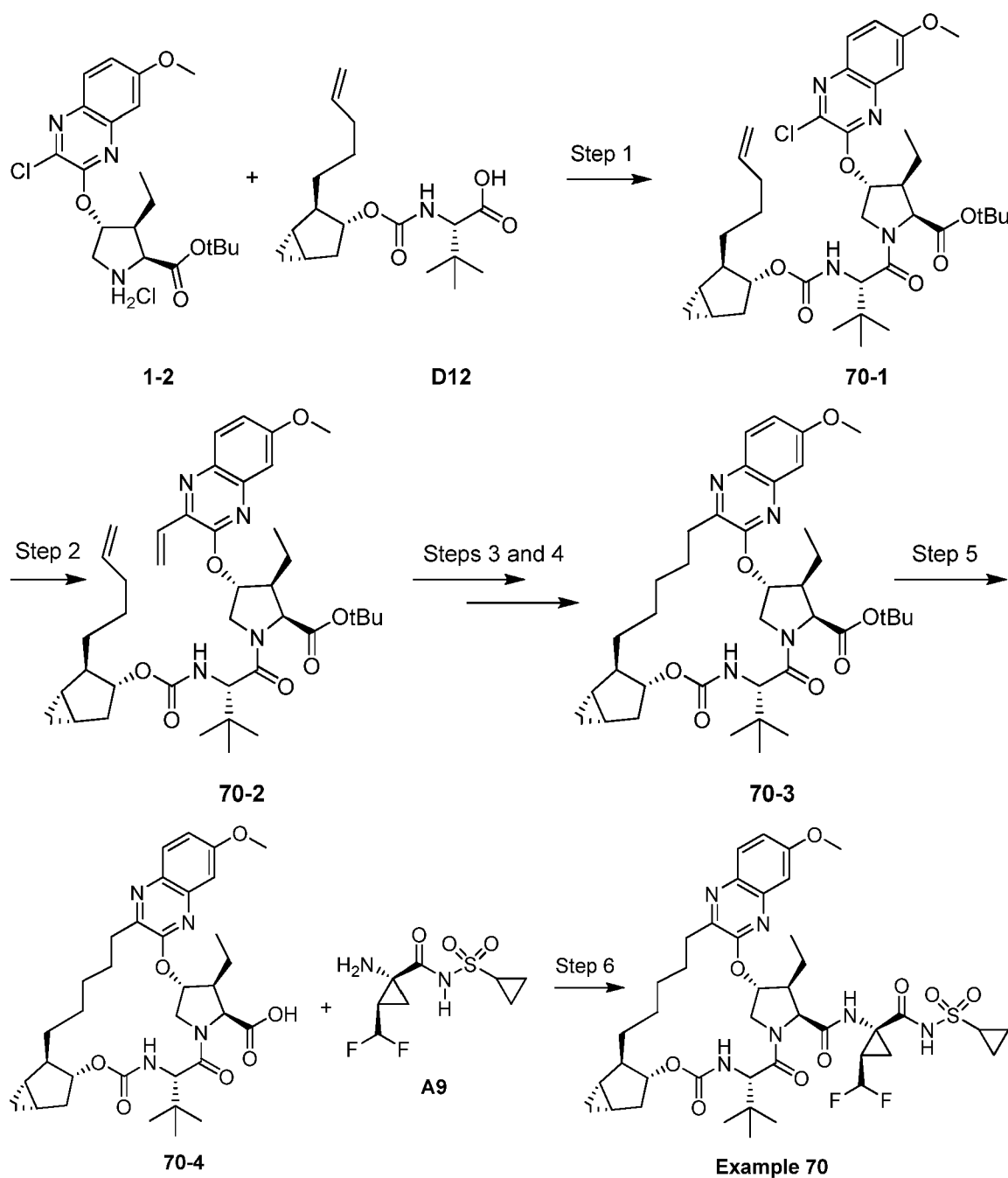
Step 1. Preparation of **69-2**. Quinoxalinol **55-1** (54 mg, 0.086 mmol) was suspended in ACN (2 mL) and treated with Cs_2CO_3 (84 mg, 0.259 mmol) and bromoethane (0.032 mL, 0.432 mmol). The reaction mixture was stirred at RT for 16 h. The reaction was filtered and the crude material was purified by flash column chromatography to afford **69-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{36}\text{H}_{52}\text{N}_4\text{O}_7$: 652.38; found: 653.41.

Step 2. Preparation of **69-3**. Intermediate **69-2** (0.086 mmol theoretical) was treated with DCM (10 mL) and TMSOTf (1.0 mL) at RT. After 1 h, the

reaction was complete determined by LCMS. The reaction was concentrated under reduced pressure to afford **69-3**, which was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₄N₄O₇: 596.32; found: 597.38.

- 5 Step 3. Preparation of Example **69**. Carboxylic acid **69-3** (0.086 mmol theoretical) was treated with intermediate **A10** (40 mg, 0.130 mmol), TBTU (47 mg, 0.147 mmol), DMAP (18 mg, 0.147 mmol), DCM (3 mL) and DIPEA (0.075 mL, 0.432 mmol). The reaction mixture was stirred at RT for 20 h, then concentrated under reduced pressure and purified by reverse phase HPLC to afford Example **69** as a TFA salt. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₆F₂N₆O₉S: 846.38; found: 847.75.

- 15 Example **70**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-10-ethyl-15-methoxy-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide



Step 1. Preparation of **70-1**: To a solution of **1-2** (575 mg, 1.41 mmol),
 5 **D12** (410 mg, 1.26 mmol) and HATU (696 mg, 1.80 mmol) in DMF (12 mL) was added DIPEA (1.0 mL, 5.64 mmol) and the reaction was stirred at rt. After stirring for 2 h, additional HATU (350 mg, 0.92 mmol) and DIPEA (0.5 mL, 2.8 mmol) was added to the reaction, and the mixture was stirred for 14 h. The reaction was quenched with sat. NaHCO₃ solution and extracted with EtOAc,
 10 washed subsequently with brine, dried over magnesium sulfate and

concentrated. The crude product was purified by silica gel chromatography (10-30% EtOAc/hexanes) to yield intermediate **70-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₄ClN₄O₇: 713.37; found: 713.95.

Step 2. Preparation of **70-2**: To a solution of **70-1** (542 mg, 0.76 mmol),
5 TEA (0.16 mL, 1.14 mmol) and potassium vinyltrifluoroborate (153 mg, 1.14 mmol) in EtOH (10 mL) was added PdCl₂(dppf) (62 mg, 0.08 mmol). The reaction was degassed with N₂ for 10 min and heated to 80 °C for 1 h. The reaction was quenched with sat. NaHCO₃ solution and extracted with EtOAc, washed subsequently with brine, dried over magnesium sulfate and concentrated. The
10 residue was purified using silica gel chromatography (0-20% EtOAc/hexanes) to give intermediate **70-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₇N₄O₇: 705.42; found: 705.05.

Step 3 and 4. Preparation of **70-3**: To a solution of **70-2** (470 mg, 0.66 mmol) in DCE (100 mL) was added Zhan 1B catalyst (49 mg, 0.07 mmol) and the
15 reaction was degassed for 30 minutes with N₂. The reaction was heated to 100 °C for 1 h, allowed to cool to rt and concentrated. The crude product was purified by silica gel chromatography to give product (358 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₃N₄O₇: 677.39; found: 677.52) that was taken up in EtOH (6 mL) and EtOAc (2 mL) and treated with Pd/C (10%, 350 mg). The atmosphere
20 was replaced with hydrogen and stirred at rt for 1.5 h. The reaction was filtered over Celite, washed with EtOAc and concentrated (358 mg intermediate **70-3**) that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₅N₄O₇: 679.41; found: 679.44.

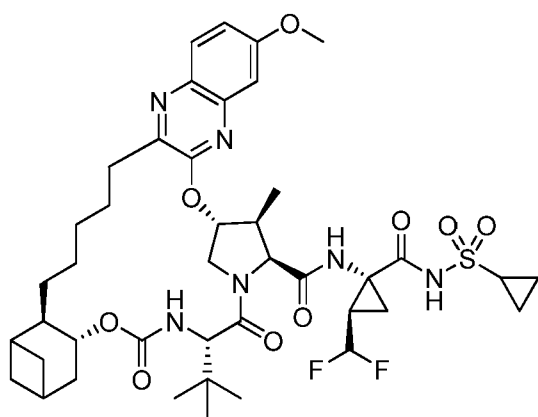
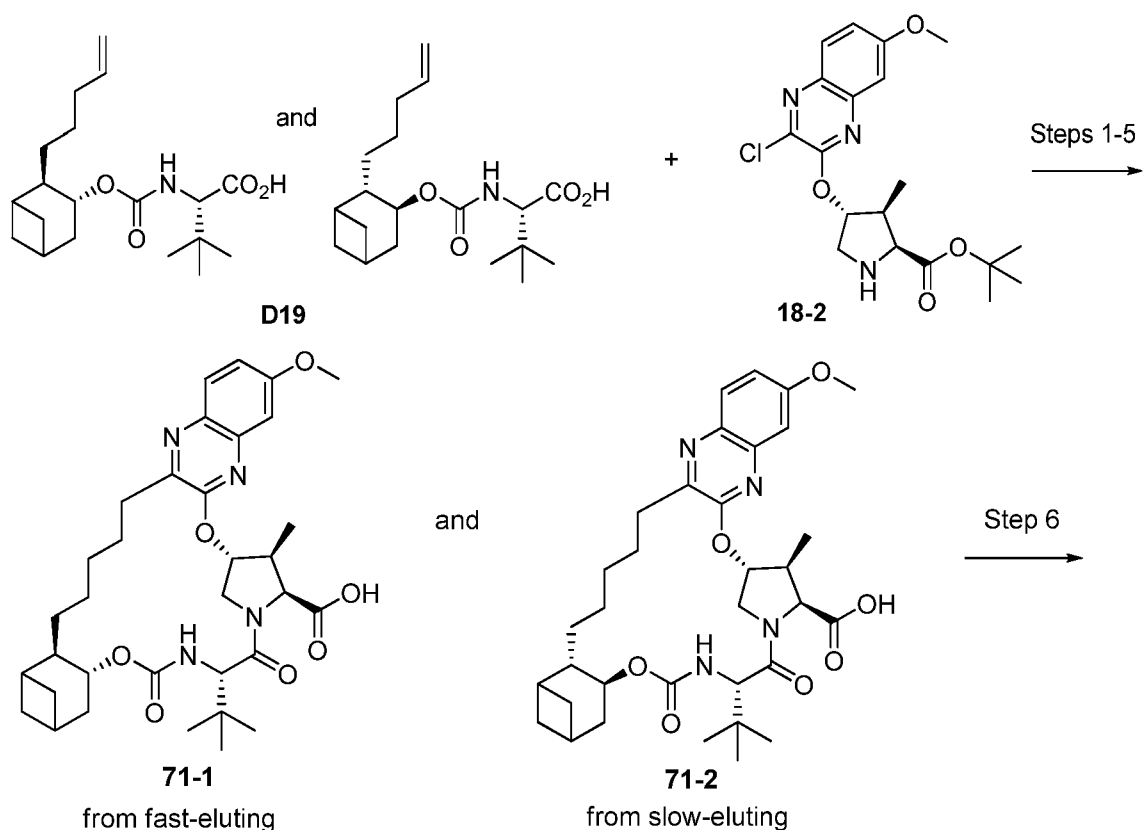
Step 5. Preparation of **70-4**: To a solution of **70-3** (100 mg, 0.15 mmol) in
25 DCM (1 mL) was added TFA (1 mL) and stirred at rt for 2 h. The reaction was diluted with EtOAc, washed with H₂O, basicified to pH 7 with sat. NaHCO₃ solution, dried over magnesium sulfate, and concentrated to give a residue of intermediate **70-4** that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.34; found: 623.44 .

30 Step 6. Preparation of Example **70**: To a solution of **70-4** (94 mg, 0.15 mmol), intermediate **A9** (65 mg, 0.22 mmol), TBTU (87 mg, 0.27 mmol) and

DMAP (27 mg, 0.22 mmol) in DCM (3 mL) was added DIPEA (0.13 mL, 0.75 mmol) and the reaction was stirred at rt for 2 h. The reaction was quenched with water, diluted with EtOAc, washed with sat. NaHCO₃, brine, dried over magnesium sulfate, and concentrated. The crude material was purified by
5 reverse phase HPLC (Gemini, 30-85% ACN/H₂O + 0.1% TFA) and lyophilized to give Example **70** (23 mg) as a TFA salt.

Analytical HPLC RetTime: 9.32 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.39; found: 859.54. ¹H NMR (400 MHz, CD₃OD) δ 9.31 (s, 1H), 7.83 (d, *J* = 9.1 Hz, 1H), 7.26 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.20 (d, *J* = 2.7 Hz, 1H), 6.09 – 5.68 (m, 2H), 5.51 (s, 1H), 5.07 – 4.97 (m, 1H), 4.70 – 4.55 (m, 1H),
10 4.42 – 4.29 (m, 2H), 4.22 (dd, *J* = 12.0, 4.1 Hz, 1H), 3.96 (s, 2H), 3.75 (t, *J* = 6.7 Hz, 2H), 3.02 (m, 2H), 2.93 – 2.67 (m, 1H), 2.56 (m, 1H), 2.13 – 1.04 (m, 30H), 1.00 (d, *J* = 6.6 Hz, 1H), 0.90 (m, 3H), 0.65 – 0.46 (m, 2H).

15 Example **71**. Preparation of (4aR,8S,11S,12S,13R,25aR)-8-tert-butyl-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-17-methoxy-12-methyl-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-hexadecahydro-1H,11H-1,3:10,13-dimethanoquinoxalino[2,3-k][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide and



Example 71

Step 1: To a solution of amine **18-2** (315 mg, 0.80 mmol), DIPEA (350 μ L, 2.0 mmol) and a 1:1 mixture of acids **D19** (270 mg, 0.80 mmol) in MeCN (8 mL) was added HATU (400 mg, 1.05 mmol). The resulting solution was stirred for 2.5 h at r.t., at which time it was diluted with EtOAc (50 mL) and 0.2 N aqueous HCl (30 mL). The phases were separated, and the organic phase was dried over MgSO_4 , filtered, and concentrated to afford a crude residue. Purification by silica

gel chromatography (10% to 30% EtOAc in hexanes) provided 474 mg of a colorless oil that was used directly in the next step.

Step 2: A suspension of the product from step 1 (474 mg, ca. 0.65 mmol), PdCl₂(dppf)•CH₂Cl₂ (40 mg, 0.049 mmol) and potassium vinyltrifluoroborate (189 mg, 1.41 mmol) in EtOH (8 mL) was sparged with Ar for several minutes and Et₃N (200 µL, 1.4 mmol) was added. The resulting mixture was heated under Ar to 75 °C via oil bath. After stirring 2.25 h, the reaction mixture was cooled to r.t. and was diluted with EtOAc (35 mL) and half-saturated brine (20 mL). The phases were separated, and the organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. Purification by silica gel chromatography provided a yellow oil that was used directly in the next step.

Step 3: A solution of the product from Step 3 (395 mg, 0.56 mmol) in 1,2-DCE (180 mL) was sparged with Ar for 10 min. Zhan 1B metathesis catalyst (61 mg, 0.083 mmol) was then added as a solution in DCE (4 mL), and the resulting solution was heated to 85 °C. After stirring 1.75 h, the reaction mixture was cooled to ambient temperature, concentrated onto silica gel (5 g), and purified by silica gel chromatography (10 to 15 to 25% EtOAc in hexanes) to afford 116 mg of a fast-eluting product and 84 mg of a slow-eluting product.

Step 4-5 (fast-eluting diastereomer): The fast-eluting product from Step 3 was dissolved in 1:1 EtOAc:EtOH (4 mL). Pd/C (10 wt. % Pd, 45 mg) was added, and the reaction vessel was purged twice with 1 atm H₂. The reaction mixture was stirred for 2.5 h under 1 atm H₂ and was then filtered through celite with EtOAc to afford a crude residue. This residue was dissolved in CH₂Cl₂ (1 mL) and was treated with TFA (2 mL). After stirring 2 h, the reaction mixture was concentrated in vacuo and was partitioned between EtOAc (15 mL) and 15% saturated aqueous NaHCO₃ (10 mL). The phases were separated, and the organic phase was washed with brine (10 mL), dried over Na₂SO₄, and filtered to provide **71-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.3; found: 623.2.

Step 4-5 (slow-eluting diastereomer): The slow-eluting product from Step 3 was dissolved in EtOAc (1 mL) and EtOH (7 mL). Pd/C (10 wt. % Pd, 85 mg)

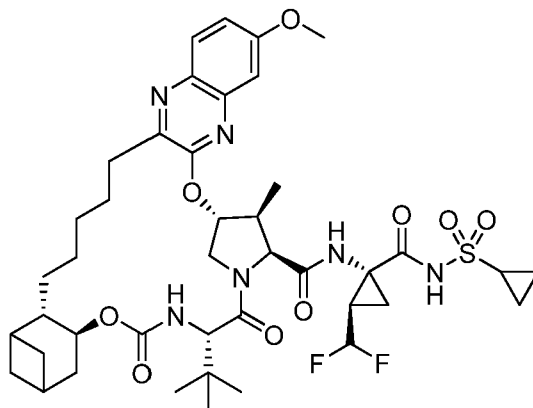
was added, and the reaction vessel was purged twice with 1 atm H₂. The reaction mixture was stirred for 3 h under 1 atm H₂ and was then filtered through celite with EtOAc to afford a crude residue. This residue was dissolved in CH₂Cl₂ (1 mL) and was treated with TFA (2 mL). After stirring 2 h, the reaction mixture
5 was concentrated in vacuo and was partitioned between EtOAc (15 mL) and 15% saturated aqueous NaHCO₃ (10 mL). The phases were separated, and the organic phase was washed with brine (10 mL), dried over Na₂SO₄, and filtered to provide **71-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₄H₄₇N₄O₇: 623.3; found: 623.2.

10 Step 6: Preparation of Example **71**: To a suspension of acid **71-1** (49 mg, 0.079 mmol) and amine hydrochloride **A9** (41 mg, 0.14 mmol) in MeCN (1 mL) was added DIPEA (100 μL, 0.57 mmol). HATU (45 mg, 0.12 mmol) was added to the resulting solution, and the reaction was stirred at rt for 14.5 h. The reaction
15 was then diluted with EtOAc (20 mL), 0.2 M aqueous HCl (10 mL) and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and was concentrated onto 2 g silica gel. Purification by silica gel
20 chromatography (4% to 45% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **71**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.4; found: 859.1. ¹H NMR (400 MHz, CDCl₃) δ 10.13 (s, 1H), 7.81 (d, *J* = 9.1 Hz, 1H), 7.63 (s, 1H), 7.19 (dd, *J* = 9.1, 2.8 Hz, 1H), 7.09 (d, *J* = 2.7 Hz, 1H), 5.97 (td, *J* = 55.5, 6.9 Hz, 1H), 5.59 – 5.45 (m, 2H), 4.96 (dd, *J* = 14.4, 6.2 Hz, 1H), 4.51 (d, *J* = 7.2 Hz, 1H),
25 4.42 (d, *J* = 9.8 Hz, 1H), 4.13 (dt, *J* = 12.0, 7.7 Hz, 2H), 3.93 (s, 3H), 2.99 – 2.63 (m, 4H), 2.40 – 2.23 (m, 2H), 2.15 – 0.83 (m, 34H).

Example **72**. Preparation of (4a*S*,8*S*,11*S*,12*S*,13*R*,25a*S*)-8-*tert*-butyl-*N*-[(1*R*,2*R*)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-17-methoxy-12-methyl-6,9-dioxo-2,3,4,4a,6,7,8,9,12,13,21,22,23,24,25,25a-

30

hexadecahydro-1H,11H-1,3:10,13-dimethanoquinoxalino[2,3-k][1,10,3,6]benzodioxadiazacyclononadecine-11-carboxamide.

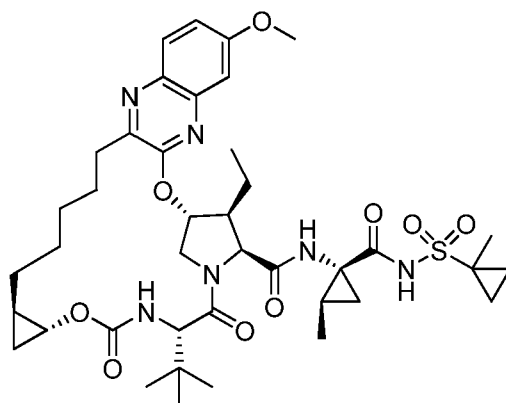


Example 72

Step 1: Preparation of Example **72**: To a suspension of acid **71-2** (49 mg, 0.079 mmol) and amine hydrochloride **A9** (38 mg, 0.13 mmol) in MeCN (1 mL) was added DIPEA (100 μ L, 0.57 mmol). HATU (41 mg, 0.11 mmol) was added to the resulting solution, and the reaction was stirred at rt for 14.5 h. The reaction was then diluted with EtOAc (20 mL), 0.2 M aqueous HCl (10 mL) and brine (10 mL). The phases were separated and the aqueous phase was extracted with EtOAc (20 mL). The combined organic phase was dried over Na₂SO₄, filtered, and concentrated to afford a crude residue. This residue was dissolved in CH₂Cl₂ and was concentrated onto 2 g silica gel. Purification by silica gel chromatography (4% to 45% acetone in hexanes) provided an amorphous residue that was lyophilized from water and MeCN to provide Example **72**.

LCMS-ESI⁺ (m/z): [M+H]⁺ calcd for C₄₂H₅₇F₂N₆O₉S: 859.4; found: 859.0. ¹H NMR (400 MHz, CDCl₃) δ 9.72 (s, 1H), 9.36 (s, 1H), 7.86 (d, J = 9.1 Hz, 1H), 7.28 (d, J = 2.7 Hz, 1H), 7.25 – 7.17 (m, 2H), 5.98 – 5.88 (m, 1H), 5.69 (td, J = 55.4, 6.9 Hz, 1H), 4.81 – 4.69 (m, 1H), 4.68 – 4.56 (m, 2H), 4.33 (d, J = 10.1 Hz, 1H), 3.99 (s, 3H), 3.35 (dd, J = 9.7, 7.0 Hz, 1H), 3.24 – 3.13 (m, 1H), 2.97 – 2.87 (m, 1H), 2.87 – 2.72 (m, 2H), 2.57 – 2.45 (m, 1H), 2.38 – 2.28 (m, 1H), 2.17 – 0.71 (m, 34H).

Example **73**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-9-ethyl-14-methoxy-N-[(1R,2R)-2-methyl-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

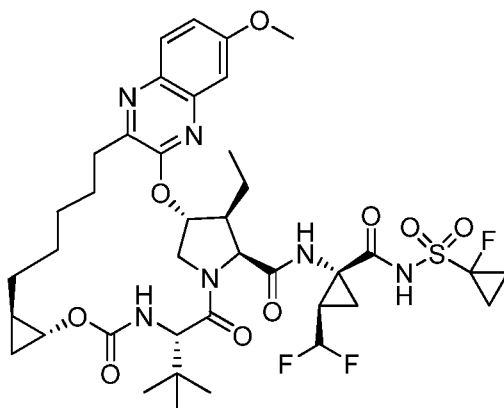


Example **73**

Example **73** was prepared similarly to Example **1** substituting Intermediate **A11** for Intermediate **A10** in Step 8. The TFA salt of Example **73** was isolated. Analytic HPLC RetTime: 8.72 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₇N₆O₉S: 797.98; found: 797.54. ¹H NMR (400 MHz, CD₃OD) δ 8.84 (s, 1H); 7.79 (d, *J* = 9.2 Hz, 1H); 7.22 (dd, *J* = 9.2, 2.4 Hz, 1H); 7.13 (d, *J* = 2.4 Hz, 1H); 5.87 (d, *J* = 3.2 Hz, 1H); 4.57 (d, *J* = 7.2 Hz, 1H); 4.39 (br s, 1H); 4.37 (br d, *J* = 10 Hz, 1H); 4.15 (dd, *J* = 12, 4 Hz, 1H); 3.92 (s, 3H); 3.74 (m, 1H); 3.10-2.88 (m, 1H); 2.80 (td, *J* = 12.4, 4 Hz, 1H); 2.58 (m, 1H); 1.89-1.66 (m, 3H); 1.66-1.38 (m, 11H); 1.52 (s, 3H); 1.23 (t, *J* = 7.2 Hz, 3H); 1.16 (d, *J* = 6 Hz, 3H); 1.10 (s, 9H); 1.02-0.84 (m, 4H); 0.78-0.66 (m, 1H); 0.55-0.20 (m, 1H).

Example **74**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-fluorocyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-

methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Example 74

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Example **74** was prepared similarly to Example **1** substituting Intermediate **A12** for Intermediate **A10** in Step 8. The TFA salt of Example **74** was isolated.

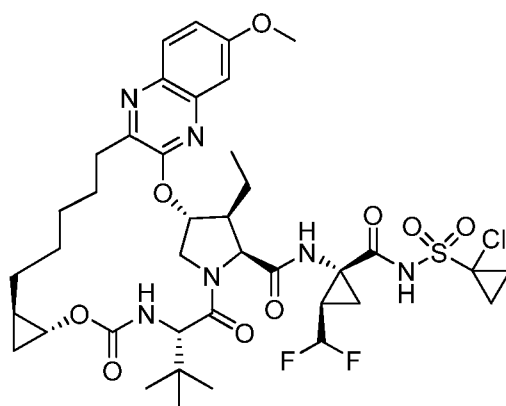
Analytic HPLC RetTime: 8.81 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

C₃₉H₅₂F₃N₆O₉S: 837.35; found: 837.54. ¹H NMR (400 MHz, CD₃OD) δ 9.26 (s, 1H); 7.79 (d, J = 9.2 Hz, 1H); 7.22 (dd, J = 9.2, 2.4 Hz, 1H); 7.14 (d, J = 2.4 Hz, 1H); 5.89 (d, J = 3.6 Hz, 1H); 5.82 (td, J_{H-F} = 56 Hz, J = 6.4 Hz, 1H); 4.56, (d, J = 7.2 Hz, 1H); 4.39 (s, 1H); 4.38 (d, J = 12 Hz, 1H); 4.16 (dd, J = 12, 7.2 Hz, 1H); 3.92 (s, 3H); 3.78-3.72 (m, 1H); 3.10-2.89 (m, 1H); 2.80 (td, J = 12, 4 Hz, 1H); 2.63-2.54 (m, 1H); 2.02 (m, 2H); 1.95-1.66 (m, 3H); 1.66-1.36 (m, 9H); 1.22 (t, J = 7.2 Hz, 3H); 1.14-1.04 (m, 2H); 1.09 (s, 9H); 1.04-0.92 (m, 2H); 0.78-0.68 (m, 1H); 0.57-0.46 (m, 1H).

15

Example **75**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-1-[(1-chlorocyclopropyl)sulfonyl]carbamoyl]-2-(difluoromethyl)cyclopropyl]-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

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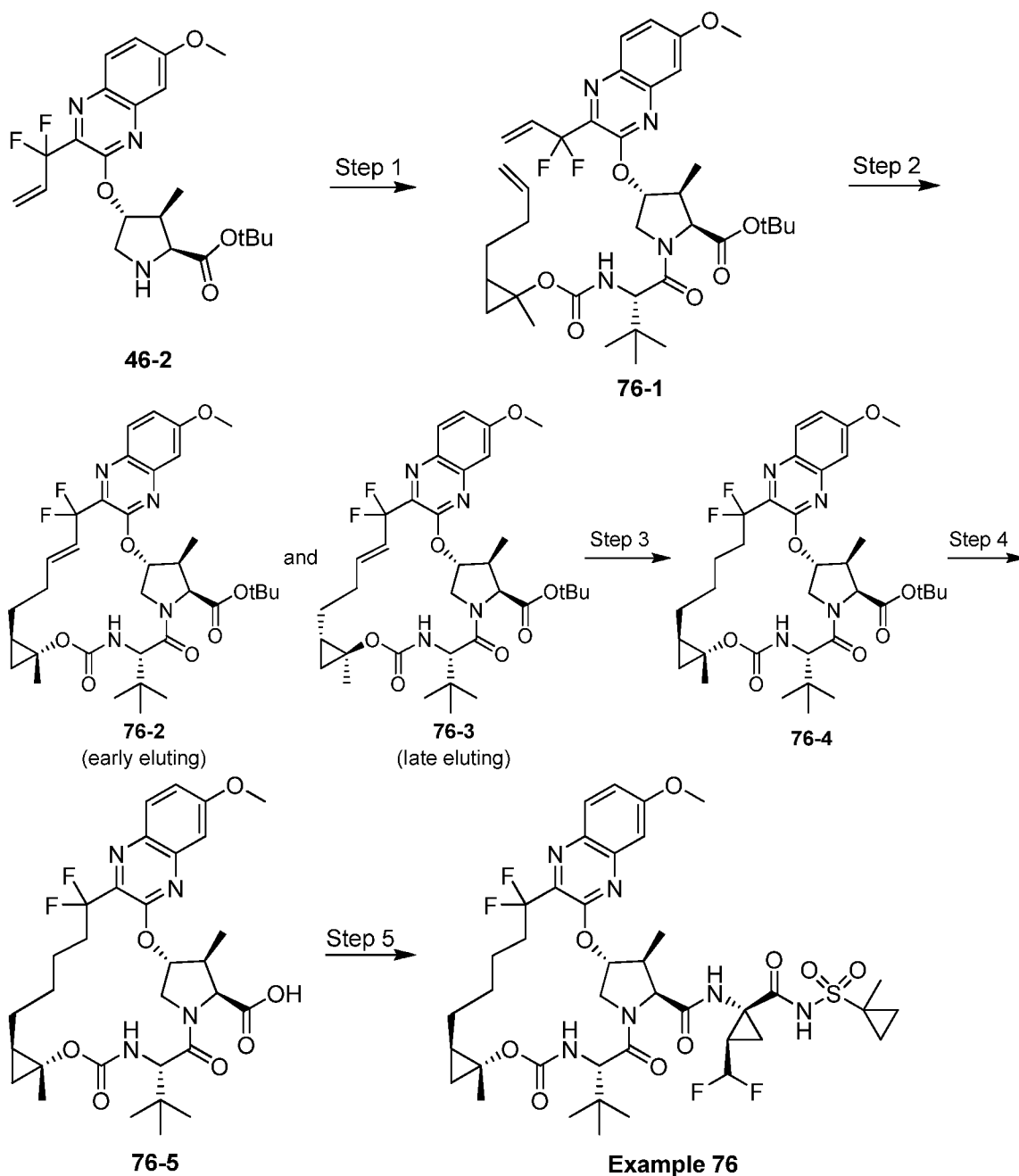


Example 75

Example **75** was prepared similarly to Example **1** substituting Intermediate **A13** for Intermediate **A10** in Step 8. The TFA salt of Example **75** was isolated.

- 5 Analytic HPLC RetTime: 8.89 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₂ClF₂N₆O₉S: 853.32; found: 853.94. ¹H NMR (400 MHz, CD₃OD) δ 9.24 (s, 1H); 7.79 (d, *J* = 9.2 Hz, 1H); 7.22 (dd, *J* = 9.2, 2.4 Hz, 1H); 7.13 (d, *J* = 2.4 Hz, 1H); 5.88 (d, *J* = 3.2 Hz, 1H); 5.84 (td, *J*_{H-F} = 55.6 Hz, *J* = 6.8 Hz, 1H); 4.57 (d, *J* = 7.2 Hz, 1H); 4.39 (br s, 1H); 4.38 (d, *J* = 12 Hz, 1H); 4.16 (dd, *J* = 12, 7.2 Hz, 1H); 3.92 (s, 3H); 3.77-3.73 (m, 1H); 3.00-2.88 (m, 1H); 2.86-2.75 (m, 1H); 2.64-2.54 (m, 1H); 2.10-1.90 (m, 4H); 1.90-1.37 (m, 12H); 1.23 (t, *J* = 7.2 Hz, 3H); 1.10 (s, 9H); 1.02-0.96 (m, 2H); 0.78-0.64 (m, 1H); 0.56-0.45 (m, 1H).
- 10

- Example **76**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-14-methoxy-1a,9-dimethyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropano[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.
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- 5 Step 1. Preparation of **76-1**: HATU (502 mg, 1.32 mmol, Oakwood) and DIPEA (0.70 mL, 4.02 mmol) were added to a mixture of **46-2** (434 mg, 0.998 mmol) and Intermediate **D17** (350 mg, 1.24 mmol) in 16 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was concentrated under reduced pressure and the resulting residue was purified by silica gel

chromatography (0–25% ethyl acetate in hexanes) to yield **76-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₁F₂N₄O₇: 701.36; found: 701.57.

Step 2. Preparation of **76-2** and **76-3**: A diastereomeric mixture **76-1** (550 mg, 0.786 mmol) and Zhan 1B catalyst (69 mg, 0.094 mmol, Strem) in 157 mL of DCE was deoxygenated under argon for 25 minutes. The mixture was then heated at reflux for 90 minutes. An additional 35 mg of Zhan 1B catalyst was added and reaction mixture was heated at reflux for 45 minutes. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–35% ethyl acetate in hexanes) to yield single diastereomers **76-2** (early eluting component) as a white solid film and **76-3** (late eluting component) as a brown solid film. Early eluting **76-2**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₇F₂N₄O₇: 673.33; found: 673.45. Late eluting **76-3**: LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₇F₂N₄O₇: 673.33; found: 673.47.

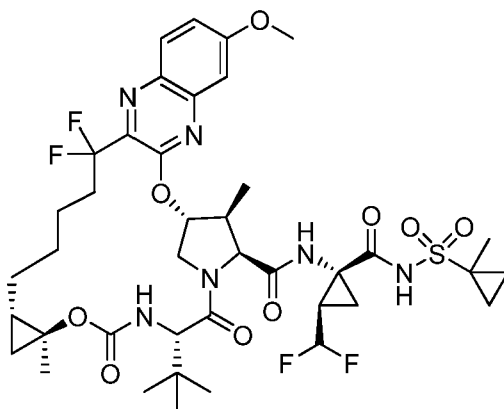
Step 3. Preparation of **76-4**: Palladium on carbon (10 wt % Pd, 51 mg, 0.048 mmol) was added to a solution of **76-2** (175 mg, 0.260 mmol) in 9 mL of ethanol. The atmosphere was replaced with hydrogen and the reaction stirred overnight. The reaction mixture was filtered over Celite and washed with ethanol. Filtrate was concentrated *in vacuo* to yield **76-4**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₉F₂N₄O₇: 675.35; found: 675.53.

Step 4. Preparation of **76-5**: TFA (1.2 mL, 15.6 mmol) was added slowly to a solution of **76-4** (155 mg, 0.230 mmol) in 3.4 mL of dichloromethane. After 4 hours, mixture was concentrated under reduced pressure to near dryness.

Resulting residue was taken up in 25 mL of ethyl acetate, washed with 15 mL of water, 15 mL of sat. NaHCO₃ (aq), and separated. Aqueous layers were extracted with ethyl acetate (3 x 20 mL). Combined organics were washed with 30 mL of brine, dried over anhydrous MgSO₄, filtered, and concentrated *in vacuo* to yield **76-5**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₄₁F₂N₄O₇: 619.29; found: 619.44.

Step 5. Preparation of Example **76**: HATU (160 mg, 0.421 mmol) and DIPEA (0.20 mL, 1.15 mmol) were added to a mixture of **76-5** (140 mg, 0.226 mmol) and Intermediate **A10** (139 mg, 0.457 mmol) in 7.5 mL of MeCN under argon. After stirring for overnight, reaction mixture was taken up in 30 mL of ethyl acetate and washed with 20 mL of 1 N aqueous HCl. Layers were separated and aqueous was extracted three times with ethyl acetate. Combined organics were washed with brine, dried over anhydrous MgSO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–45% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **76** (Analytic HPLC RetTime: 8.80 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₃F₄N₆O₉S: 869.35; found: 869.59. ¹H NMR (400 MHz, CD₃OD): 9.19 (s, 1H), 7.94 (d, J = 9.2 Hz, 1H), 7.32 (dd, J = 9.2, 2.8 Hz, 1H), 7.27 (d, J = 2.8 Hz, 1H), 5.78 (td, J_{H-F} = 56 Hz, J = 7.2 Hz, 1H), 5.76–5.74 (m, 1H), 4.56 (d, J = 6.4 Hz, 1H), 4.48 (d, J = 12 Hz, 1H), 4.27–4.19 (m, 1H), 4.22 (s, 1H), 3.97 (s, 3H), 2.76–2.70 (m, 1H), 2.62–2.43 (m, 1H), 2.14–1.94 (m, 3H), 1.90–1.80 (m, 1H), 1.80–1.62 (m, 3H), 1.56–1.52 (m, 2H), 1.51 (s, 3H), 1.49 (s, 3H), 1.41–1.36 (m, 1H), 1.27–1.18 (m, 1H), 1.11 (s, 9H), 1.09–1.04 (m, 5H), 1.03–0.94 (m, 2H), 0.87–0.81 (m, 3H), 0.17–0.12 (m, 1H).

