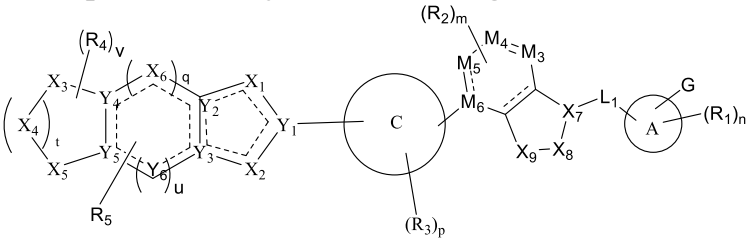
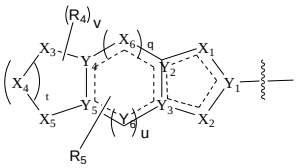
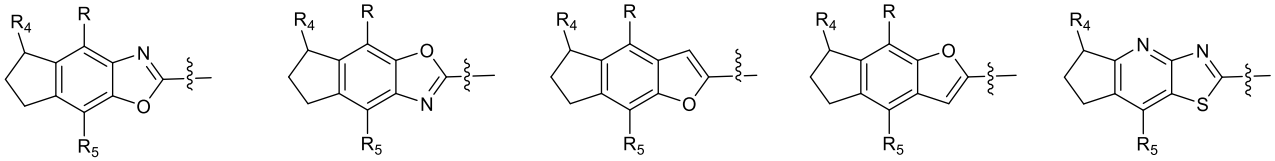
Claims

1. A compound represented by the following formula I:



I

wherein,  is selected from the group consisting of:



;

n, m, p, and v are each independently selected from the group consisting of 0, 1, 2, 3, 4, and 5;

X_7 is CR;

X_8 and X_9 are each independently $C(R)_2$;

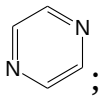
M_3, M_4, and M_5 are each independently CR;

R is H;

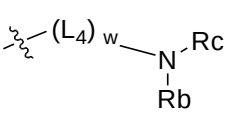
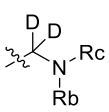
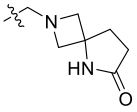
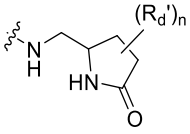
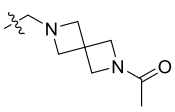
M_6 is C;

and ⫽ represents single bond or double bond;

(C) is benzene ring;

(A) has a structure selected from the group consisting of , and ,  ;

L_1 is selected from the group consisting of -S- and -O-;

G is  ,  ,  ,  , or  ; wherein, w is 0, 1, 2 or 3; each R_d' are independently selected from the group consisting of H, substituted or unsubstituted C_1-C_6 alkyl, substituted or unsubstituted C_3-C_{10} cycloalkyl, and substituted or unsubstituted C_6-C_{10} aryl;

each L_4 is substituted or unsubstituted C1-C4 alkylene, or NR_f; wherein, a hydrogen on a carbon atom of the substituted or unsubstituted C1-C4 alkylene

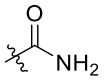
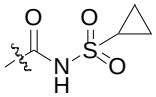
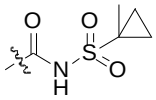
may be each independently substituted by deuterium, provided that a structure formed by each L_4 is chemically stable; R_g is selected from the group consisting of H, substituted or unsubstituted C_1-C_6 alkyl;

R_b and R_c together with the adjacent N atom form substituted or unsubstituted 3-10 membered heterocyclyl having 1-3 heteroatoms selected from N, S and O;

R_1, R_2, R_3 and R_5 are each independently selected from the group consisting of H, -CN, trifluoromethyl, $-CHF_2$, $-OCF_3$, $-OCHF_2$, sulfonamido, nitro, hydroxyl, halogen, substituted or unsubstituted C1-C10 alkyl, substituted or unsubstituted C1-C6 alkoxy, substituted or unsubstituted C3-C8 cycloalkyl, -CN, hydroxyl, and substituted or unsubstituted C1-C6 amino;

R_4 is selected from the group selected from NR_dR_e;

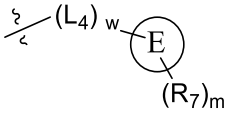
R_d and R_e together with the adjacent N atom form substituted or unsubstituted 3-10 membered heterocyclyl having 1-3 heteroatoms selected from N, S and O;

unless otherwise specified, the "substituted" refers to substitution with one or more substituents selected from the group consisting of halogen $-CH_2Cl$, $-CHCl_2$, $-CCl_3$, $-CH_2F$, $-CHF_2$, $-CF_3$, oxo, -CN, hydroxyl, amino, C1-C6 alkylamino, carboxyl, -NHAc,  , ,  ,  , and a group unsubstituted or substituted by R_z, wherein the group is selected from C1-C6 alkyl, C1-C6 alkoxy, C3-C8 cycloalkyl, and 5-10 membered heterocyclyl with 1-3 heteroatoms selected from N, S and O; the R_z substituent is selected from the group consisting of halogen, hydroxyl, carboxyl, cyano, C1-C6 alkoxy, and C1-C6 alkylamino;

in the above formulas, any one of the heteroatoms is selected from the group consisting of B, P, N, S and O.

2. The compound as defined in claim 1, wherein R_3 is methyl, C1-C6 alkyl or alkoxy; C3-C6 cycloalkyl, -F, Cl, Br, $-CH_2Cl$, $-CH_2Br$, $-CHCl_2$, $-CCl_3$, $-CH_2F$, $-CHF_2$, $-CF_3$, -CN, hydroxyl, amino or alkyl substituted amino.

3. The compound as defined in claim 1, or the optical isomer, hydrate, solvate thereof, or the pharmaceutically acceptable salt thereof, wherein ring has a substitutent as shown in the following formula IV:



IV

wherein, w is 0, 1, 2, or 3;

each L_4 is independently selected from the group consisting of substituted or unsubstituted C1-C4 alkylene, and NR_f; R_f is selected from the group consisting of H, substituted or unsubstituted C_1-C_6 alkyl; wherein, a hydrogen on a carbon

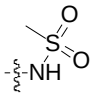
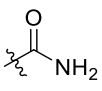
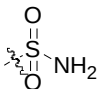
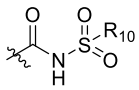
atom of the substituted or unsubstituted C1-C4 alkylene is each independently optionally substituted by deuterium, provided that a structure formed by each L_4 is chemically stable;

(E) is selected from the group consisting of substituted or unsubstituted C3-C10 cycloalkyl, and substituted or unsubstituted 3-10 membered heterocyclyl having 1-3 heteroatoms selected from B, P, N, S and O;

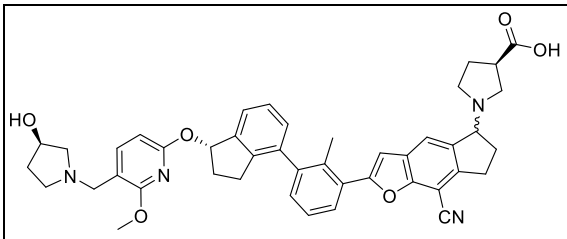
each R_7 is independently selected from the group consisting of substituted or unsubstituted C1-C6 alkyl, -CN, hydroxy, amino, carboxyl; R_f is defiend as above; wherein a hydrogen on a carbon atom of Rf is optionally independently substituted by deuterium; wherein, the substituted means being substituted by a group selected from halogen, hydroxyl, carboxyl, cyano, and C1- C6 alkoxy.

4. The compound as defined in claim 3, wherein w is 1, L_4 is C1-C4 alkylene, and (E) is 3-8 membered nitrogen-containing heterocyclyl, or substituted or unsubstituted 4-10 membered cyclic amido, wherein a hydrogen on the ring-forming carbon atom of 3-8 membered nitrogen-containing heterocyclyl, and substituted or unsubstituted 4-10 membered cyclic amido is optionally independently substituted by deuterium.

5. The compound as defined in claim 3, wherein $(L_4)_w$ is $-CH_2-NH-CH_2-$, and (E) is 3-8 membered nitrogen-containing heterocyclyl, or substituted or unsubstituted 4-10 membered cyclic amido, wherein a hydrogen on the ring-forming carbon atom of 3-8 membered nitrogen-containing heterocyclyl, and substituted or unsubstituted 4-10 membered cyclic amido is optionally independently substituted by deuterium.

6. The compound as defined in claim 1, wherein R_4 is selected from the group consisting of $-NR_dR_e$; R_d and R_e are each independently selected from the group consisting of H, substituted or unsubstituted C_1-C_6 alkyl, and substituted or unsubstituted C_3-C_{10} cycloalkyl; or R_d and R_e together form substituted or unsubstituted 3-10 membered heterocyclyl having 1-3 heteroatoms selected from N, S and O; wherein the substituted means being substituted by a substituent selected from carboxyl, hydroxyl,  ,  ,  , and  ; R_{10} is substituted or unsubstituted C_3-C_{10} cycloalkyl, wherein a hydrogen on a carbon atom of Rd, Re and R_{10} is optionally independently substituted by deuterium.

