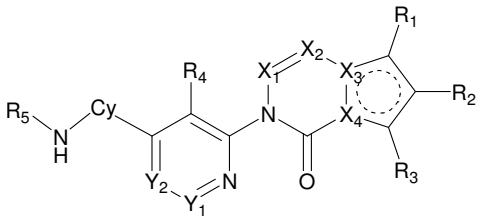
CLAIMS

1. A compound of formula (I):



(I)

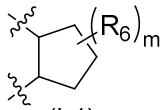
or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein

X_1 and X_2 are each independently CH;

X_3 and X_4 are each independently C or N;

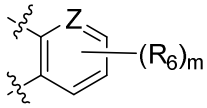
Y_1 and Y_2 are each independently CR_{10} or N;

R_1 and R_2 together with the carbon atoms to which they are attached form the following structures:



(I-1)

, or



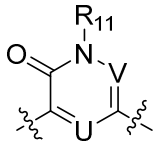
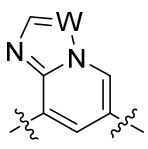
(I-2)

,

wherein R_6 is independently selected from deuterium, halogen, hydroxyl, C_{1-6} alkyl, C_{2-6} alkynyl, C_{1-6} deuteroalkyl and C_{1-6} haloalkyl; or two R_6 together with the carbon atoms to which they are attached form 3-6 membered cycloalkyl; m is 0, 1, 2, 3 or 4; Z is N or CR_7; R_7 is selected from hydrogen, deuterium, C_{1-6} alkyl, halogen and C_{1-6} haloalkyl;

R_3 is hydrogen, deuterium, halogen or C_{1-6} haloalkyl;

R_4 is hydrogen, halogen, -CN, C_{1-6} alkyl, C_{2-6} alkynyl, -(C_{1-3} alkyl)-OH, -(C_{1-3} alkyl)-O-(C_{1-3} alkyl), -O-(C_{1-3} alkyl), -CHO, $-C(O)NH_2$, $-C(O)NHCH_3$, $-C(O)N(CH_3)_2$ or 3-hydroxyl-oxetan-3-yl, wherein the C_{1-6} alkyl or C_{1-3} alkyl is each optionally substituted with one or more deuterium or halo;

Cy is  or ,wherein R_{11} is selected from hydrogen, C_{1-6} alkyl and C_{3-6} cycloalkyl, wherein the C_{1-6} alkyl is optionally substituted with one or more deuterium or halo;

U, V and W are each independently N or CR_{12}; R_{12} is hydrogen, deuterium or halogen;

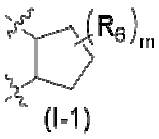
R_5 is hydrogen, C_{1-6} alkyl, -C(O)-(C_{1-6} alkyl), -C(O)-(C_{3-6} cycloalkyl), -C(O)-phenyl, -C(O)NH-(C_{1-6} alkyl), -C(O)NH-(C_{3-6} cycloalkyl), $-C(O)N(C_{1-6}$ alkyl$)_2$, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl, wherein the C_{1-6} alkyl, C_{3-6} cycloalkyl, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl is each optionally substituted with one or more groups selected from:

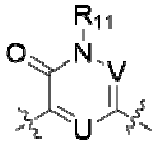
1) halogen;
2) oxo;
3) -CN;

4) C_{1-6} alkyl;
5) C_{2-6} alkenyl;
6) C_{2-6} alkynyl;
7) C_{1-6} alkoxy;
8) C_{1-6} haloalkyl;
9) -(C_{1-6} alkyl)-OH;
10) -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);
11) C_{3-6} cycloalkyl;
12) 3-12 membered heterocyclyl optionally substituted with one or more groups selected from: deuterium, halogen, hydroxyl, oxo, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, C_{3-6} cycloalkyl, C_{2-6} alkynyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-OH, 4-6 membered heterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl, C_{3-6} cycloalkyl or 4-6 membered heterocyclyl is each optionally substituted with one or more groups selected from: deuterium, halogen, -NH_2, -OH, -NH(C_{1-6} alkyl), -N(C_{1-6} alkyl)$_2$ and -NH(C_{3-6} cycloalkyl);
13) 5-6 membered monocyclic heteroaryl optionally substituted with one or more groups selected from: halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
14) phenyl optionally substituted with one or more groups selected from: halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N-(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
15) -NR_a'R_a'', wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, C_{3-6} cycloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents of -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -NR_e'R_e'', and R_e' and R_e'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl;
16) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl optionally substituted with one or more groups selected from: deuterium, halogen, -OH, C_{1-6} alkyl, -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl), -NH_2, -NH(C_{1-6} alkyl), -N(C_{1-6} alkyl)$_2$, -NH(C_{3-6} cycloalkyl) and -(C_{1-6} alkyl)-OH; and
17) -C(O)R_c, wherein R_c is selected from hydrogen, C_{1-6} alkyl, C_{2-6} alkenyl, C_{2-6} alkynyl, -(C_{1-6} alkyl)-OH and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