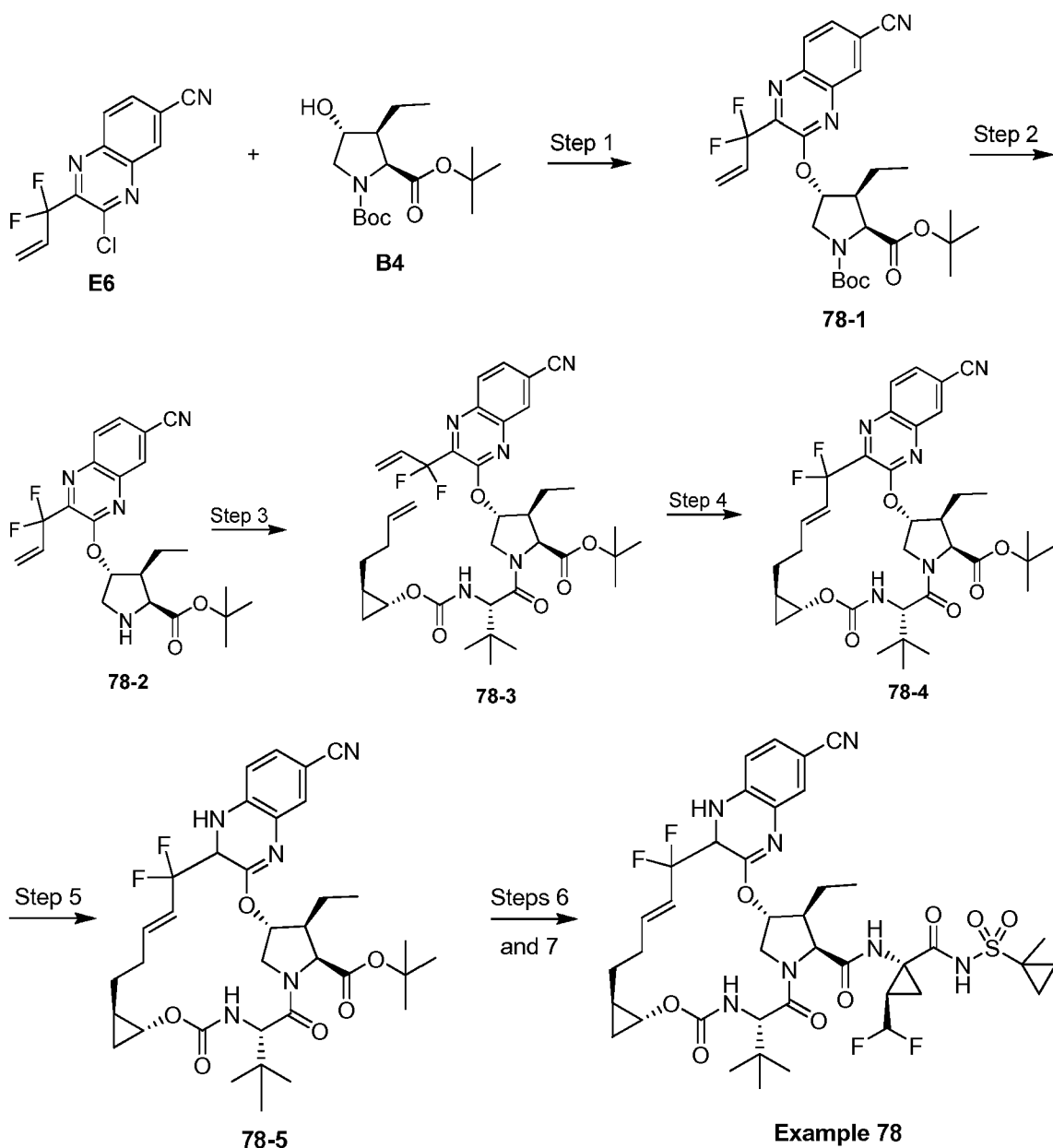
Example **77**. Preparation of (1aS,5S,8S,9S,10R,22aS)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-14-methoxy-1a,9-dimethyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

**Example 77**

Example **77** was prepared in a similar fashion to Example **76**, substituting late eluting **76-3** for early eluting **76-2** in step 3. Example **76** was then isolated. Analytic HPLC RetTime: 8.46 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

- 5 C₄₀H₅₃F₄N₆O₉S: 869.35; found: 869.53. ¹H NMR (400 MHz, CD₃OD): 7.95 (d, J = 8.8 Hz, 1H), 7.32 (d, J = 8.8 Hz, 1H), 7.28 (s, 1H), 6.58-6.54 (m, 1H), 5.75 (td, J_{H-F} = 55 Hz, J = 6.8 Hz, 1H), 5.54-5.50 (m, 1H), 4.65 (d, J = 6.8 Hz, 1H), 4.46 (d, J = 12.8 Hz, 1H), 4.26-4.18 (m, 1H), 3.97 (s, 3H), 2.92-2.71 (m, 1H), 2.50-1.94 (m, 6H), 1.68-1.57 (m, 2H), 1.56-1.52 (m, 2H), 1.51 (s, 3H), 1.50-1.47 (m, 1H),
 10 1.46-1.38 (m, 3H), 1.44 (s, 3H), 1.27-1.18 (m, 2H), 1.17-1.01 (m, 3H), 1.09 (s, 9H), 0.94-0.82 (m, 4H), 0.17-0.12 (m, 1H).

- Example **78**. Preparation of (1aR,5S,8S,9S,10R,19E,22aR)-5-tert-butyl-14-cyano-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,17,17a,18,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



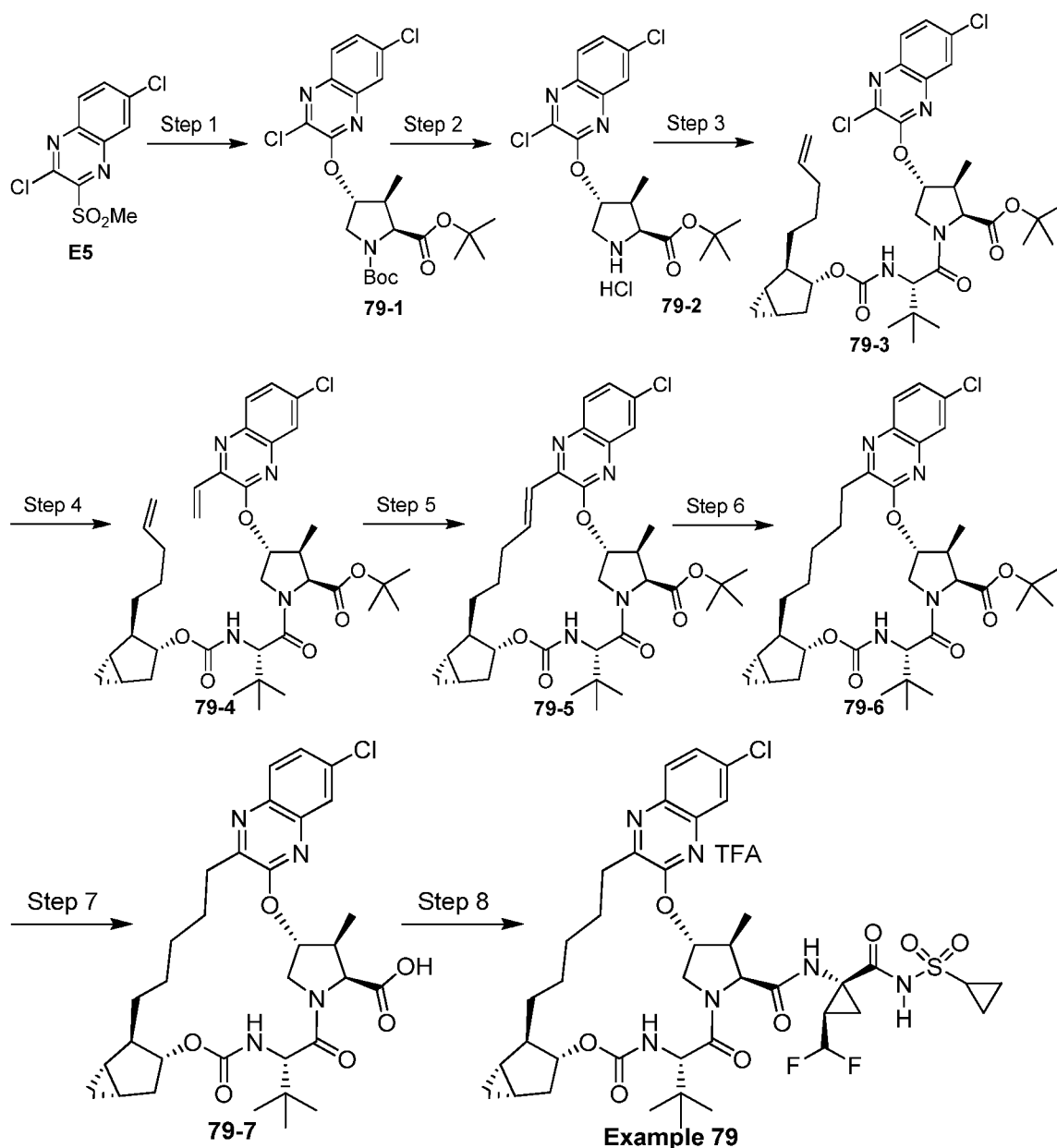
5 Steps 1-4. Intermediate **78-4** was prepared similarly to Intermediate **17-4**, using **E6** in place of **E3**.

Step 5: To a solution of **78-4** (90 mg, 0.135 mmol) in EtOH (0.7 mL) was added NaBH_4 (21 mg, 0.54 mmol). The reaction mixture was stirred at rt for 1 h. After which time the reaction mixture was filtered through a pad of celite and
 10 concentrated to give intermediate **78-5**, which was used subsequently without

further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₅F₂N₅O₆ : 669.76; found: 669.73.

Steps 6 and 7: Preparation of **Example 78**: To a solution of **78-5** (35 mg, 0.31 mmol) in DCM (0.4 mL), TFA (0.2 mL) was added and the mixture was stirred at 20 °C for 3 h. Solvents were removed *in vacuo* to afford a residue was used subsequently without further purification. To a suspension of this residue (33 mg, 0.05 mmol) and Intermediate **A10** (27 mg, 0.1 mmol) in DCM (0.3 mL) was added TBTU (26 mg, 0.08 mmol) and DIPEA (35 µL, 0.2 mmol) at rt. After 1h, the solution was directly purified by reverse phase HPLC (Gemini 5u C18 110Å column, 50-100% ACN/H₂O + 0.1% TFA) and lyophilized to afford the TFA salt of **Example 78**. Analytical HPLC RetTime: 7.994 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₄₉F₄N₇O₈S: 863.92; found: 864.20. . ¹H NMR (400 MHz, CD₃OD) δ 9.35 (s, 1H), 7.29 (d, 1H), 7.18 (dd, 1H), 6.64 (d, 1H), 6.01-5.82 (m, 2H), 5.41 (m, 2H), 4.57 – 4.07 (m, 5H), 3.52 (m, 1H), 2.55-2.28 (m, 2H), 2.06 – 1.98 (m, 2H), 1.85 (m, 1H), 1.69 – 1.37 (m, 9H), 1.33 (m, 2H), 1.06-0.87 (m, 16H), 0.70 (m, 2H), 0.49 (m, 1H).

Example 79. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-15-chloro-N-[(1R,2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.



- 5 Step 1. Preparation of **79-1**. Sulfonyl quinoxaline **E5** (920 mg, 3.32 mmol) was suspended in MeCN (17 mL), then treated with intermediate **B1** (1.00 g, 3.32 mmol) and Cs₂CO₃. After 17 h, the reaction mixture was filtered over celite and concentrated under reduced pressure. The crude residue was purified by silica column chromatography (10% to 30% EtOAc/Hex) to afford ether **79-1**.
- 10 LCMS-ESI⁺ (*m/z*): [M-Boc+2H]⁺ calcd for C₁₈H₂₂Cl₂N₃O₃: 398.10; found: 398.12.

Step 2. Preparation of **79-2**. *tert*-Butyl carbamate **79-1** (513 mg, 1.03 mmol) was dissolved in DCM (10 mL) and treated with HCl (4.0 mL in dioxane, 5 mL, 20 mmol). The reaction mixture was stirred at RT for 1.5 h, then concentrated under reduced pressure to afford amine hydrochloride **79-2**, which was carried on without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₈H₂₂Cl₂N₃O₃: 398.10; found: 398.16.

Step 3. Preparation of **79-3**. Amine hydrochloride **79-2** (1.03 mmol theoretical) and intermediate **D12** (336 mg, 1.04 mmol) were combined and treated with BEP (285 mg, 1.04 mmol), EtOAc (9 mL), NMP (1 mL) and DIPEA (0.90 mL, 5.2 mmol). The reaction mixture was stirred at 50 °C for 3 h, then cooled to RT. After an additional 15 h, the reaction mixture was diluted with EtOAc. The organic solution was washed with saturated aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. The crude residue was purified by silica column chromatography (10% to 25% EtOAc/Hex) to afford amide **79-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉Cl₂N₄O₆: 703.30; found: 703.91.

Step 4. Preparation of **79-4**. Chloro quinoxaline **79-3** (541 mg, 0.769 mmol) was treated with potassium vinyltrifluoroborate (154 mg, 1.15 mmol), Pd(dppf)Cl₂ dichloromethane adduct (63 mg, 0.077 mmol), EtOH (8 mL) and triethylamine (0.16 mL, 1.15 mmol). The stirred mixture was heated to reflux for 1 h, then cooled to RT and diluted with EtOAc. The organic solution was washed with saturated aqueous NaHCO₃ and brine, then dried over MgSO₄, filtered and concentrated under reduced pressure. The crude residue was purified by silica column chromatography (10% to 30% EtOAc/Hex) to afford vinyl quinoxaline **79-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₂ClN₄O₆: 695.36; found: 695.10.

Step 5. Preparation of **79-5**. Vinyl quinoxaline **79-4** (390 mg, 0.561 mmol) was treated with DCE (112 mL) and Zhan-B catalyst (38 mg, 0.0561 mmol). The stirred mixture was degassed with bubbling N₂ for 25 min, then heated to reflux under an Ar atmosphere. After 1.5 h, the mixture was cooled to RT and concentrated under reduced pressure. The crude residue was purified by silica

column chromatography (10% to 30% EtOAc/Hex) to afford macrocycle **79-5** .
LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₈ClN₄O₆: 667.33; found: 667.86.

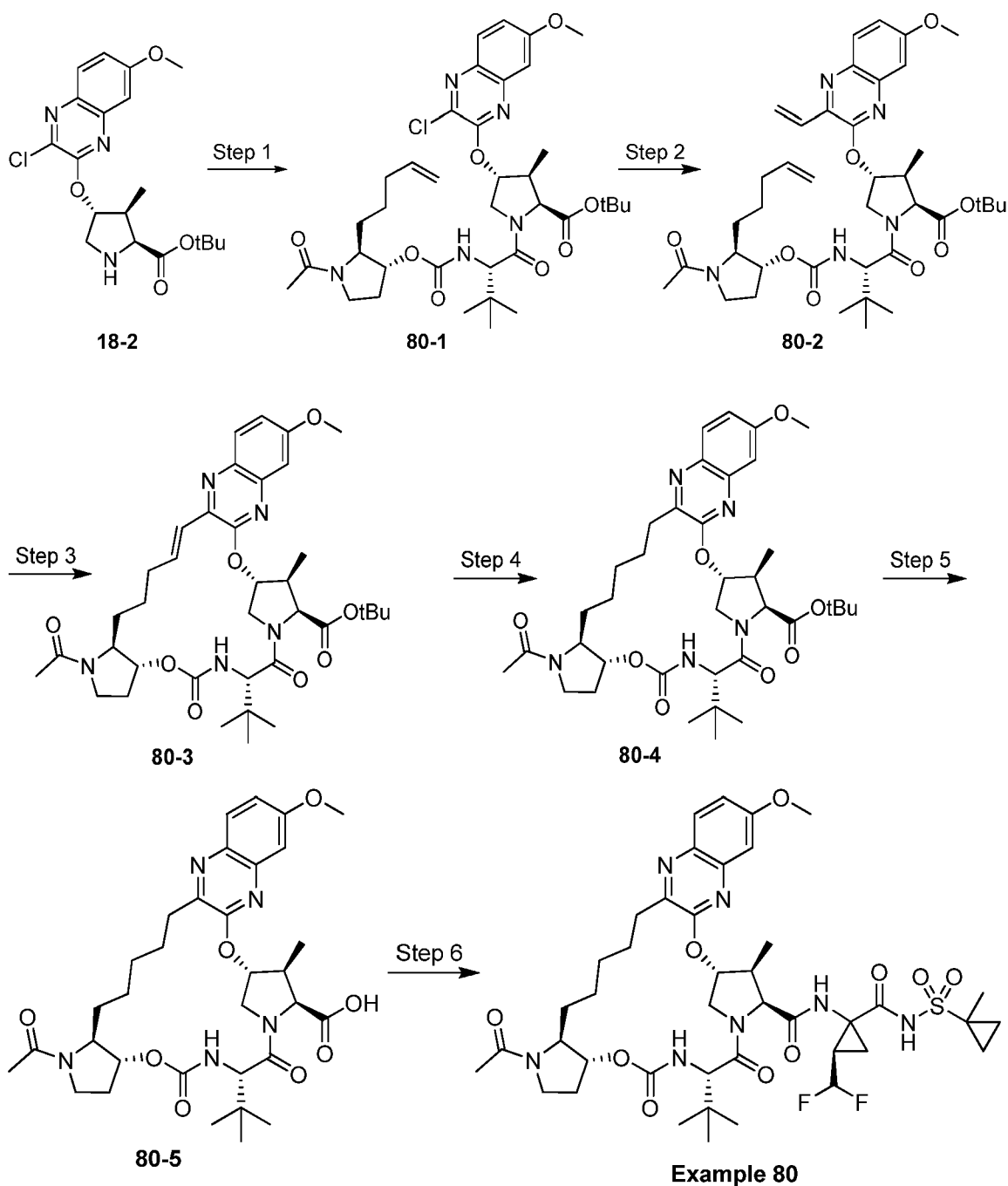
Step 6. Preparation of **79-6**. Macrocycle **79-5** (198 mg, 0.297 mmol) was treated with EtOAc (100 mL) and 5% Rh/alumina (100 mg). H₂ gas was bubbled
5 through the solution for 1 min and the reaction mixture was stirred at RT under an atmosphere of H₂. After 45 min, more 5% Rh/alumina (200 mg) was added. Again, H₂ gas was bubbled through the solution for 1 min and the reaction mixture was stirred at RT under an atmosphere of H₂. After another 1 h, the reaction mixture was filtered over celite and concentrated under reduced
10 pressure. The material (**79-6**) was carried on without purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₀ClN₄O₆: 669.34; found: 669.63.

Step 7. Preparation of **79-7**. Macrocycle **79-6** (0.297 mmol theoretical) was treated with DCM (10 mL) and TFA (10 mL). The reaction mixture was stirred at RT for 14 h, then concentrated under reduced pressure. The crude
15 residue was dissolved in EtOAc and the organic solution was washed with saturated aqueous NaHCO₃ and 1 M citric acid. Brine was added after the citric acid wash to break up the emulsion that formed. The organic layer was dried over MgSO₄, filtered and concentrated under reduced pressure. The crude residue was purified by silica column chromatography (100% EtOAc) to afford
20 impure **79-7** that was carried on without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₂ClN₄O₆: 613.28; found: 613.22.

Step 8. Preparation of Example **79**. Carboxylic acid **79-7** (0.264 mmol theoretical) was treated with intermediate **A9** (156 mg, 0.537 mmol), TBTU (170 mg, 0.528 mmol), DMAP (65 mg, 0.528 mmol), DCM (2 mL) and DIPEA (0.23
25 mL, 1.3 mmol). The reaction mixture was stirred at RT for 19 h then concentrated under reduced pressure. The crude residue was purified by reverse phase HPLC to afford Example **79** as a TFA salt . LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₂ClF₂N₆O₈S: 849.32; found: 849.16. ¹H NMR (400 MHz, CD₃OD) δ 9.17 (s, 1H), 7.86 (t, *J* = 8.1 Hz, 1H), 7.77 (t, *J* = 3.5 Hz, 1H), 7.55 (dd, *J* = 8.8, 2.3 Hz, 1H), 5.84 (td, *J* = 55.7, 6.7 Hz, 1H), 5.62 (d, *J* = 3.5 Hz, 1H), 4.98 (t, *J* = 10.6 Hz, 1H), 4.53 (t, *J* = 9.3 Hz, 1H), 4.42 – 4.26 (m, 2H), 4.19 (dd, *J* = 12.0, 3.9 Hz, 1H),

3.34 (d, $J = 7.6$ Hz, 1H), 2.99 (tt, $J = 8.2, 4.8$ Hz, 2H), 2.78 (ddt, $J = 21.6, 14.2, 5.7$ Hz, 2H), 2.28 – 2.12 (m, 1H), 2.08 – 1.16 (m, 19H), 1.16 – 0.96 (m, 17H), 0.58 (dd, $J = 8.3, 4.1$ Hz, 1H), 0.55 – 0.44 (m, 1H).

- 5 Example **80**. Preparation of (3aR,7S,10S,11S,12R)-1-acetyl-7-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-16-methoxy-11-methyl-5,8-dioxo-1,2,3,3a,5,6,7,8,11,12,20,21,22,23,24,24a-hexadecahydro-10H-9,12-methanopyrrolo[2',3':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-
- 10 b]quinoxaline-10-carboxamide



- 5 Step 1. Preparation of **80-1**: Amine **18-2** (195 mg, 0.495 mmol) and Intermediate **D18** (192.8 mg, 0.544 mmol) were dissolved in DMF (10 mL). DIPEA (430 μ L, 2.48 mmol) was added followed by HATU (207 mg, 0.544 mmol) at room temperature. After 1.5 h, the reaction mixture was concentrated in vacuo and the crude residue was directly purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **80-1** (2:1 diastereomeric ratio favoring
- 10

desired). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₃ClN₅O₈: 730.3; found: 730.48.

Step 2. Preparation of **80-2**: A stirred heterogeneous mixture of **80-1** (314 mg, 0.431 mmol), PdCl₂(dppf)•CH₂Cl₂ (35.2 mg, 0.043 mmol) and potassium vinyltrifluoroborate (86.6 mg, 0.646 mmol) in EtOH (2.2 mL) was sparged with argon for 15 min. Triethylamine (320 μL, 2.3 mmol) was added and the mixture was heated to 80 °C. After 40 min, the reaction mixture was cooled to ambient temperature and was diluted with toluene (5 mL). The resulting mixture was concentrated and the crude residue was directly purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **80-2** (2:1 diastereomeric ratio favoring desired). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₉H₅₆N₅O₈: 722.4; found: 722.54.

Step 3. Preparation of **80-3**: **80-2** (228 mg, 0.320 mmol) was dissolved in DCE (64 mL) and the solution was sparged with Ar for 15 min. Zhan 1B catalyst (23 mg, 0.032 mmol) was added and the resulting solution was stirred at 100 °C under Ar. After 45 min, the reaction mixture was cooled to rt, was concentrated *in vacuo* and was directly purified by silica gel chromatography (0–100% ethyl acetate/hexanes gradient) to afford **80-3** (5:2 diastereomeric ratio favoring desired). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₂N₅O₈: 694.37; found: 694.53.

Step 4: Preparation of **80-4**: Olefin **80-3** (164 mg, 0.237 mmol) was dissolved in ethanol (1.19 mL) and the reaction vessel was purged with Ar. Pd/C (10 wt % Pd, 25 mg) was added in a single portion and the reaction vessel was purged thrice with H₂. The reaction was stirred at rt under 1 atm H₂ for 2 h and was diluted with ethyl acetate (10 mL). The resulting mixture was filtered through a pad of Celite and concentrated to afford a crude residue of **80-4** (5:2 diastereomeric ratio favoring desired) that was used without further purification (LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₄N₅O₈: 696.39; found: 696.56).

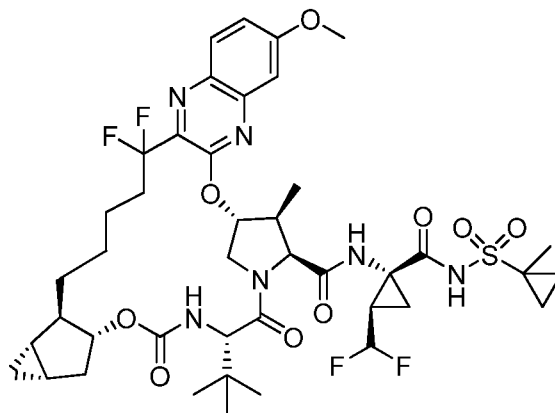
Step 5. Preparation of **80-5**: To a solution of **80-4** (164 mg, 240 μmol) in DCM (1.2 mL) was added TFA (0.45 mL) at rt. After 7 h, the reaction mixture was diluted with ethyl acetate (50 mL) and the resulting mixture was extracted with 1N aqueous sodium hydroxide solution (40 mL). The aqueous layer was

then slowly acidified to pH=3 with concentrated hydrochloric acid, and was extracted with ethyl acetate (2 × 50 mL). The combined organic extracts were dried over anhydrous sodium sulfate and were concentrated *in vacuo*. The residue was azeotropically dried with toluene (3 × 5 mL) to afford **80-5** (5:2 diastereomeric ratio favoring desired) that was used without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₆N₅O₈: 640.33; found: 640.48.

Step 6. Preparation of Example **80**: To a solution of **80-5** (140 mg, 219 μmol) and Intermediate **A10** (133 mg, 438 μmol) in MeCN (1.1 mL) was added HATU (169 mg, 438 μmol) followed by DIPEA (190 μL, 1.09 mmol) at rt under an argon atmosphere. After 15 h, the reaction mixture was concentrated *in vacuo*, was purified by preparatory HPLC (Gemini 5u C18 110Å column, 5–100% MeCN/H₂O, 0.1% trifluoroacetic acid modifier) and was lyophilized to afford Example **80** (5:2 diastereomeric ratio favoring desired) as a light yellow solid TFA salt. Analytic HPLC RetTime: 7.91 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₈F₂N₇O₁₀S: 890.39; found: 890.64. ¹H NMR (400 MHz, CD₃OD, Minor diastereomer denoted by *) δ 9.18 (s, 1H), 9.14 (s, 1H*), 7.78 (br d, *J* = 9.0 Hz, 1H, 1H*), 7.21 (br d, *J* = 9.0 Hz, 1H, 1H*), 7.18 (br s, 1H, 1H*), 5.80 (br td, *J*_{H-F} = 55.8 Hz, *J* = 6.8 Hz, 1H, 1H*), 5.64 (br s, 1H, 1H*), 5.23 (d, *J* = 4.7 Hz, 1H*), 5.15 (d, *J* = 4.7 Hz, 1H), 4.56 (d, *J* = 6.7 Hz, 1H, 1H*), 4.46 (d, *J* = 12.1 Hz, 1H*), 4.41 (d, *J* = 12.0 Hz, 1H), 4.30 – 4.22 (m, 1H, 1H*), 4.22 – 4.07 (m, 1H, 1H*), 4.02 – 3.79 (m, 1H, 1H*) 3.92 (br s, 3H, 3H*), 3.73 – 3.52 (m, 2H, 2H*), 3.05 – 2.68 (m, 3H, 3H*), 2.40 – 2.21 (m, 1H, 1H*), 2.13 – 1.94 (m, 4H, 4H*), 1.83 (s, 2H, 2H*), 1.75 – 1.20 (m, 12H, 12H*), 1.12 (s, 9H*), 1.10 (s, 9H), 1.06 (br d, *J* = 7.3 Hz, 3H, 3H*), 0.92 – 0.85 (m, 4H, 4H*).

Example **81**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-19,19-difluoro-15-methoxy-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-

methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.



Example 81

Example **81** was prepared in a similar fashion to Example **62**, substituting

Intermediate **A10** for Intermediate **A9** in Step 5. Example **81** was isolated.

Analytic HPLC RetTime: 9.36 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

C₄₂H₅₅F₄N₆O₉S: 895.36; found: 895.59. ¹H NMR (400 MHz, CD₃OD): δ 9.23 (s,

1H), 7.93 (d, *J* = 8.8 Hz, 1H), 7.31 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.26 (d, *J* = 2.4 Hz,

1H), 5.80 (td, *J*_{H-F} = 56 Hz, *J* = 6.8 Hz, 1H), 5.73 (d, *J* = 3.2 Hz, 1H), 4.94 (d, *J* =

7.2 Hz, 1H), 4.56 (d, *J* = 6.8 Hz, 1H), 4.36 (d, *J* = 6.8 Hz, 1H), 4.32 (s, 1H), 4.22–

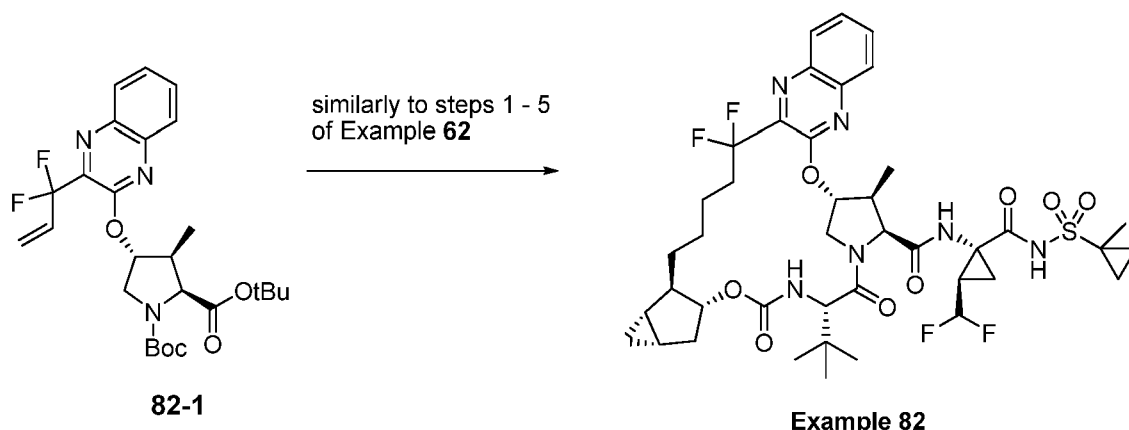
4.16 (dd, *J* = 12, 4 Hz, 1H), 3.97 (s, 3H), 2.79–2.71 (m, 1H), 2.61–2.52 (m, 1H),

2.26–2.16 (m, 1H), 2.08–1.92 (m, 4H), 1.82–1.64 (m, 3H), 1.60–1.54 (m, 3H),

1.53–1.46 (m, 1H), 1.52 (s, 3H), 1.44–1.26 (m, 5H), 1.08 (s, 9H), 1.07–0.98 (m,

4H), 0.94–0.84 (m, 3H), 0.60–0.48 (m, 2H).

Example **82**. Preparation of (1*a*S,2*a*R,6*S*,9*S*,10*S*,11*R*,23*a*R,23*b*S)-6-tert-butyl-N-[(1*R*,2*R*)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-19,19-difluoro-10-methyl-4,7-dioxo-1*a*,2,2*a*,4,5,6,7,10,11,19,20,21,22,23,23*a*,23*b*-hexadecahydro-1*H*,9*H*-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-*b*]quinoxaline-9-carboxamide



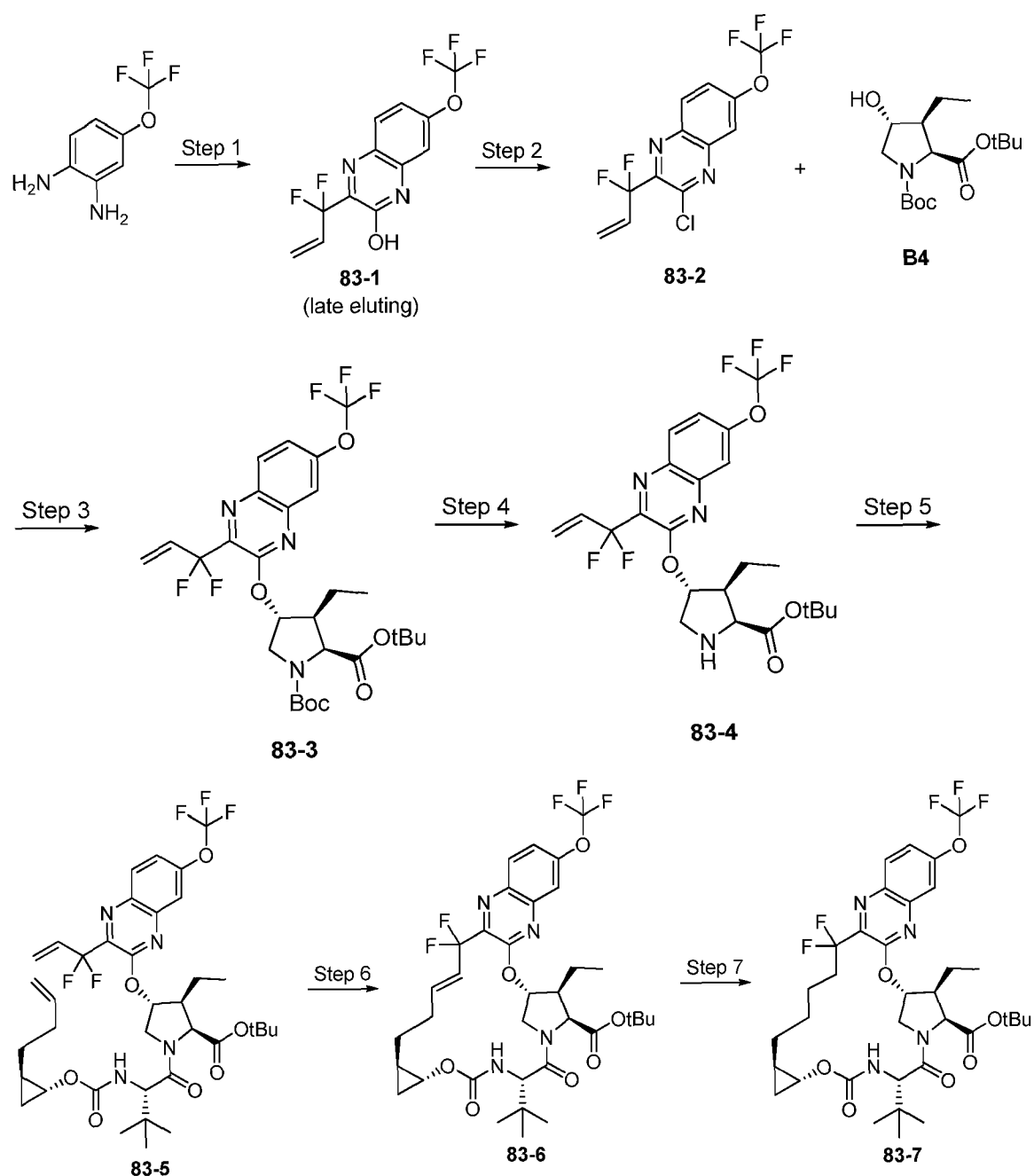
Intermediate **82-1** was prepared in a similar fashion to intermediate **46-2**, substituting intermediate **E3** with **E4** in Step 1. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₆H₃₄F₂N₃O₅: 506.25; found: 506.59.

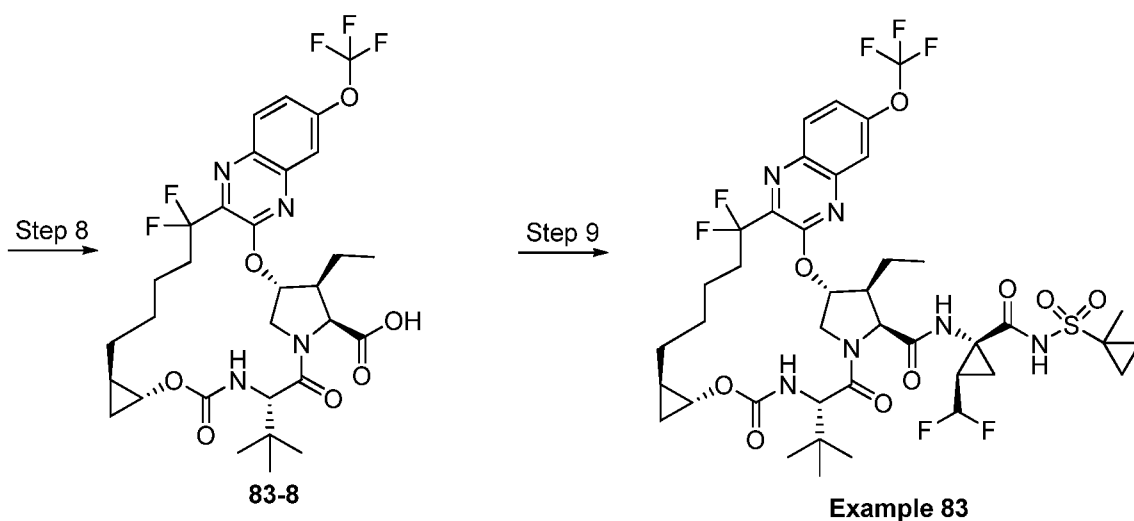
5 Example **82** was prepared in a similar fashion to Example **62**, substituting Intermediate **82-1** for Intermediate **46-2** in Step 1. Example **82** was isolated. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₂F₄N₆O₈S: 864.35; found: 865.43. ¹H NMR (400 MHz, cdcl₃) δ 9.82 (s, 1H), 7.89 – 7.72 (m, 2H), 7.67 (t, *J* = 7.6 Hz, 1H), 6.93 (s, 1H), 6.12 – 5.65 (m, 2H), 5.34 (d, *J* = 8.6 Hz, 1H), 4.90 (d, *J* = 7.4 Hz, 1H), 4.45 (t, *J* = 9.3 Hz, 2H), 4.27 (d, *J* = 7.9 Hz, 1H), 4.13 (dd, *J* = 11.9, 3.9 Hz, 1H), 2.77 – 2.64 (m, 2H), 2.27 – 2.12 (m, 1H), 2.13 – 1.86 (m, 4H), 1.82 – 1.19 (m, 15H), 1.18 – 0.98 (m, 13H), 0.89 – 0.77 (m, 2H), 0.53 (dd, *J* = 13.3, 8.1 Hz, 1H), 0.43 (d, *J* = 4.2 Hz, 1H).