7. The compound as defined in claim 1, wherein the compound is selected from the following table:



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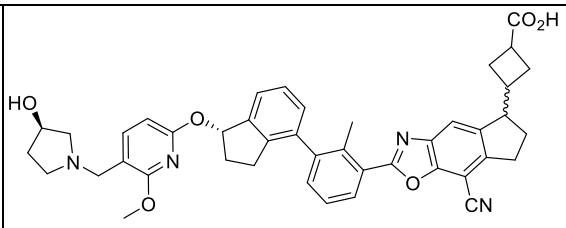

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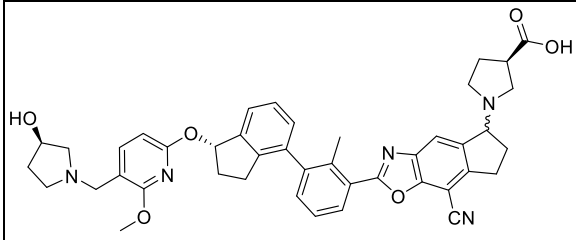

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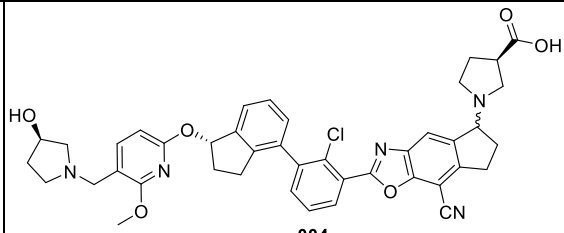

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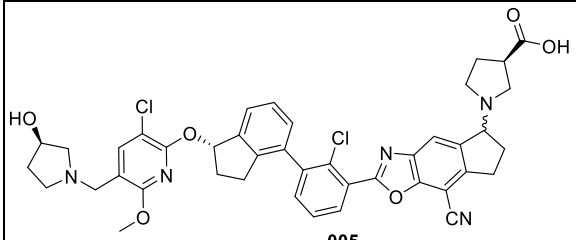

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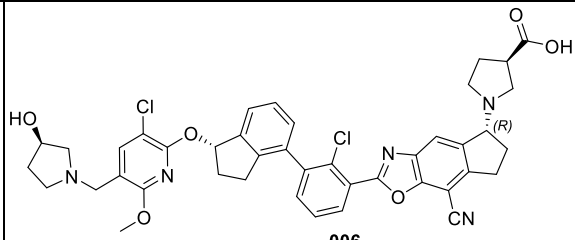

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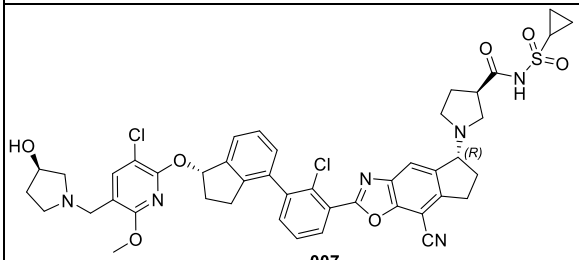

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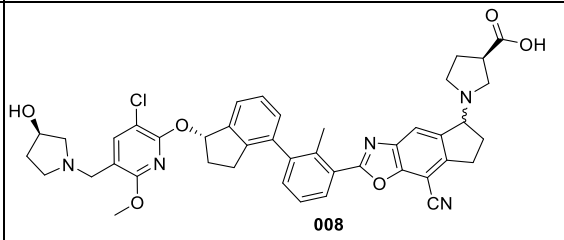

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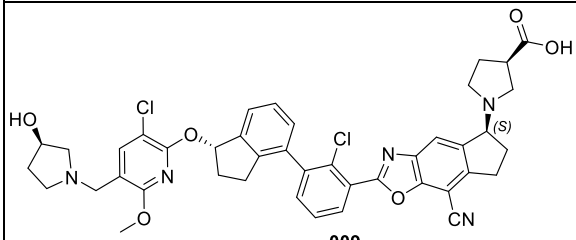

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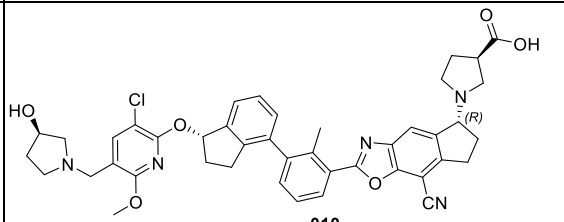

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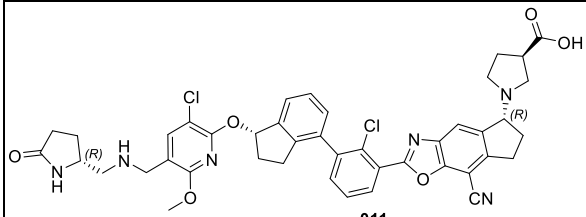

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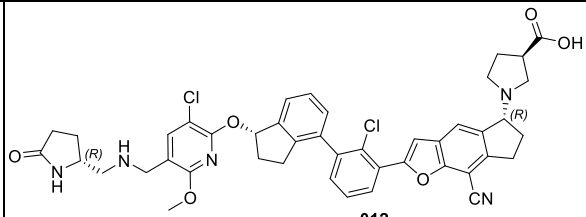

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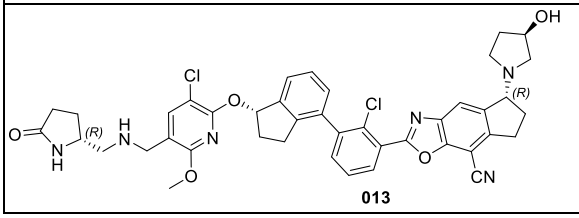

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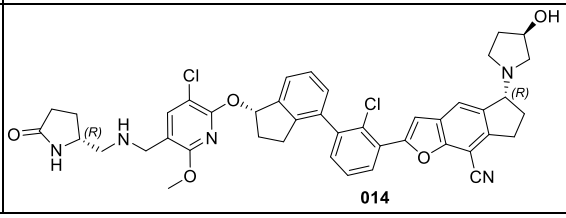

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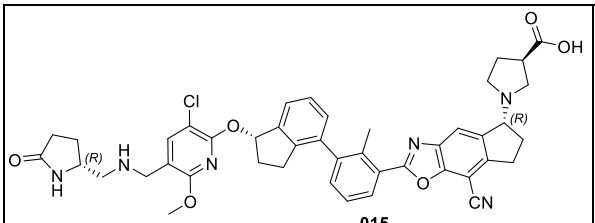

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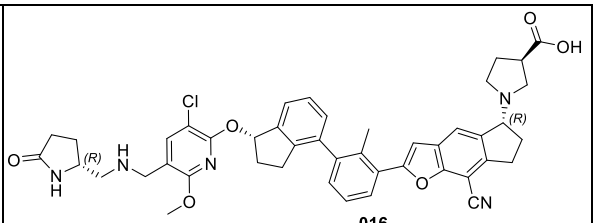

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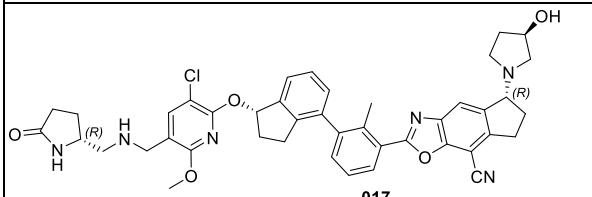

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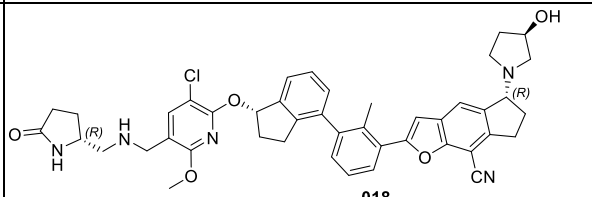

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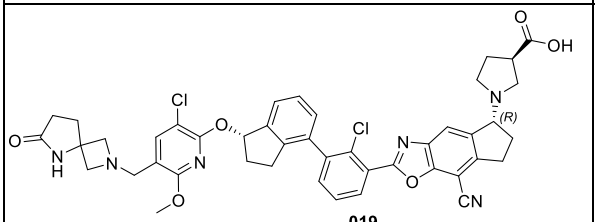

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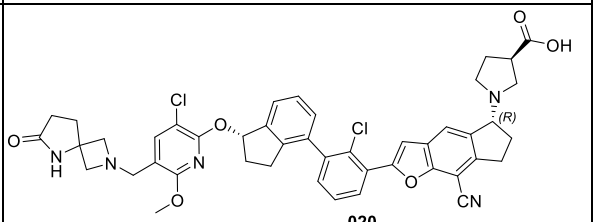

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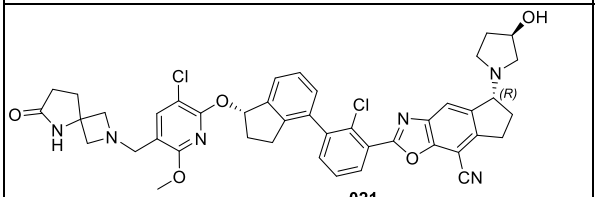

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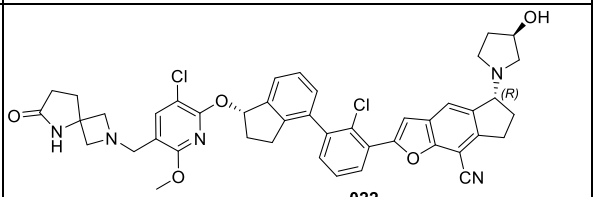

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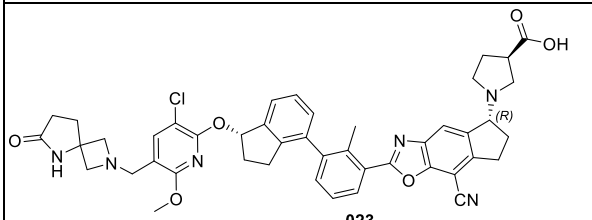