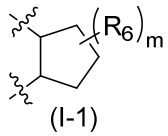
R_{10} is hydrogen, deuterium, halogen, CN, C_{1-6} alkyl or C_{1-6} haloalkyl;

provided that if R_1 and R_2 together with the carbon atoms to which they are attached form the following structures:

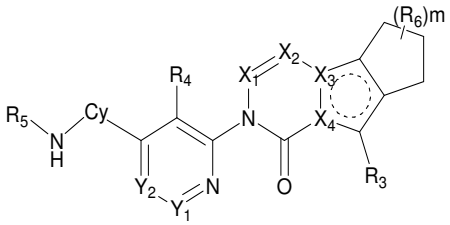


, and Cy is 

, then the 3-12 membered heterocyclyl, when substituted, is not piperazin-1-yl substituted with C_{1-6} alkyl at both 2- and 6- positions.

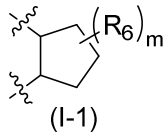
2. The compound of claim 1, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_1 and R_2 together with the carbon atoms to which they are attached form 

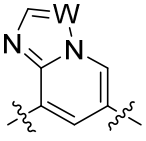
, i.e. the compound is a compound of formula (IA):



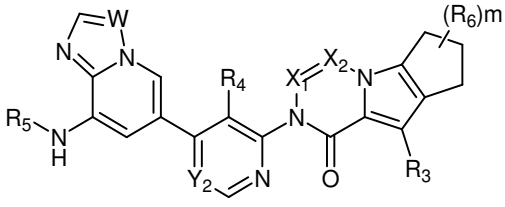
(IA)

.

3. The compound of claim 2, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_1 and R_2 together with the carbon atoms to which they are attached form 

, X_3 is N, X_4 is C, Y_1 is CH, Cy is 

, and the compound is a compound of formula (II):



(II)

wherein

X_1 and X_2 are each independently CH;

Y_2 is CH or N;

R_3 is hydrogen, deuterium, halogen or C_{1-6} haloalkyl;

R_4 is hydrogen, halogen, -CN, C_{1-6} alkyl, -(C_{1-3} alkyl)-OH, -(C_{1-3} deuteroalkyl)-OH, -(C_{1-3} alkyl)-O-(C_{1-3} alkyl), -O-(C_{1-3} alkyl), -CHO, -C(O)NH_2, -C(O)$NHCH_3$, -C(O)$N(CH_3)_2$ or 3-hydroxyl-oxetan-3-yl, wherein the C_{1-6} alkyl is optionally substituted with one or more halo;

W is N or CR_{12}, and R_{12} is hydrogen or halogen;

R_5 is hydrogen, C_{1-6} alkyl, -C(O)-(C_{1-6} alkyl), -C(O)-(C_{3-6} cycloalkyl), -C(O)-phenyl, -C(O)NH-(C_{1-6} alkyl), -C(O)NH-(C_{3-6} cycloalkyl), -C(O)N(C_{1-6} alkyl)$_2$, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl, wherein the C_{1-6} alkyl, C_{3-6} cycloalkyl, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl is each optionally substituted with one or more groups selected from:

1) halogen;
2) oxo;
3) -CN;
4) C_{1-6} alkyl;
5) C_{2-6} alkenyl;
6) C_{2-6} alkynyl;
7) C_{1-6} alkoxy;
8) C_{1-6} haloalkyl;
9) -(C_{1-6} alkyl)-OH;
10) -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);
11) C_{3-6} cycloalkyl;
12) 3-12 membered heterocyclyl optionally substituted with one or more substituents selected from halogen, hydroxyl, oxo, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, C_{3-6} cycloalkyl, C_{2-6} alkynyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-OH, 4-6 membered heterocyclyl, 4-6 membered fluoroheterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl is optionally substituted with one or more -OH;
13) 5-6 membered monocyclic heteroaryl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
14) phenyl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
15) -$NR_a'R_a''$, wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, C_{3-6} cycloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents of -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -$NR_e'R_e''$, and R_e' and R_e'' are each independently