10

15 Example **83**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-14-(trifluoromethoxy)-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

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Step 1. Preparation of **83-1**: HATU (3.06 g, 8.05 mmol) was added slowly to a solution of 3,3-difluoro-2-oxopent-4-enoic acid (1.03 g, 6.86 mmol) in 10 mL of DMF. A mixture of 4-(trifluoromethoxy)benzene-1,2-diamine (1.29 g, 6.71 mmol) and DIPEA (1.4 mL, 8.05 mmol) in 12 mL of DMF was then added. After stirring overnight, reaction mixture was poured into 175 mL of water and extracted with ethyl acetate (4 x 100 mL). Combined organics were washed with 50% brine, dried over anhydrous Na₂SO₄, filtered, and concentrated under reduced pressure. Resulting solid was purified via silica gel column chromatography (0–25% ethyl acetate in hexanes) to yield intermediate **83-1**, the late eluting product. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₂H₈F₅N₂O₂: 307.04; found: 307.29.

Step 2. Preparation of **83-2**: A solution of **83-1** (924 mg, 3.01 mmol) in 2 mL DMF was treated with POCl₃ (0.56 mL, 6.04 mmol) and heated at 80 °C for 2.5 hours. After cooling to room temperature, reaction mixture was diluted with 25 mL of EtOAc and added slowly to 20 mL of water with vigorous stirring. Layers were separated and aqueous was extracted with ethyl acetate. Combined organics were washed subsequently with saturated aqueous sodium bicarbonate and brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure to give intermediate **83-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₂H₇ClF₅N₂O: 324.01; found: 324.13.

Step 3. Preparation of **83-3**: Cs_2CO_3 (606 mg, 1.86 mmol) was added to a mixture of intermediate **83-2** (460 mg, 1.54 mmol) and intermediate **B4** (564 mg, 1.79 mmol) in 12 mL of DMF at room temperature. Reaction mixture was heated at 85 °C overnight. After cooling to room temperature, mixture was

5 poured into 50 mL of water and extracted with ethyl acetate (4 x 40 mL). Combined organics were washed with 90 mL of 50% brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure. Resulting solid was purified via silica gel column chromatography (0–30% ethyl acetate in hexanes) to give **83-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{28}\text{H}_{35}\text{F}_5\text{N}_3\text{O}_6$: 604.24; found:

10 604.20.

Step 4. Preparation of **83-4**: Quinoxaline ether **83-3** (290 mg, 0.647 mmol) was dissolved in 4.1 mL of tert-butyl acetate and 1.1 mL of dichloromethane at room temperature. MeSO_3H (0.25 mL, 3.88 mmol) was added dropwise and reaction mixture stirred at rt for 2 h. The reaction mixture

15 was transferred to a stirred mixture of EtOAc (20 mL) and saturated aqueous NaHCO_3 (30 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (2 x 20 mL). The combined organic phase was dried over anhydrous Na_2SO_4 , filtered, and concentrated *in vacuo* to afford amine **83-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{23}\text{H}_{27}\text{F}_5\text{N}_3\text{O}_4$: 504.18; found: 504.31.

20 Step 5. Preparation of **83-5**: HATU (260 mg, 0.684 mmol, Oakwood) and DIPEA (0.40 mL, 2.30 mmol) were added to a mixture of **83-4** (258 mg, 0.512 mmol) and Intermediate **D11** (177 mg, 0.657 mmol) in 7 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was concentrated under reduced pressure and the resulting residue was purified by silica gel

25 chromatography (0–20% ethyl acetate in hexanes) to yield **83-5**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for $\text{C}_{37}\text{H}_{48}\text{F}_5\text{N}_4\text{O}_7$: 755.34; found: 755.49.

Step 6. Preparation of **83-6**: A mixture of **83-5** (215 mg, 0.285 mmol) and Zhan 1B catalyst (29 mg, 0.040 mmol, Strem) in 60 mL of DCE was deoxygenated with argon for 15 minutes. The mixture was then heated at reflux

30 for 90 minutes. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel

chromatography (0–40% ethyl acetate in hexanes) to yield **83-6**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₄F₅N₄O₇: 727.31; found: 727.43.

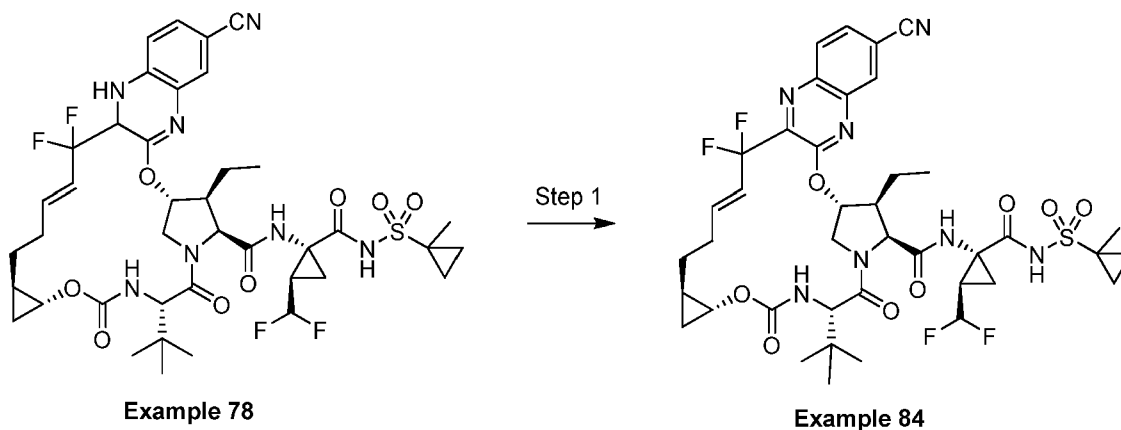
Step 7. Preparation of **83-7**: Palladium on carbon (10 wt % Pd, 40 mg, 0.038 mmol) was added to a solution of **83-6** (129 mg, 0.178 mmol) in 9 mL of ethanol. The atmosphere was replaced with hydrogen and the reaction stirred overnight. The reaction mixture was filtered over Celite and washed with ethanol. Filtrate was concentrated *in vacuo* to yield a residue, which was purified via silica gel column chromatography (0–30% ethyl acetate in hexanes) to yield **83-7**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₆F₅N₄O₇: 729.32; found: 729.45.

Step 8. Preparation of **83-8**: TFA (0.62 mL, 8.09 mmol) was added slowly to a solution of **83-7** (79 mg, 0.109 mmol) in 1.8 mL of dichloromethane. After 4 hours, mixture was concentrated under reduced pressure to near dryness. Resulting residue was taken up in 10 mL of ethyl acetate, washed with 8 mL of water, 8 mL of sat. NaHCO₃ (aq), and separated. Aqueous layers were extracted with ethyl acetate (3 x 10 mL). Combined organics were washed with 10 mL of brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo* to yield **83-8**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₃₈F₅N₄O₇: 673.26; found: 673.10.

Step 9. Preparation of Example **83**: HATU (84 mg, 0.221 mmol, Oakwood) and DIPEA (0.095 mL, 0.547 mmol) were added to a mixture of **83-8** (72 mg, 0.107 mmol) and Intermediate **A10** (66 mg, 0.217 mmol) in 4 mL of acetonitrile under argon. After stirring for overnight, reaction mixture was taken up in 20 mL of ethyl acetate and washed with 10 mL of 1 N aqueous HCl. The aqueous layer was extracted three times with ethyl acetate. Combined organics were washed with 50% brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **83**. Analytic HPLC RetTime: 9.12 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₀F₇N₆O₉S: 923.32; found: 923.10. ¹H NMR (400 MHz, CD₃OD): δ 9.26 (s, 1H), 8.01–7.91 (m, 2H), 7.78–7.63 (m,

1H), 5.95 (d, J = 3.6 Hz, 1H), 5.83 (td, J_{H-F} = 61 Hz, J = 6.0 Hz, 1H), 4.59 (d, J = 7.2 Hz, 1H), 4.42 (d, J = 12.4 Hz, 1H), 4.35 (s, 1H), 4.22–4.11 (m, 1H), 3.72–3.66 (m, 1H), 2.71–2.49 (m, 2H), 2.18–1.94 (m, 3H), 1.90–1.75 (m, 3H), 1.74–1.62 (m, 2H), 1.60–1.48 (m, 3H), 1.51 (s, 3H), 1.50–1.24 (m, 4H), 1.22–1.18 (m, 2H), 1.08 (s, 9H), 1.07–0.84 (m, 5H), 0.81–0.64 (m, 1H), 0.54–0.44 (m, 1H).

Example **84**. Preparation of (1aR,5S,8S,9S,10R,19E,22aR)-5-tert-butyl-14-cyano-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,18,21,22,22a-dodecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

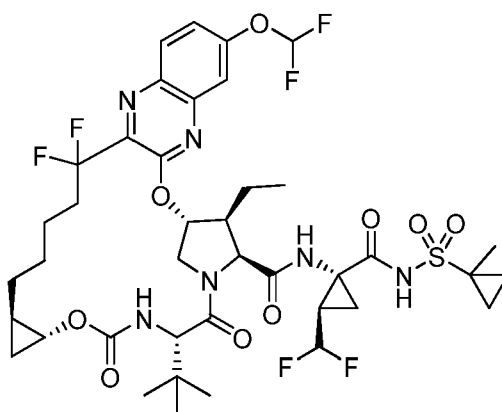


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Step 1: Preparation of Example **84**. Crude Example **78** (8.7 mg, 0.01 mmol) was redissolved in ACN (0.3 mL) and treated with DDQ (3.4 mg, 0.015 mmol). After 10 min, the solution was directly purified by reverse phase HPLC (Gemini 5u C18 110Å column, 50–100% ACN/H₂O + 0.1% TFA) and lyophilized to afford the TFA salt of Example **84**. Analytical HPLC RetTime: 8.385 min. LCMS-ESI⁺ (m/z): [M+H]⁺ calcd for C₄₀H₄₇F₄N₇O₈S: 861.90; found: 862.89. ¹H NMR (400 MHz, CD₃OD) ¹H NMR (400 MHz, CD₃OD) δ 9.21 (s, 1H), 8.25 (d, 1H), 8.20 (d, 1H), 7.91 (dd, 1H), 6.32 (m, 2H), 5.97–5.61 (m, 2H), 4.82 (m, 1H), 4.58 – 4.13 (m, 4H), 3.71–3.49 (m, 3H), 2.61 (m, 2H), 2.23 (m, 1H), 2.00 – 1.80

(m, 3H), 1.56 – 1.20 (m, 10H), 1.20 (m, 3H), 1.07 (m, 8H), 0.98-0.82 (m, 3H), 0.55 (m, 1H).

Example **85**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-14-(difluoromethoxy)-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

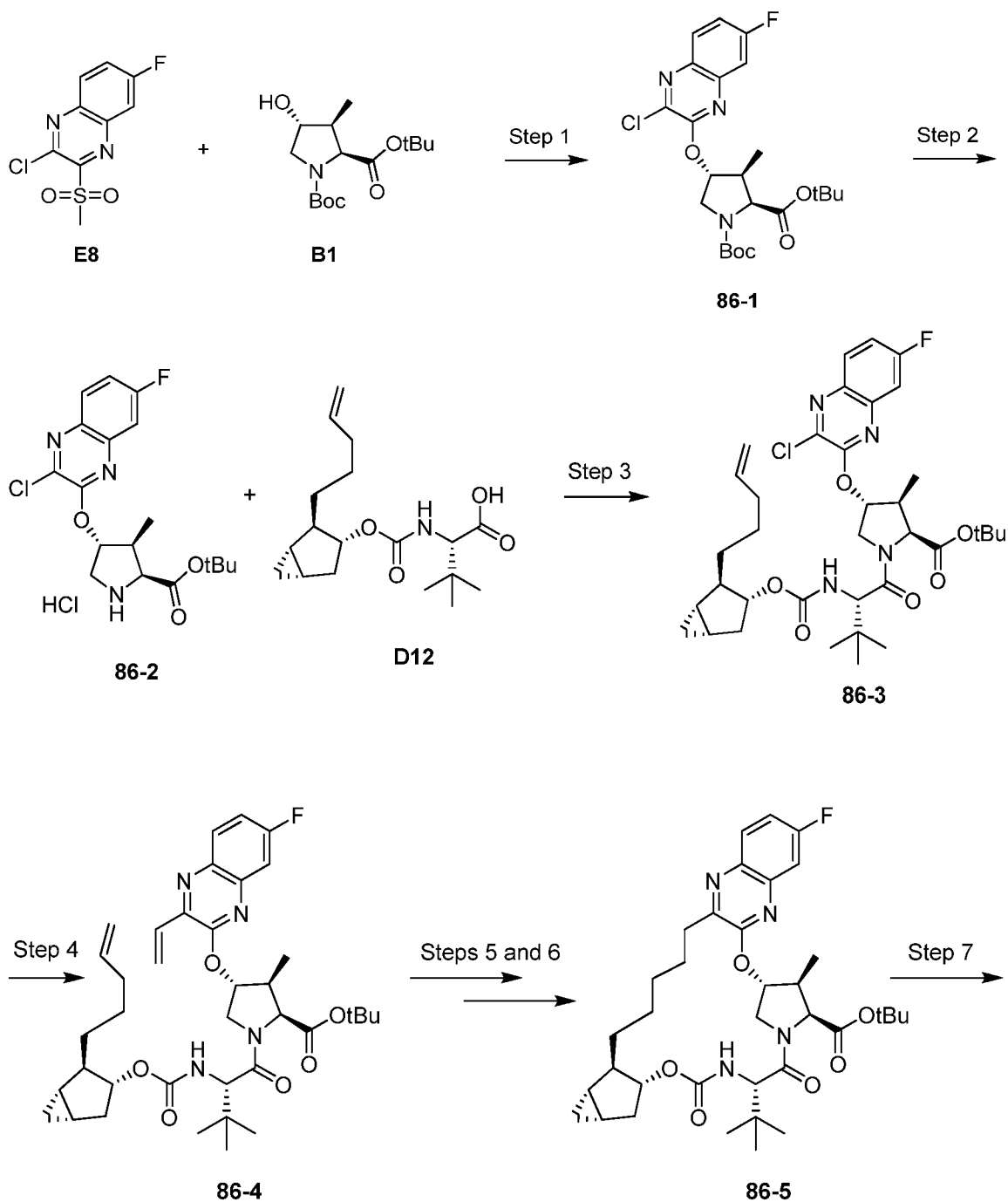


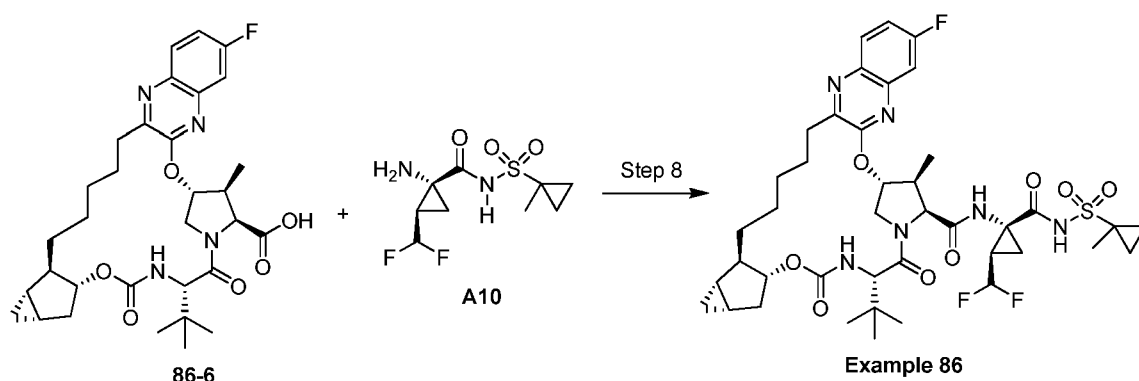
Example **85**

Example **85** was prepared similarly to Example **83**, by using intermediate **E7** in place of **83-2** in step 3. Analytical HPLC RetTime: 8.725 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₀F₆N₆O₉S: 904.92; found: 905.16. ¹H NMR (400 MHz, CD₃OD) δ 9.23 (s, 1H), 7.88 (d, 1H), 7.76 (d, 1H), 7.62 (dd, 1H), 7.03 (dd, 1H), 5.94-5.65 (m, 3H), 4.57 – 4.14 (m, 4H), 3.66 (m, 1H), 2.57 (m, 2H), 2.01 – 1.97 (m, 3H), 1.82 – 1.77 (m, 3H), 1.64 (m, 1H), 1.57 – 1.33 (m, 10H), 1.20 (m, 3H), 1.06-0.87 (m, 12H), 0.87 (m, 2H), 0.48 (m, 1H).

Example **86**. Preparation of (1aS,2aR,6S,9S,10S,11R,23aR,23bS)-6-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-15-fluoro-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1H,9H-8,11-

methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononade
cino[11,12-b]quinoxaline-9-carboxamide.





Step 1. Preparation of **86-1**: To a solution of **E8** (1.5 g, 5.75 mmol) and **B1** (1.9 g, 6.34 mmol) in MeCN (50 mL) is added Cs₂CO₃ (3.09 g, 9.49 mmol). After stirring at rt for 60 h, the reaction mixture was filtered over celite and concentrated. The crude residue was purified by silica gel chromatography (5-35% EtOAc/hexanes) to yield product **86-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₃H₃₀ClFN₃O₅ - Boc: 482.13; found: 382.04.

Step 2. Preparation of **86-2**: To a solution of **86-1** (747 mg, 1.55 mmol) in CH₂Cl₂ (5 mL) is added HCl (5 mL, 4 M in dioxane) and allowed to stir for 3 h. The reaction mixture was concentrated to give a residue that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₁₈H₂₃Cl₂FN₃O₃ - HCl: 382.13; found: 382.08.

Step 3. Preparation of **86-3**: To a solution of **86-2** (397 mg, 0.95 mmol), **D12** (308 mg, 0.95 mmol) and BEP (312 mg, 1.14 mmol) in EtOAc (9 mL) and NMP (1 mL) was added DIPEA (0.7 mL, 3.8 mmol) and the reaction was stirred at 50 °C overnight. The reaction was quenched with sat. NaHCO₃ solution and extracted with EtOAc, washed subsequently with brine, dried over magnesium sulfate and concentrated. The crude product was purified by silica gel to yield **86-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₉ClFN₄O₆: 687.33; found: 687.44.

Step 4. Preparation of **86-4**: To a solution of **86-3** (266 mg, 0.39 mmol), TEA (0.08 mL, 0.58 mmol) and potassium vinyltrifluoroborate (78 mg, 0.58 mmol) in EtOH (8 mL) was added PdCl₂(dppf) (32 mg, 0.04 mmol). The reaction was degassed with N₂ for 10 min and heated to 75 °C for 1 h. The reaction was quenched with sat. NaHCO₃ solution and extracted with EtOAc, washed subsequently with brine, dried over magnesium sulfate and concentrated. The

residue was purified using silica gel chromatography (0-25% EtOAc/hexanes) to give **86-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₅₂FN₄O₆: 679.39; found: 679.52.

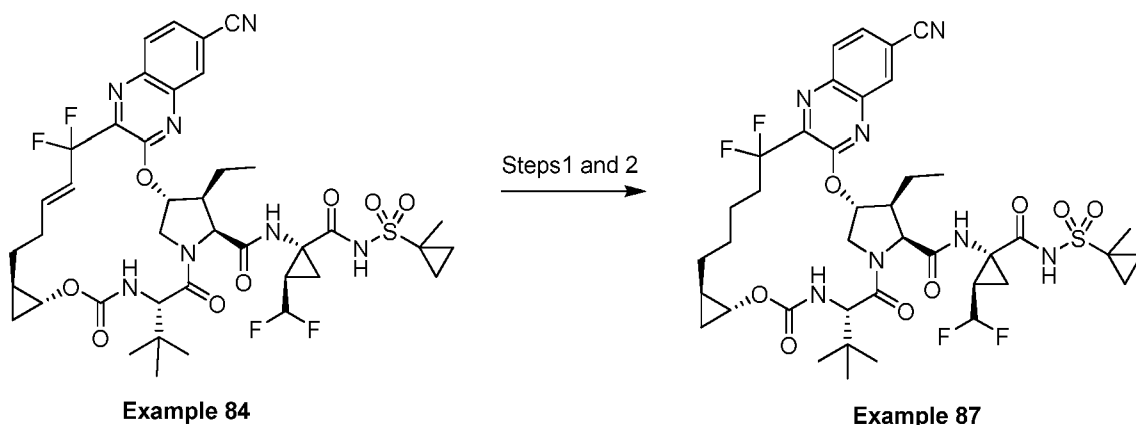
Step 5 and 6. Preparation of **86-5**: To a solution of **86-4** (262 mg, 0.38 mmol) in DCE (50 mL) was added Zhan 1B catalyst (28 mg, 0.04 mmol) and the reaction was degassed for 25 minutes with N₂. The reaction was heated to 100 °C for 1 h, allowed to cool to rt and concentrated. The crude product was purified by silica gel chromatography (0-30% EtOAc/hexanes) to give olefin product (182 mg; LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₄₈FN₄O₆: 651.36; found: 651.38) that was taken up in EtOH (5 mL) and EtOAc (1 mL) and treated with Pd/C (10%, 55 mg). The atmosphere was replaced with hydrogen and stirred at rt for 1.25 h. The reaction was filtered over Celite, washed with EtOAc and concentrated to give **86-5** that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₀FN₄O₆: 653.37; found: 653.46.

Step 7. Preparation of **86-6**: To a solution of **86-5** (182 mg, 0.28 mmol) in DCM (3 mL) was added TFA (3 mL) and stirred at rt for 18 h. The reaction was diluted with EtOAc, washed with H₂O, basicified to pH 7 with sat. NaHCO₃ solution, washed with 1M citric acid solution, dried over magnesium sulfate, and concentrated to give a residue of **86-6** that was used subsequently without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₂H₄₂FN₄O₆: 597.31; found: 597.15.

Step 8. Preparation of Example **86**: To a solution of **86-6** (24 mg, 0.04 mmol), intermediate **A10** (18 mg, 0.06 mmol), TBTU (23 mg, 0.07 mmol) and DMAP (7 mg, 0.06 mmol) in DMF (3 mL) was added DIPEA (35 µL, 0.20 mmol) and the reaction was stirred at rt for 3 h. Additional intermediate **A10** (18 mg, 0.06 mmol), TBTU (23 mg, 0.07 mmol), DMAP (7 mg, 0.06 mmol), and DIPEA (35 µL, 0.20 mmol) was added and the reaction was stirred at rt for 16 h. The crude material was purified by reverse phase HPLC (Gemini, 30-85% ACN/H₂O + 0.1% TFA) and lyophilized to give Example **86** as a TFA salt. Analytical HPLC RetTime: 9.25 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₄F₃N₆O₈S: 847.37;

found: 847.18. ^1H NMR (400 MHz, CD_3OD) δ 9.18 (s, 1H), 8.13 – 7.84 (m, 2H), 7.59 – 7.21 (m, 2H), 6.07 – 5.58 (m, 2H), 5.00 (d, J = 7.4 Hz, 1H), 4.57 (d, J = 7.0 Hz, 1H), 4.45 – 4.27 (m, 2H), 4.20 (dd, J = 12.0, 4.0 Hz, 1H), 3.11 – 2.94 (m, 3H), 2.92 – 2.70 (m, 4H), 2.32 – 2.14 (m, 1H), 2.10 – 1.94 (m, 2H), 1.86 (m, 1H), 1.77 (d, J = 14.5 Hz, 1H), 1.74 – 1.21 (m, 15H), 1.21 – 1.01 (m, 10H), 1.00 – 0.84 (m, 2H), 0.60 (m, 1H), 0.53 (m, 1H).

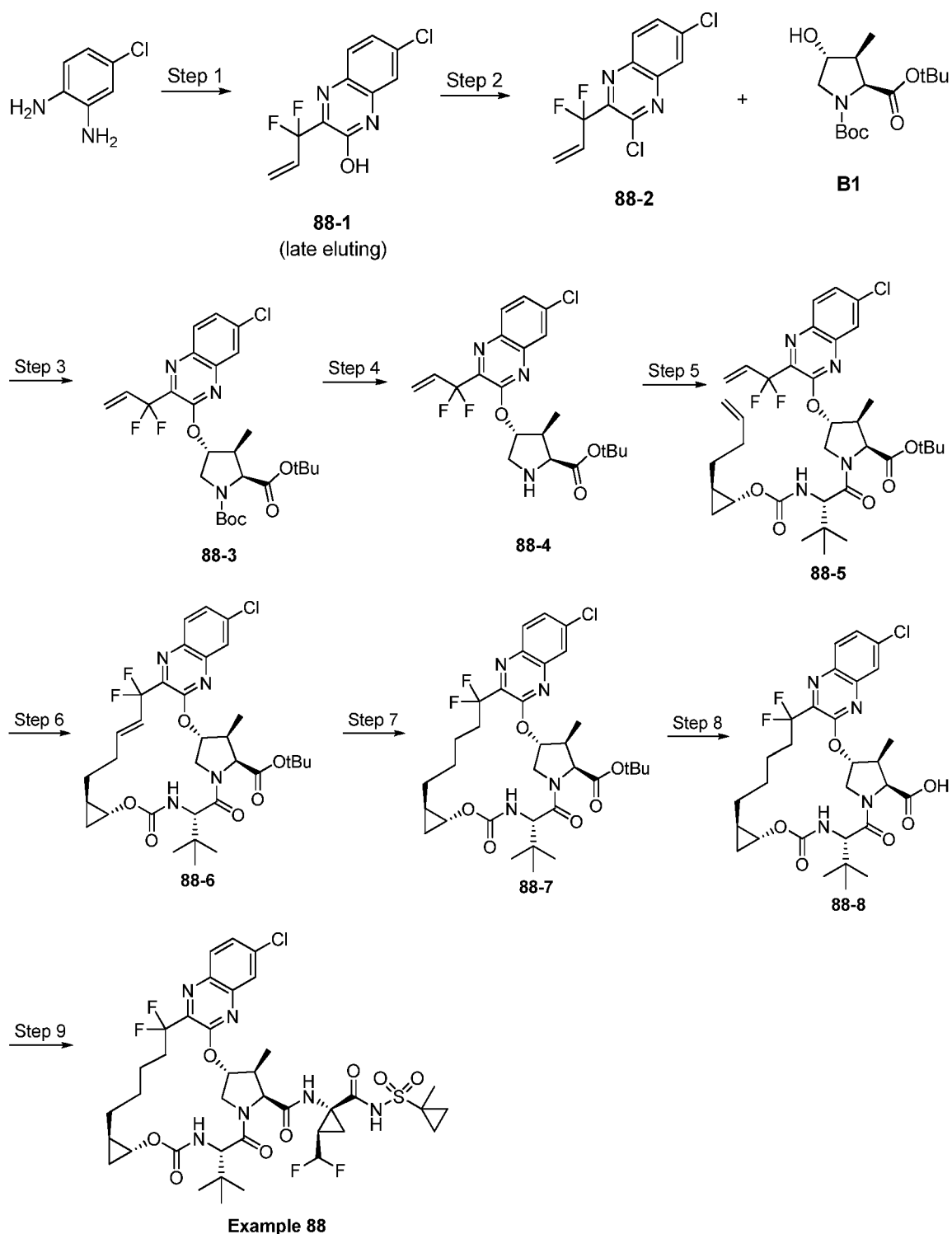
Example **87**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-14-cyano-N-[(1R,2R)-2-(difluoromethyl)-1-[[[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropana[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Steps 1 and 2. Preparation of Example **87**. To a solution of Example **84** (100 mg, 0.11 mmol) in EtOAc (3 mL) was added Pd/C (10 wt % Pd, 30 mg). The reaction vessel was purged twice with H_2 and was stirred at rt under 1 atm H_2 for 6h. After which time the reaction mixture was filtered through a pad of celite and concentrated. The reaction reduced the quinoxaline ring. The crude material was redissolved in ACN (5 mL) and treated with DDQ (34 mg, 0.15 mmol). After 1h, the solution was directly purified by reverse phase HPLC (Gemini 5u C18 110Å column, 50-100% ACN/ H_2O + 0.1% TFA) and lyophilized to afford the TFA salt of Example **87**. Analytical HPLC RetTime: 8.463 min. LCMS-ESI $^+$ (m/z): $[\text{M}+\text{H}]^+$

calcd for C₄₀H₄₉F₄N₇O₈S: 863.92; found: 864.18. ¹H NMR (400 MHz, CD₃OD) δ 9.24 (s, 1H), 8.27 (d, 1H), 8.20 (d, 1H), 7.91 (dd, 1H), 5.93-5.82 (m, 3H), 4.88 (m, 1H), 4.58 – 4.13 (m, 5H), 3.71-3.49 (m, 3H), 2.59 (m, 2H), 2.03 – 1.96 (m, 3H), 1.82 – 1.77 (m, 3H), 1.65 – 1.35 (m, 11H), 1.20 (m, 3H), 1.06-0.87 (m, 8H), 0.71 (m, 2H), 0.48 (m, 1H).

Example 88. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-14-chloro-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-9-methyl-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide



- 5 Step 1. Preparation of **88-1**: HATU (4.56 g, 12 mmol) was added slowly to a solution of 3,3-difluoro-2-oxopent-4-enoic acid (1.52 g, 10.1 mmol) in 14 mL of DMF. A mixture of 4-chlorobenzene-1,2-diamine (1.43 g, 10 mmol) and DIPEA (2.1 mL, 12 mmol) in 20 mL of DMF was then added. After stirring

overnight, reaction mixture was poured into 30 mL of 1 N aqueous HCl and extracted with ethyl acetate (5 x 40 mL). Combined organics were dried over anhydrous Na₂SO₄, filtered, and concentrated under reduced pressure.

Resulting solid was purified via silica gel column chromatography (0–45% ethyl acetate in hexanes) to yield intermediate **88-1** as the late eluting product. ¹H NMR (400 MHz, CDCl₃): δ 12.1 (s, 1H), 7.99 (m, 1H), 7.61-7.58 (m, 1H), 7.33-7.31 (m, 1H), 6.61-6.48 (m, 1H), 5.96-5.90 (m, 1H), 5.67-5.63 (m, 1H).

Step 2. Preparation of **88-2**: A solution of intermediate **88-1** (648 mg, 2.53 mmol) in 2 mL DMF was treated with POCl₃ (0.49 mL, 5.26 mmol) and heated at 80 °C for 3 hours. After cooling to room temperature, reaction mixture was diluted with 20 mL of EtOAc and added slowly to 15 mL of water with vigorous stirring. Layers were separated and aqueous was extracted with ethyl acetate. Combined organics were washed subsequently with saturated aqueous sodium bicarbonate and brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure to give intermediate **88-2**. ¹H NMR (400 MHz, CDCl₃) δ 8.184 (d, J = 1.6 Hz, 1H), 8.01 (d, J = 8.8 Hz, 1H), 7.82 (dd, J = 9.4, 2 Hz, 1H), 6.56–6.43 (m, 1H), 5.88 (m, 1H), 5.70 (d, J = 10.8 Hz, 1H).

Step 3. Preparation of **88-3**: Cs₂CO₃ (660 mg, 2.03 mmol) was added to a mixture of intermediate **88-2** (425 mg, 1.54 mmol) and intermediate **B1** (570 mg, 1.89 mmol) in 9 mL of DMF at room temperature. Reaction mixture was heated at 85 °C overnight. After cooling to room temperature, mixture was poured into 40 mL of water and extracted with ethyl acetate (4 x 30 mL). Combined organics were washed with 75 mL of 50% brine, dried over anhydrous sodium sulfate and concentrated under reduced pressure. Resulting solid was purified via silica gel column chromatography (0–20% ethyl acetate in hexanes) to give **88-3**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₆H₃₃ClF₂N₃O₅: 540.20; found: 540.12.

Step 4. Preparation of **88-4**: Quinoxaline ether **88-3** (458 mg, 0.848 mmol) was dissolved in 4.2 mL of tert-butyl acetate and 1.2 mL of dichloromethane at room temperature. MeSO₃H (0.30 mL, 4.67 mmol) was added dropwise and reaction mixture stirred at rt for 2 h. The reaction mixture

was transferred to a stirred mixture of EtOAc (20 mL) and saturated aqueous NaHCO₃ (30 mL). The phases were separated, and the aqueous phase was extracted with EtOAc (2 x 20 mL). The combined organic phase was dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo* to afford amine **88-4** as a yellow solid film LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₁H₂₅ClF₂N₃O₃: 440.15; found: 440.29.

Step 5. Preparation of **88-5**: HATU (360 mg, 0.947 mmol, Oakwood) and DIPEA (0.51 mL, 2.91 mmol) were added to a mixture of **88-4** (320 mg, 0.727 mmol) and Intermediate **D11** (237 mg, 0.880 mmol) in 10 mL of acetonitrile under argon. After stirring overnight, the reaction mixture was concentrated under reduced pressure and the resulting residue was purified by silica gel chromatography (0–20% ethyl acetate in hexanes) to yield **88-5**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₅H₄₆ClF₂N₄O₆: 691.30; found: 691.50.

Step 6. Preparation of **88-6**: A mixture of **88-5** (390 mg, 0.564 mmol) and Zhan 1B catalyst (55 mg, 0.075 mmol, Strem) in 100 mL of DCE was deoxygenated with argon for 15 minutes. The mixture was then heated at reflux for 110 minutes. After cooling to room temperature, reaction mixture was concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–25% ethyl acetate in hexanes) to yield **88-6**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₂ClF₂N₄O₆: 663.27; found: 663.33.

Step 7. Preparation of mixture of **88-7**: Rhodium on alumina (5 wt % Rh, 31 mg, 0.015 mmol) was added to a solution of **88-6** (90 mg, 0.136 mmol) in 9 mL of ethanol. The atmosphere was replaced with hydrogen and mixture was stirred overnight. The reaction was filtered over Celite, washing with ethanol. LC/MS analysis indicated about 60% starting material remained. A solution of the residue in 8 mL of ethanol was resubjected to hydrogenation conditions utilizing 25 mg of Rhodium on alumina (5 wt % Rh) overnight. The reaction was filtered over Celite, washing with ethanol. Filtrate was concentrated *in vacuo* to yield as residue, which was purified via silica gel column chromatography (0–30% ethyl acetate in hexanes) to yield **88-7**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₄ClF₂N₄O₆: 665.28; found: 665.48.

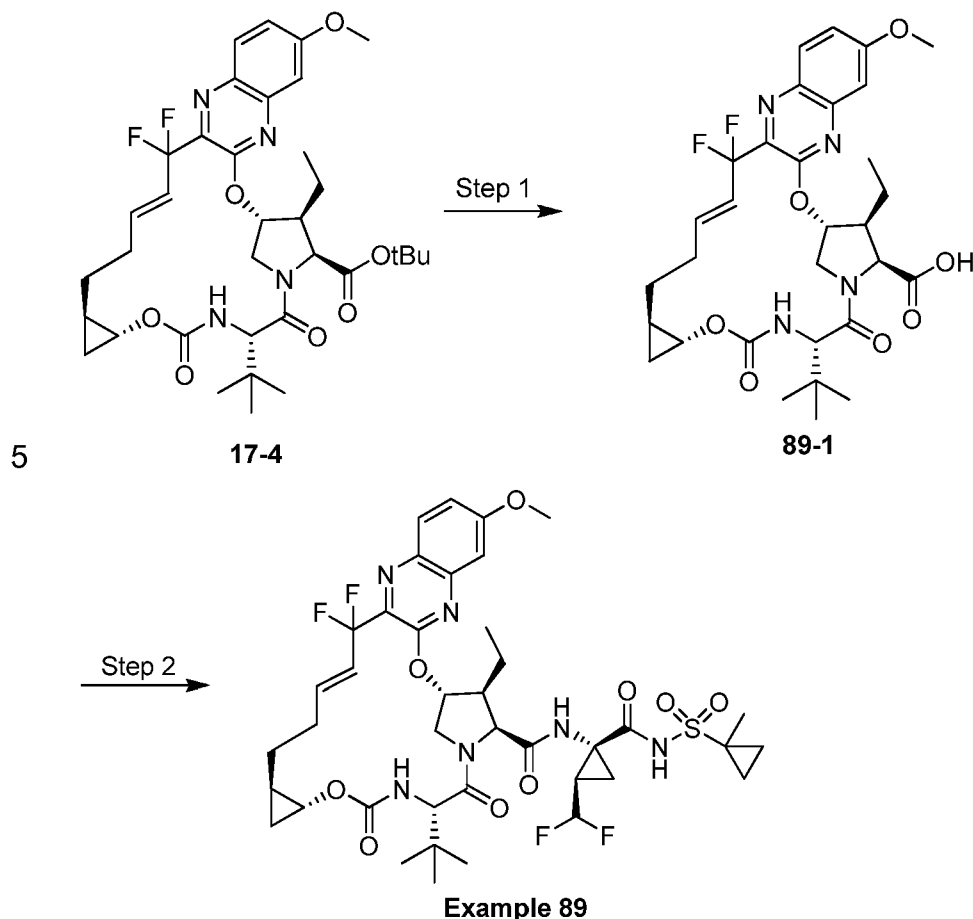
Step 8. Preparation of **88-8**: TFA (0.45 mL, 5.86 mmol) was added slowly to a solution of **88-7** (52 mg, 0.078 mmol) in 2 mL of dichloromethane. After 3 hours, mixture was concentrated under reduced pressure to near dryness.