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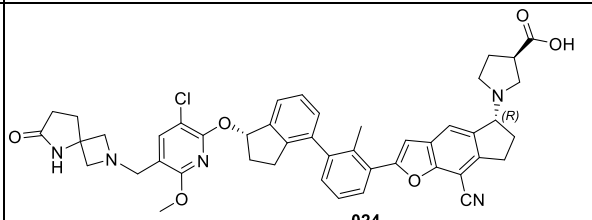

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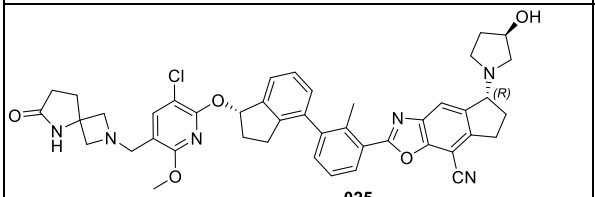

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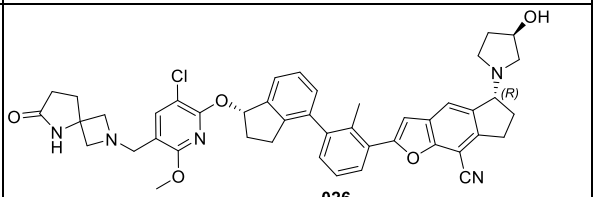

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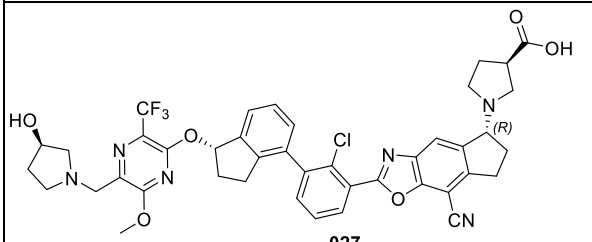

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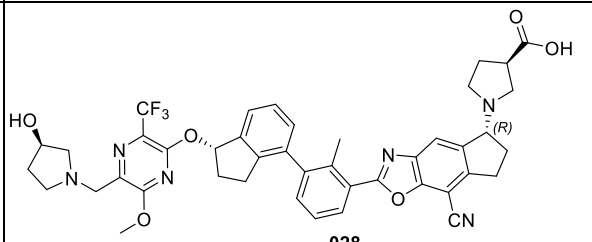

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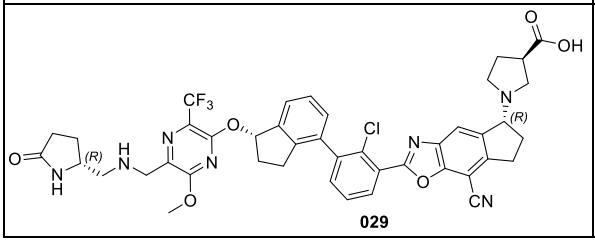

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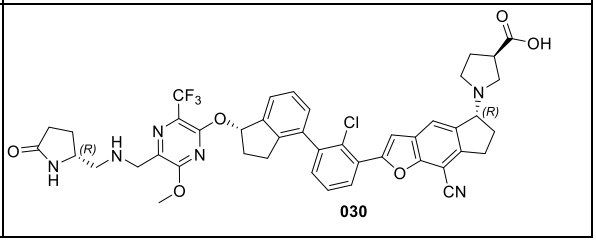

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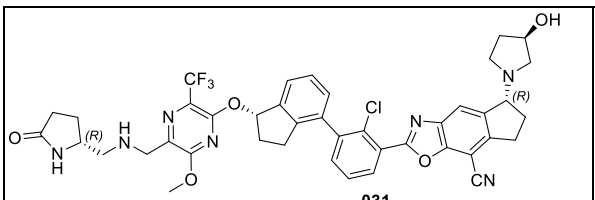

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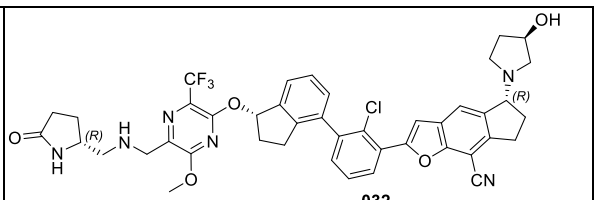

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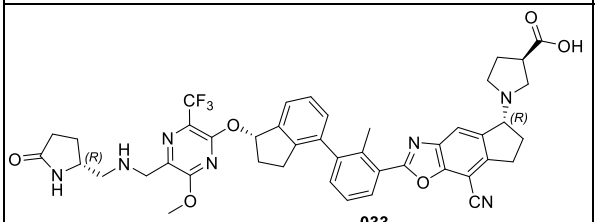

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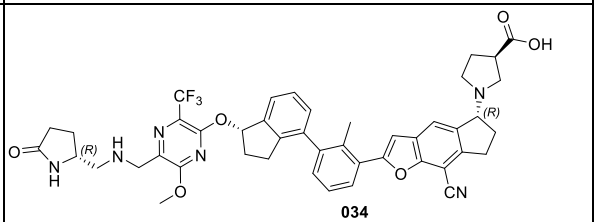

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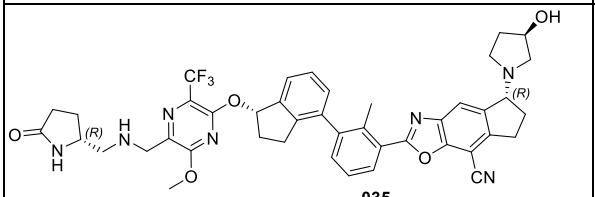

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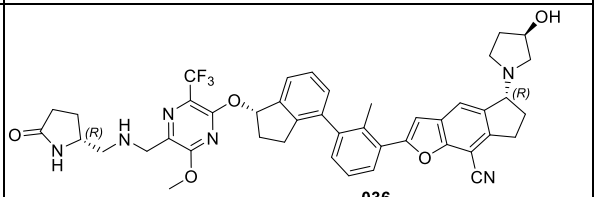

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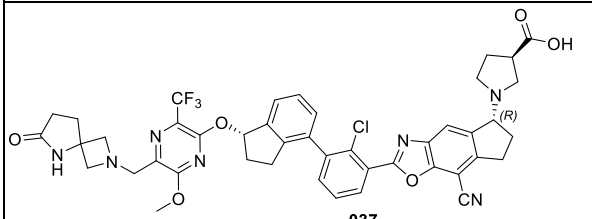

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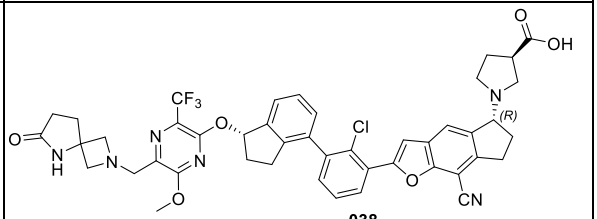

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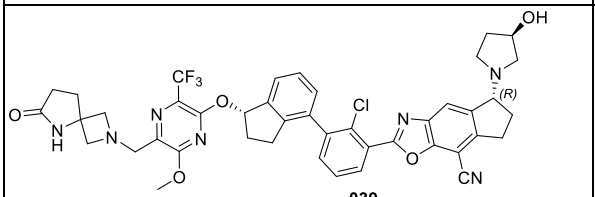

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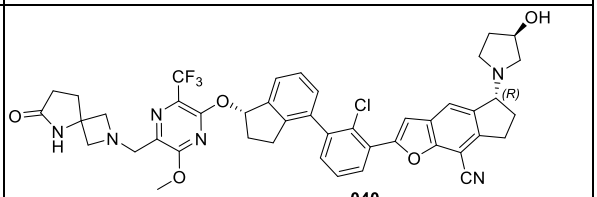

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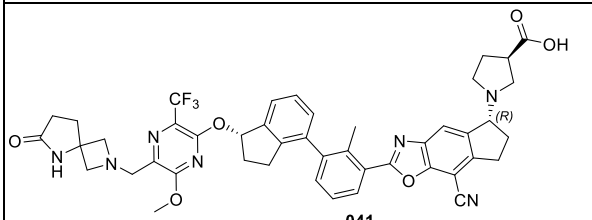

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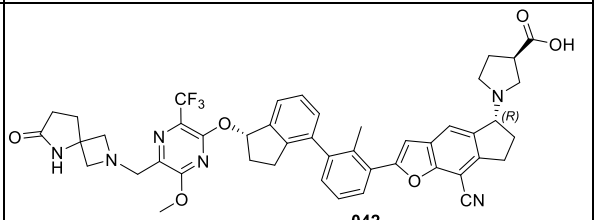

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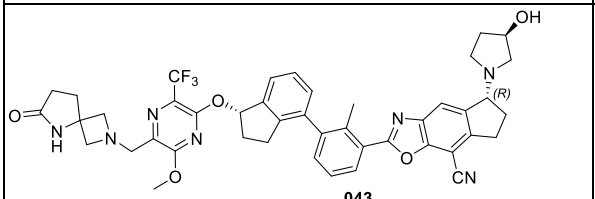

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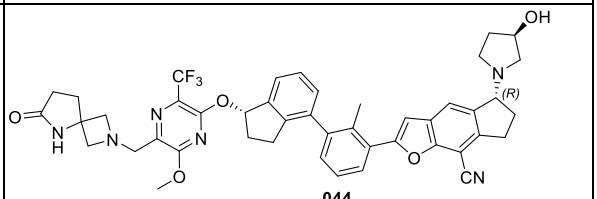