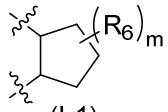
selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl;

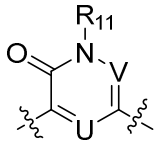
16) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents selected from halogen, -OH, C_{1-6} alkyl, -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and -(C_{1-6} alkyl)-OH; and

17) -C(O)R_c, wherein R_c is selected from hydrogen, C_{1-6} alkyl, C_{2-6} alkenyl, C_{2-6} alkynyl and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

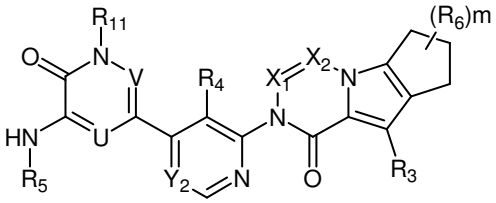
R_6 is halogen, C_{1-6} alkyl or hydroxyl; and

m is 0, 1, 2 or 3.

4. The compound of claim 2, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_1 and R_2 together with the carbon atoms to which they are attached form 

(I-1), X_3 is N, X_4 is C, Y_1 is CH, Cy is 

, and the compound is a compound of formula (III):



(III)

wherein

X_1 and X_2 are each independently CH;

Y_2 is CH or N;

R_3 is hydrogen, deuterium, halogen or C_{1-6} haloalkyl;

R_4 is hydrogen, halogen, -CN, C_{1-6} alkyl, -(C_{1-3} alkyl)-OH, -(C_{1-3} deuteroalkyl)-OH, -(C_{1-3} alkyl)-O-(C_{1-3} alkyl), -O-(C_{1-3} alkyl), -CHO, -$C(O)NH_2$, -$C(O)NHCH_3$, -$C(O)N(CH_3)_2$ or 3-hydroxyl-oxetan-3-yl, wherein the C_{1-6} alkyl is optionally substituted with one or more halo;

U and V are each independently selected from N or CH;

R_5 is hydrogen, C_{1-6} alkyl, -C(O)-(C_{1-6} alkyl), -C(O)-(C_{3-6} cycloalkyl), -C(O)-phenyl, -C(O)NH-(C_{1-6} alkyl), -C(O)NH-(C_{3-6} cycloalkyl), -C(O)N(C_{1-6} alkyl)$_2$, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl, wherein the C_{1-6} alkyl, C_{3-6} cycloalkyl, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl is each optionally substituted with one or more groups selected from:

1) halogen;
2) oxo;
3) -CN;
4) C_{1-6} alkyl;
5) C_{2-6} alkenyl;
6) C_{2-6} alkynyl;
7) C_{1-6} alkoxy;
8) C_{1-6} haloalkyl;
9) -(C_{1-6} alkyl)-OH;
10) -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);
11) C_{3-6} cycloalkyl;
12) 3-12 membered heterocyclyl optionally substituted with one or more substituents selected from halogen, hydroxyl, oxo, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, C_{3-6} cycloalkyl, C_{2-6} alkynyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-OH, 4-6 membered heterocyclyl, 4-6 membered fluoroheterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl is optionally substituted with one or more -OH;
13) 5-6 membered monocyclic heteroaryl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
14)phenyl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;
15) -NR_a'R_a'', wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, C_{3-6} cycloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents of -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -NR_e'R_e'', and R_e' and R_e'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl;
16) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents selected from halogen, -OH, C_{1-6} alkyl, -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and -(C_{1-6} alkyl)-OH; and
17) -C(O)R_c, wherein R_c is selected from hydrogen, C_{1-6} alkyl, C_{2-6} alkenyl, C_{2-6} alkynyl and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

R_6 is halogen, C_{1-6} alkyl or hydroxyl;

m is 0, 1, 2 or 3; and

R_{11} is hydrogen, C_{1-6} alkyl or C_{1-6} deuteroalkyl;

provided that the 3-12 membered heterocyclyl, when substituted, is not piperazin-1-yl substituted with C_{1-6} alkyl at both 2- and 6- positions.