Resulting residue was taken up in 10 mL of ethyl acetate, washed with 8 mL of water, 8 mL of sat. NaHCO₃ (aq), and separated. Aqueous layers were extracted with ethyl acetate (3 x 10 mL). Combined organics were washed with 10 mL of brine, dried over anhydrous MgSO₄, filtered, and concentrated *in vacuo* to yield **88-8**, which was used in the next step without further purification. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₉H₃₆ClF₂N₄O₆: 609.22; found: 609.42.

Step 9. Preparation of Example **88**: HATU (58 mg, 0.153 mmol, Oakwood) and DIPEA (0.065 mL, 0.374 mmol) were added to a mixture of **88-8** (45 mg, 0.074 mmol) and Intermediate **A10** (49 mg, 0.161 mmol) in 2.5 mL of acetonitrile under argon. After stirring for overnight, reaction mixture was taken up in 15 mL of ethyl acetate and washed with 10 mL of 1 N aqueous HCl. The aqueous layer was extracted three times with ethyl acetate. Combined organics were washed with 50% brine, dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. The resulting residue was purified by silica gel chromatography (0–50% ethyl acetate in hexanes) and reverse phase prep HPLC (50–100% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) to yield the trifluoroacetic acid salt of Example **88**. Analytic HPLC RetTime: 8.92 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₈H₄₈ClF₄N₆O₈S: 859.28; found: 859.42. ¹H NMR (400 MHz, CD₃OD): δ 9.23 (s, 1H), 8.10 (s, 1H), 7.90 (d, J = 8.8 Hz, 1H), 7.81 (d, J = 8.8 Hz, 1H), 5.81 (td, J_{H-F} = 56 Hz, J = 6.0 Hz, 1H), 5.69–5.66 (m, 1H), 4.56 (d, J = 7.2 Hz, 1H), 4.43 (d, J = 12 Hz, 1H), 4.34 (s, 1H), 4.22–4.16 (dd, J = 12, 4 Hz, 1H), 3.71–3.66 (m, 1H), 2.83–2.76 (m, 1H), 2.61–2.48 (m, 1H), 2.11–1.94 (m, 4H), 1.88–1.72 (m, 4H), 1.71–1.62 (m, 1H), 1.58–1.54 (m, 2H), 1.51 (s, 3H), 1.50–1.36 (m, 2H), 1.09 (s, 9H), 1.08–1.01 (m, 3H), 1.01–0.94 (m, 2H), 0.93–0.86 (m, 2H), 0.80–0.68 (m, 1H), 0.52–0.46 (m, 1H).

Example **89**. Preparation of (1aR,5S,8S,9S,10R,19E,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-

methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18,18-difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,21,22,22a-dodecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Step 1. Preparation of **89-1**: **17-4** (95 mg, 0.14 mmol) in 0.4 mL DCM was treated with 0.4 mL TFA and stirred at rt for 2 h. The reaction mixture was diluted with 5 mL DCM and then treated with water and saturated sodium bicarbonate to pH 6.5. The layers were separated and the organic phase was washed once more with water, then dried over anhydrous sodium sulfate, filtered and concentrated to give **89-1**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₁H₃₉F₂N₄O₇: 617.3; found: 616.7.

Step 2. Preparation of Example **89**: A mixture of **89-1** from step 1 (41 mg, 0.066 mmol), Intermediate **A10** (24 mg, 0.079 mmol), HATU (30 mg, 0.079 mmol), and DIPEA (0.057 mL, 0.33 mmol) in DMF (0.4 mL) was stirred at rt

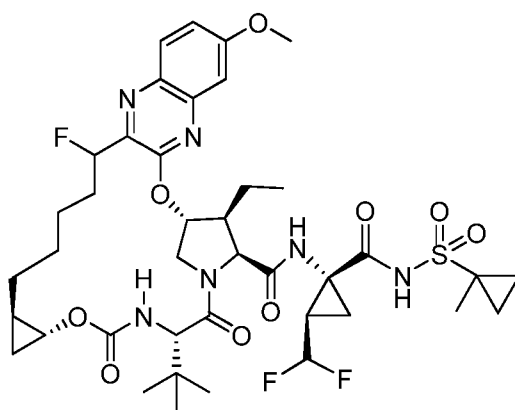
overnight. The mixture was diluted with 2 N HCl (1 mL) and extracted with dichloromethane. The organic phase was dried over sodium sulfate, filtered and concentrated. The crude product mixture was purified by reverse phase prep

- 5 Example **89**. Analytic HPLC RetTime: 8.65 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₁F₄N₆O₉S: 867.3; found: 866.9. ¹H NMR (400 MHz, CDCl₃) δ 9.890 (s, 1H), 7.98 (d, *J* = 9.2 Hz, 1H), 7.28 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.06 (d, *J* = 2.8 Hz, 1H), 6.75 (br s, 1H), 6.30 – 5.93 (m, 2H), 5.92 (td, *J*_{H-F} = 52 Hz, *J* = 6.8 Hz, 1H), 5.47 (d, *J* = 10 Hz, 1H), 4.53 (d, *J* = 12 Hz, 1H), 4.48 (d, *J* = 10.4 Hz, 1H), 4.42 (d, *J* = 6.8 Hz, 1H), 4.07 (dd, *J* = 11.6, 3.2 Hz, 1H), 3.98 - 3.94 (m, 1H), 3.95 (s, 3H), 3.57 (m, 1H), 2.60 - 2.48 (m, 2H), 2.20 (m, 1H), 2.06 (m, 1H), 1.90 (m, 1H), 1.80 (m, 1H), 1.63 (m, 2H), 1.50 (s, 3H), 1.56 – 1.36 (m, 2H), 1.26 (m, 1H), 1.19 (t, *J* = 7.2 Hz, 3H), 1.09 (s, 9H), 1.03-0.93 (m, 2H), 0.85 (m, 2H), 0.76 (m, 1H), 0.53 (m, 1H).

15

- Example **90**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(1R,2R)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-9-ethyl-18-fluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

20

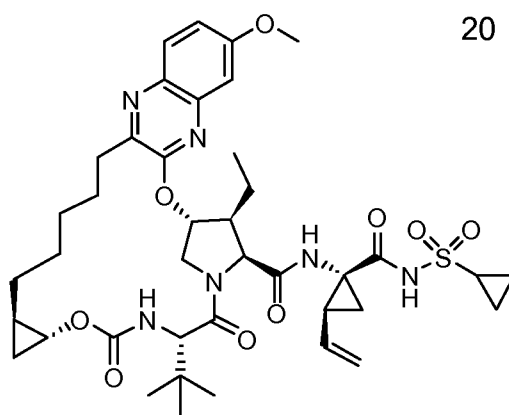


Example **90**

Further purification of a synthesis of compound **17** by reverse phase prep HPLC (60-88% acetonitrile in water, with 0.1% trifluoroacetic acid buffer) allowed isolation of example **93** as a minor side product. Analytic HPLC RetTime: 8.64 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₀H₅₄F₃N₆O₉S: 851.4; found: 851.4.

- 5 ¹H NMR (400 MHz, CDCl₃) δ 9.93 (br s, 1H), 7.88 (d, *J* = 9.1 Hz, 1H), 7.22 (d, *J* = 2.4 Hz, 1H), 7.06 (d, *J* = 2.4 Hz, 1H), 6.55 (s, 1H), 5.91 (td, *J*_{H-F} = 136 Hz, *J* = 8 Hz, 1H), 5.81 (td, *J*_{H-F} = 52 Hz, *J* = 8 Hz, 1H), 5.30 (d, *J* = 9.7 Hz, 1H), 4.44 (d, *J* = 12.0 Hz, 1H), 4.38 (d, *J* = 6.7 Hz, 1H), 4.32 (d, *J* = 9.8 Hz, 1H), 4.07 (m, 1H), 3.93 (s, 3H), 3.72 (m, 1H), 2.59 (m, 1H), 2.35 (m, 1H), 2.06 (m, 4H), 1.88 (m, 1H), 1.78 (m, 1H), 1.71 – 1.52 (m, 4H), 1.48 (s, 3H), 1.48 – 1.41 (m, 2H), 1.23 (m, 2H), 1.21 (t, *J* = 8.0 Hz, 3H), 1.08 (s, 9H), 1.05 – 0.90 (m, 2H), 0.84 (m, 2H), 0.66 (m, 1H), 0.48 (m, 1H).

- Example **91**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
15 {(1R,2S)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethenylcyclopropyl}-9-ethyl-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

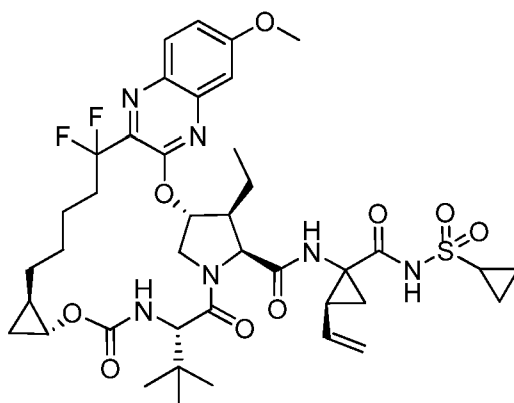


Example **91**

Example **91** was prepared similarly to Example **1** substituting Intermediate **A1** for Intermediate **A10** in Step 8. The TFA salt of Example **91** was isolated. Analytic HPLC RetTime: 8.72 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

$C_{40}H_{55}N_6O_9S$: 795.96; found: 795.94. ^1H NMR (400 MHz, CD_3OD) δ 9.03 (s, 1H); 7.80 (d, J = 9.2 Hz, 1H); 7.24 (dd, J = 9.2, 2.4 Hz, 1H); 7.16 (d, J = 2.4 Hz, 1H); 5.90 (d, J = 3.6 Hz, 1H); 5.68 (m, 1H); 5.25 (d, J = 17.2 Hz, 1.6 Hz, 1H); 5.10 (d, J = 11.2, 1.6 Hz, 1H); 4.57 (d, J = 6.8 Hz, 1H); 4.39 (br s, 1H); 4.37 (d, J = 9.2 Hz, 1H); 4.16 (dd, J = 12.8, 4.4 Hz, 1H); 3.93 (s, 3H); 3.77-3.72 (m, 1H); 3.02-2.88 (m, 1H); 2.86-2.75 (m, 1H); 2.64-2.54 (m, 1H); 2.18 (q, J = 8.8 Hz, 1H); 1.90-1.66 (m, 4H); 1.66-1.40 (m, 6H); 1.38-1.32 (m, 1H); 1.30-1.20 (m, 5H); 1.10 (s, 9H); 1.14-1.02 (m, 2H); 0.77-0.68 (m, 1H); 0.54-0.45 (m, 1H).

Example **92**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-
 10 {(1R,2S)-1-[(cyclopropylsulfonyl)carbamoyl]-2-ethenylcyclopropyl}-9-ethyl-18,18-difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro -8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



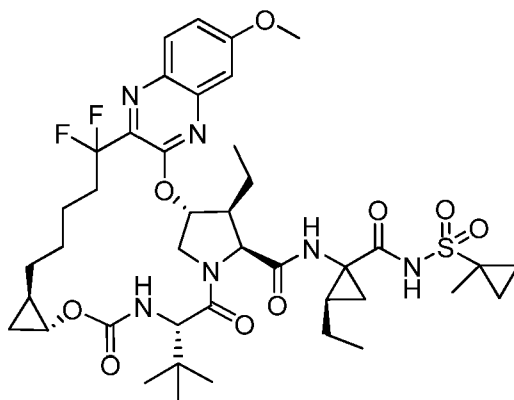
Example **92**

Example **92** was prepared in a similar fashion to Example **17**, substituting Intermediate **A1** for Intermediate **A10** in Step 7. Example **92** was isolated .

Analytic HPLC RetTime: 8.75 min. LCMS-ESI⁺ (m/z): $[M+H]^+$ calcd for $C_{40}H_{53}F_2N_6O_9S$: 831.36; found: 831.25. ^1H NMR (400 MHz, Chloroform- d) δ 9.98 (s, 1H), 7.96 (d, J = 9.2 Hz, 1H), 7.40 – 7.19 (m, 1H), 7.08 (s, 1H), 6.56 (s, 1H), 5.91 (d, J = 3.8 Hz, 1H), 5.86 – 5.64 (m, 1H), 5.34 (d, J = 9.7 Hz, 1H), 5.21 (d, J = 17.2 Hz, 1H), 5.10 (d, J = 10.3 Hz, 1H), 4.53 – 4.26 (m, 2H), 4.15 – 4.02 (m, 1H), 3.95 (s, 3H), 3.73 – 3.57 (m, 1H), 2.97 – 2.81 (m, 1H), 2.64 – 2.37 (m, 2H),

2.21 – 2.06 (m, 1H), 2.06 – 1.88 (m, 2H), 1.88 – 1.55 (m, 4H), 1.55 – 1.12 (m, 10H), 1.07 (s, 9H), 1.02 – 0.78 (m, 5H), 0.78 – 0.61 (m, 1H), 0.47 (q, $J = 7.3, 6.2$ Hz, 1H).

- 5 Example **93**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-9-ethyl-N-[(2R)-2-ethyl-1-[[[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-18,18-difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradeca hydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.



Example 93

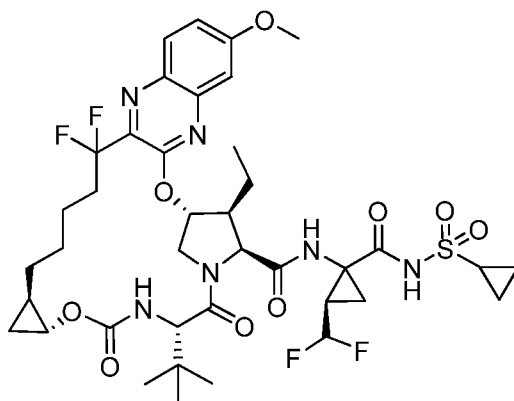
Example **93** was prepared in a similar fashion to Example **17**, substituting Intermediate **A4** for Intermediate **A10** in Step 7. Example **93** was isolated. Analytic HPLC RetTime: 8.03 min. LCMS-ESI⁺ (m/z): $[M+H]^+$ calcd for

- 15 $C_{41}H_{57}F_2N_6O_9S$: 847.39; found: 846.99. ¹H NMR (400 MHz, CDCl₃) δ 7.95 (d, $J = 8.9$ Hz, 1H), 7.27 (m, 1H), 7.08 (s, 1H), 6.65 (s, 1H), 5.91 (s, 1H), 5.41 (d, $J = 9.0$ Hz, 1H), 4.82 (m, 2H), 4.47 (d, $J = 6.2$ Hz, 1H), 4.35 (dd, $J = 35.7, 10.7$ Hz, 2H), 4.07 (m, 1H), 3.94 (s, 3H), 3.63 (m, 1H), 2.50 (m, 2H), 1.95 (m, 2H), 1.94 (m, 2H), 1.78 (m, 3H), 1.64 (m, 4H), 1.48 (m, 6H), 1.19 (m, 4H), 1.07 (s, 9H), 1.05 –
20 0.88 (m, 4H), 0.88 – 0.75 (m, 1H), 0.67 (m, 1H), 0.47 (m, 1H).

Example **94**. Preparation of (1aR,5S,8S,9S,10R,22aR)-5-tert-butyl-N-[(2R)-1-[(cyclopropylsulfonyl)carbamoyl]-2-(difluoromethyl)cyclopropyl]-9-ethyl-

18,18-difluoro-14-methoxy-3,6-dioxo-1,1a,3,4,5,6,9,10,18,19,20,21,22,22a-tetradecahydro-8H-7,10-methanocyclopropa[18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-8-carboxamide.

5



Example 94

Example **94** was prepared in a similar fashion to Example **17**, substituting Intermediate **A9** for Intermediate **A10** in Step 7. Example **94** was isolated.

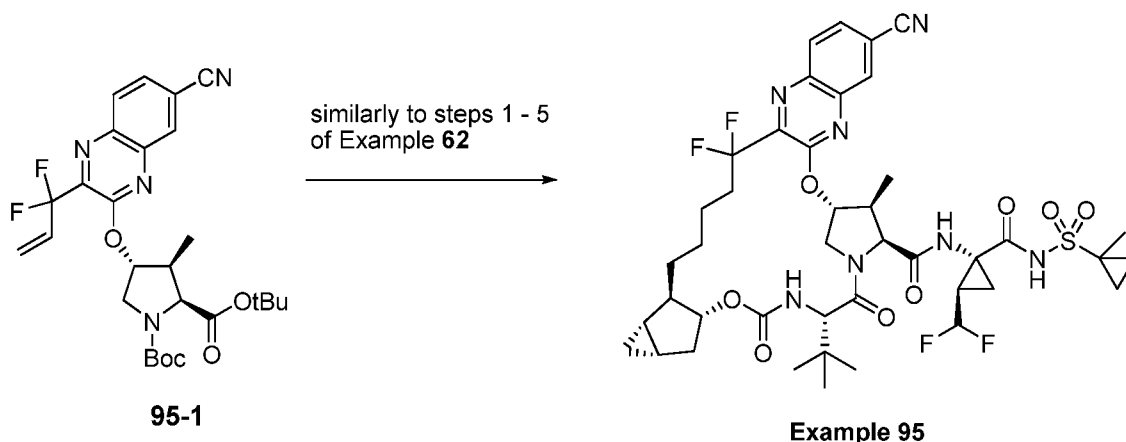
Analytic HPLC RetTime: 8.71 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for

- 10 C₃₉H₅₁F₄N₆O₉S: 855.34; found: 855.26. ¹H NMR (400 MHz, CDCl₃) δ 10.22 (s, 1H), 8.02 (d, *J* = 9.2 Hz, 1H), 7.33 (d, *J* = 12 Hz, 1H), 7.12 (s, 1H), 5.95 (td, *J*_{HF} = 52 Hz, *J* = 8 Hz, 1H), 5.50 (d, *J* = 9.7 Hz, 1H), 4.53 (d, *J* = 6.4 Hz, 1H), 4.46 (dd, *J* = 26.4, 10.7 Hz, 2H), 4.13 (d, *J* = 11.5 Hz, 1H), 4.00 (s, 3H), 3.68 (m, 1H), 2.91 (m, 1H), 2.57 (m, 3H), 2.13 (m, 2H), 1.94 (m, 2H), 1.73 (m, 3H), 1.50 (m, 3H),
15 1.33 (m, 3H), 1.22 (t, *J* = 7.2 Hz, 3H), 1.13 (s, 9H), 1.00 – 0.95 (m, 4H), 0.95 – 0.85 (m, 1H), 0.69 (m, 1H), 0.51 (m, 1H).

Example **95**. Preparation of (1a*S*,2a*R*,6*S*,9*S*,10*S*,11*R*,23a*R*,23b*S*)-6-tert-butyl-15-cyano-N-[(1*R*,2*R*)-2-(difluoromethyl)-1-[(1-

- 20 methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-19,19-difluoro-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11, 19,20,21,22,23,23a,23b-hexadecahydro-1*H*,9*H*-8,11-

methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.

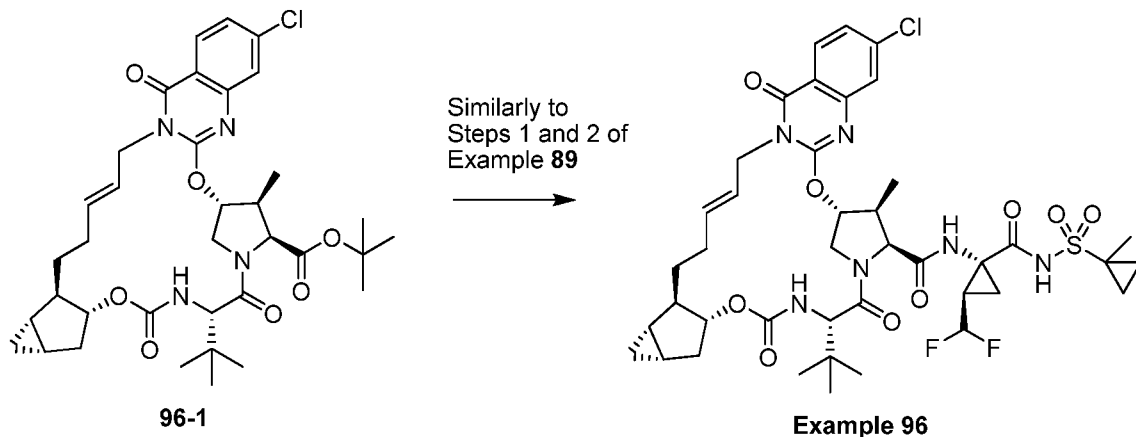


5 Intermediate **95-1** was prepared in a similar fashion to Intermediate **46-2**, substituting **E6** for Intermediate **E3** in Step 1. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₂₇H₃₃F₂N₄O₅: 531.24; found: 531.2.

Example **95** was prepared in a similar fashion to Example **62**, substituting Intermediate **95-1** for Intermediate **46-2** in Step 1 and substituting Intermediate **A10** for Intermediate **A9** in Step 5. Example **95** was isolated. Analytic HPLC RetTime: 8.86 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₂F₄N₇O₈S: 890.35; found: 889.94. ¹H NMR (400 MHz, CDCl₃) δ 9.34 (s, 1H), 7.80 (m, 2H), 7.42 (d, *J* = 8.6 Hz, 1H), 6.85 (s, 1H), 6.69 (s, 1H), 5.38 (m, 1H), 5.29 (m, 3H), 5.02 (d, *J* = 8.8 Hz, 1H), 4.46 (d, *J* = 7.4 Hz, 1H), 4.10 – 3.97 (m, 2H), 3.84 (d, *J* = 7.9 Hz, 1H), 3.74 (d, *J* = 8.6 Hz, 1H), 2.42 – 2.29 (m, 1H), 2.10 (s, 1H), 1.87 – 1.72 (m, 1H), 1.69 – 1.48 (m, 4H), 1.38 (d, *J* = 14.8 Hz, 2H), 1.30 – 1.08 (m, 4H), 0.99 (s, 5H), 0.89 (m, 3H), 0.69 (s, 10H), 0.64 (m, 1H), 0.43 (s, 1H), 0.11 (m, 1H), 0.01 (m, 1H).

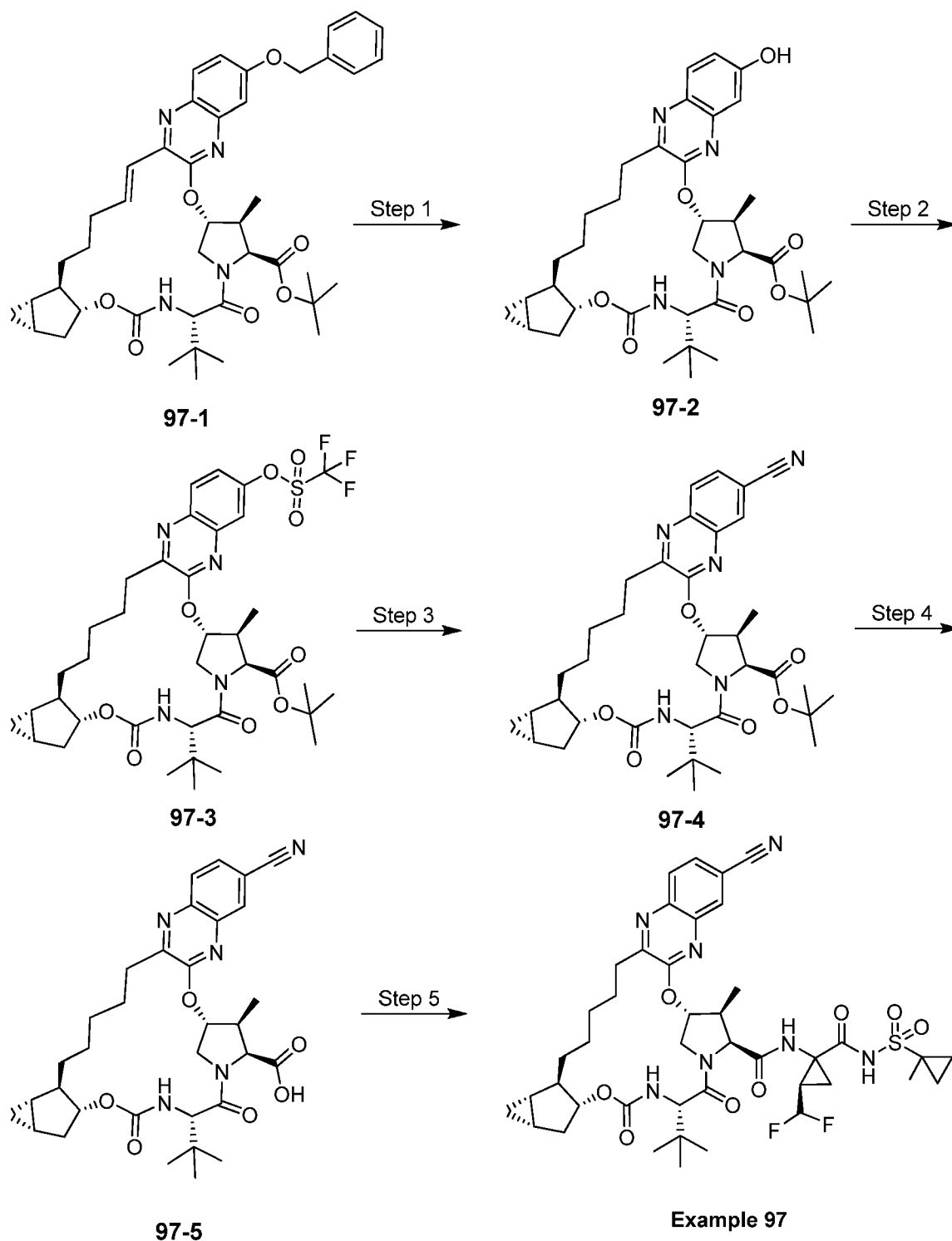
20 Example **96**. Preparation of (1a*S*,2a*R*,6*S*,9*S*,10*S*,11*R*,21*E*,24a*R*,24b*S*)-6-tert-butyl-15-chloro-N-[(1*R*,2*R*)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-10-methyl-4,7,18-trioxo-1a,2,2a,4,5,6,7,10,11,20,23, 24,24a,24b-tetradecahydro-1*H*,9*H*,18*H*-8,11-

methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6,12]dioxatriazacyclononadecino[11,12-b]quinazoline-9-carboxamide.



- 5 Example **96** was prepared in a similar fashion to Example **89**, substituting intermediate **96-1** for intermediate **17-4** in Step 1. Intermediate **96-1** was prepared in a similar fashion to intermediate **17-4** of Example **17**, substituting **E9** for **E3** and **B1** for **B4** in Step 1, and substituting intermediate **D16** for intermediate **D11** in Step 3. Example **96** was isolated. Analytic HPLC RetTime:
- 10 9.18 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₁H₅₂ClF₂N₆O₉S: 877.32; found: 877.61. ¹H NMR (400 MHz, Chloroform-*d*) δ 9.76 (s, 1H), 8.03 (d, *J* = 8.6 Hz, 1H), 7.39 (m, 1H), 7.27 (m, 1H), 6.80 (s, 1H), 5.92 (m, 1H), 5.87 – 5.73 (m, 1H), 5.68 (m, 1H), 5.64 – 5.51 (m, 1H), 5.21 (m, 1H), 4.93 (m, 2H), 4.52 – 4.32 (m, 3H), 4.15 – 3.94 (m, 2H), 2.86 – 2.71 (m, 1H), 2.26 (m, 1H), 2.15 (m, 2H), 2.10 – 2.02 (m, 1H), 2.02 – 1.84 (m, 2H), 1.77 (m, 2H), 1.61 (s, 3H), 1.50 (m, 4H), 1.42 – 1.17 (m, 6H), 1.17 – 0.92 (m, 10H), 0.92 – 0.78 (m, 2H), 0.51 – 0.37 (m, 1H).
- 15

- Example **97**. Preparation of (1a*S*,2a*R*,6*S*,9*S*,10*S*,11*R*,23a*R*,23b*S*)-6-tert-butyl-15-cyano-N-[(2*R*)-2-(difluoromethyl)-1-[(1-methylcyclopropyl)sulfonyl]carbamoyl]cyclopropyl]-10-methyl-4,7-dioxo-1a,2,2a,4,5,6,7,10,11,19,20,21,22,23,23a,23b-hexadecahydro-1*H*,9*H*-8,11-methanocyclopropa[4',5']cyclopenta[1',2':18,19][1,10,3,6]dioxadiazacyclononadecino[11,12-b]quinoxaline-9-carboxamide.
- 20



5 Intermediate **97-1** was prepared in a similar fashion to intermediate **79-5**, substituting **E2** for **E5** in Step 1. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₃H₅₅N₄O₇: 739.41; found: 739.31.

Step 1. Preparation of **97-2**. Macrocyclic olefin **97-1** (0.84 g, 1.14 mmol) was dissolved in 114 mL ethanol and 114 mL ethyl acetate. After degassing with Argon, 0.84 g of 5% Pd/C Degussa-type was added and the mixture was hydrogenated for 4 hours at 1 atm. Filtration through celite, concentration, and silica gel chromatography (40% - 60% ethyl acetate in hexanes gradient) provided intermediate **97-2**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₆H₅₁N₄O₇: 651.38; found: 651.32.

Step 2. Preparation of **97-3**. An ice cold solution of macrocycle phenol **97-2** (0.47 g, 0.73 mmol) and triethylamine (0.81 ml, 5.81 mmol) in 3 mL DCM was treated with trifluoromethanesulfonic anhydride solution, 1 M in methylene chloride (0.18 ml, 1.09 mmol) dropwise. After stirring for 2 hours, the reaction was quenched with water and extracted with ethyl acetate. The organic layer was washed with water and brine, dried over Na₂SO₄, filtered and concentrated. Silica gel chromatography using a 5% - 50% ethyl acetate in hexanes gradient gave **97-3** as the first eluting peak (55 mg). LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₀F₃N₄O₉S: 783.33; found: 782.96.

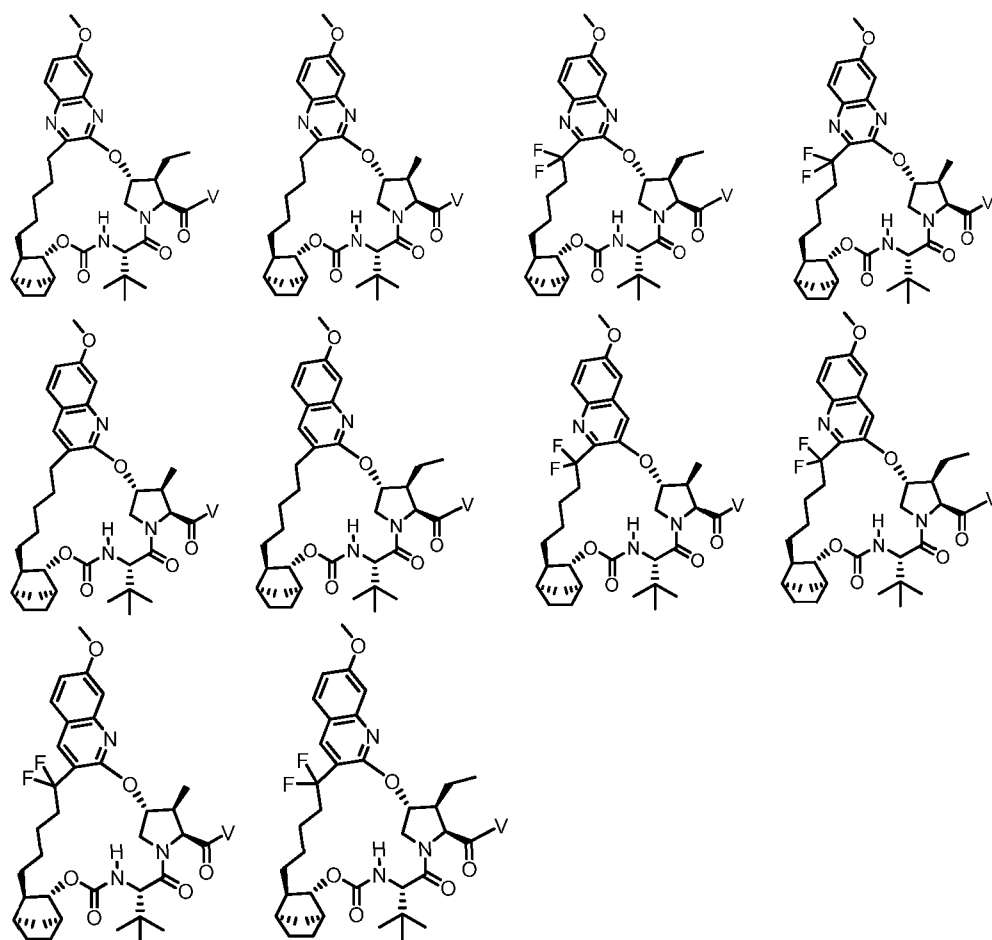
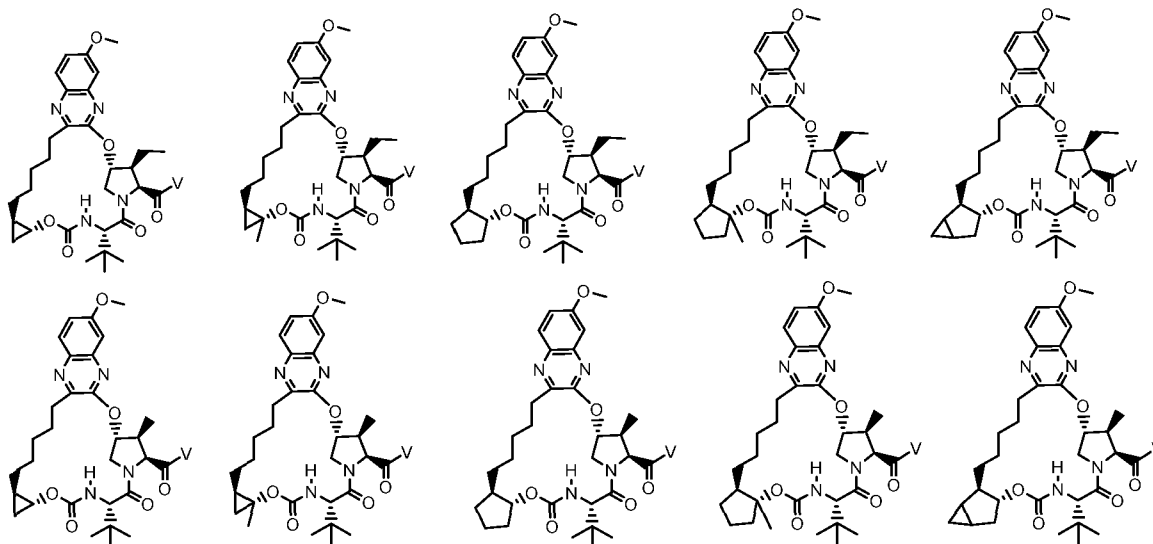
Step 3. Preparation of **97-4**. Degassed a mixture of macrocycle triflate **97-3** (408 mg, 0.52 mmol), tetrakis(triphenylphosphine)palladium (30.11 mg, 0.03 mmol), Zinc cyanide, 98% (61.21 mg, 0.52 mmol) in 2.6 mL DMF for 10 minutes. The reaction was heated at 80 °C for 1 hour. An additional 60 mg tetrakis(triphenylphosphine)palladium and 120 mg Zinc cyanide were added and heating was continued for 30 minutes. The reaction was quenched with saturated ammonium chloride solution and extracted with ethyl acetate. The organic phase was separated, dried over anhydrous sodium sulphate, filtered and concentrated. The crude product was purified by silica gel chromatography using a gradient of 5% -70% ethyl acetate in hexanes to give intermediate **97-4**. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₇H₅₀N₅O₆: 660.38; found: 660.10.