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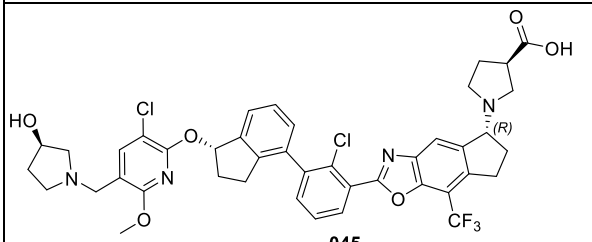

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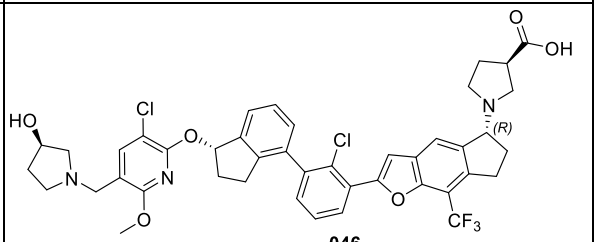

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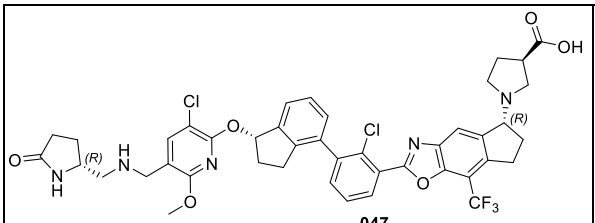

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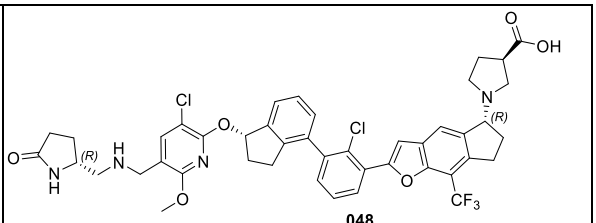

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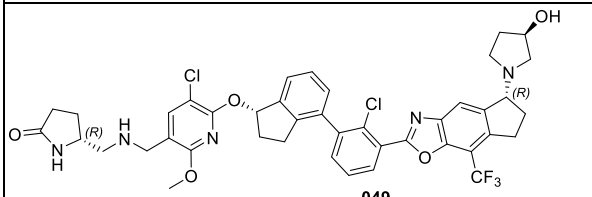

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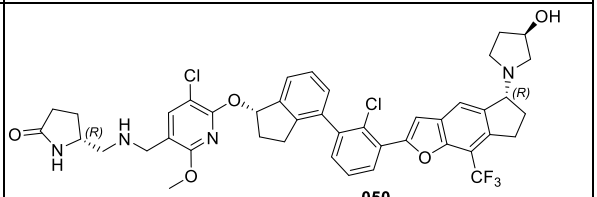

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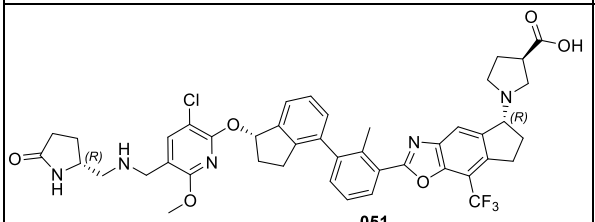

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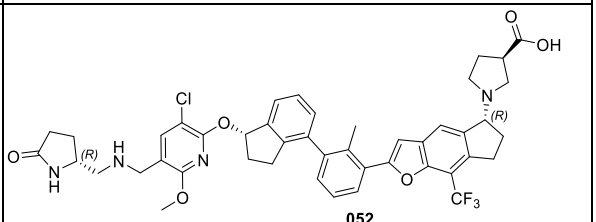

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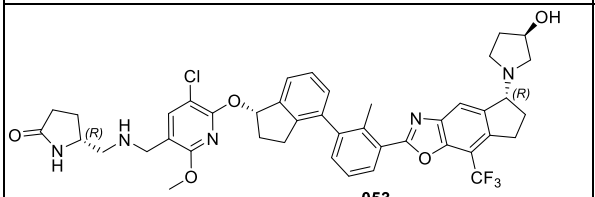

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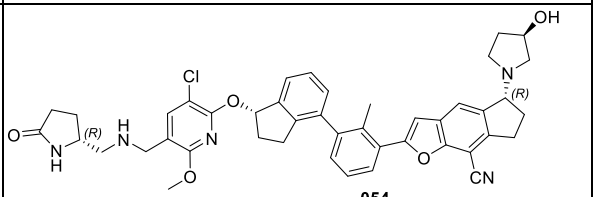

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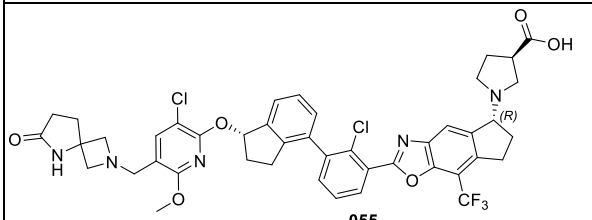

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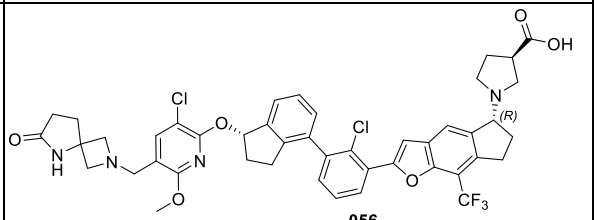

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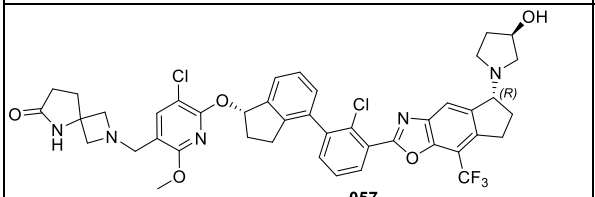

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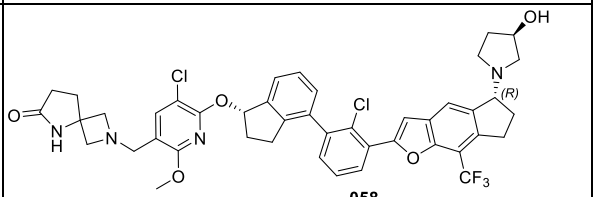

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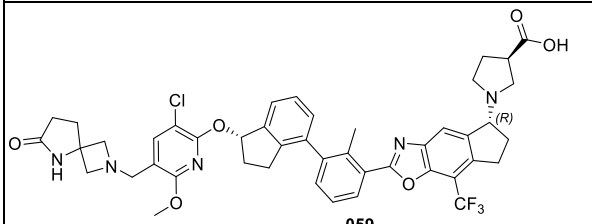

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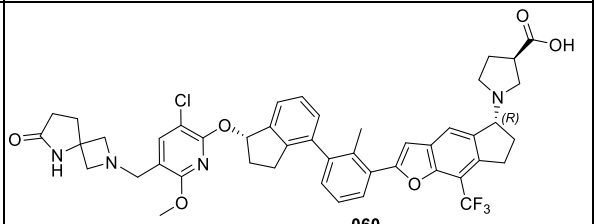

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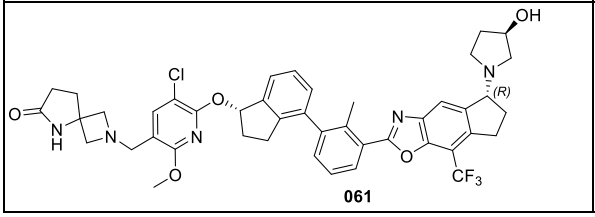

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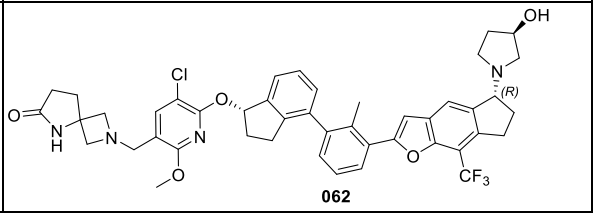

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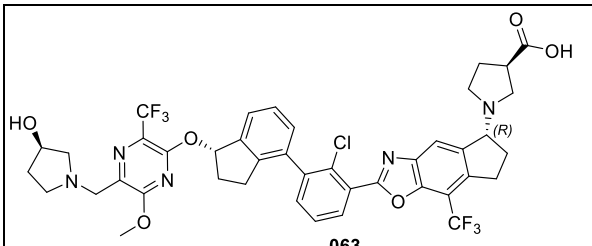

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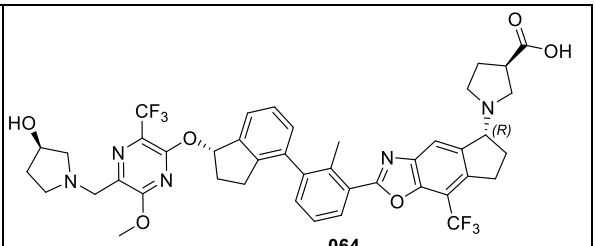

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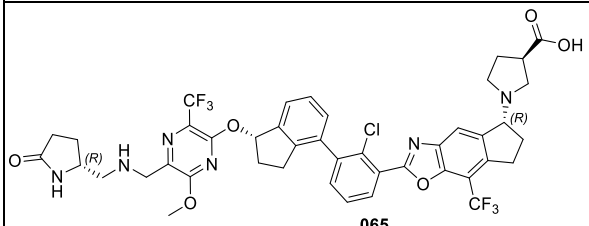