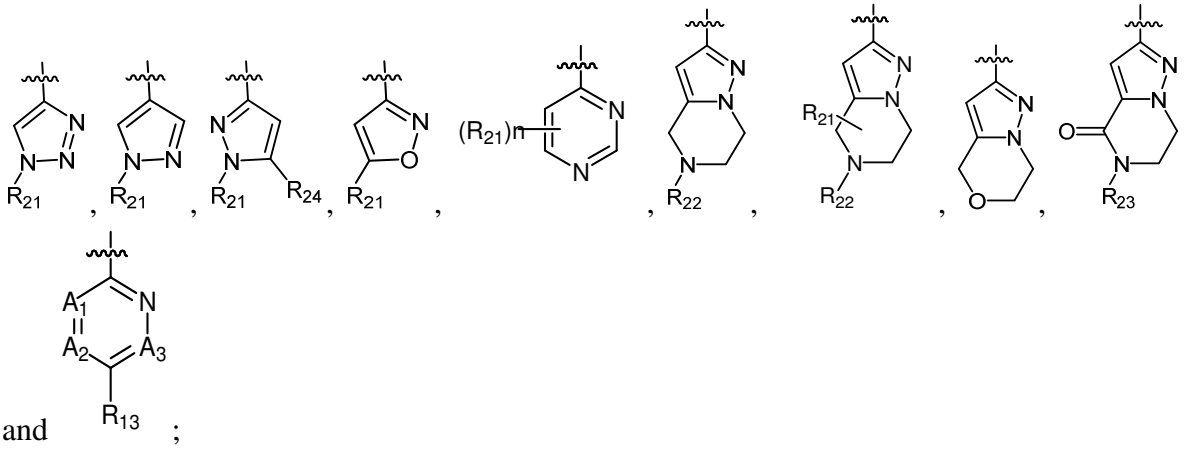
5. The compound of any one of claims 1-4, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein Y_2 is CH.

6. The compound of any one of claims 1-5, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_3 is hydrogen or halogen.

7. The compound of any one of claims 1-6, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_4 is C_{1-6} alkyl, -(C_{1-3} alkyl)-OH, -(C_{1-3} deuteroalkyl)-OH, -(C_{1-3} alkyl)-O-(C_{1-3} alkyl) or -CHO, wherein the C_{1-6} alkyl is optionally substituted with one or more halo.

8. The compound of any one of claims 1-7, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_3 is hydrogen, and R_4 is -(C_{1-3} alkyl)-OH.

9. The compound of any one of claims 1-8, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_5 is selected from



and ;

wherein

R_{21} is selected from C_{1-6} alkyl, C_{1-6} haloalkyl and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

n is 0, 1 or 2;

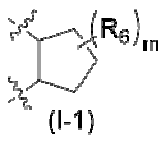
R_{22} and R_{23} are each independently selected from hydrogen, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), 4-6 membered heterocyclyl or -C(O)R_c, and R_c is selected from hydrogen, C_{1-6} alkyl or -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

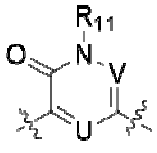
R_{24} is selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), or -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl;

A_1, A_2 and A_3 are each independently CH or N; and R_{13} is selected from:

1) hydrogen;
2) C_{1-6} alkyl;
3) C_{1-6} alkoxy;
4) halogen;
5) C_{3-6} cycloalkyl;
6) 3-12 membered heterocyclyl optionally substituted with one or more substituents selected from oxo, -CN, C_{1-6} alkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), 4-6 membered heterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl is optionally substituted with one or more -OH;
7) phenyl optionally substituted with one or more substituents selected from 4-6 membered heterocyclyl;
8) -NR_a'R_a'', wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -NR_e'R_e'', and R_e' and R_e'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl; and
9) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more C_{1-6} alkyl;

provided that if R_1 and R_2 together with the carbon atoms to which they are attached form the following structures:

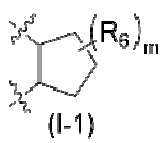


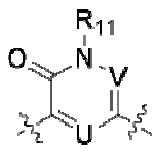
, and Cy is 

, then the 3-12 membered heterocyclyl, when substituted, is not piperazin-1-yl substituted with C_{1-6} alkyl at both 2- and 6- positions.