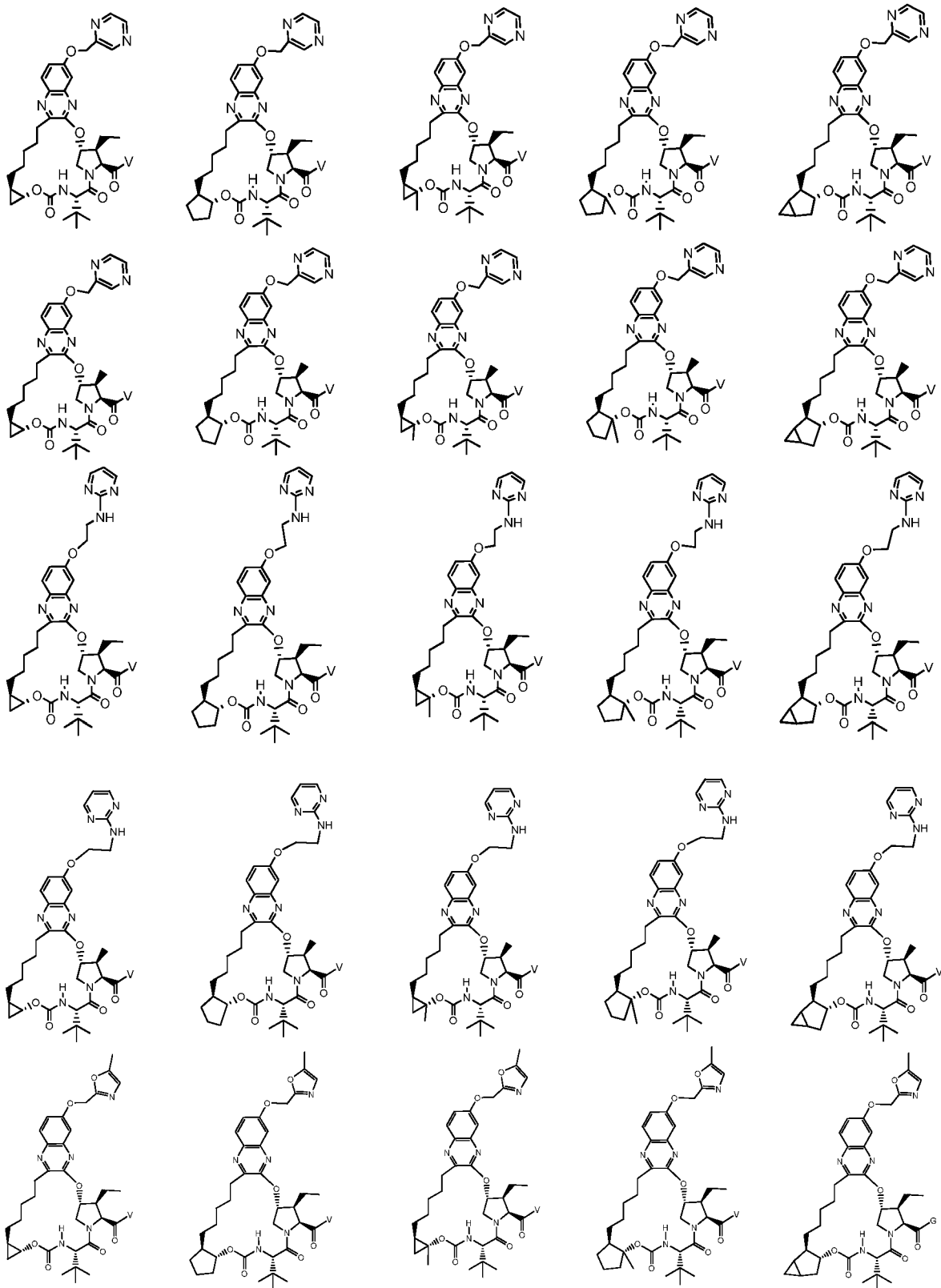
Step 4. Preparation of **97-5**. A solution of **97-4** (290 mg, 0.44 mmol) in 1mL DCM was treated with 0.5 mL of TFA and stirred overnight. Water was added and the mixture was extracted with ethyl acetate. The organic phase was separated, dried over anhydrous sodium sulphate, filtered and concentrated.

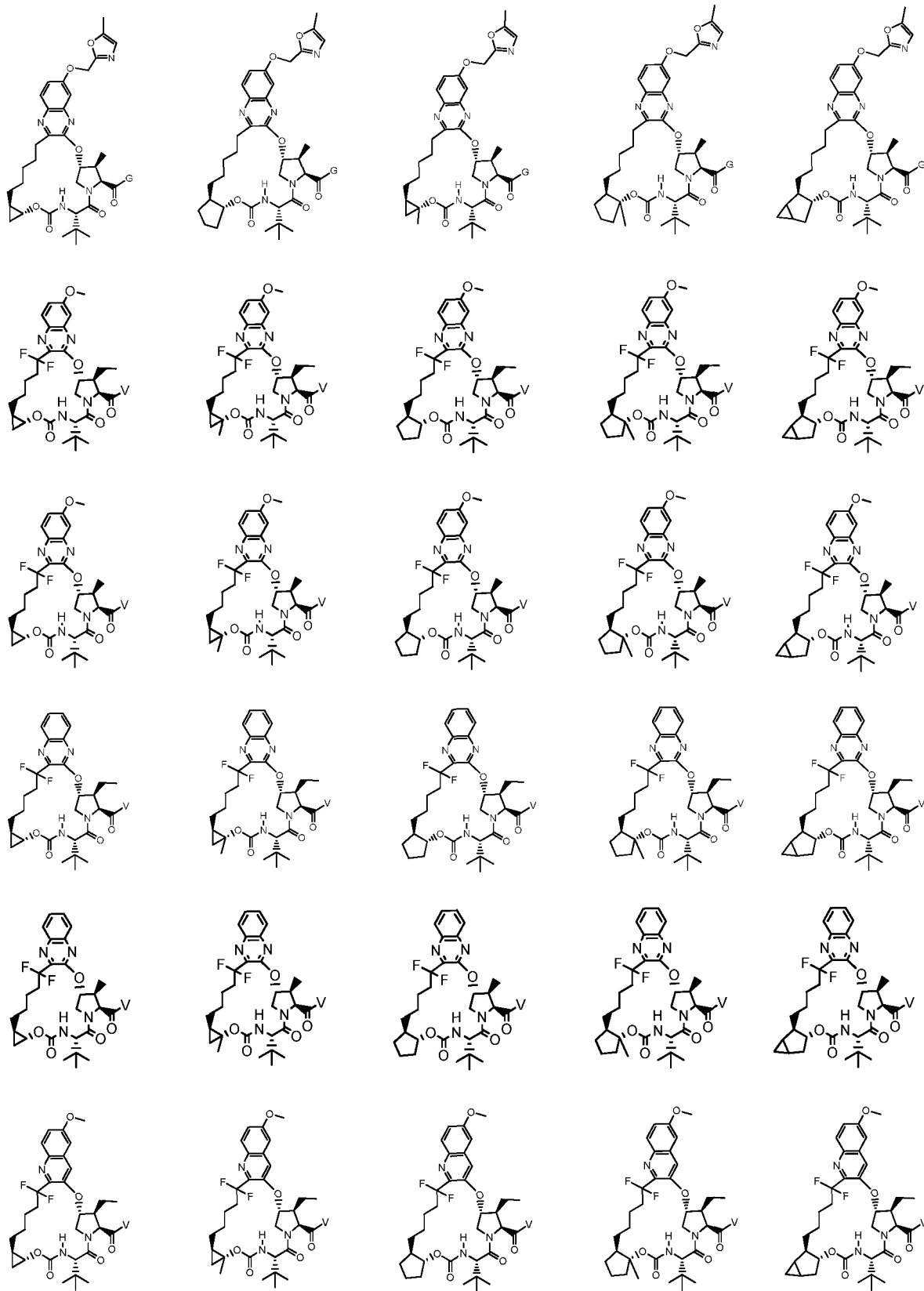
The crude product was purified by silica gel chromatography using a gradient of 10% -70% ethyl acetate in hexanes to give intermediate **97-5** (216 mg) as a white solid. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₃₃H₄₂N₅O₆: 604.31; found: 604.00.

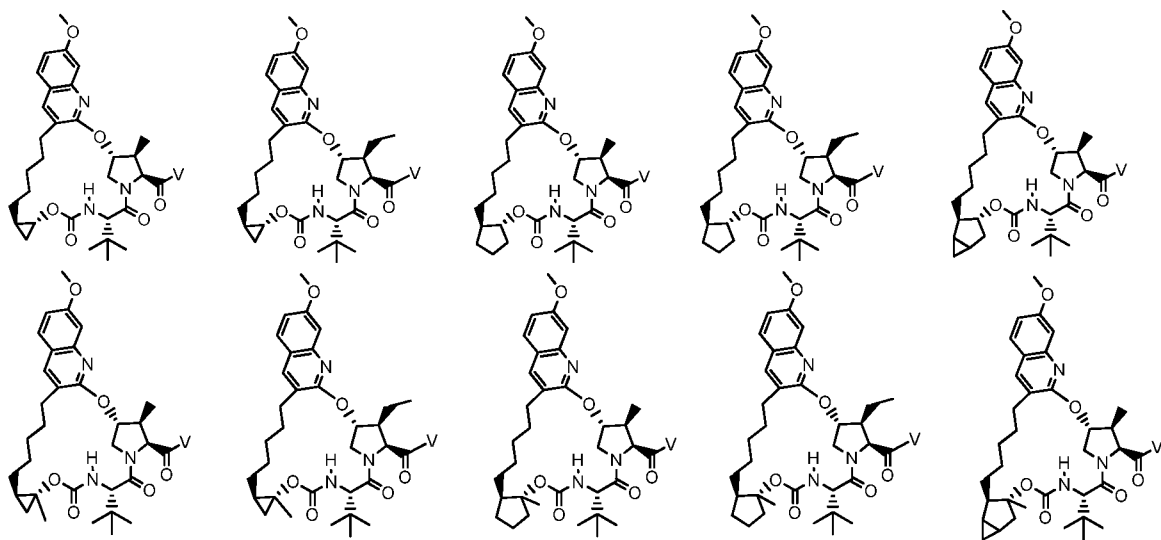
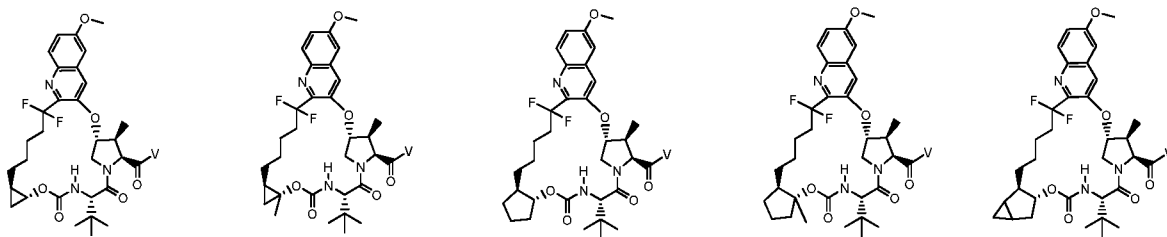
- 5 Step 5. Preparation of Example **97**. A mixture of **97-5** (50 mg, 0.08 mmol), HATU (37.79 mg, 0.1 mmol), in 0.3 mL DMF was stirred 5 min, then **A10** (50 mg, 0.08 mmol) and DIPEA (0.06 ml, 0.33 mmol) were added. After 45 min at rt, the reaction was incomplete (LCMS). Added another 20 mg of **A10** and stirred for 2 hours. 2 mL of 1 N HCl was added, and the mixture was extracted with
- 10 DCM. The crude product was purified by silica gel chromatography using a gradient of 30% - 65% ethyl acetate in hexanes. Combined product fractions contained some residual DMF. Water was added, which generated a precipitate (14 mg). The filtrate was extracted with ethyl acetate, and the extracts were combined with the precipitate. The resulting solution was dried over anhydrous
- 15 sodium sulphate, filtered, concentrated and dried under reduced pressure to give Example **97**. Analytic HPLC RetTime: 9.06 min. LCMS-ESI⁺ (*m/z*): [M+H]⁺ calcd for C₄₂H₅₄F₂N₇O₈S: 854.98; found: 853.88. ¹H NMR (400 MHz, CDCl₃) δ 9.77 (br s, 1H), 8.05 (m, 1H), 7.93 (m, 1H), 7.62 (m, 1H), 7.20 (m, 1H), 7.08 (m, 1H), 6 - 5.65 (m, 1H), 5.56 (m, 1H), 5.17 (m, 1H), 4.90 (m, 1H), 4.38 (m, 2H), 4.22 (m,
- 20 1H), 4.06 (m, 1H), 3.57 (m, 1H), 2.88 (m, 1H), 2.70 (m, 5H), 2.28 – 2.08 (m, 1H), 2.04 – 1.30 (m, 12H), 1.29 - 1.09 (m, 9H), 1.08 – 0.96 (m, 4H), 0.85 – 0.67 (m, 3H), 0.43 (m, 1H), 0.34 (m, 1H), 0.19 - 0.03 (m, 1H).

The following compounds can be made with the synthetic methods of this disclosure, or by means generally well known in the art:

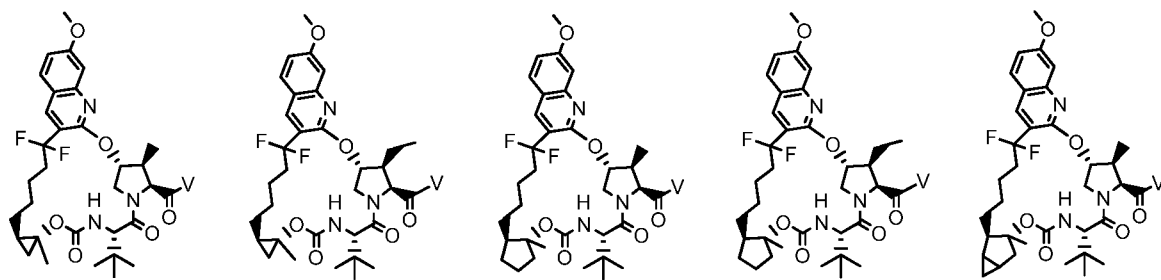
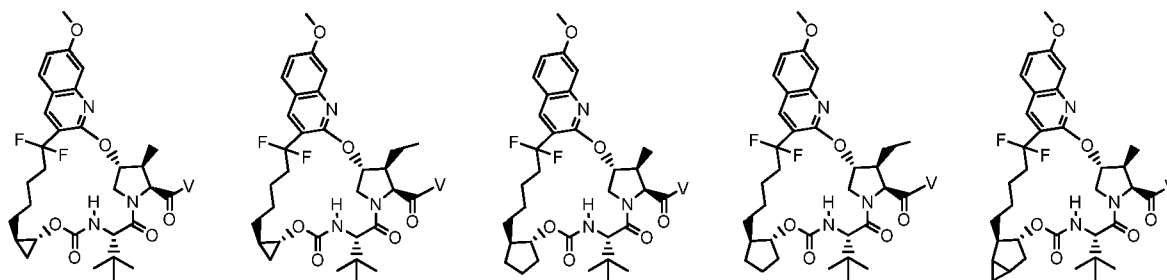




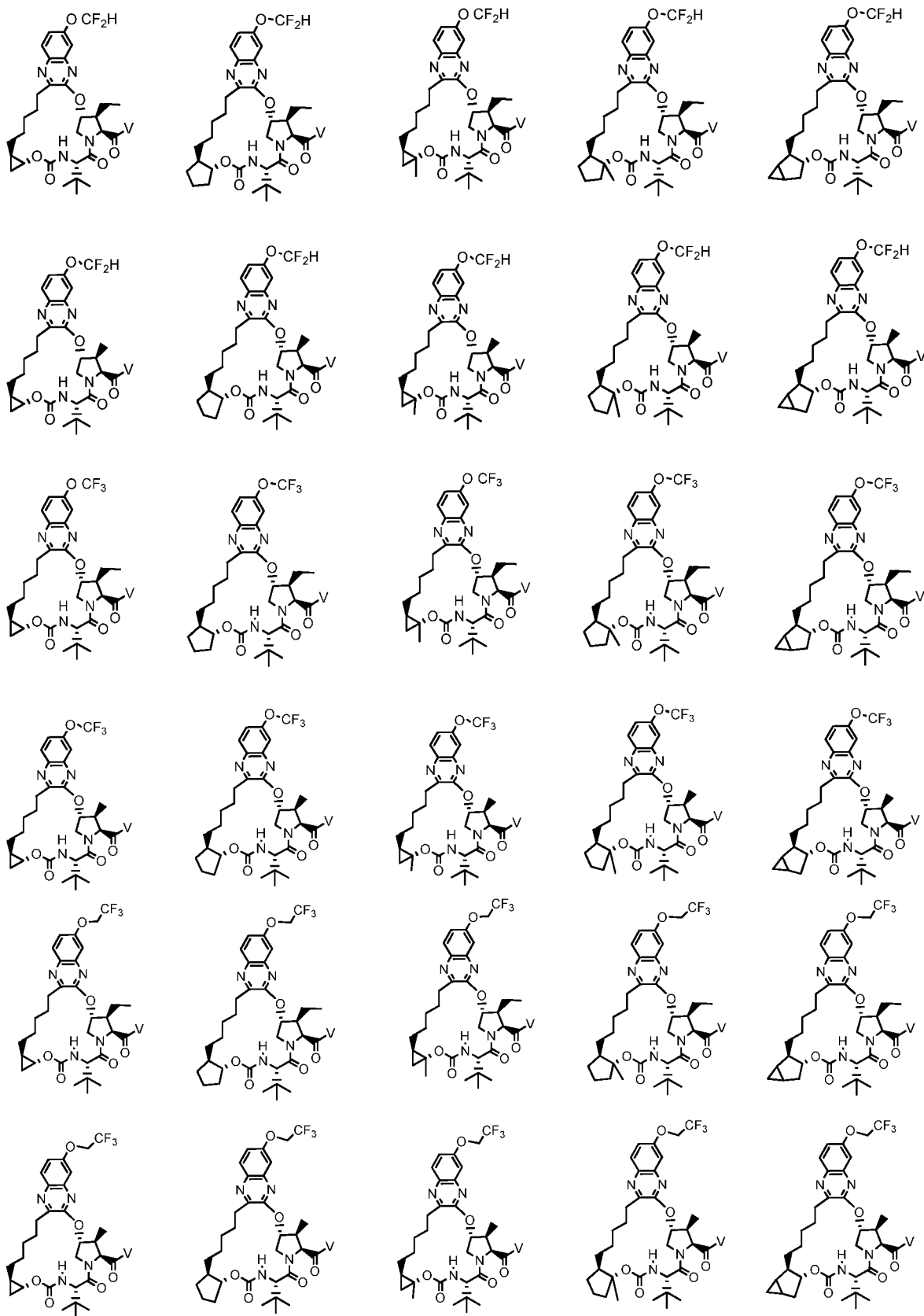


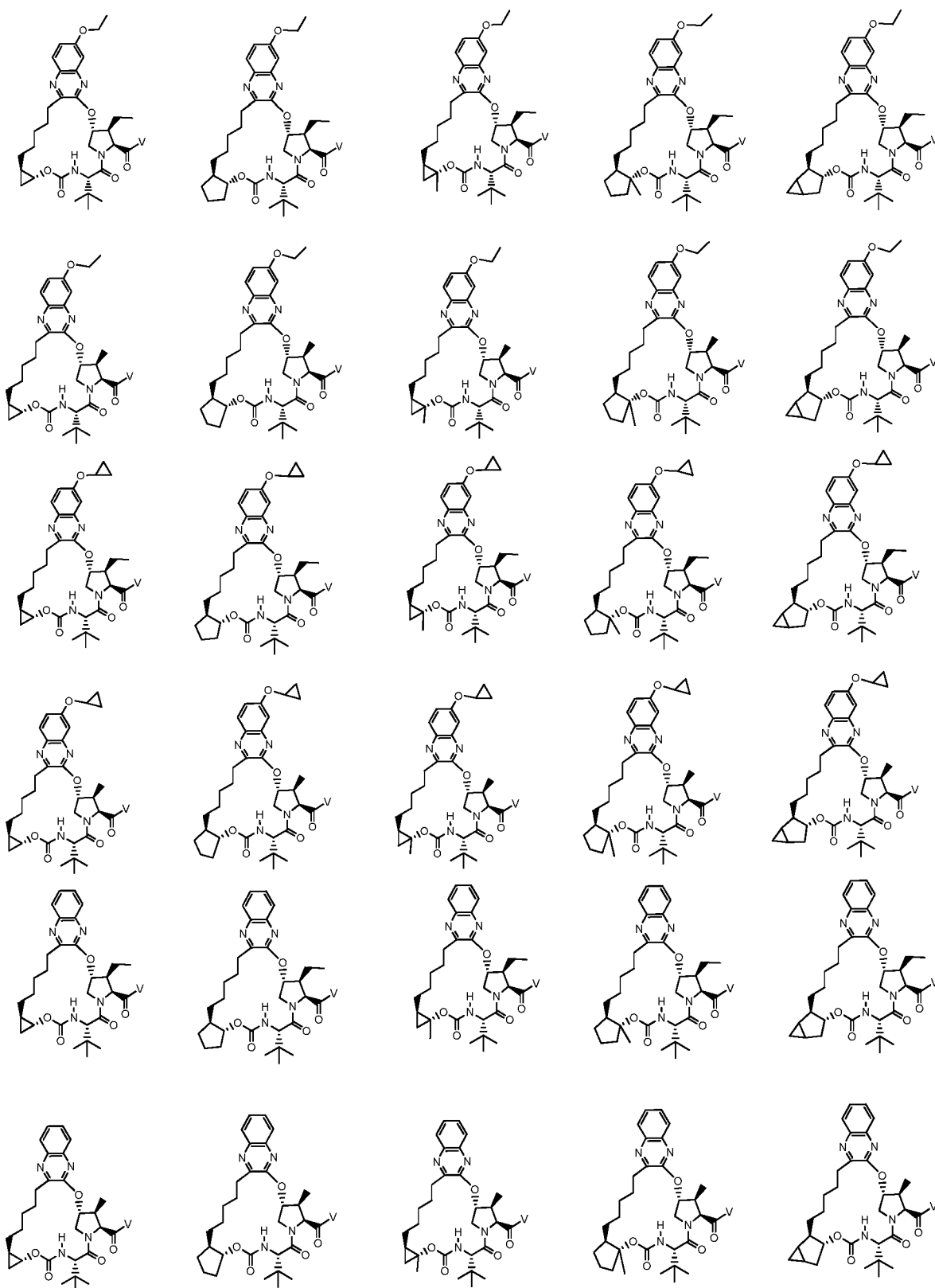


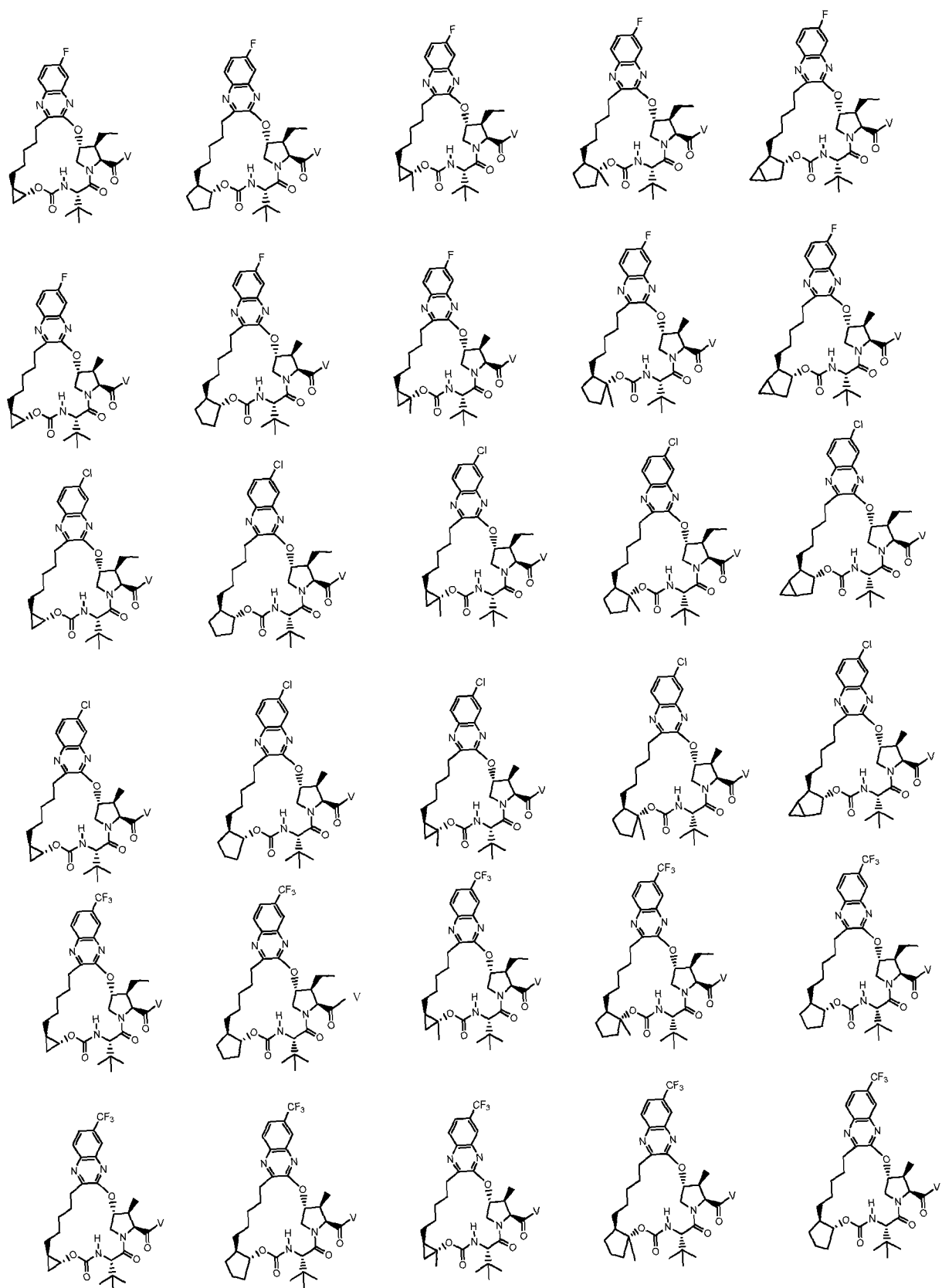
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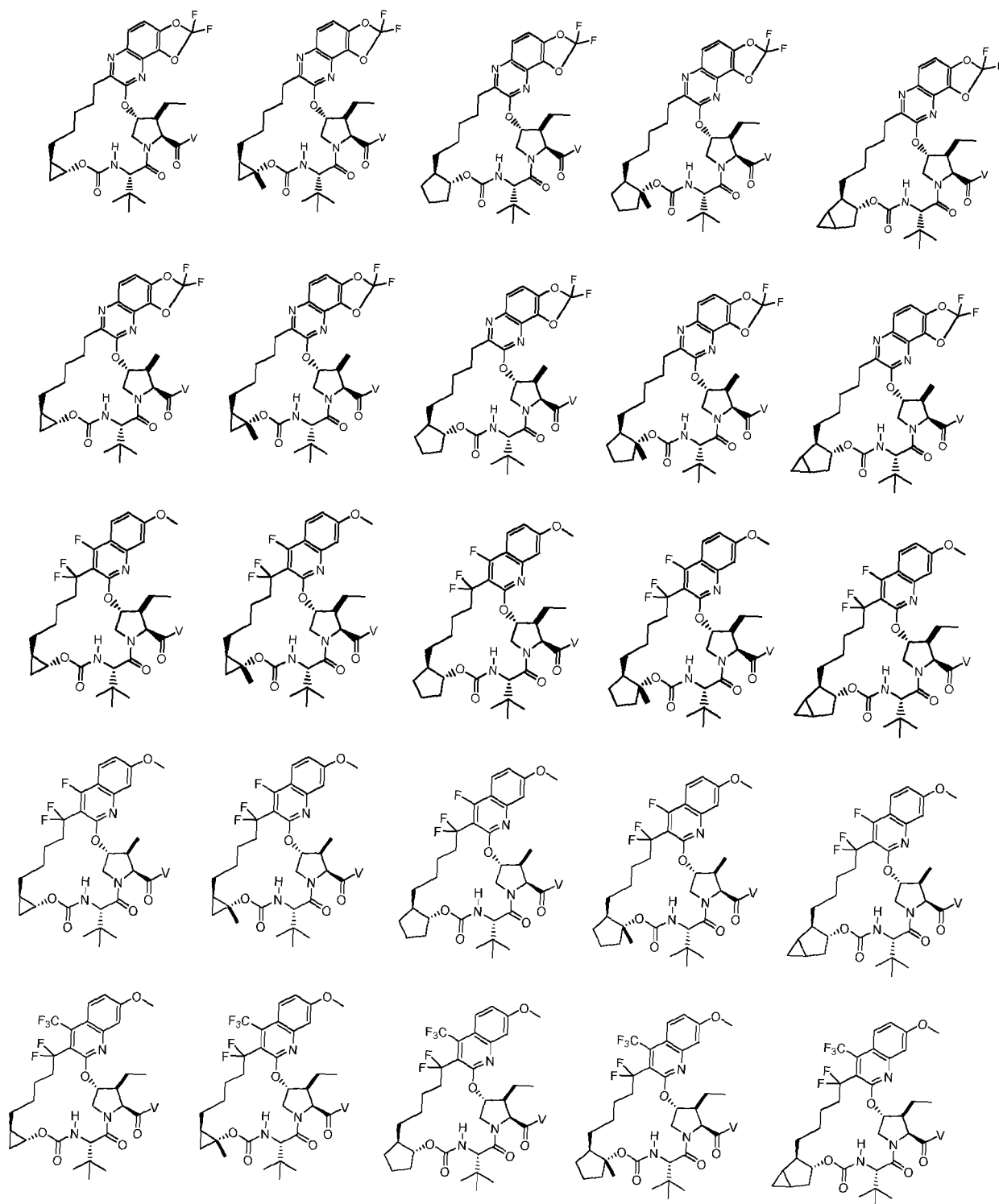
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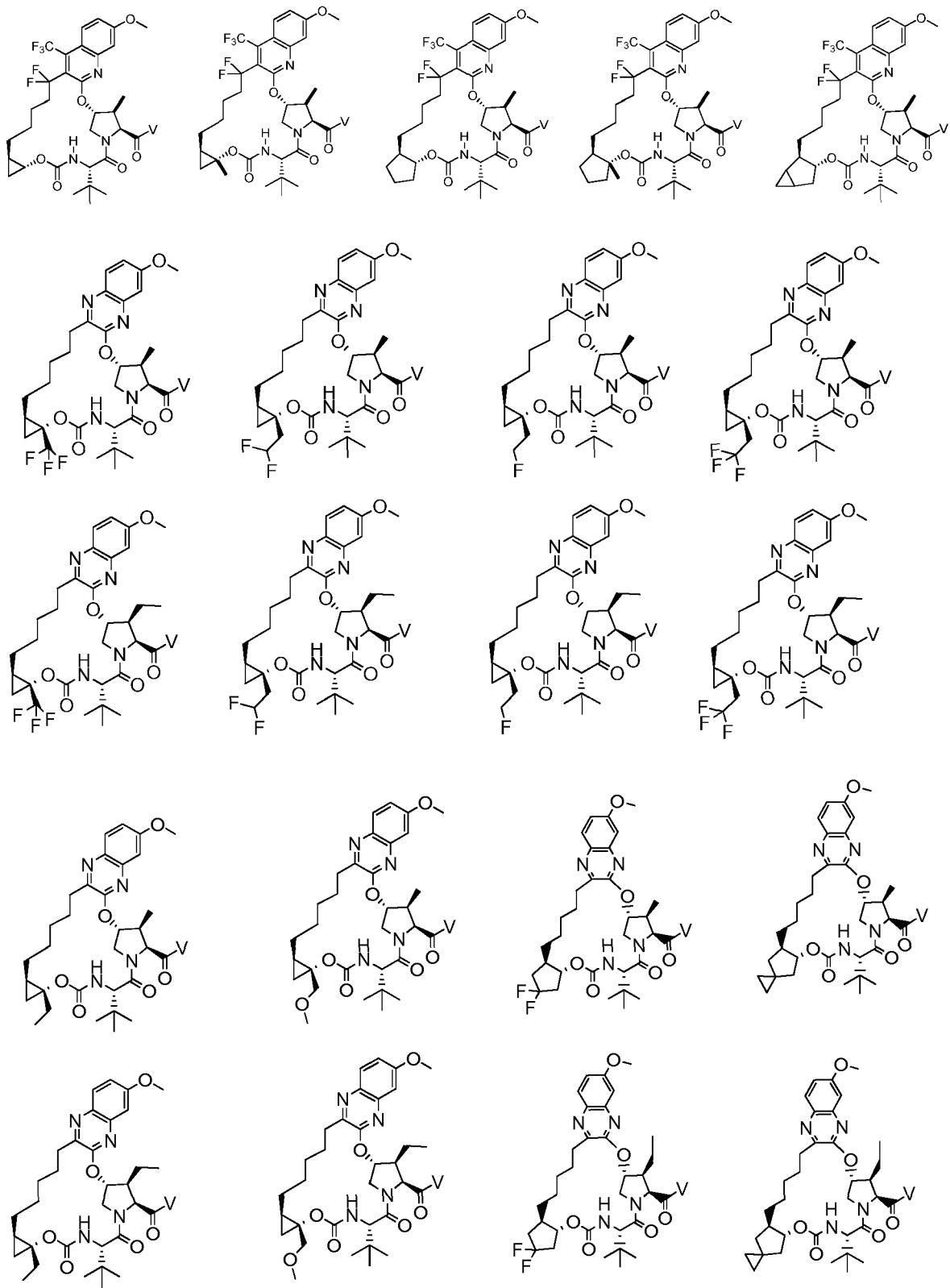


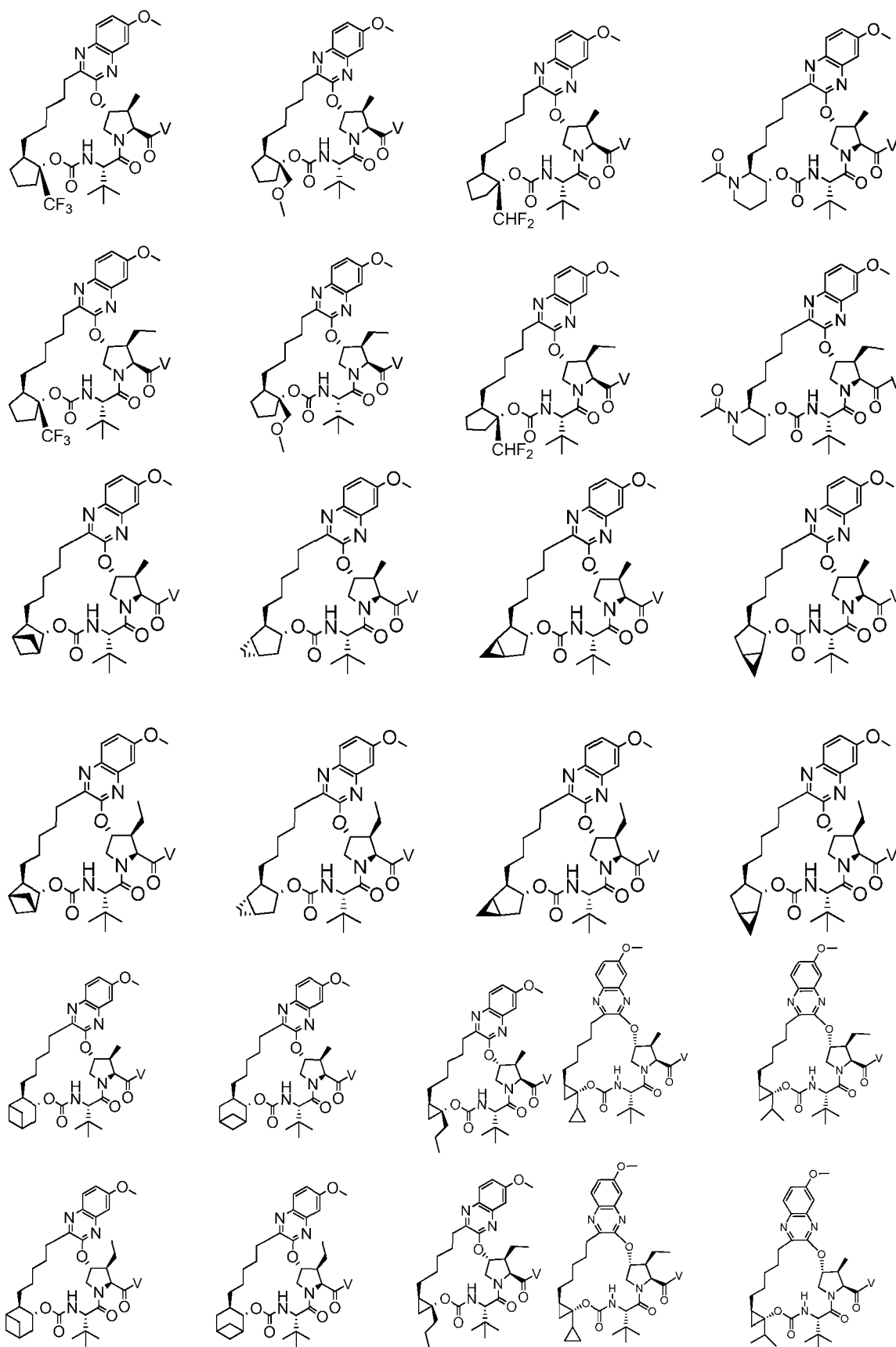


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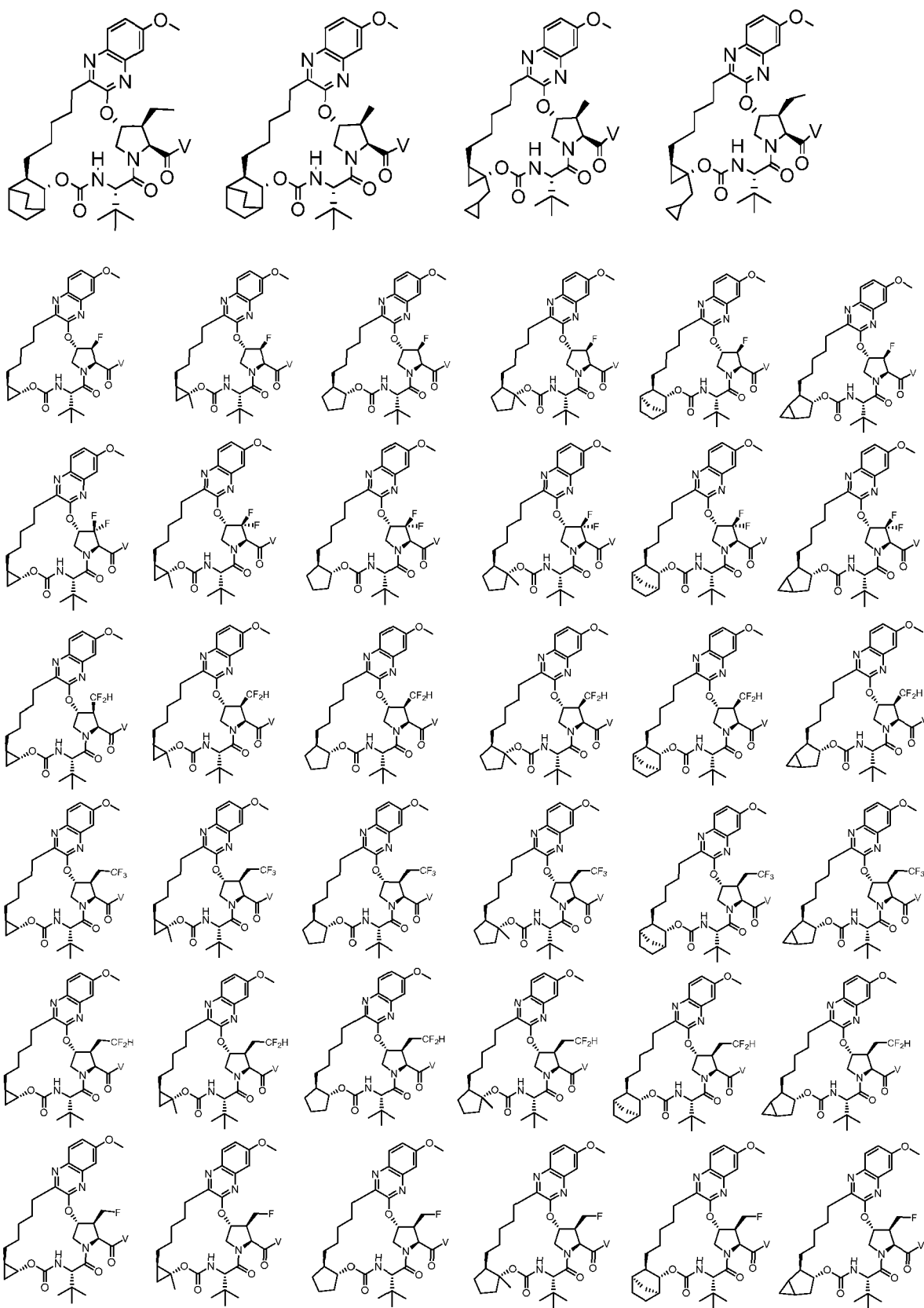