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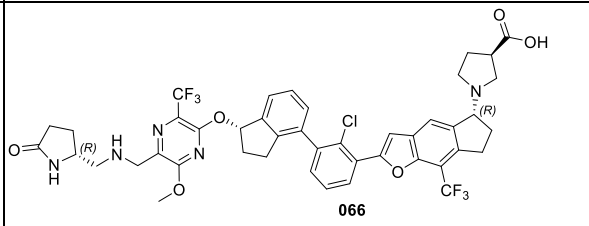

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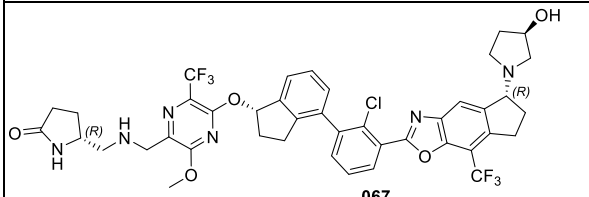

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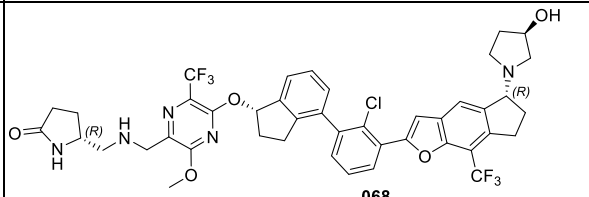

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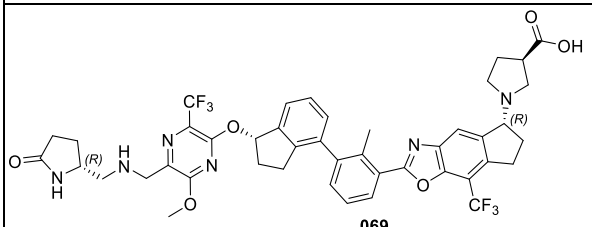

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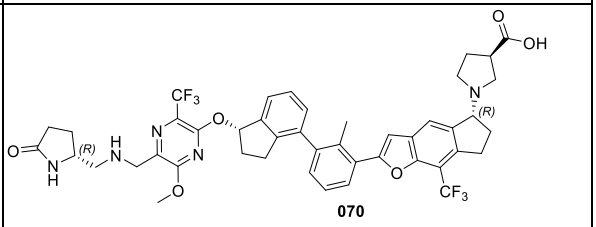

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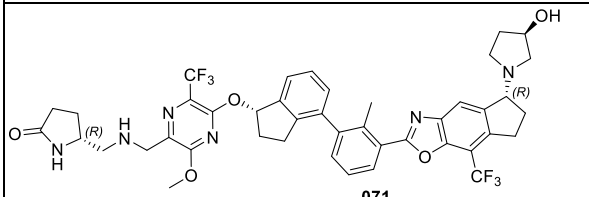

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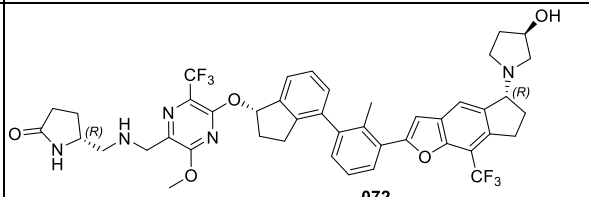

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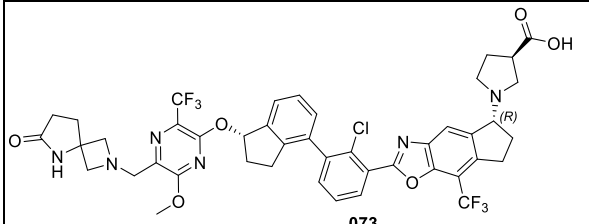

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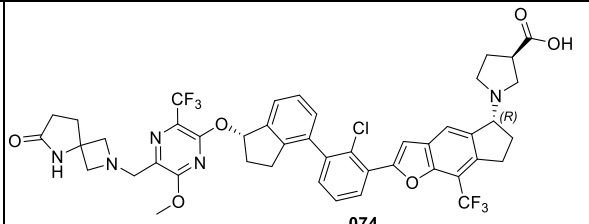

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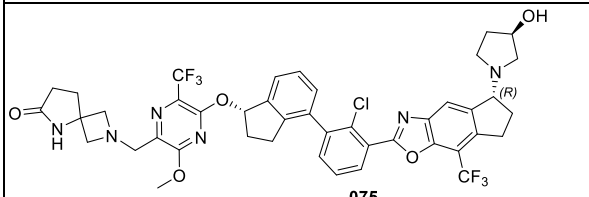

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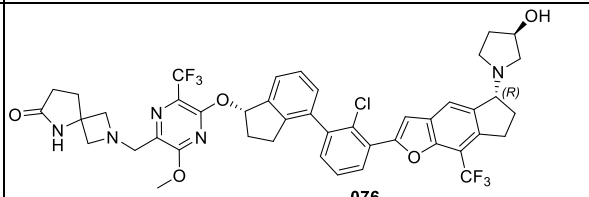

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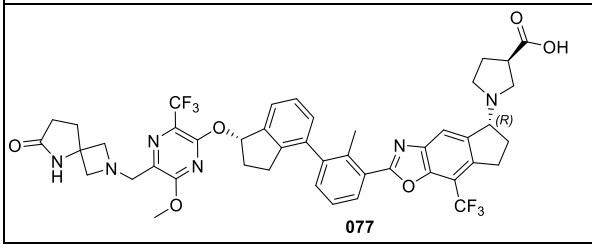

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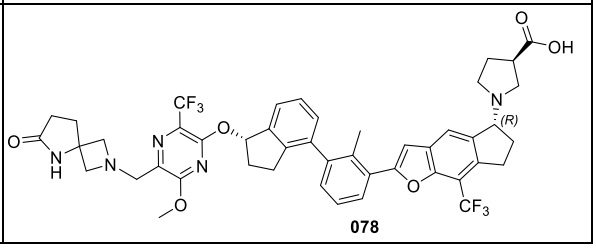

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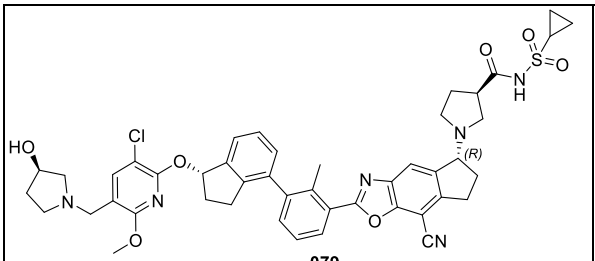

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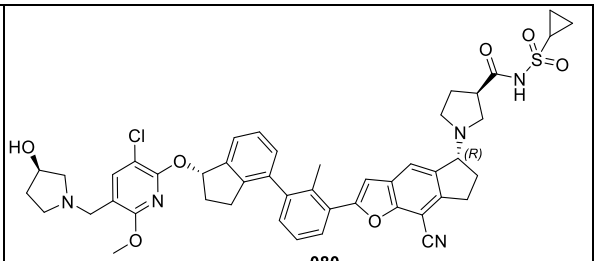

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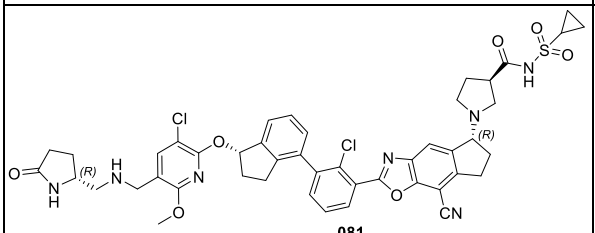

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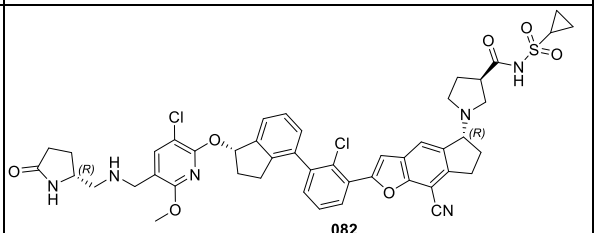

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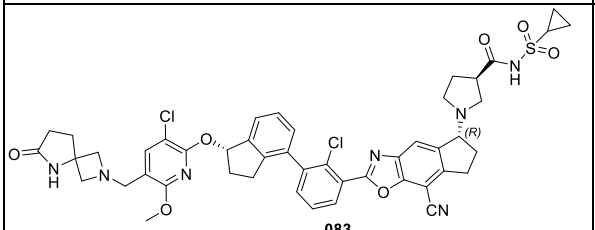

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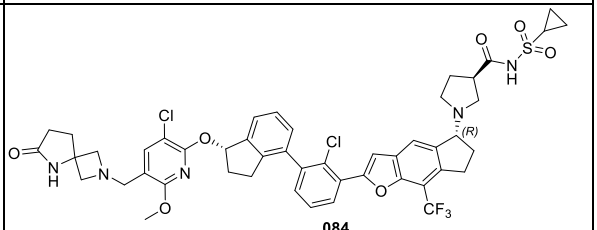