10. The compound of claim 9, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_{13} is piperazinyl optionally substituted with one or more substituents selected from C_{1-6} alkyl and 4-5 membered heterocyclyl;

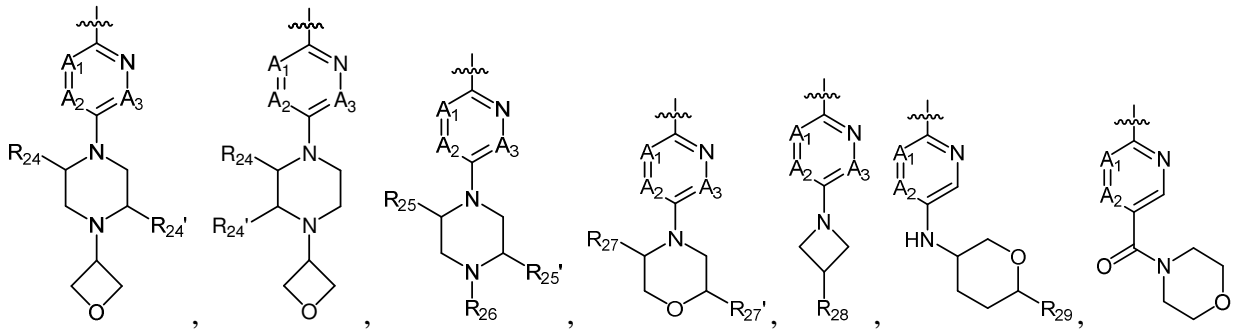
provided thatif R_1 and R_2 together with the carbon atoms to which they are attached form the following structures:

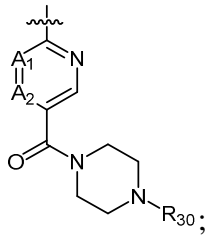


, and Cy is 

, then the 3-12 membered heterocyclyl, when substituted, is not piperazin-1-yl substituted with C_{1-6} alkyl at both 2- and 6- positions.

11. The compound of any one of claims 1-9, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_5 is selected from



and ;

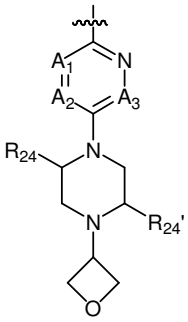
wherein R_{24}, R_{24}', R_{25}, R_{25}', R_{27} and R_{27}' are each independently selected from hydrogen, oxo and $C_{1\text{-}6}$ alkyl;

R_{26} is $C_{1\text{-}6}$ alkyl, -($C_{1\text{-}6}$ alkyl)-O-($C_{1\text{-}6}$ alkyl) or tetrahydrofuranyl;

R_{28} is $C_{1\text{-}6}$ alkoxy; R_{29} is hydrogen or -($C_{1\text{-}6}$ alkyl)-OH;

R_{30} is $C_{1\text{-}6}$ alkyl; and

A_1, A_2 and A_3 are each independently CH or N.

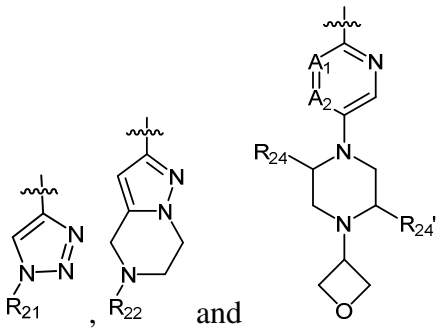
12. The compound of any one of claims 1-11, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_5 is , whereinA_1, A_2 and A_3 are each independently CH or N, and R_{24} and R_{24}' are each independently selected from hydrogen, oxo and $C_{1\text{-}6}$ alkyl.

13. The compound of claim 12, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_{24} and R_{24}' are each independently selected from hydrogen and $C_{1\text{-}6}$ alkyl.

14. The compound of any one of claims 12-13, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein

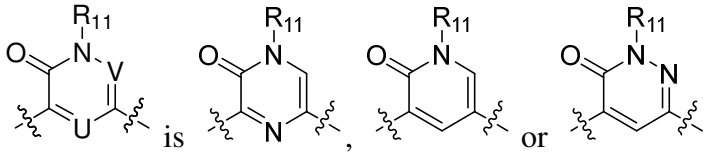
A_1, A_2 and A_3 are all CH, or A_1 is N, and both A_2 and A_3 are CH, or A_3 is N, and both A_1 and A_2 are CH.

15. The compound of any one of claims 1-9, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_5 is selected from:



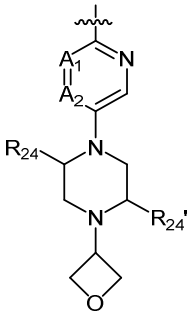
wherein R_{21} is C_{1-6} alkyl; R_{22} is selected from hydrogen, C_{1-6} alkyl and 4 membered heterocyclyl; A_1 and A_2 are respectively CH; and R_{24} and R_{24}' are each independently selected from hydrogen and C_{1-6} alkyl.