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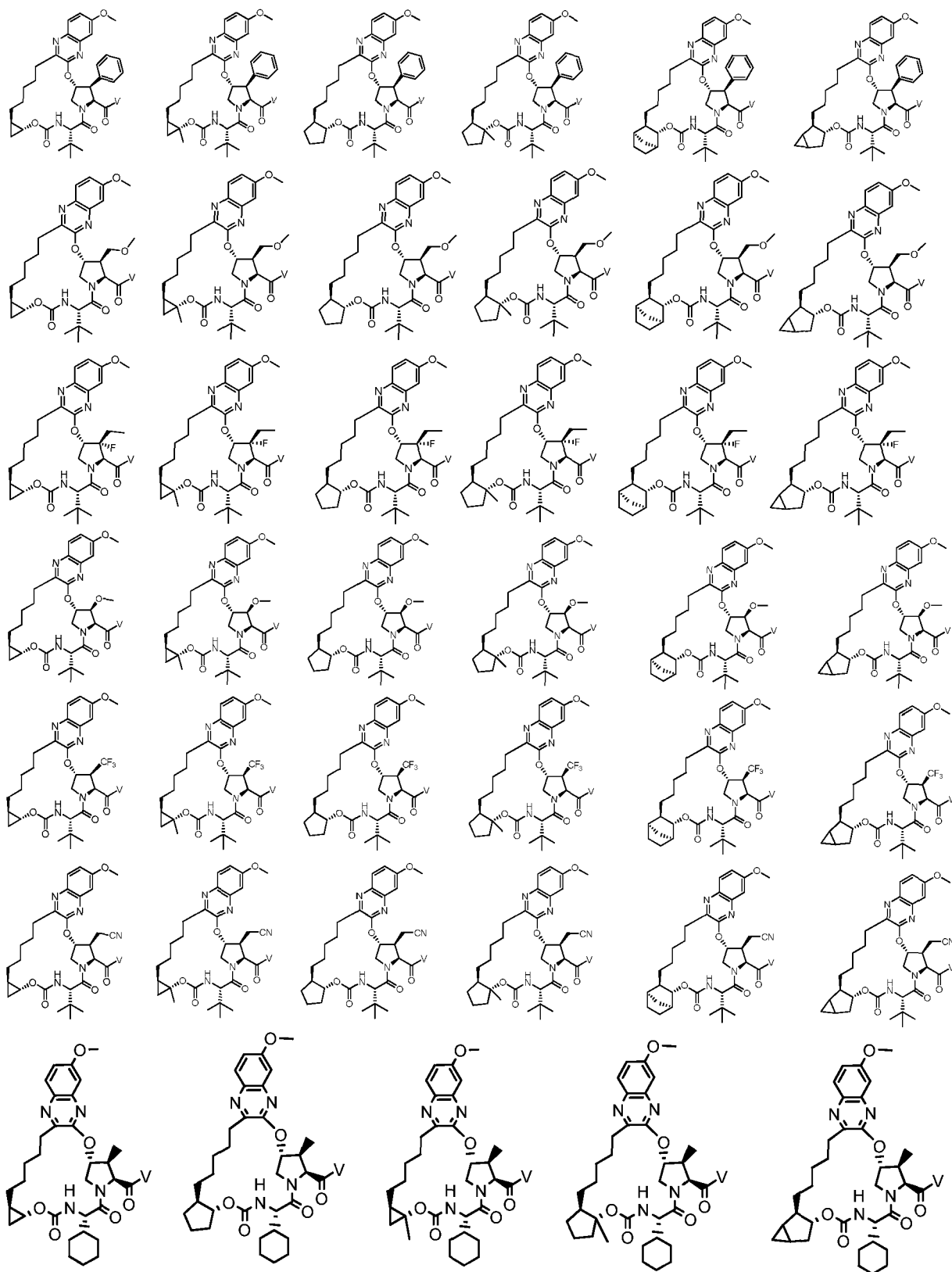


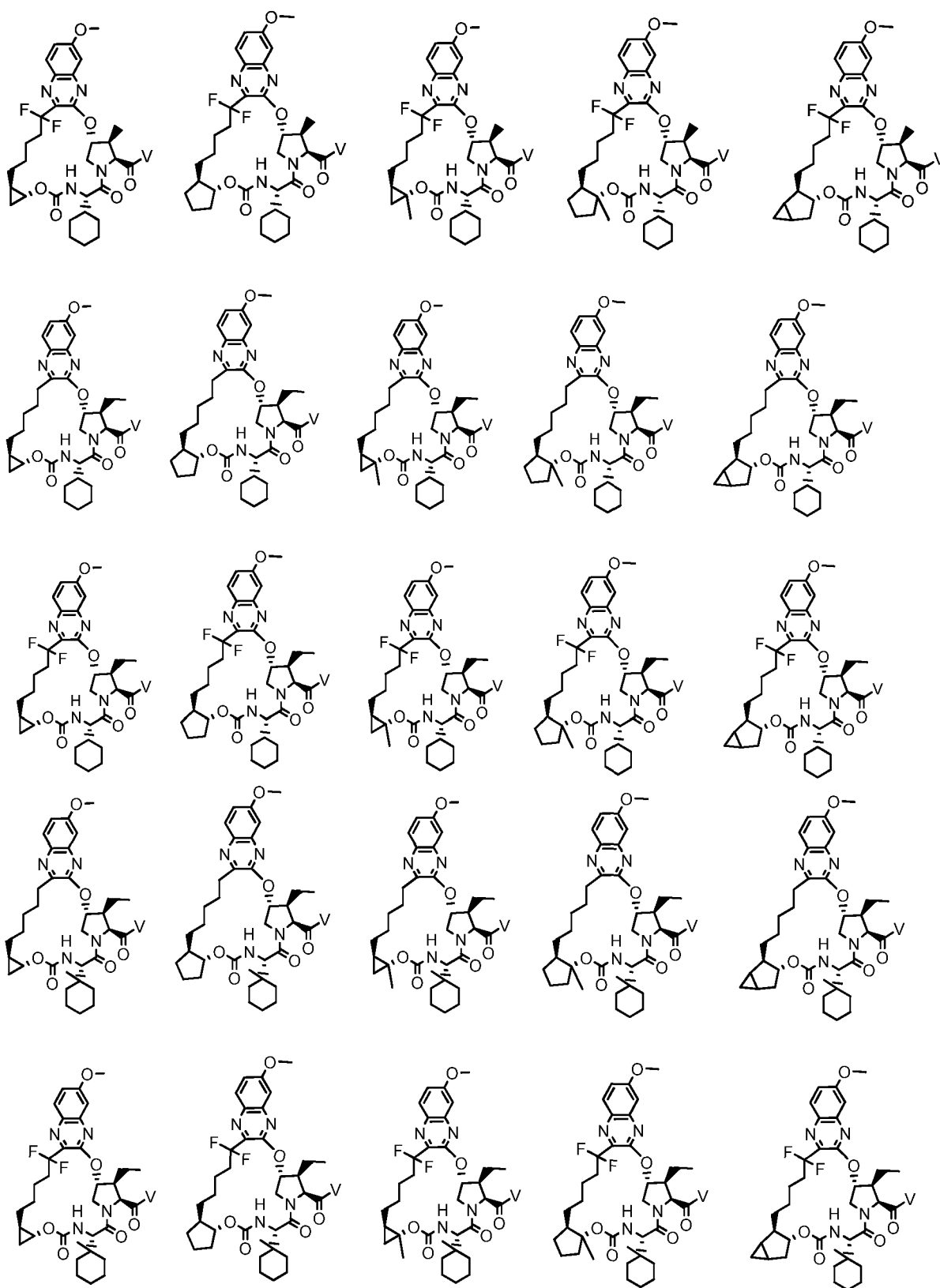


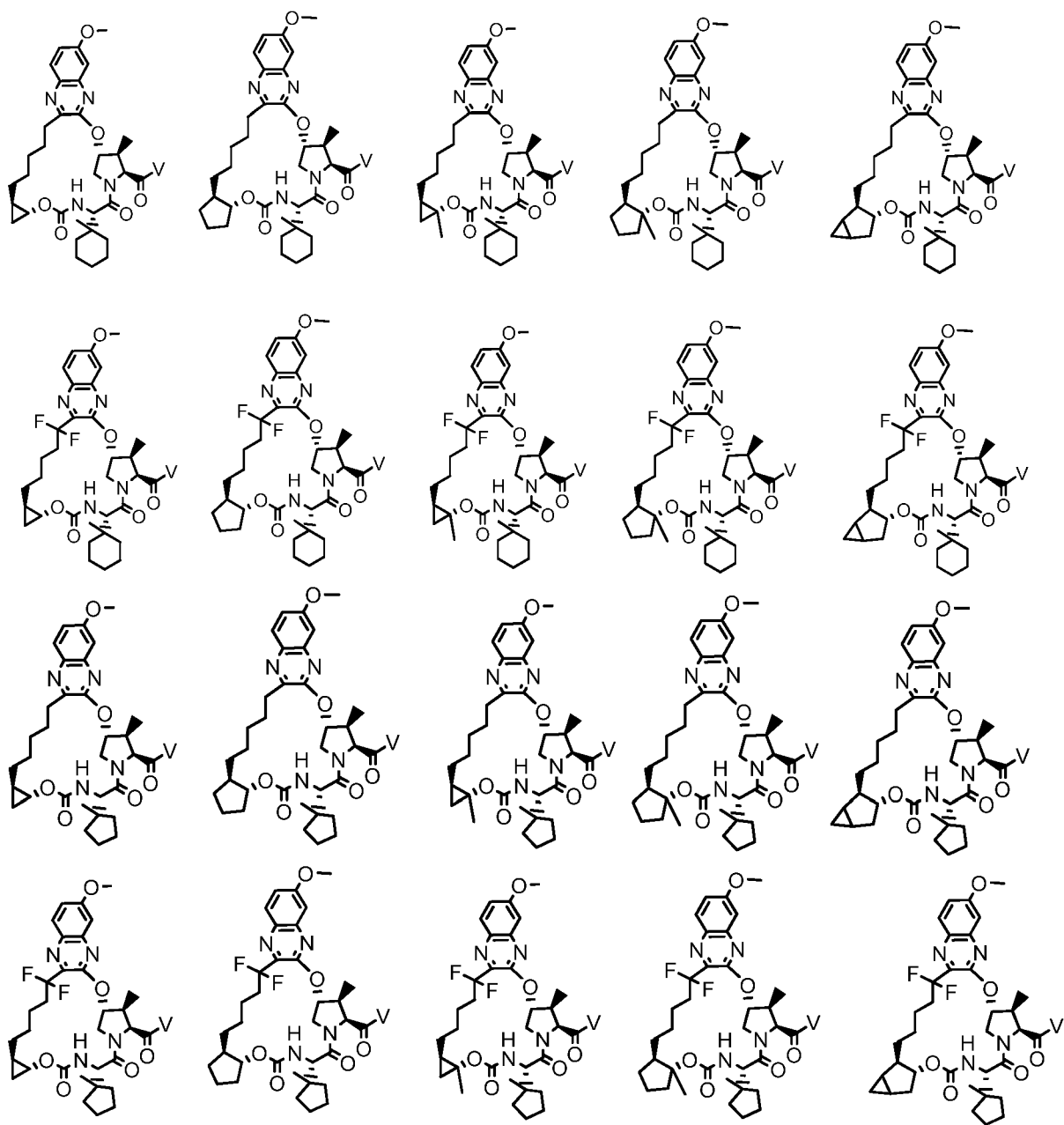
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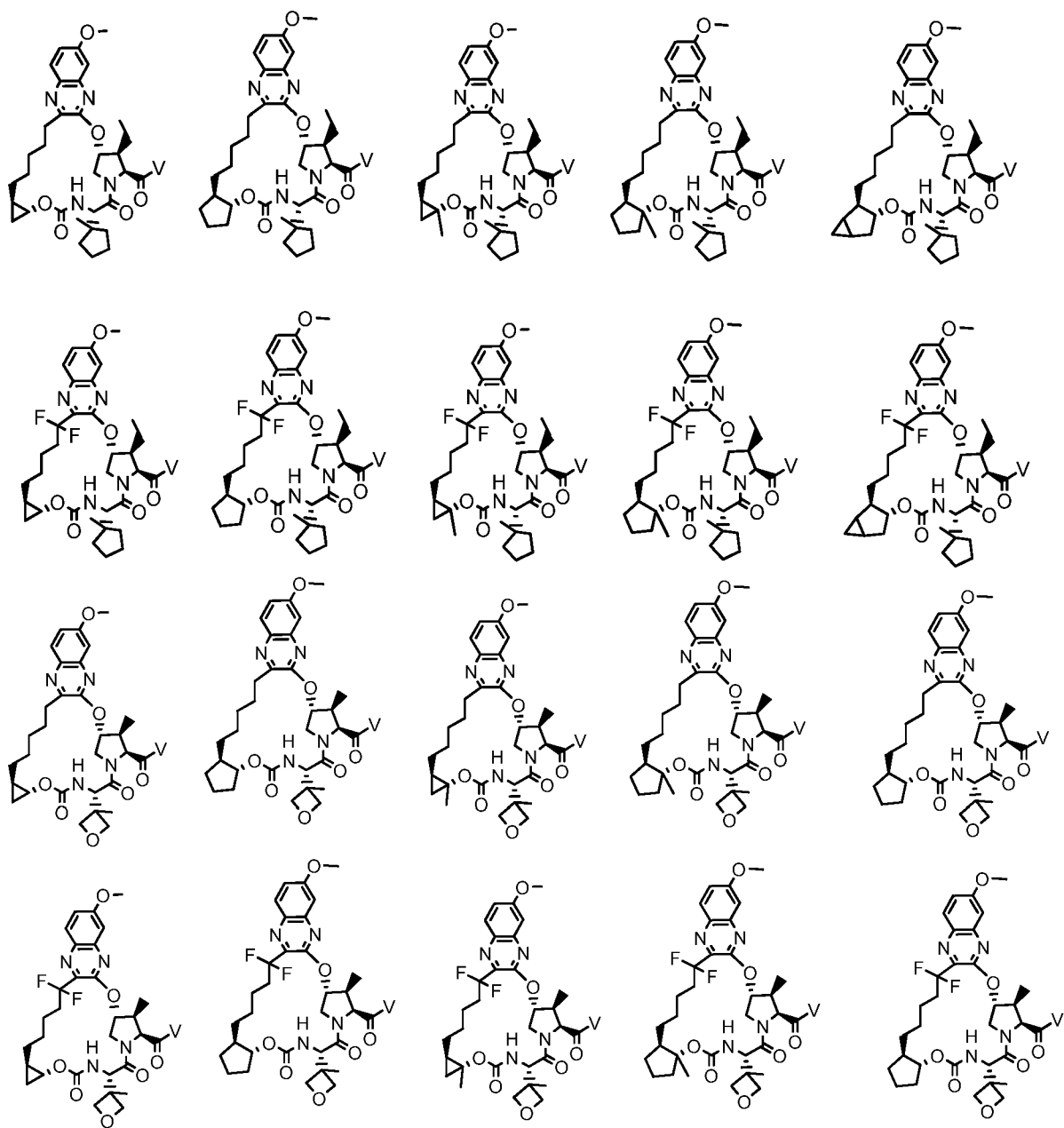


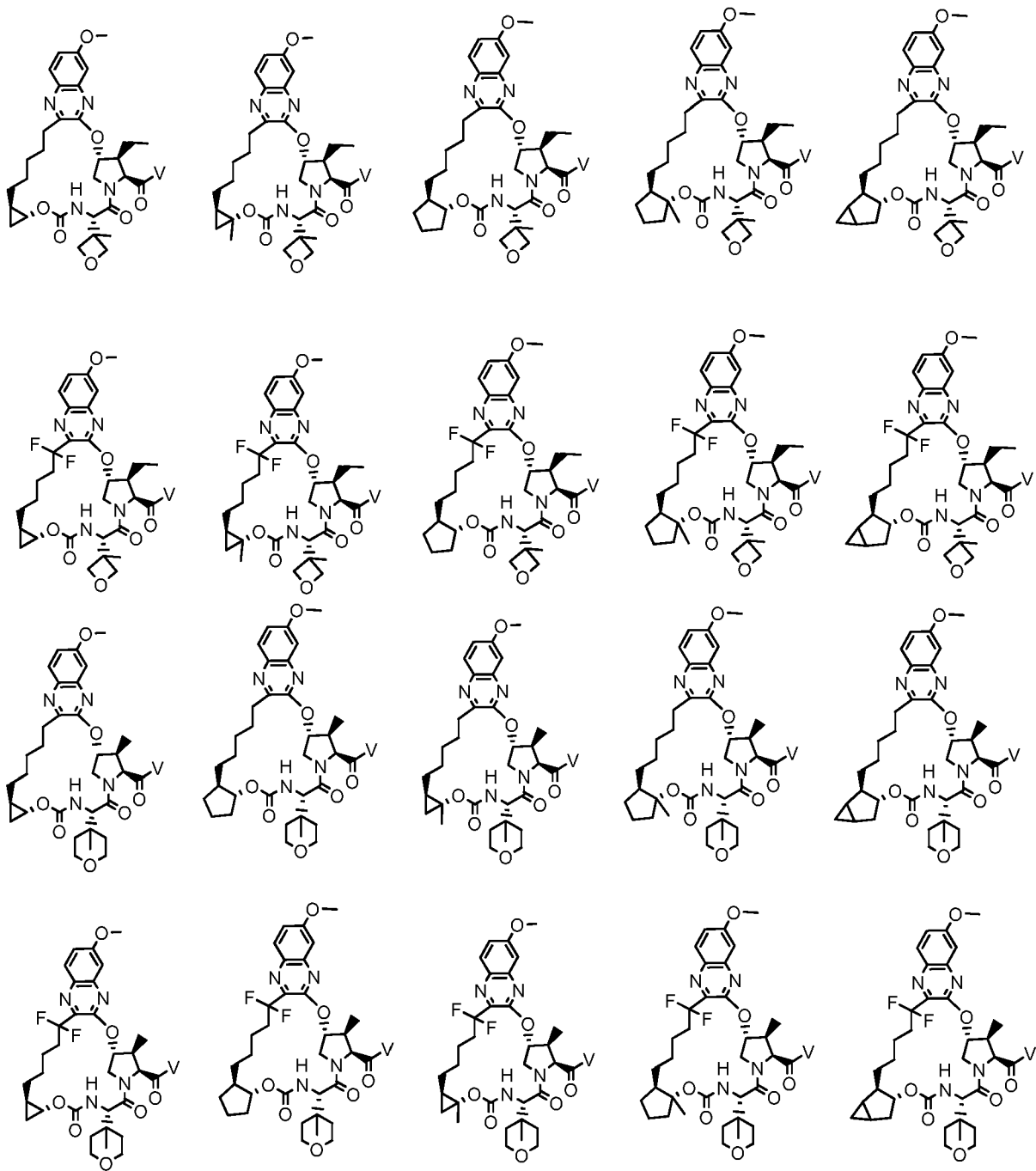
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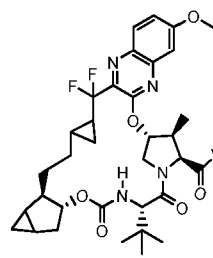
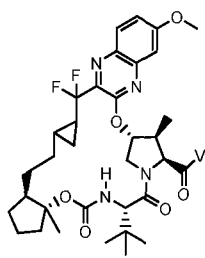
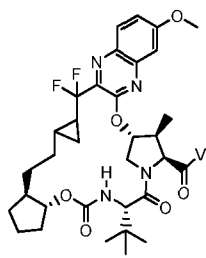
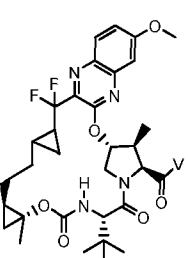
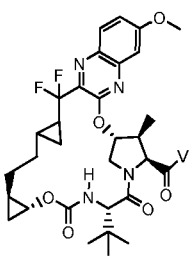
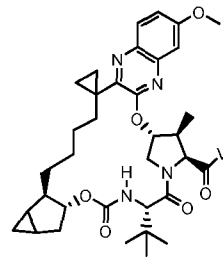
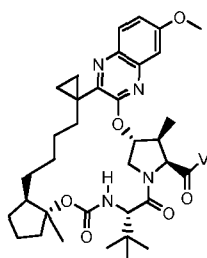
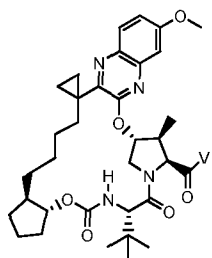
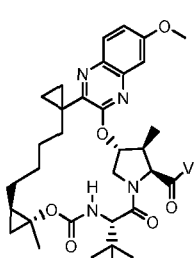
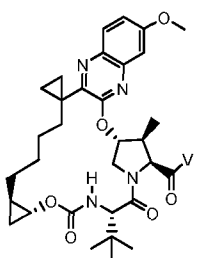
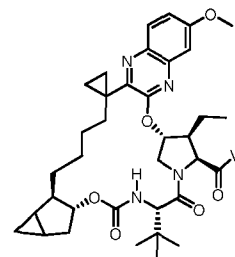
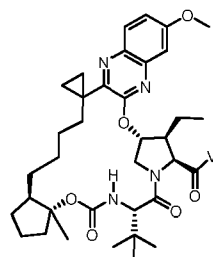
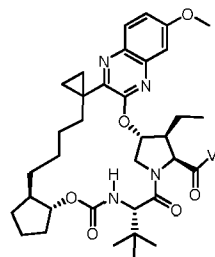
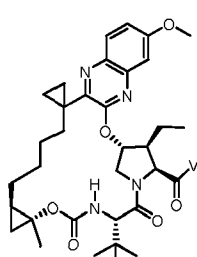
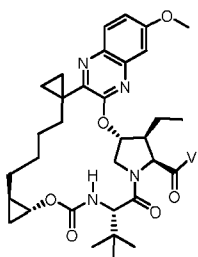
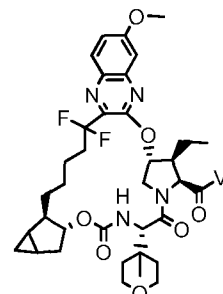
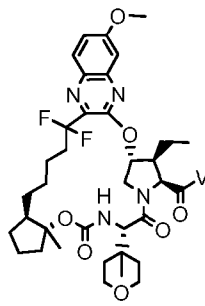
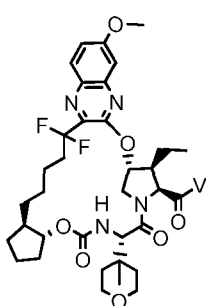
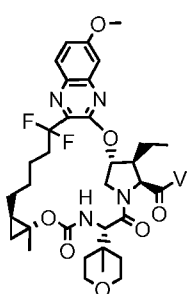
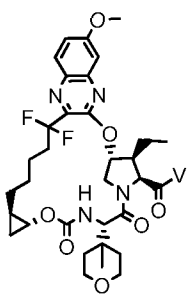
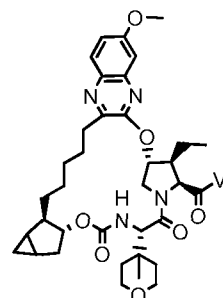
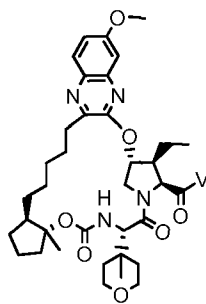
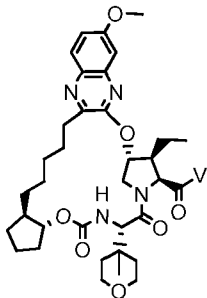
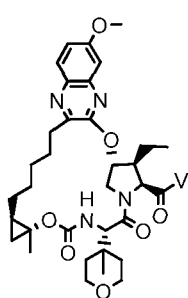
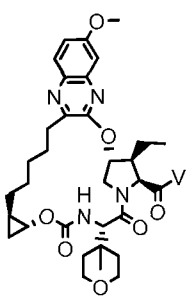