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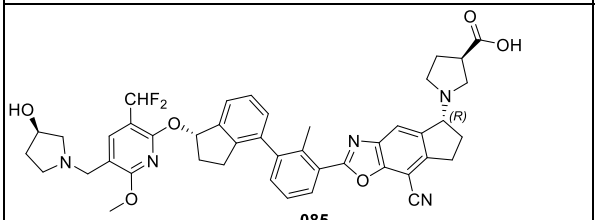

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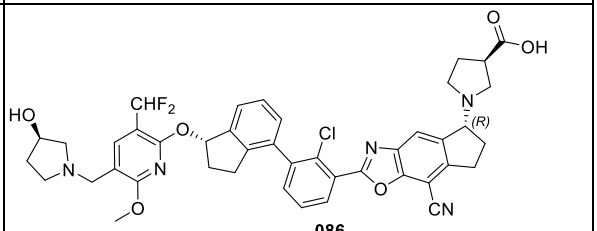

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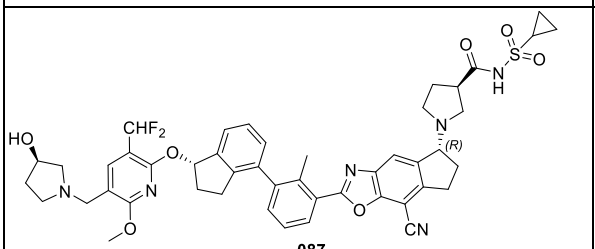

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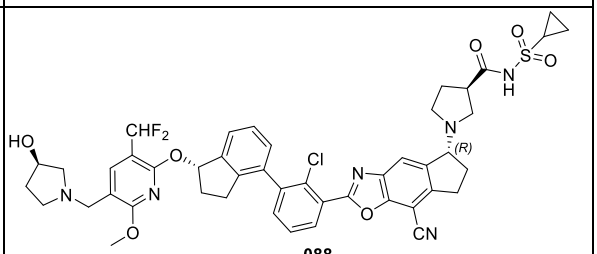

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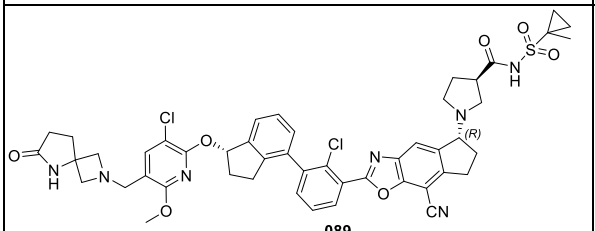

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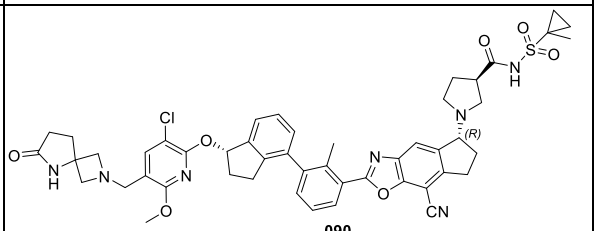

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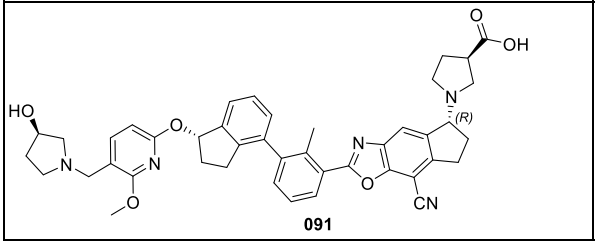

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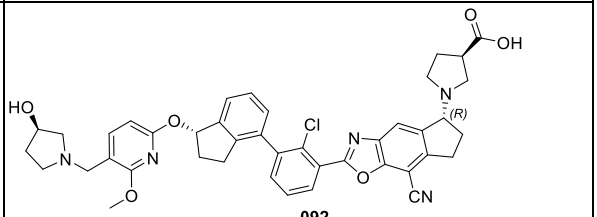

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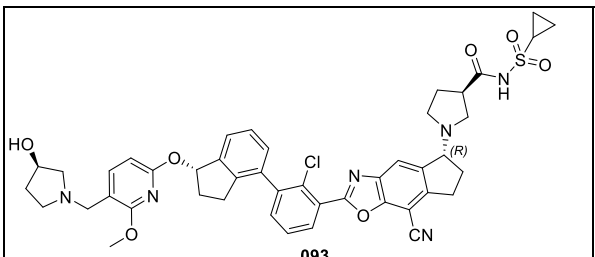

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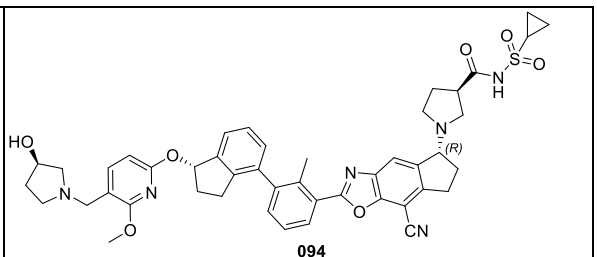

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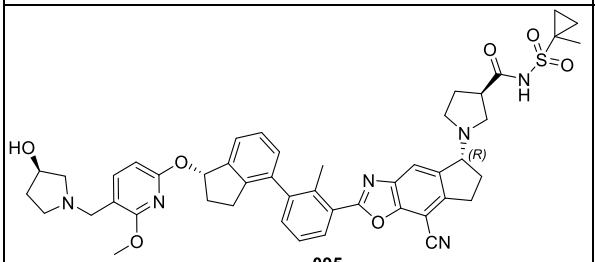

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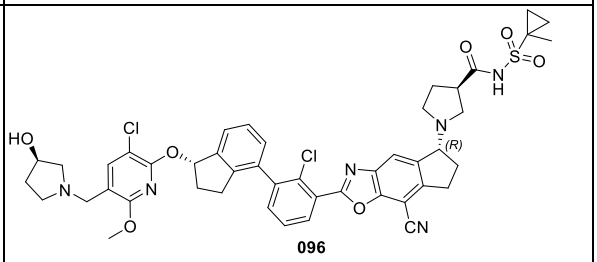

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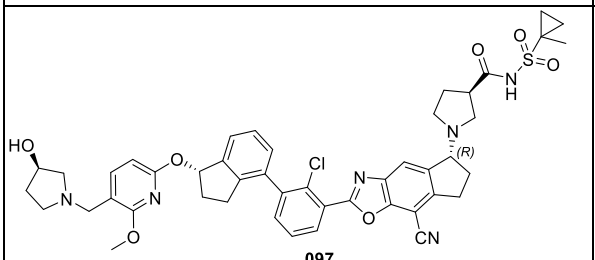

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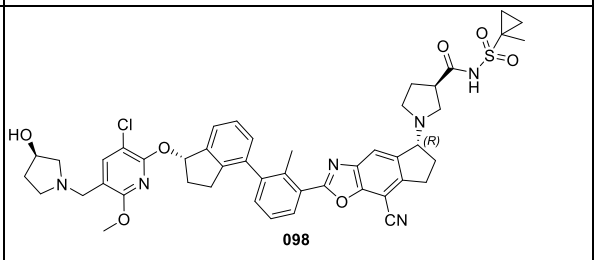

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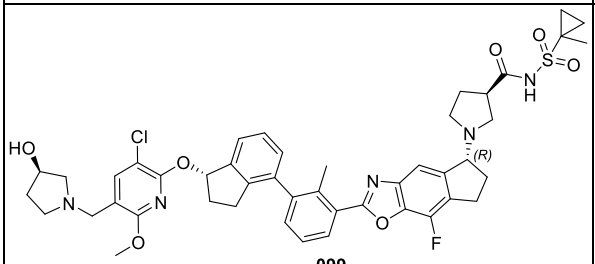

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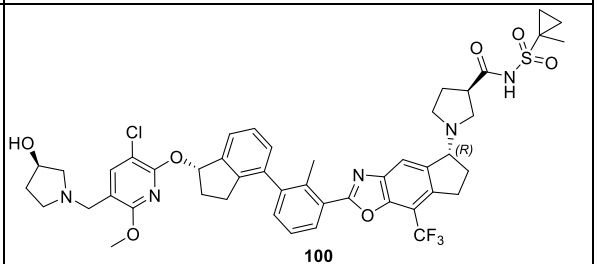

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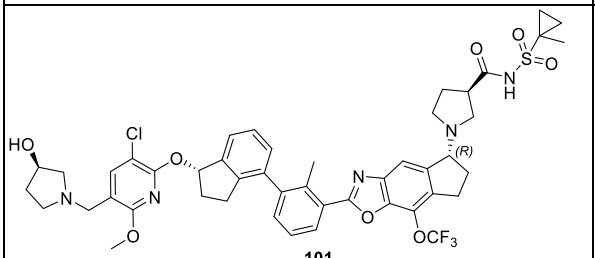

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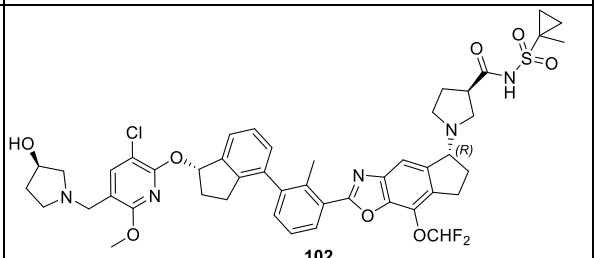