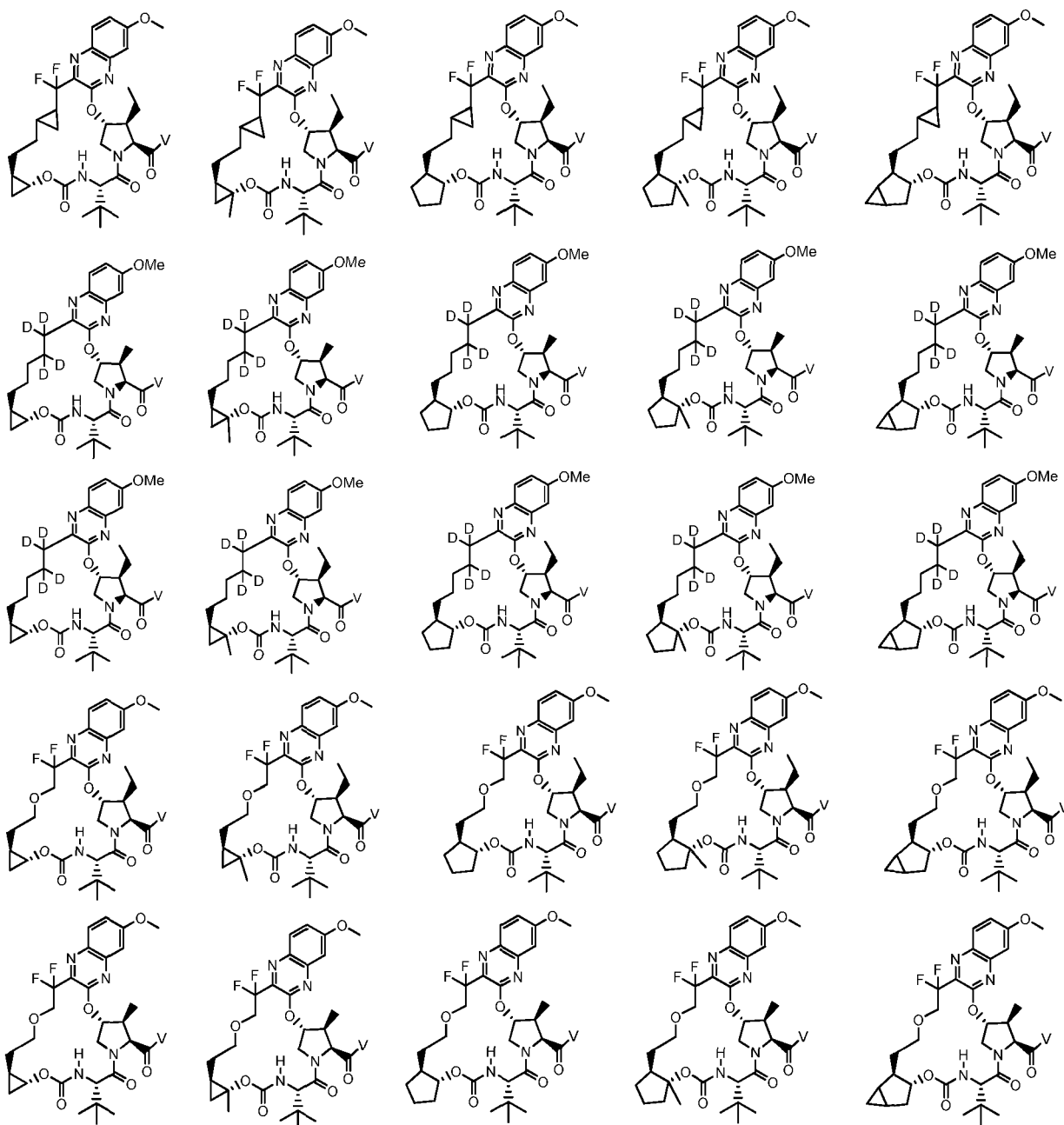




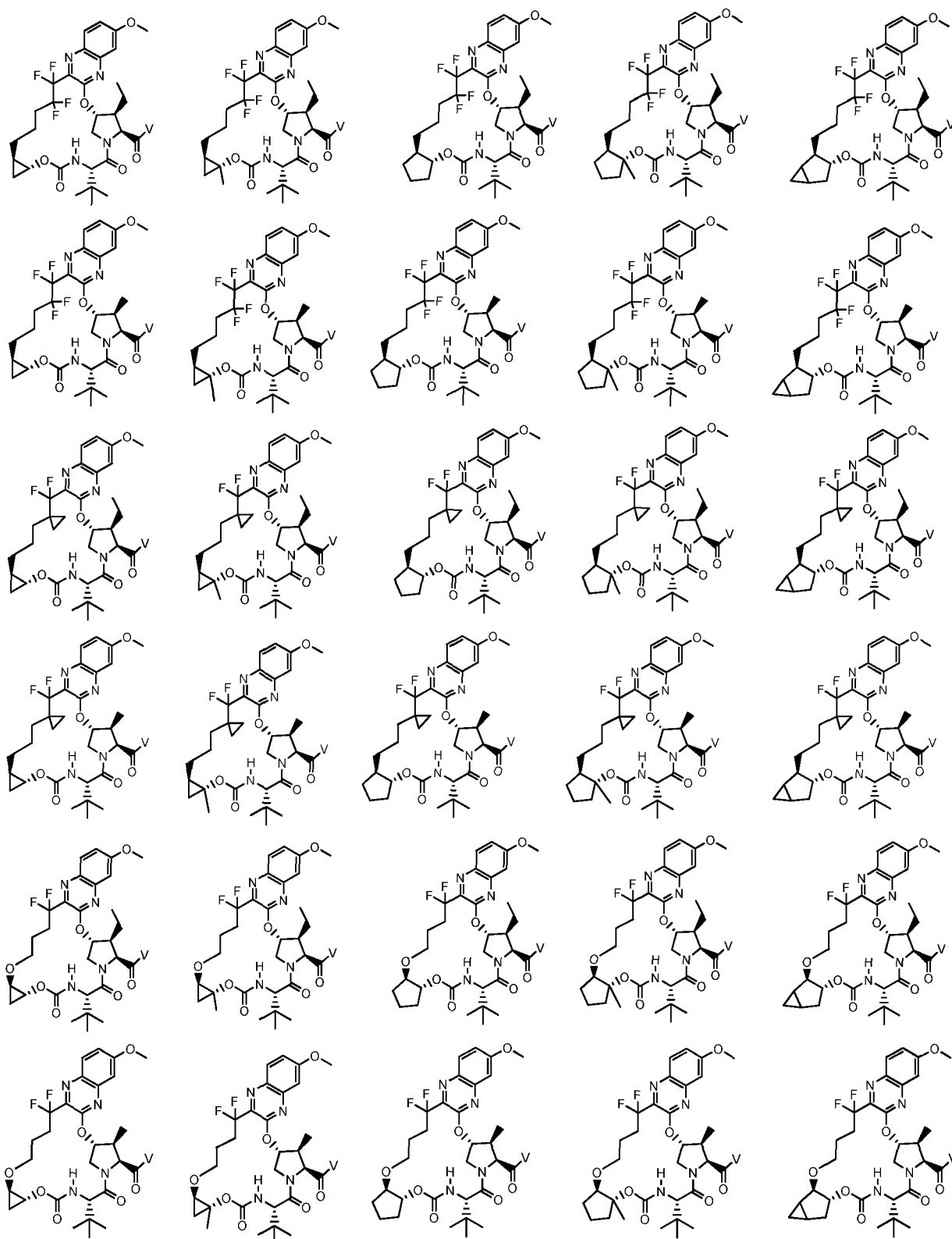


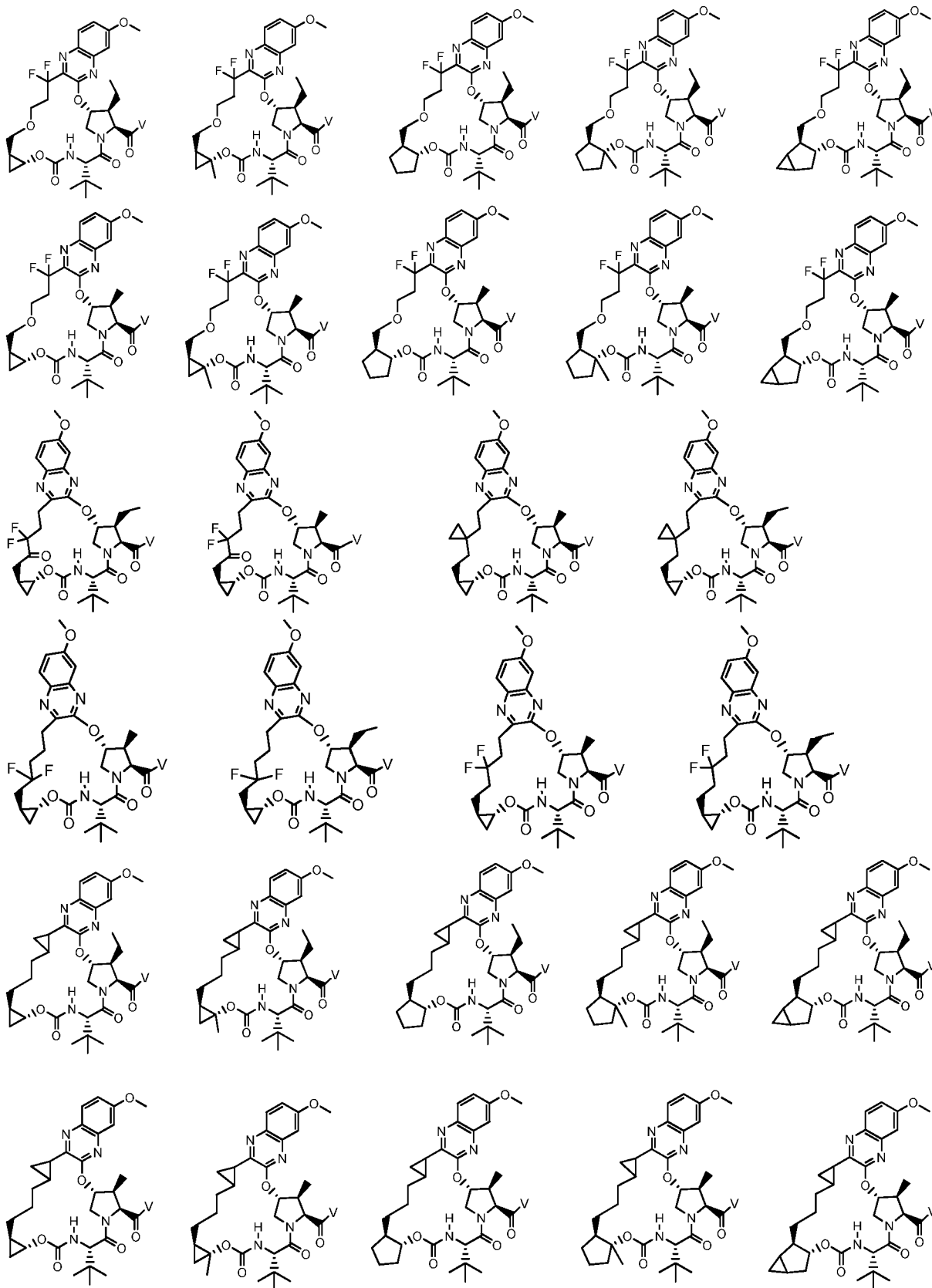


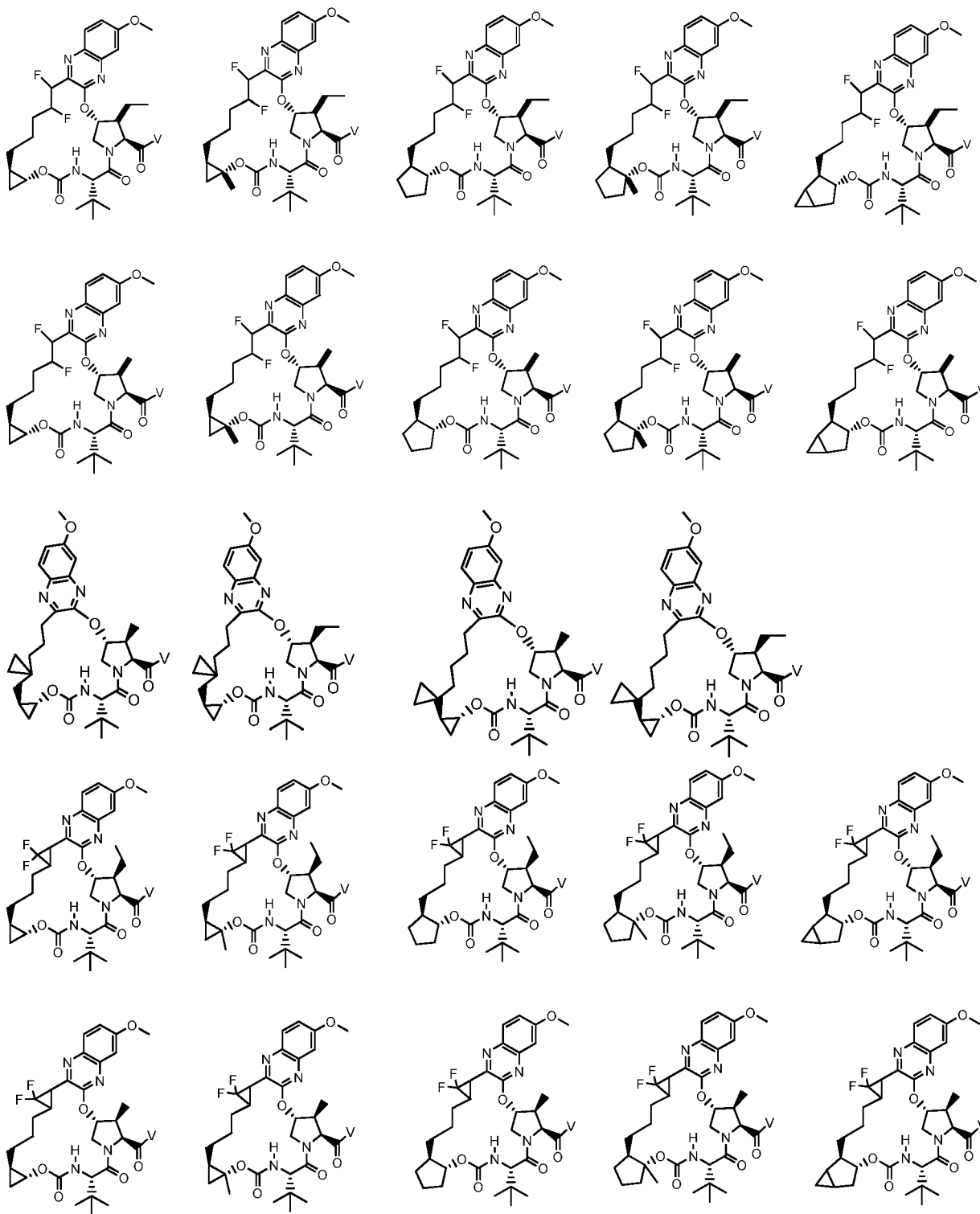


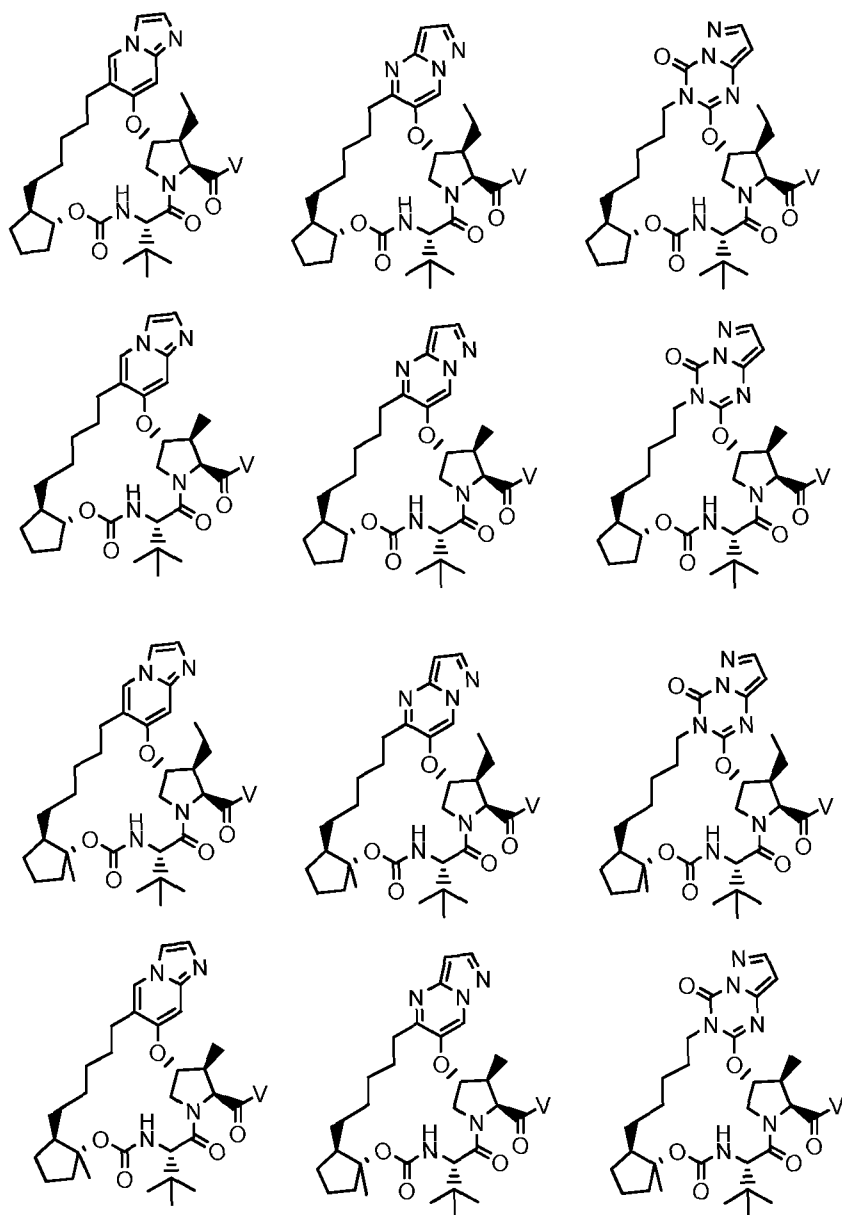


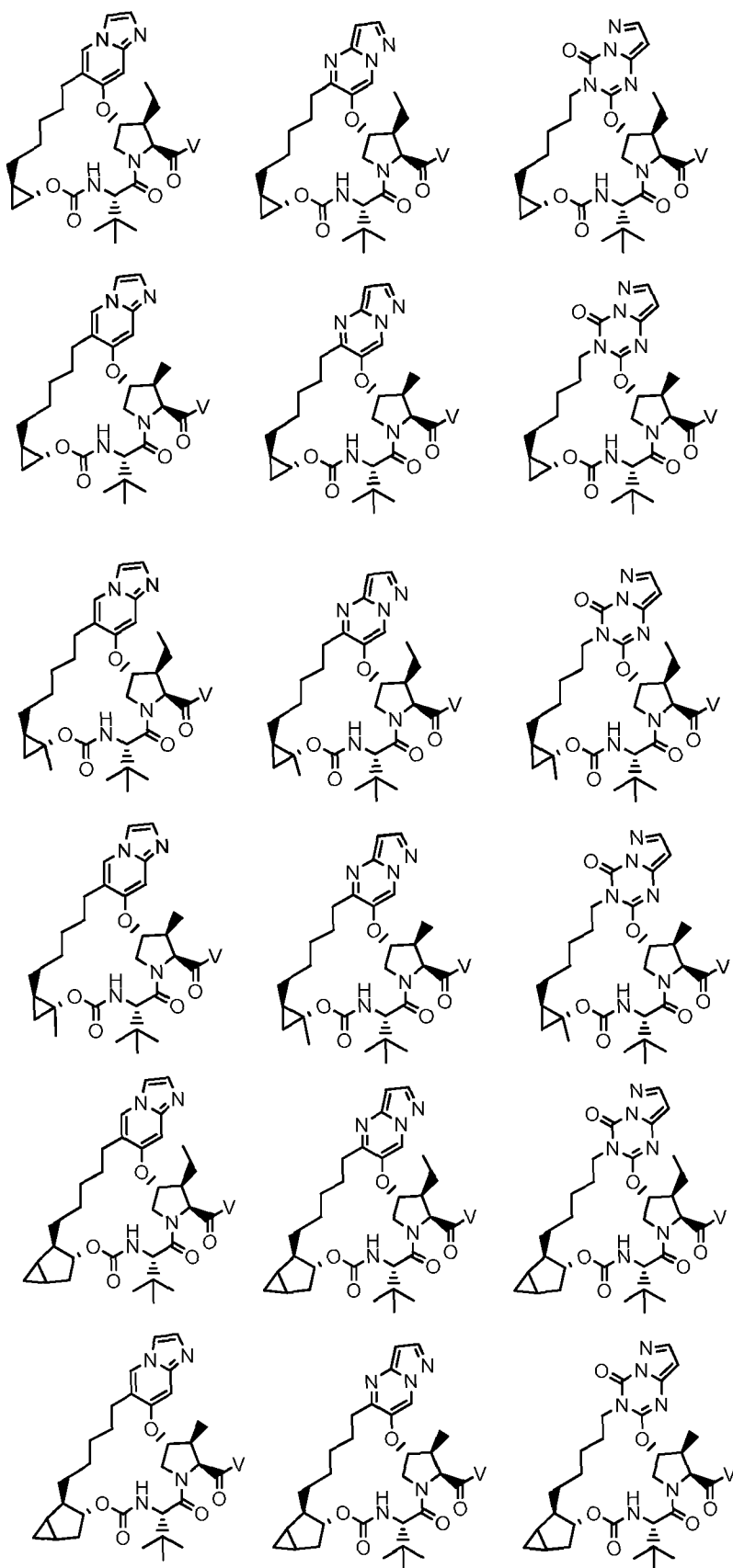
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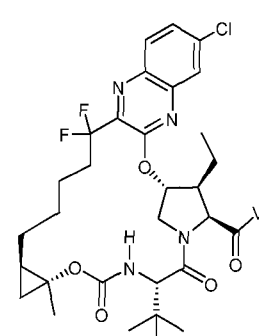
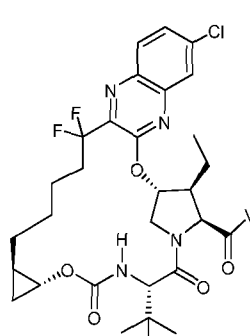
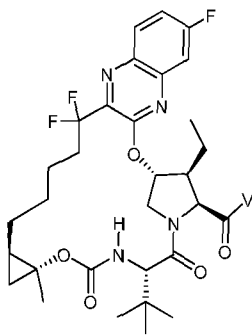
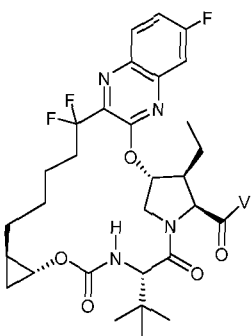
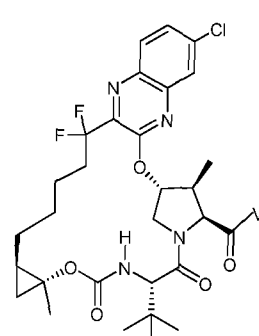
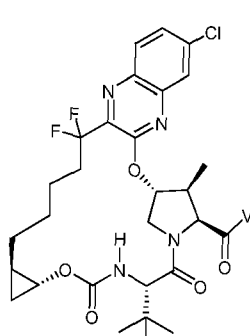
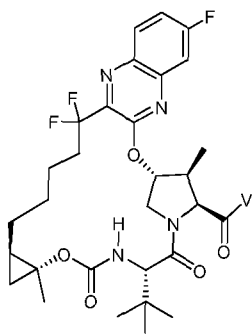
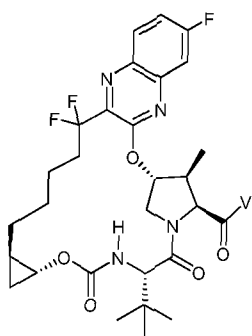




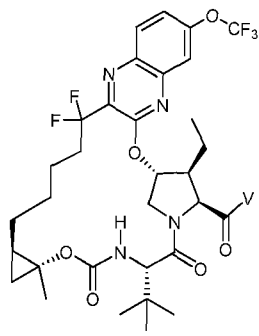
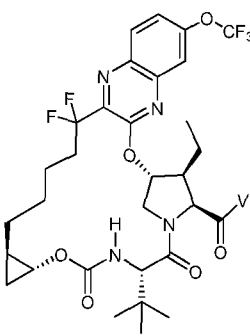
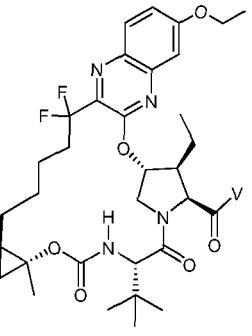
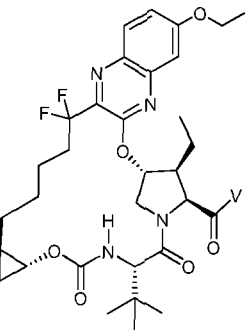
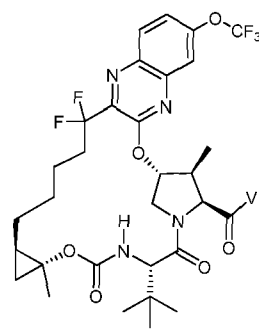
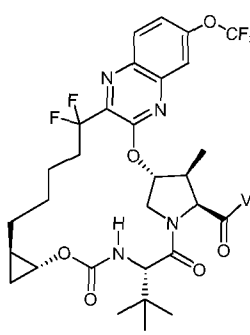
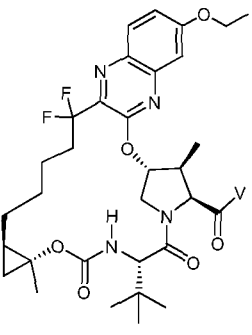
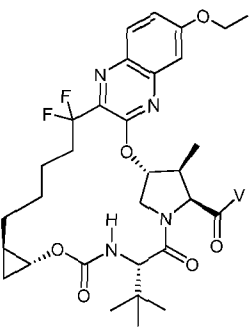


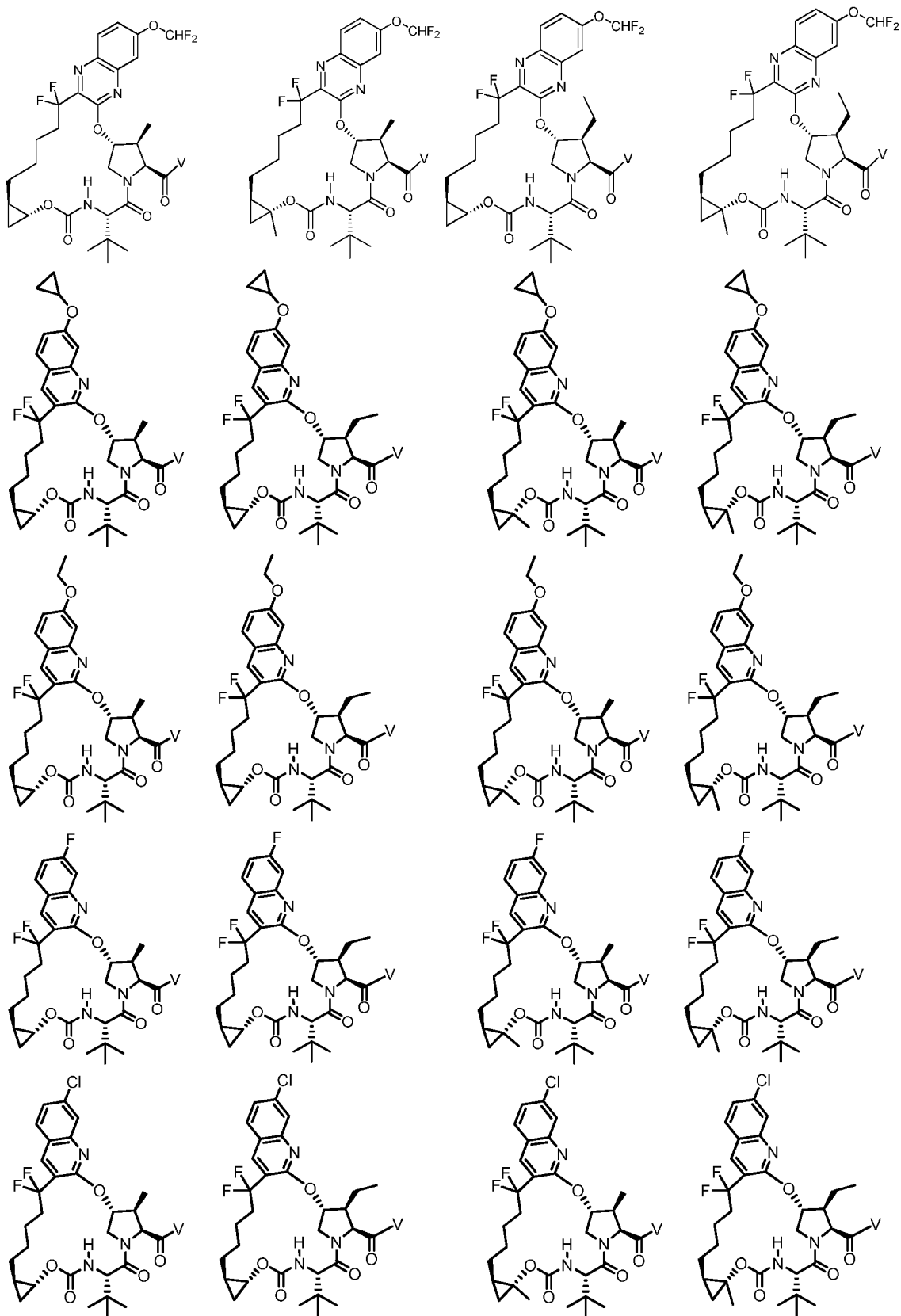


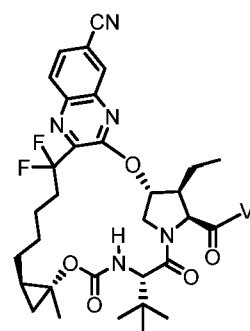
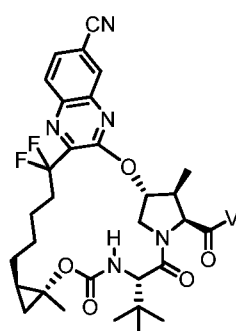
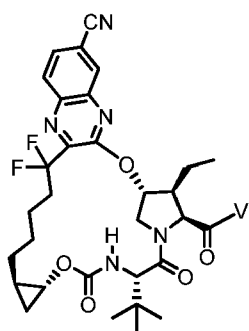
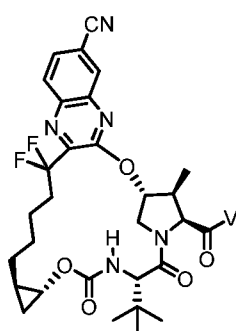
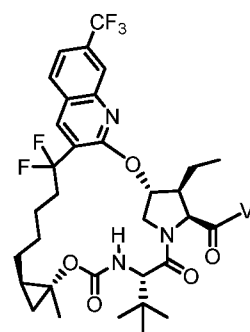
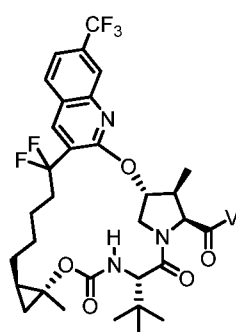
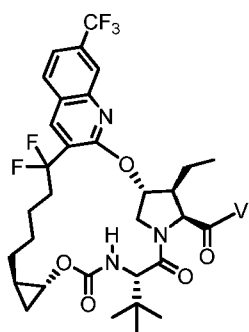
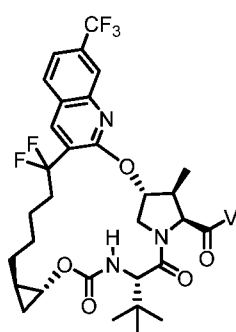
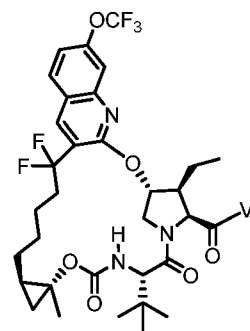
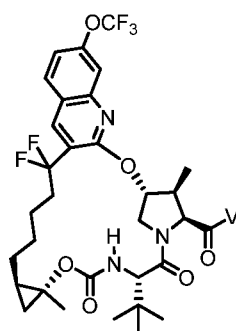
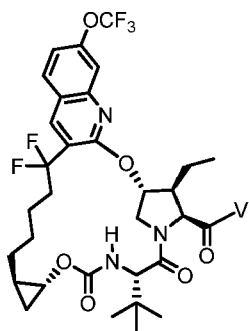
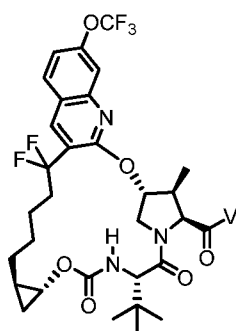




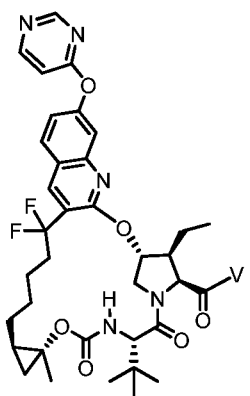
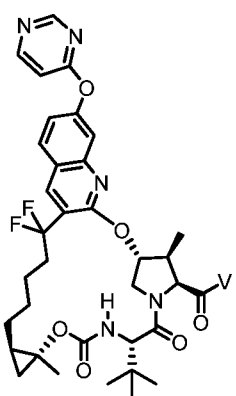
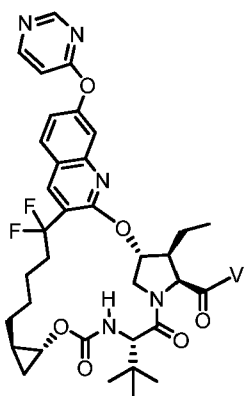
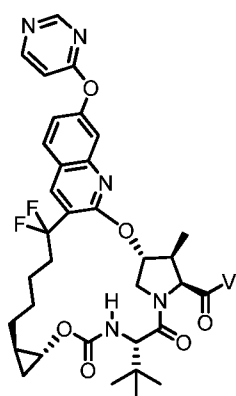
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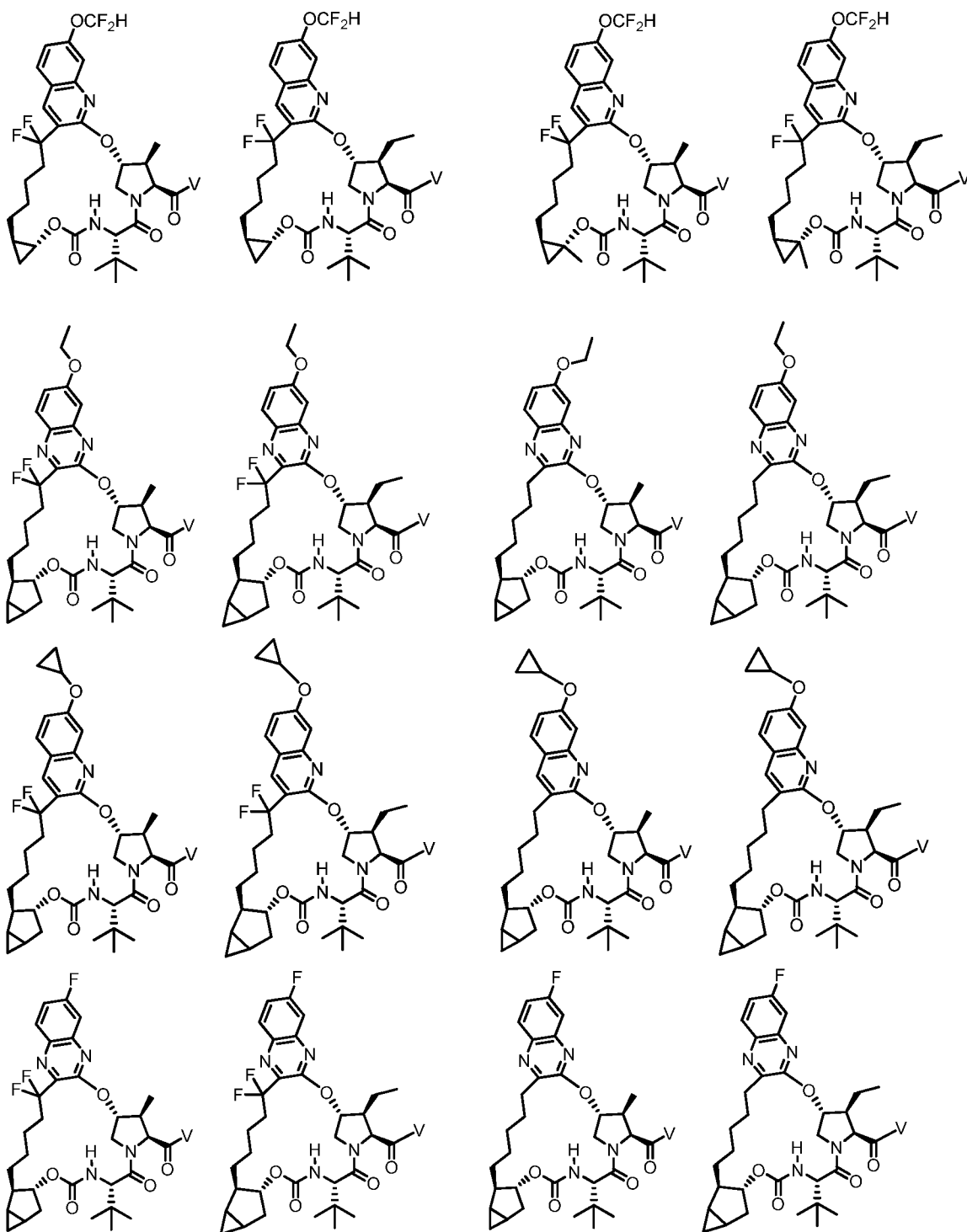


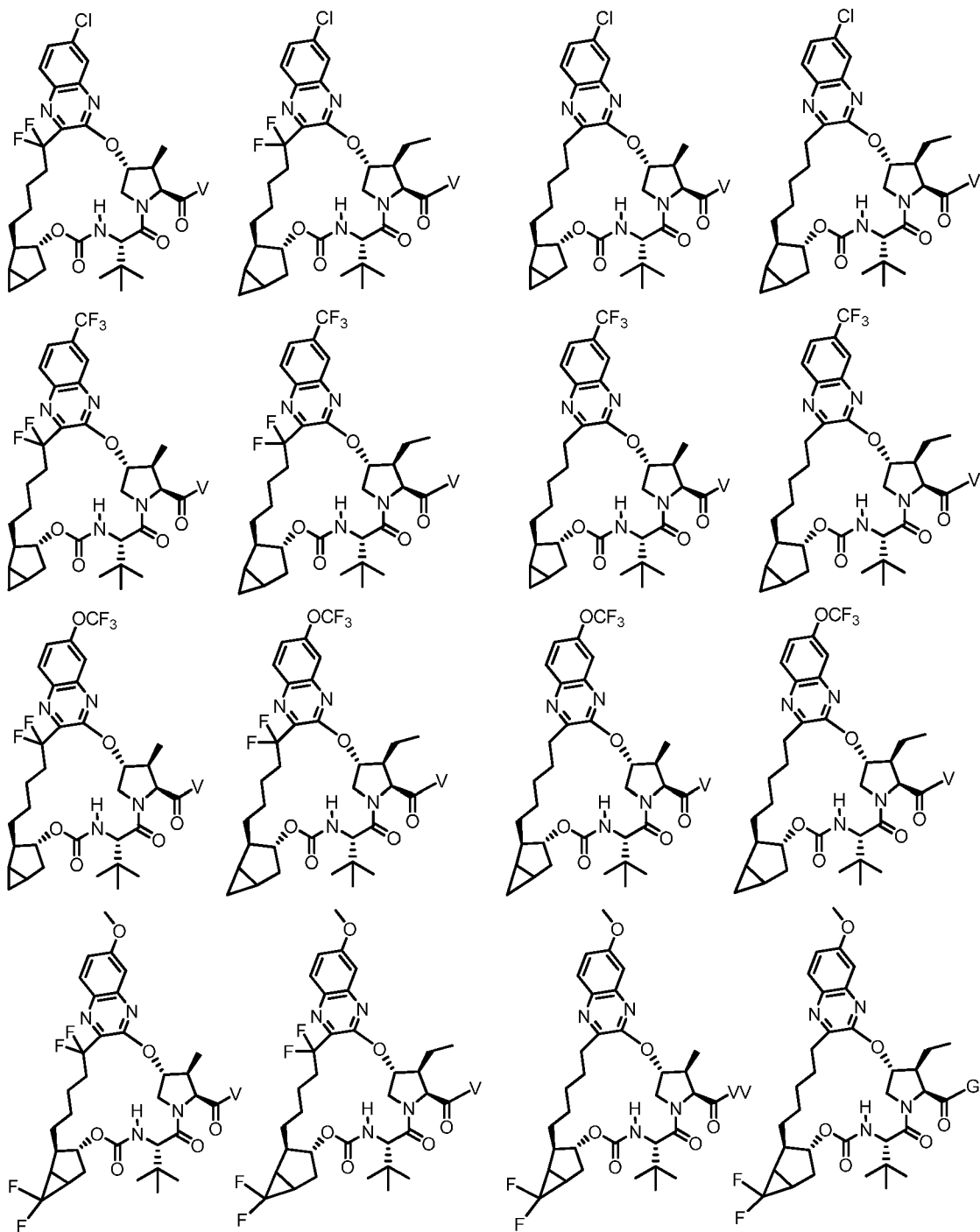


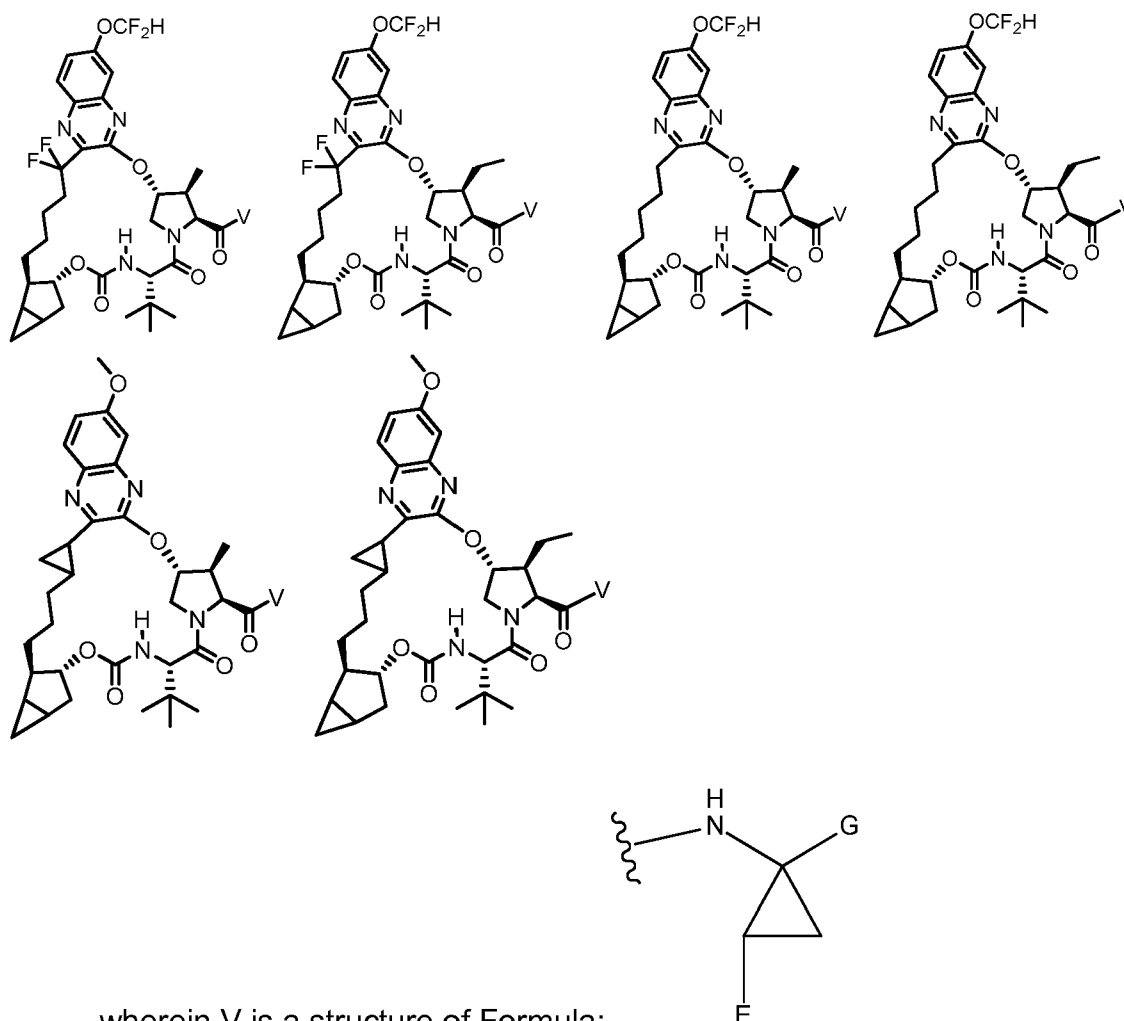


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wherein V is a structure of Formula:

and wherein E and G are defined as above.

Biological Activity

Expression and Purification of Genotype 1a, 2a, and 3 NS3 Proteases

Generation of NS3 Protease Expression Plasmids

The coding sequence of the genotype 1b (con-1 strain) HCV NS3 protease domain was PCR amplified from a plasmid encoding the I389luc-ubi-neo/NS3-3'/ET replicon (Reblikon, Mainz, Germany). The 5'-PCR primer was designed to encode an N-terminal K₃ hexahistidine tag and to insert an in-frame recombinant Tobacco Etch virus (rTEV) protease cleavage site into the NS3 coding sequence. The resulting DNA fragment was cloned into the pET28

protein expression vector (Invitrogen, Carlsbad, CA) yielding the p28-N6H-Tev-NS3(181)1b.

The coding sequences for the genotype 3 HCV protease domain was amplified by RT-PCR using a Titan One Tube RT-PCR Kit (Roche, Indianapolis, IN) and RNA extracted from HCV-positive human serum (BBI Diagnostics, MA) using a QIAmp UltraSens Virus Kit (Qiagen, Valencia, CA). 5' PCR primers were designed to encode N-terminal hexahistidine tags and to insert in-frame rTEV protease cleavage sites into the NS3 protease coding sequences. The resulting DNA fragments were cloned into pET28 yielding the expression vectors p28-N6H-Tev-NS3(181)1a and p28-N6H-Tev-NS3(181)3, respectively.

NS3 Protease Protein Expression

BL21AI bacteria (Invitrogen, Carlsbad, CA) were transformed with genotype 1b or 3 NS3 expression vectors and used to inoculate a 20 L fermentation vessel (Sartorius BBI System Inc., Bethlehem, PA), containing 18 L of fresh 2YT medium supplemented with 50 µg/mL kanamycin. When cell densities reached an OD₆₀₀ of 1, the temperature of the cultures was reduced from 37 °C to 28 °C and induction was immediately initiated by the addition of 30 µM ZnSO₄, 14 mM L-arabinose and 1 mM Isopropyl β- D –thiogalactoside (IPTG) final concentrations. Cells were harvested by centrifugation four hours post-induction and were stored as frozen pellets at -80 °C prior to NS3 protein purification.

Purification of NS3 Proteases

Purification of Genotype 1b NS3 Protease

Cell pellets were thawed and resuspended at 10 mL/g cells in lysis buffer containing 50 mM tris pH 7.6, 300 mM NaCl, 0.1% 3-[(3-cholamidopropyl)dimethylammonio]-1-propanesulfonate (CHAPS), 5% glycerol, and 2 mM β-mercaptoethanol. Cell suspensions were then sonicated, filtered through cheesecloth, and passed three times through a microfluidizer at 18,000 pounds/in². The resulting lysates were centrifuged at 15500 rpm for 45 minutes

and supernatants were loaded onto a HisTrap HP column (GE Lifesciences) pre-equilibrated with five volumes of Ni buffer A (50 mM tris pH 7.6, 300 mM NaCl, 0.1% CHAPS, 5% glycerol, 2 mM β -mercaptoethanol, 50 mM imidazole-HCl).

Proteins were eluted with a 0-100% gradient of Ni buffer A plus 500 mM

- 5 imidazole-HCl and fractions were collected and pooled. The HisTrap pool was diluted 1:10 with SP-A buffer (50 mM tris pH 7.0, 10% glycerol, 2 mM dithiothreitol (DTT)) and loaded onto a HiTrap SP-HP column (GE Lifesciences) equilibrated with SP-A buffer. NS3 protease was eluted with a 0-100% SP-B buffer (SP-A buffer plus 1 M NaCl) gradient. Concentrated pools of NS3-
10 containing SP fractions were aliquoted, snap frozen in liquid nitrogen and stored at -80° C.

Purification of Genotype 3 NS3 Protease

- Bacterial pellets collected from the expression of genotype 3 HCV NS3 protease were homogenized in Lysis Buffer (25 mM tris, pH 7.5 buffer containing
15 150 mM NaCl and 1 mM phenylmethanesulfonyl fluoride (PMSF)) and passed through a microfluidizer at 18,000 pounds/in². Homogenized cell lysates were centrifuged at 30,000 $\times$ g for 30 minutes at 4° C. The resulting P1 pellets were washed with Wash Buffer I (25 mM tris, pH 7.5 containing 1% CHAPS) followed by centrifugation at 10,000 $\times$ g for 30 minutes at 4° C. The resulting P2 pellets
20 were washed with Wash Buffer II (50 mM CAPS buffer, pH 10.8, containing 2 M NaCl and 2 M urea) followed by centrifugation at 30,000 $\times$ g for minutes at 4° C. The resulting P3 pellets were resuspended in Solubilization Buffer (20 ml of 25 mM tris, pH 7.5 containing 150 mM NaCl and 8 M urea) and incubated at 4° C for one hour. Solubilized proteins were passed through a 0.45 micron filter. Protein
25 concentrations were measured and the solutions were adjusted to 40 mM DTT, incubated for 30 minutes at 4° C and then quickly diluted into Refolding Buffer (25 mM tris, pH 8.5, 0.8 M Guanidine-HCl, 0.4 M L-Arginine, 10 mM ZnSO₄) while stirring. Protein solutions were incubated at 4° C overnight to allow refolding. Refolded proteases were centrifuged at 30,000 $\times$ g for 10 minutes to
30 remove residual precipitates. Final protein concentrations were then measured

and the NS3 proteases were aliquoted, snap frozen in liquid nitrogen and stored at -80° C.

Ki Determination for Genotypes 1b and 3a NS3 Protease.

Purified NS3 protease domain (amino acids 1-181) of the genotype 1b and
5 3a virus were generated as above. The internally quenched fluorogenic
depsipeptide substrate Ac-DED(Edans)-EEAbuΨ[COO]ASK(Dabcyl)-NH₂ and a
synthetic peptide containing the hydrophobic core residues of the NS4A protein
cofactor (KKGSVVIVGRILSGRKK; NS4A peptide) were obtained from Anaspec,
Inc. (San Jose, CA). Other chemicals and biochemicals were of reagent grade or
10 better and were purchased from standard suppliers.

Reactions were run at room temperature in buffer consisting of 50 mM
HEPES, 40% glycerol, 0.05% Triton X-100, 10 mM DTT, and 10% DMSO. The
final assay solutions contained 50 pM NS3 genotype 1b protease or 200 pM
genotype 3a protease, 20 μM NS4A peptide, and 4 μM substrate (genotype 1b) or
15 2 μM substrate (genotype 3a). Inhibitor concentrations varied from 100 nM to 5 pM
in 3-fold dilutions, and no-inhibitor controls were included.

Compound dilutions were made in DMSO at 20 × final concentration.
Reaction mixtures were prepared in 96-well assay plates. A solution of enzyme
and NS4A peptide in assay buffer (25 μL volume with both reagents at 4 × final
20 concentration) was mixed with 45 μL assay buffer and 5 μL of either inhibitor or
DMSO, and pre-incubated at room temperature for 1 hour. The reaction was
started by addition of 25 μL substrate solution at 4 × final concentration. Plates
were mixed vigorously for 5-10 seconds and reactions were allowed to proceed
for 90 minutes. fluorescence was measured every 30 s between 90 and 120
25 minutes reaction time using a Tecan InfiniTe M1000 or PerkinElmer Envision
multimode plate reader with an excitation wavelength of 340 nm and an emission
wavelength of 490 nm.

Rates were calculated from the progress curves at steady state, in the
time frame of 90-120 minutes after addition of substrate. To determine the K_i ,
30 rates were plotted as a function of inhibitor concentration, and the data were fit
with equation 1 (Morrison, J. F., *Biochimica et Biophysica Acta* **1969**, 185, 269-

286) to calculate K_i^{app} using GraphPad Prism 5. Active fraction of enzyme was determined by active site titration with known potent inhibitors. K_i was calculated from $K_i^{app}/(1 + [S]/K_m)$. K_i results for representative compounds for genotype 1b and 3a (**Ki 1B** and **Ki 3A**, respectively) are reported in Table 1.

5

$$\frac{v}{v_0} = \frac{[E]_t - [I]_t - K_i^{app} + \sqrt{([E]_t - [I]_t - K_i^{app})^2 + 4[E]_t K_i^{app}}}{2[E]_t} \quad (1)$$

Evaluation of cell-based anti-HCV activity:

Antiviral potency (EC_{50}) was determined in both stable subgenomic HCV replicon cell lines and transient-transfected HCV replicon cells. The term half maximal effective concentration (EC_{50}) refers to the concentration of a drug which induces a response halfway between the baseline and maximum after the exposure time specified below.

Stable subgenomic HCV replicons for genotype 1a, 1b, 2a, 3a, and 4a were established in Huh-7-derived cells as described by Lohmann et al (Lohmann V, Korner F, Koch J, et al Replication of subgenomic hepatitis C virus RNAs in a hepatoma cell line. Science 1999; 285:119-3). Each stable cell line contains a bicistronic HCV replicon that encodes a humanized *Renilla* luciferase (hRLuc) reporter gene fused to a selectable neomycin-resistance gene, followed by an EMCV IRES and the NS3-NS5B coding region of HCV. Selection for cells constitutively expressing the HCV replicon was achieved in the presence of the selection antibiotic, neomycin (G418). Luciferase activity was measured as a marker for intracellular HCV replication levels.

The genotype 1a stable replicon was derived from the H77 HCV strain and contained adaptive mutations P1496L and S2204I. The genotype 1b stable replicon was derived from the Con1 HCV strain and contained adaptive mutations E1202G, T1280I, and K1846T. The genotype 2a stable replicon was derived from the JFH-1 HCV strain and did not require adaptive mutations. The

genotype 3a stable replicon was derived from the S52 HCV strain and contained adaptive mutations P1121L, A1198T and S2210I (equivalent to S2204I in genotype 1). The genotype 4a stable replicon was derived from the ED43 HCV strain and contained adaptive mutations Q1691R and S2204I. All replicon cell lines were propagated in Huh-7-derived cells and maintained in Dulbecco's modified Eagle's Medium (DMEM) supplemented with 10% fetal bovine serum (FBS) and 0.5 mg/mL G418.

Transient-transfected HCV replicons were established for genotype 1a, 1b, 3a and NS3/4a protease inhibitor resistant variants D168A in genotype 1b or R155K in genotype 1a. Transient-transfected replicons are also bicistronic subgenomic replicons but do not contain the neomycin selectable marker present in stable replicons. These replicons encode the poliovirus IRES followed by the hRLuc reporter gene, the EMCV IRES and finally the NS3-NS5B coding region of HCV. The genotype 1a (H77) and 1b (Con1) wild-type replicons were derived from the same strain and contained the same adaptive mutations as listed above. The genotype 3a transient replicon was derived from the S52 HCV strain as above, but contained slightly different adaptive mutations P1112L, K1615E and S2210I. Specifically, the secondary adaptive mutation A1198T (A166T) in the protease domain of the stable genotype 3a replicon was replaced with K1615E (K583E) in the NS3 helicase, with no effect on replication efficiency. Removal of A166T located in the protease domain minimizes the impact of this variant on inhibitors targeting the protease domain and represents a protease domain closer to wild type for genotype 3a. Resistant replicons encoding NS3/4 protease inhibitor mutations were introduced into the 1b or 1a wild-type NS3 gene by site directed mutagenesis. In vitro transcribed RNAs from all transient replicons were transfected into naive Huh-7-derived cell lines by electroporation. Luciferase activity was measured as a marker for intracellular HCV replication levels

To perform EC₅₀ assays, cells from each HCV replicon were dispensed into 384-well plates. Compounds were dissolved in DMSO at a concentration of 10 mM and diluted in DMSO using an automated pipetting instrument. Three-fold serially diluted compounds were directly added to the cells using an

automated instrument. DMSO was used as a negative (solvent; no inhibition) control, and a combination of three HCV inhibitors including a protease inhibitor; an NS5A inhibitor and a nucleoside inhibitor was used at concentrations > 100 x EC₅₀ as a positive control (100% inhibition). Seventy-two hours later, cells were

5 lysed and *Renilla* luciferase activity were quantified as recommended by the manufacturer (Promega-Madison, WI). Non-linear regression was performed to calculate EC₅₀ values.

Results are shown in Tables 1 and 2:

**Table 1: Biological Activity Values
For Stable Subgenomic HCV Replicon Cell Lines**

Example	Ki 1B (nM)	Ki 3A (nM)	EC ₅₀ 1A RLUC* (nM)	EC ₅₀ 1B RLUC* (nM)	EC ₅₀ 2A RLUC* (nM)	EC ₅₀ 3A RLUC* (nM)	EC ₅₀ 4A RLUC* (nM)
1	0.03	0.07	4.4	3.9	4.1	46	3.1
2	0.01	0.04	4.0	3.1	3.9	77	2.7
3	0.18	0.56	11.7	9.8	28	546	10
4	0.17	0.56	10.7	9.6	16	271	7.9
5	0.04	0.17	8.7	7.4	11	405	6.9
6	0.20	0.62	35	36	34	1361	34
7	0.05	0.06	4.9	3.8	4.2	67	3.2
8	0.07	0.42	16	8.6	20	465	13
9	0.15	0.59	17	7.9	23	1268	11
10	0.16	0.52	30	22	49	978	26
11	0.23	0.88	28	17	34	1162	19
12	0.27	1.2	34	18	25	2013	21
13	0.04	0.18	13	9.5	26	685	11
14	0.07	0.24	9.7	6.8	7.0	308	7.3
15	0.05	0.30	11	6.8	9.8	550	7.8
16	0.09	0.21	12	7.4	6.2	201	8.1
17	0.04	0.06	3.9	3.3	3.7	15	2.9
18	0.03	0.10	3.9	2.6	5.0	70	2.8
19	0.02	0.13	4.0	2.6	4.6	89	3.1
20	0.12	0.53	8.1	5.2	19	392	5.9
21	0.10	0.45	6.8	4.7	12	263	6.2
22	0.07	1.3	15	7.5	27	727	11
23	0.08	1.1	13	7.5	23	587	9.9
24	0.05	0.92	12	7.5	20	663	9.2
25	0.05	0.39	8.8	6.3	13	409	7.1
26	0.05	0.17	6.3	4.3	12	297	6.0
27	0.03	0.08	6.6	5.2	6.7	266	6.1

Example	Ki 1B (nM)	Ki 3A (nM)	EC ₅₀ 1A RLUC* (nM)	EC ₅₀ 1B RLUC* (nM)	EC ₅₀ 2A RLUC* (nM)	EC ₅₀ 3A RLUC* (nM)	EC ₅₀ 4A RLUC* (nM)
28	0.03	0.08	6.7	4.6	6.2	266	4.1
29	0.06	0.12	10	8.9	11	137	7.2
30	0.14	0.63	55	35	47	2437	31
31	0.13	4.9	40	18	63	2071	20
32	0.18	0.87	59	30	35	2311	30
33	0.03	0.06	7.6	2.8	4.9	16	2.3
34	0.10	0.28	12	13	18	322	9.7
35	0.07	0.23	9.1	11	7.4	162	7.6
36	0.10	1.7	23	14	53	585	9.1
37	0.10	0.19	24	22	16	575	15
38	0.03	0.70	7.8	4.2	5.4	151	5.5
39	0.08	0.20	34	39	41	321	26
40	0.08	0.18	25	22	48	360	18
41	0.18	0.79	135	142	106	2606	135
42	0.10	0.75	20	16	17	343	14
43	0.06	0.16	4.9	3.8	5.2	92	3.6
44	0.03	0.08	3.1	2.1	2.9	53	2.2
45	0.04	0.48	21	8.3	24	549	13
46	0.03	0.05	3.1	2.7	3.8	17	2.5
47	0.07	0.19	3.8	3.6	12	58	4.2
48	0.07	0.09	2.0	1.8	9.7	73	2.2
49	0.04	0.07	3.7	4.1	5.2	20	3.5
50	63	100	4444	4444	379	19708	4444
51	0.31	0.84	40	39	103	1221	30
52	0.25	1.3	195	245	380	2307	161
53	0.03	0.09	51	7.7	13	18	2.8
54	0.11	0.50	33	18	76	260	13
55	0.09	0.20	13	3.8	12	140	3.5
56	0.38	1.0	41	37	57	1026	57
57	0.07	0.28	12	11	21	166	4.9
58	0.07	0.17	12	9.7	12	134	12
59	0.04	0.06	5.4	11	13	20	5.6
60	0.04	0.08	11	4.8	7.7	45	5.4
61	0.06	0.09	13	10	8.7	28	11
62	0.04	0.03	3.4	3.0	5.0	8.5	2.4
63	0.03	0.01	4.2	2.9	3.2	11	3.2
64	0.07	1.2	100	38	48	671	34
65	0.08	0.07	12	8.4	7.7	30	8.1
66	0.04	0.06	37	20	105	1786	25
67	0.04	0.32	11	12	24	383	12
68	0.05	0.63	13	7.7	18	364	9.4
69	0.07	0.17	5.2	4.9	11	64	5.8

Example	Ki 1B (nM)	Ki 3A (nM)	EC ₅₀ 1A RLUC* (nM)	EC ₅₀ 1B RLUC* (nM)	EC ₅₀ 2A RLUC* (nM)	EC ₅₀ 3A RLUC* (nM)	EC ₅₀ 4A RLUC* (nM)
70	0.05	0.05	8.4	8.5	15	41	6.4
71	0.03	0.14	6.5	5.3	23	160	5.3
72	0.05	4.1	365	300	740	1819	383
73	0.11	0.82	7.9	7.5	22	178	7.2
74	0.03	0.12	8.0	5.0	18	374	8.3
75	0.03	0.12	9.9	6.4	18	240	10
76	0.03	0.06	2.4	2.2	2.4	9.0	1.9
77	nt	nt	23	12	29	741	16
78	0.21	0.82	267	394	195	1115	225
79	0.06	0.06	7.0	5.8	4.1	71	5.6
80	0.49	13	1127	344	748	44444	1182
81	0.04	0.05	4.0	3.6	3.6	12	4.3
82	0.03	0.04	8.5	9.3	4.7	25	10
83	0.09	0.48	62	58	19	1219	42
84	0.04	0.08	5.9	5.7	7.2	27	6.4
85	0.05	0.03	16	17	7.7	304	9.2
86	0.04	0.07	5.6	5.5	5.9	42	5.7
87	0.02	0.05	4.8	3.9	3.3	14	3.8
88	0.02	0.29	9.3	4.6	2.7	105	4.1
89	0.03	0.05	6.0	6.1	4.3	19	4.6
90	0.06	0.13	12	9.6	8.8	114	10.4
91	nt	nt	2.4	1.9	4.0	149	2.4
92	nt	nt	3.3	3.2	4.6	58	3.2
93	nt	nt	12	14	15	116	11
94	nt	nt	3.8	5.2	3.3	32	3.0
96	nt	nt	12	11	5.4	77	8.9
97	nt	nt	6.3	4.6	5.8	67	5.3

nt – not tested

*RULC: *Renilla* luciferase

**Table 2: Biological Activity Values
For Transient-Transfected HCV Replicon Cell Lines**

5

	EC ₅₀ 3A WT* (nM)	EC ₅₀ 1A WT* (nM)	EC ₅₀ 1A R155K [†] (nM)	EC ₅₀ 1B WT* (nM)	EC ₅₀ 1B D168A [‡] (nM)
1	17	3.2	4.9	2.2	17
2	nt	2.4	7.0	1.0	33
3	nt	6.6	32	3.5	128
4	68	7.1	20	6.5	66
5	nt	3.7	17	3.2	91
6	nt	26	58	11	216

	EC₅₀ 3A WT* (nM)	EC₅₀ 1A WT* (nM)	EC₅₀ 1A R155K[†] (nM)	EC₅₀ 1B WT* (nM)	EC₅₀ 1B D168A[‡] (nM)
7	14	3.8	6.7	2.3	20
8	nt	8.8	28	4.8	89
9	nt	12	208	2.5	360
10	nt	37	131	10	493
11	nt	20	159	9.4	605
12	nt	14	283	5.7	640
13	nt	8.6	59	3.1	209
14	nt	7.4	21	4.0	99
15	nt	6.5	20	3.0	182
16	nt	9.4	22	5.8	61
17	6.1	2.9	2.8	1.7	4.3
18	nt	2.3	5.0	1.2	24
19	nt	2.1	3.4	1.1	28
20	Nt	3.4	17	2.7	90
21	nt	4.1	15	3.8	70
22	nt	8.6	48	2.6	242
23	nt	9.5	36	3.6	173
24	nt	9.3	49	3.2	284
25	nt	4.4	17	3.6	116
26	nt	3.6	12	1.9	109
27	nt	6.0	20	4.3	70
28	nt	3.0	9	3.4	54
29	nt	4.8	11	3.1	48
30	nt	41	296	31	503
31	nt	27	154	6.6	805
32	nt	44	547	14	653
33	5.3	2.6	2.5	1.6	4.2
34	46	15	18	9	64
35	35	12	17	10	38
36	128	16	271	9.4	333
37	69	29	51	22	159
38	nt	4.5	8.4	2.8	25
39	89	23	63	16	105
40	156	17	74	8.6	129
41	539	164	505	154	715
42	nt	17	35	10	109
43	nt	3.8	8.7	2.4	41
44	7.0	2.4	4.0	1.4	15
45	nt	13	35	5.3	88
46	6.788	2.4	3.2	1.2	4.5
47	17	5.4	6.1	2.0	12
48	13	1.7	4.0	1.1	6.5

	EC₅₀ 3A WT* (nM)	EC₅₀ 1A WT* (nM)	EC₅₀ 1A R155K[†] (nM)	EC₅₀ 1B WT* (nM)	EC₅₀ 1B D168A[‡] (nM)
49	6.3	3.5	3.8	2.8	4.2
50	26825	4444	3830	4444	4444
51	265	28	92	24	318
52	538	150	516	161	887
53	15	5.3	5.6	2.0	11
54	147	19	27	10	123
55	71	8.0	32	2.3	53
56	226	63	168	59	252
57	54	12	17	7.5	48
58	38	12	18	14	23
59	15	10	6.8	6.8	6.4
60	9.8	5.8	8.6	2.3	15
61	13	12	10	9.3	6.7
62	4.0	3.5	2.7	1.5	2.0
63	6.9	4.1	4.0	2.1	3.4
64	256	37	50	17	104
65	17	9.4	8.1	6.4	11
66	735	35	240	14	396
67	107	14	42	10	86
68	139	14	37	4.4	78
69	42	8.2	15	3.9	28
70	17	7.7	5.4	6.1	7.3
71	49	9.1	30	3.8	66
72	642	600	227	165	687
73	45	8.8	25	6.2	75
74	138	8.8	44	2.1	56
75	56	14	45	3.5	51
76	3.4	2.0	2.1	1.0	2.8
77	472	21	34	5.0	80
78	194	189	225	156	248
79	9.2	6.1	7.1	3.0	11
80	nt	403	2862	53	443
81	4.3	3.7	2.5	2.4	2.7
82	16	7.8	6.2	4.1	5.7
83	300	62	133	27	202
84	11	5.4	4.0	2.5	5.2
85	101	12	22	7.0	57
86	16	4.0	3.7	3.4	10
87	7.7	2.9	2.8	1.3	4.0
88	35	5.0	14	5.5	24
89	5.5	6.0	3.7	3.2	5.1
90	43	nt	nt	nt	nt

	EC ₅₀ 3A WT* (nM)	EC ₅₀ 1A WT* (nM)	EC ₅₀ 1A R155K [†] (nM)	EC ₅₀ 1B WT* (nM)	EC ₅₀ 1B D168A [‡] (nM)
91	25	2.3	3.5	1.3	9.2
92	8.0	3.0	3.0	1.7	5.3
93	26	13	13	14	39
94	10	3.2	3.1	1.9	9.2
96	12	5.2	3.8	4.1	3.6
97	5.8	3.6	3.7	2.5	8.8

nt: not tested

*WT = wild type

[†] NS3/4a protease inhibitor resistant variants R155K in genotype 1a

[‡] NS3/4a protease inhibitor resistant variants D168A in genotype 1b

5 The data in Tables 1 and 2 represent an average over time of each assays for each compound. For certain compounds, multiple assays have been conducted over the life of the project. Thus, the data reported in Tables 1 and 2 include the data reported in the priority document, as well as data generated in the intervening period.

10 **Pharmaceutical Compositions**

The following illustrate representative pharmaceutical dosage forms, containing a compound of Formulas I, II, III, or IV (such as any one of IVa-IVh) ('Compound X'), for therapeutic or prophylactic use in humans.

15	<u>(i) Tablet 1</u>	<u>mg/tablet</u>
	Compound X=	100.0
	Lactose	77.5
	Povidone	15.0
	Croscarmellose sodium	12.0
20	Microcrystalline cellulose	92.5
	Magnesium stearate	<u>3.0</u>
		300.0
	<u>(ii) Tablet 2</u>	<u>mg/tablet</u>
25	Compound X=	20.0
	Microcrystalline cellulose	410.0
	Starch	50.0
	Sodium starch glycolate	15.0
	Magnesium stearate	<u>5.0</u>
30		500.0

	<u>(iii) Capsule</u>	<u>mg/capsule</u>
	Compound X=	10.0
	Colloidal silicon dioxide	1.5
5	Lactose	465.5
	Pregelatinized starch	120.0
	Magnesium stearate	<u>3.0</u>
		600.0
10	<u>(iv) Injection (1 mg/ml)</u>	<u>mg/ml</u>
	Compound X= (free acid form)	1.0
	Dibasic sodium phosphate	12.0
	Monobasic sodium phosphate	0.7
	Sodium chloride	4.5
15	1.0 N Sodium hydroxide solution	
	(pH adjustment to 7.0-7.5)	q.s.
	Water for injection	q.s. ad 1 mL

20 The above formulations may be obtained by conventional procedures well known in the pharmaceutical art.

25 All references, including publications, patents, and patent documents are incorporated by reference herein, as though individually incorporated by reference. The invention has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the invention.

30 The use of the terms "a" and "an" and "the" and similar references in the context of this disclosure (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., such as, preferred, preferably) provided herein, is intended
35 merely to further illustrate the content of the disclosure and does not pose a limitation on the scope of the claims. No language in the specification should be

construed as indicating any non-claimed element as essential to the practice of the present disclosure.

Alternative embodiments of the claimed disclosure are described herein, including the best mode known to the inventors for practicing the claimed invention. Of these, variations of the disclosed embodiments will become apparent to those of ordinary skill in the art upon reading the foregoing disclosure. The inventors expect skilled artisans to employ such variations as appropriate (e.g., altering or combining features or embodiments), and the inventors intend for the invention to be practiced otherwise than as specifically described herein.

Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

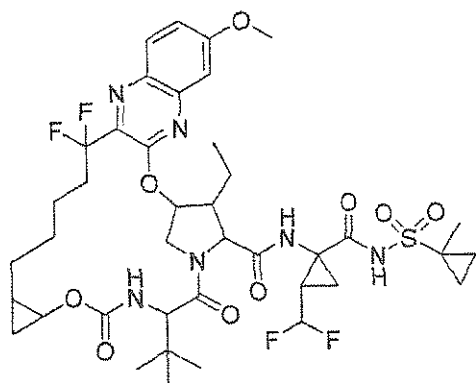
The use of individual numerical values is stated as approximations as though the values were preceded by the word "about" or "approximately." Similarly, the numerical values in the various ranges specified in this application, unless expressly indicated otherwise, are stated as approximations as though the minimum and maximum values within the stated ranges were both preceded by the word "about" or "approximately." In this manner, variations above and below the stated ranges can be used to achieve substantially the same results as values within the ranges. As used herein, the terms "about" and "approximately" when referring to a numerical value shall have their plain and ordinary meanings to a person of ordinary skill in the art to which the disclosed subject matter is most closely related or the art relevant to the range or element at issue. The amount of broadening from the strict numerical boundary depends upon many factors. For example, some of the factors which may be considered include the criticality of the element and/or the effect a given amount of variation will have on the performance of the claimed subject matter, as well as other considerations known to those of skill in the art. As used herein, the use of differing amounts of

significant digits for different numerical values is not meant to limit how the use of the words "about" or "approximately" will serve to broaden a particular numerical value or range. Thus, as a general matter, "about" or "approximately" broaden the numerical value. Also, the disclosure of ranges is intended as a continuous
5 range including every value between the minimum and maximum values plus the broadening of the range afforded by the use of the term "about" or "approximately." Thus, recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate
10 value is incorporated into the specification as if it were individually recited herein.

It is to be understood that any ranges, ratios and ranges of ratios that can be formed by, or derived from, any of the data disclosed herein represent further embodiments of the present disclosure and are included as part of the disclosure as though they were explicitly set forth. This includes ranges that can be formed
15 that do or do not include a finite upper and/or lower boundary. Accordingly, a person of ordinary skill in the art most closely related to a particular range, ratio or range of ratios will appreciate that such values are unambiguously derivable from the data presented herein.

CLAIMS

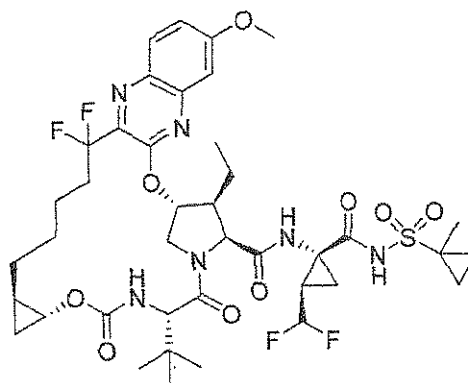
1. A compound of Formula IVa:



(IVa)

or a pharmaceutically acceptable salt thereof.

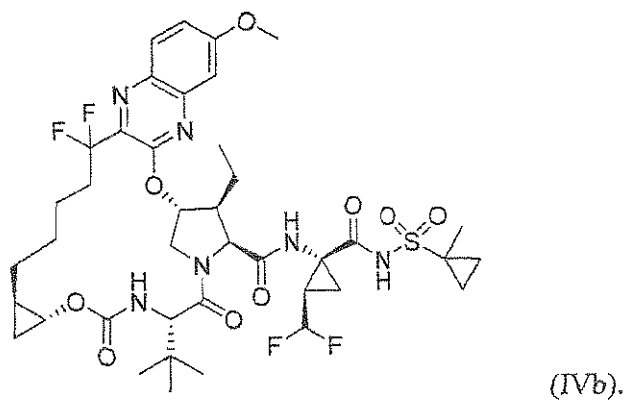
2. A compound according to claim 1 which is a compound of Formula IVb:



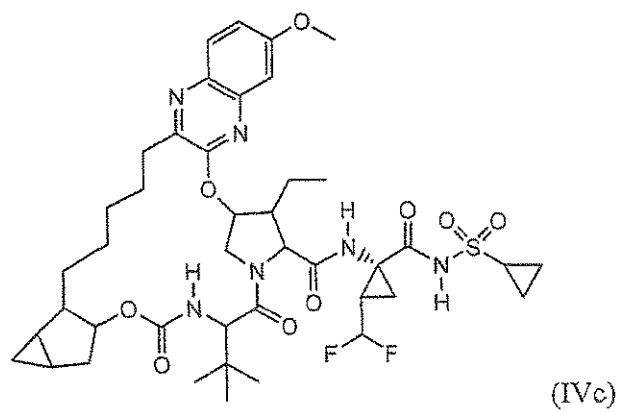
(IVb)

or a pharmaceutically acceptable salt thereof.

3. A compound according to claim 1 which is a compound of Formula IVb:

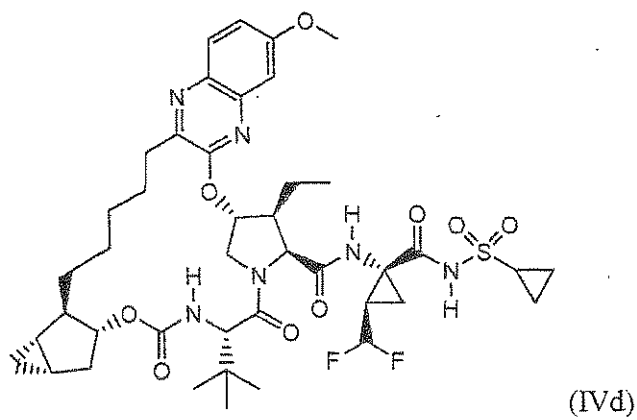


4. A compound of Formula IVc:



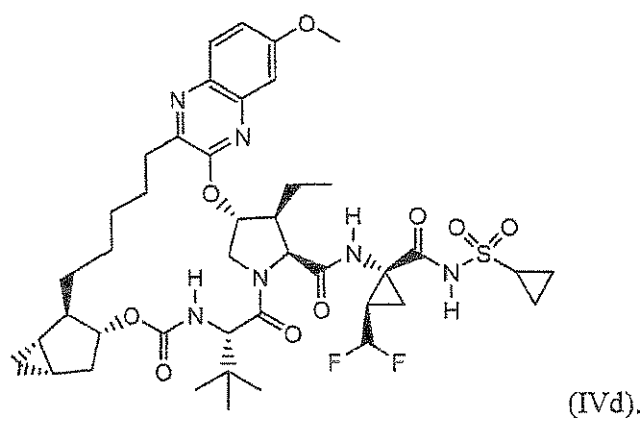
or a pharmaceutically acceptable salt thereof.

5. A compound according to claim 4 which is a compound of Formula IVd:

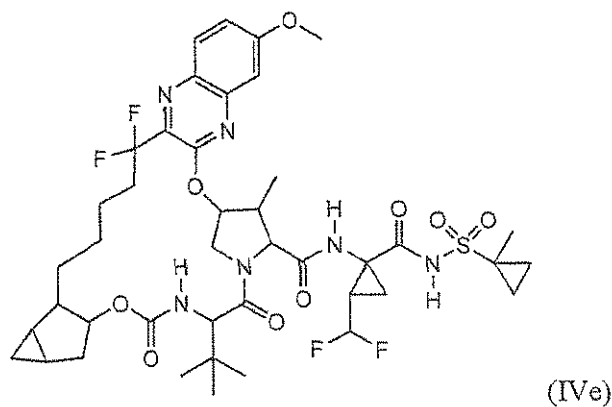


or a pharmaceutically acceptable salt thereof.

6. A compound according to claim 4 which is a compound of Formula IVd:

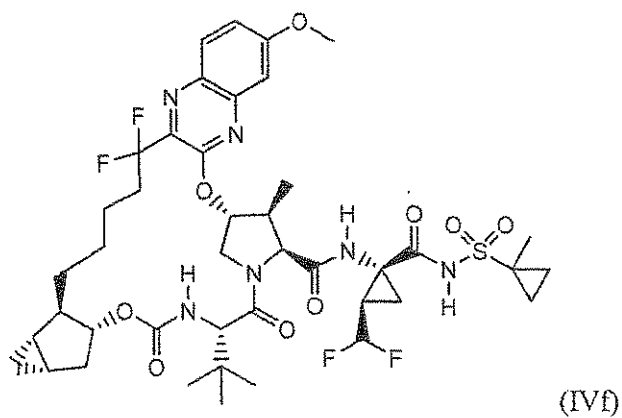


7. A compound of Formula IVe:



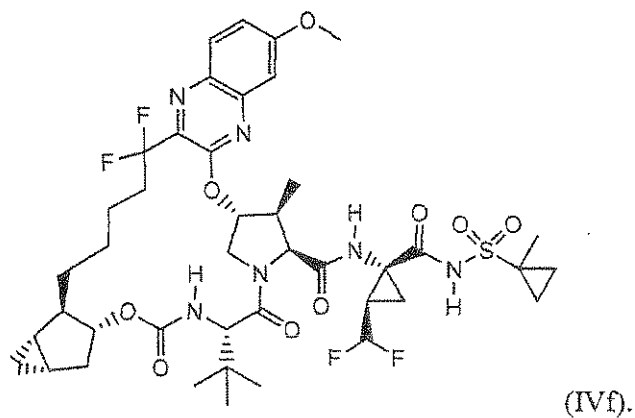
or a pharmaceutically acceptable salt thereof.

8. A compound according to claim 7, which is a compound of Formula IVf:

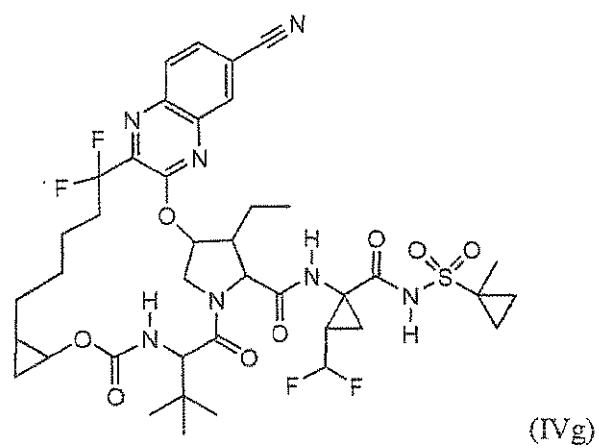


or a pharmaceutically acceptable salt thereof.

9. A compound according to claim 7, which is a compound of Formula IVf:

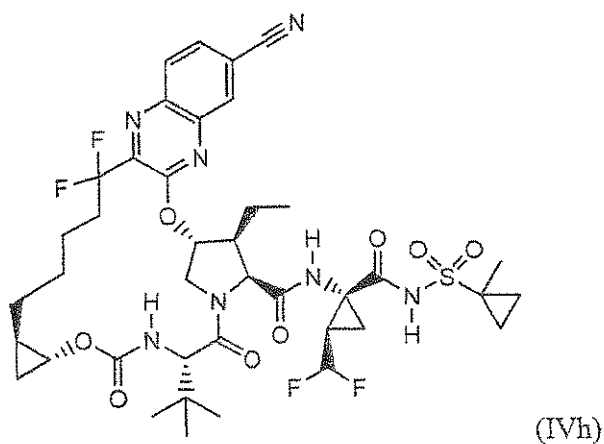


10. A compound of Formula IVg:



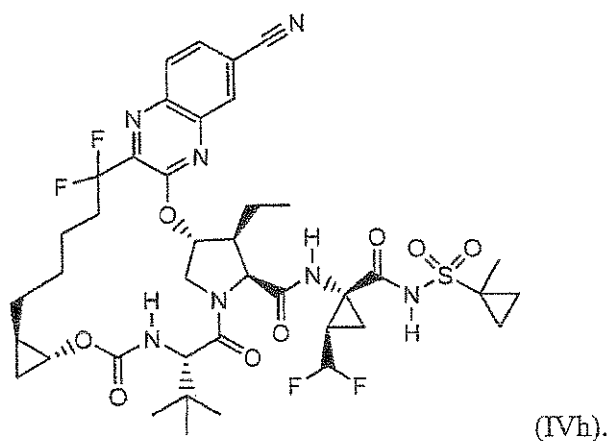
or a pharmaceutically acceptable salt thereof.

11. A compound according to claim 10, which is a compound of Formula IVh:



or a pharmaceutically acceptable salt thereof.

12. A compound according to claim 10, which is a compound of Formula IVh:



13. A pharmaceutical composition comprising a compound of any one of claims 1-12, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable excipient.

14. A compound of any one of claims 1 to 12, or a pharmaceutically acceptable salt thereof for use in medical therapy.

15. The pharmaceutical composition according to claim 13 for use in treating hepatitis C virus infection.

16. A compound of any one of claims 1 to 12, or a pharmaceutically acceptable salt thereof, for use in the prophylactic or therapeutic treatment of a hepatitis C virus infection.