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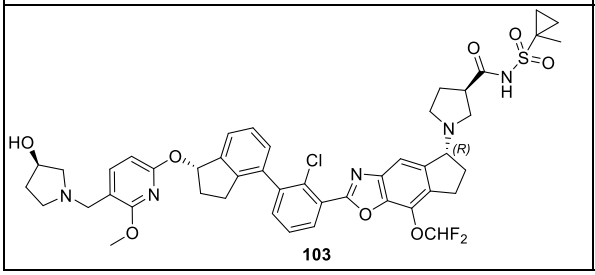

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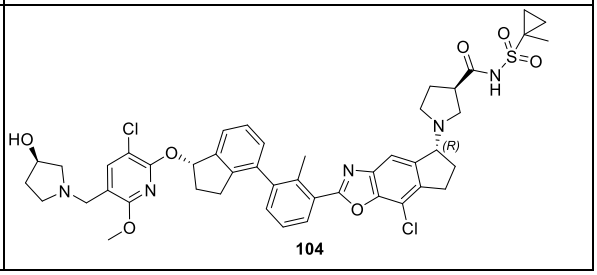

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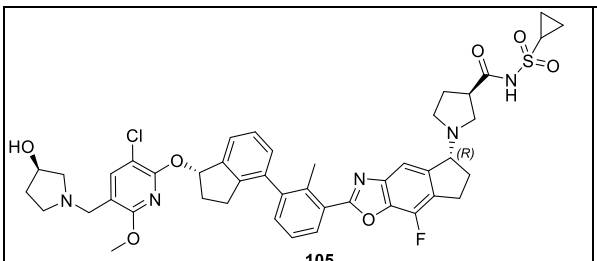
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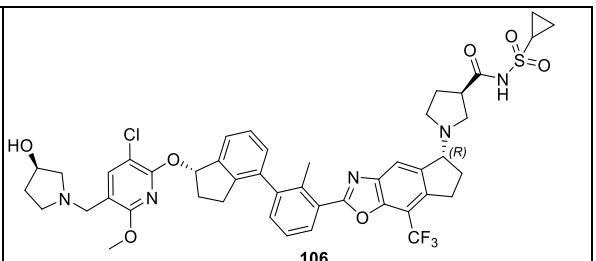
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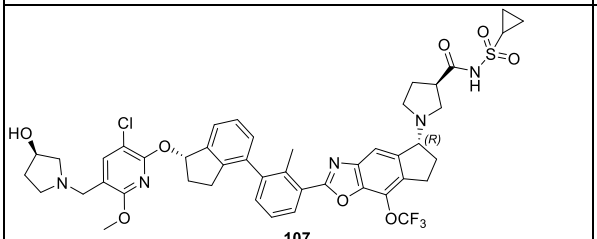
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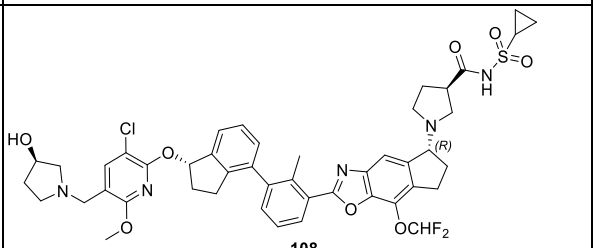
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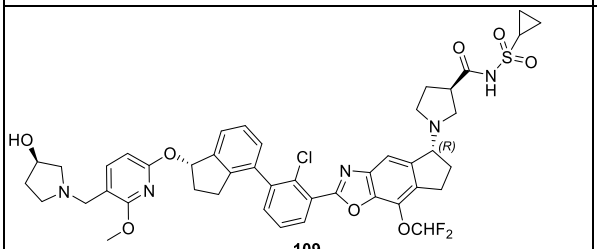
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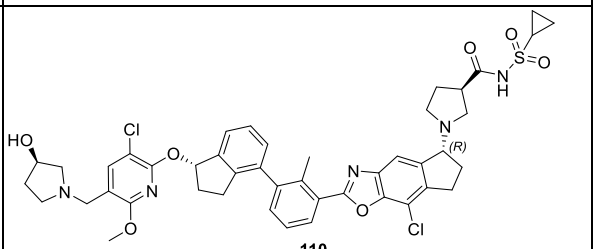
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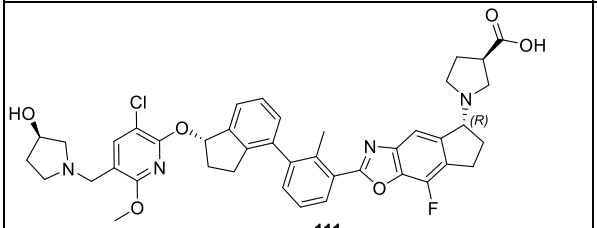
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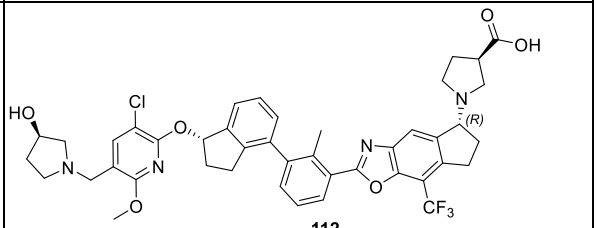
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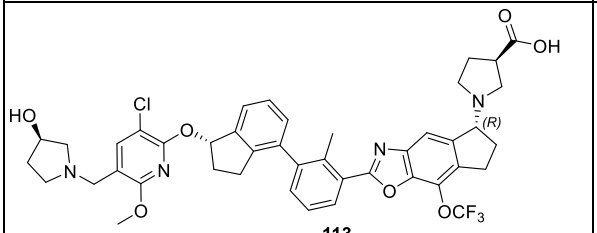
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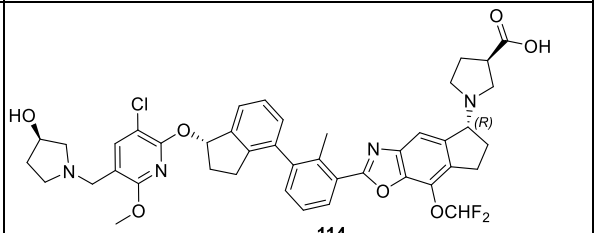
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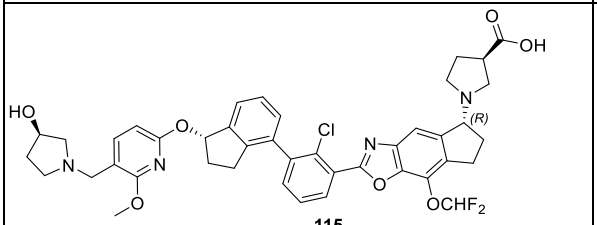
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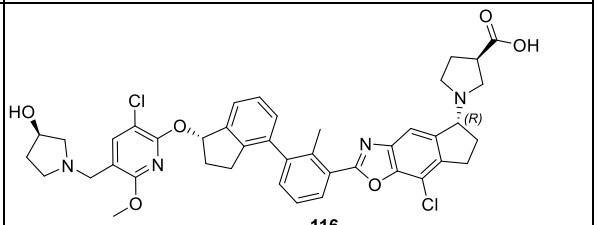
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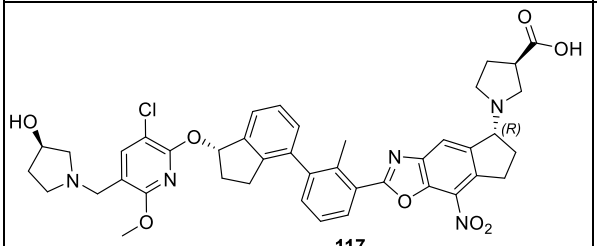
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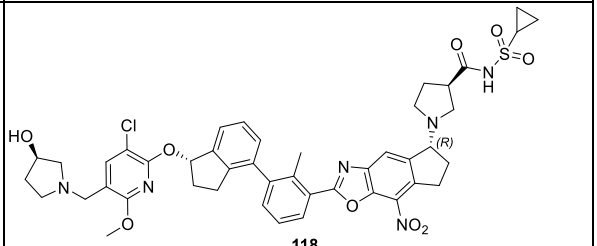
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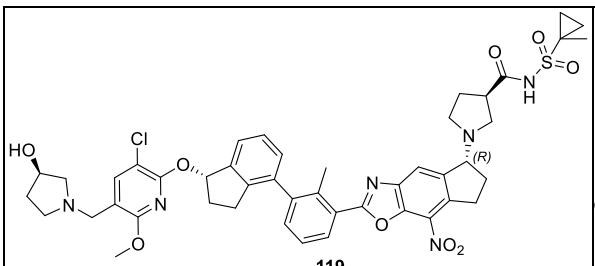
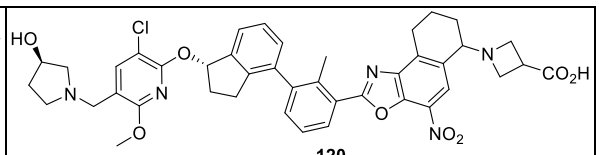
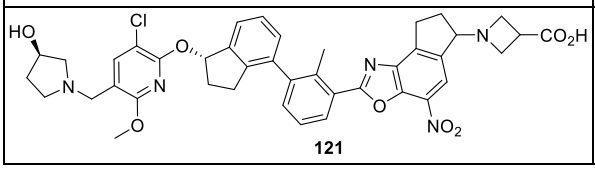
 119	 120 and
 121	

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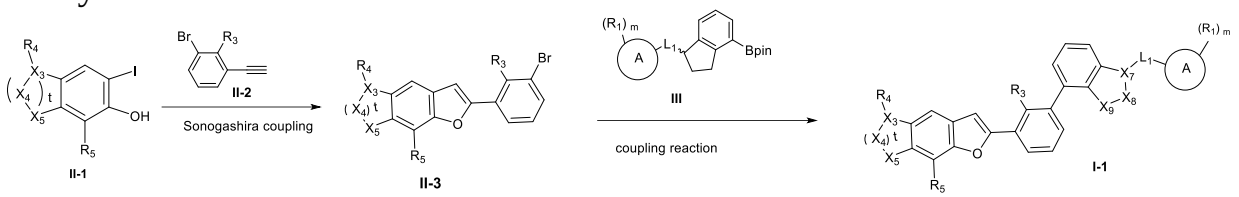
8. A preparation method of a compound of formula I as defined in claim 1, wherein the compound of formula I is the compound of formula I-1 and I-2, and the method comprises steps selected from the steps shown in Synthesis Scheme 1 or 2:

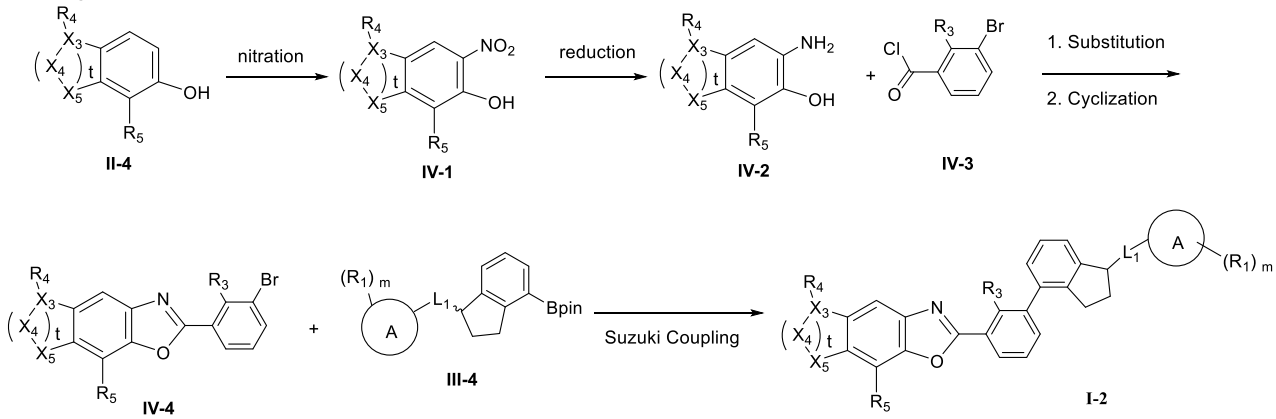
Synthesis Scheme 1:



(a) subjecting intermediates II-1 and II-2 as raw materials to Sonogashira coupling reaction catalyzed by palladium catalyst to obtain intermediate II-3;

(b) subjecting II-3 and III as raw materials to a coupling reaction in the presence of palladium catalyst and ligand to obtain intermediate I-1;

Synthesis Scheme 2:



(a) reacting compound **II-4** as a raw material with a nitrifying agent to form intermediate **IV-1**;

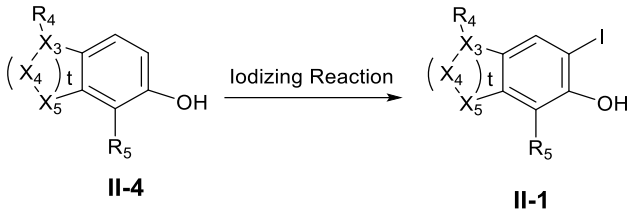
(b) subjecting **IV-1** as a raw material to a reduction reaction under reducing condition to form intermediate **IV-2**;

(c) subjecting **IV-2** and **IV-3** as raw materials to an affinity substitution reaction under alkaline conditionan to obtain amide intermediate; and then subjecting to a cyclization reaction in the presence of suitable dehydration reagent to obtain an intermediate **IV-4**;

(d) subjecting **IV-4** and **III-4** as raw materials to a coupling reaction under the conditions of catalyst and ligand to form target product **I-2**;

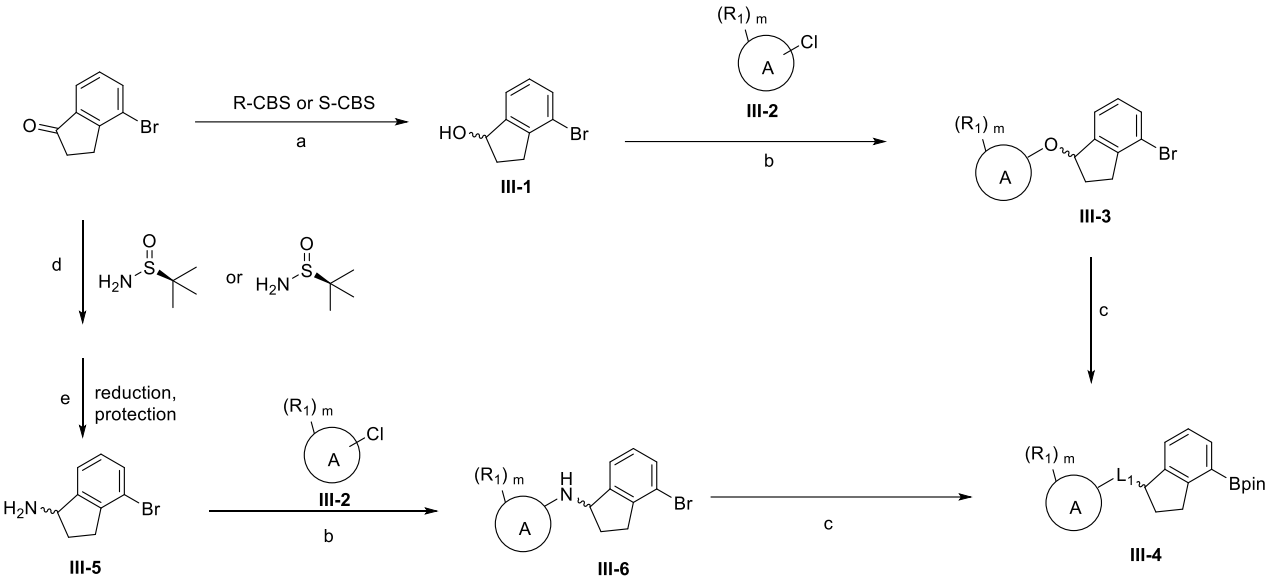
X_3, X_4, X_5, X_7, X_8, X_9, R_1, R_3, R_4, R_5, t, and m are defined as above.

9. The method as defined in claim 8, wherein the preparation method of intermediate II-1 is as follows:



subjecting II-4 as raw material to a halogenation reaction catalyzed by Lewis acid to obtain intermediate II-1.

10. The method as defined in claim 9, wherein the preparation method of intermediate III-1 is as follows:



(a) reacting compound 4-bromoindanone as a raw material under the action of chiral auxiliary such as R/S-CBS and reducing agent such as borane to form chiral alcohol **1-2**;

(b) subjecting **III-1** or **III-5** and **III-2** as raw materials to an affinity substitution reaction under basic condition to obtain intermediate **III-3** or **III-6**;

(c) subjecting **III-3** or **III-6** and bis(pinacolato)diboron as raw materials to a boronation reaction under the presence of palladium catalyst and ligand to obtain intermediate **III-1**;

(d), (e) reacting compound 4-bromoindanone and R/S-tert-butylsulfonimide as raw materials under the action of Lwesis acid and reducing agent to form a protected chiral amino compound, and then the protective group is removed under acidic condition to obtain a chiral amino compound **III-5**.

11. A pharmaceutical composition comprising (1) the compound as defined in claim 1; and (2) a pharmaceutically acceptable carrier; wherein the pharmaceutically

acceptable carrier is selected from cellulose and the derivatives thereof, gelatin, talc, solid lubricants, calcium sulfate, vegetable oils, polyols, emulsifiers, wetting agent, coloring agents, flavoring agents, stabilizers, antioxidants, preservatives, pyrogen-free water.

12. Use of the compound as defined in claim 1, or the pharmaceutical composition as defined in claim 11, for the preparation of a pharmaceutical composition for preventing and/or treating diseases related to the activity or expression of PD-1/PD-L1, wherein the diseases are selected from the group consisting of cancer, infectious disease, and autoimmune disease.

13. The use as defined in claim 12, wherein the cancer is selected from the group consisting of pancreatic cancer, bladder cancer, colorectal cancer, breast cancer, prostate cancer, kidney cancer, hepatocellular carcinoma, lung cancer, ovary cancer, cervical cancer, stomach cancer, esophageal cancer, melanoma, neuroendocrine cancer, central nervous system cancer, brain cancer, bone cancer, soft tissue sarcoma, non-small cell lung cancer, small cell lung cancer or colon cancer, skin cancer, lung cancer, urinary system tumor, blood tumor, glioma, digestive system tumor, reproductive system tumor, lymphoma, nervous system tumor, brain tumor, head and neck cancer.

14. The use as defined in claim 12, wherein the infectious disease is selected from bacterial infection and viral infection.

15. The use as defined in claim 12, wherein the autoimmune disease is selected from the group consisting of organ-specific autoimmune disease and systemic autoimmune disease.

16. The use as defined in claim 12, wherein the pharmaceutical composition further comprises at least one therapeutic agent selected from the group consisting of nivolumab, pembrolizumab, atezolizumab and ipilimumab.