16. The compound of any one of claims 4-15, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein



is , , or , wherein R_{11} is C_{1-6} alkyl or C_{1-6} deuteroalkyl.

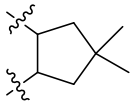
17. The compound of claim 4, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein both X_1 and X_2 are CH; Y_2 is CH; R_3 is hydrogen; R_4 is -(C_{1-3} alkyl)-OH; U is CH, V is N or CH, and

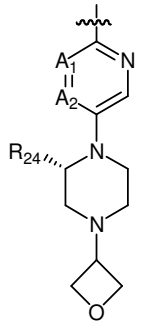
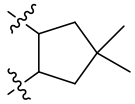


R_{11} is C_{1-3} alkyl; R_5 is selected from , whereinR_{24} and R_{24}' are each independently selected from hydrogen, oxo and C_{1-6} alkyl, both A_1 and A_2 are CH, or A_1 is N and A_2 is CH; R_6 is C_{1-6} alkyl; and m is 0 or 2.

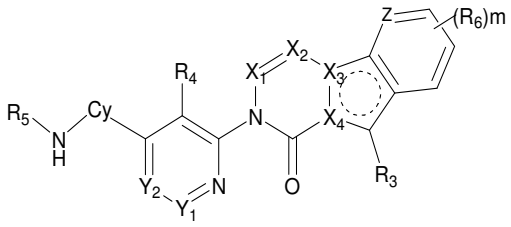
18. The compound of any one of claims 4-17, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein both U and V are CH, and R_{11} is methyl.

19. The compound of any one of claims 1-18, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_6 is C_{1-3} alkyl; and m is 2.

20. The compound of any one of claims 1-19, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_6 together with the five-membered ring to which they are attached forms .

21. The compound of claim 4, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein both X_1 and X_2 are CH; Y_2 is CH; R_3 is hydrogen; R_4 is -(C_{1-3} alkyl)-OH; both U and V are CH, and R_{11} is methyl; R_5 is selected from , wherein R_{24} is C_{1-3} alkyl, and both A_1 and A_2 are CH; and R_6 together with the five-membered ring to which they are attached forms .

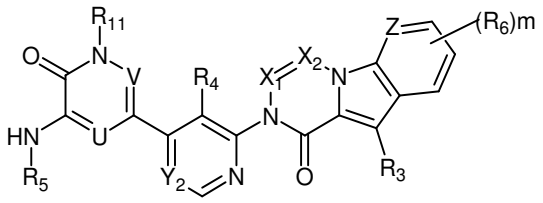
22. The compound of claim 1, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein the compound is a compound of formula (IB)



(IB)

.

23. The compound of claim 22, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein the compound is a compound of formula (IV):



(IV)

wherein

X_1 and X_2 are each independently CH;

Y_2 is CH or N;

R_3 is hydrogen, deuterium, halogen or C_{1-6} haloalkyl;

R_4 is hydrogen, halogen, -CN, C_{1-6} alkyl, -(C_{1-3} alkyl)-OH, -(C_{1-3} deuteroalkyl)-OH, -(C_{1-3} alkyl)-O-(C_{1-3} alkyl), -O-(C_{1-3} alkyl), -CHO, -C(O)NH_2, -C(O)$NHCH_3$, -C(O)$N(CH_3)_2$ or 3-hydroxyl-oxetan-3-yl, wherein the C_{1-6} alkyl is optionally substituted with one or more halo;

U and V are each independently selected from N or CH;

Z is N or CH;

R_5 is hydrogen, C_{1-6} alkyl, -C(O)-(C_{1-6} alkyl), -C(O)-(C_{3-6} cycloalkyl), -C(O)-phenyl, -C(O)NH-(C_{1-6} alkyl), -C(O)NH-(C_{3-6} cycloalkyl), -C(O)N(C_{1-6} alkyl)$_2$, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl, wherein the C_{1-6} alkyl, C_{3-6} cycloalkyl, phenyl, 5-6 membered monocyclic heteroaryl or 8-10 membered bicyclic heteroaryl is each optionally substituted with one or more groups selected from:

1) halogen;
2) oxo;
3) -CN;
4) C_{1-6} alkyl;
5) C_{2-6} alkenyl;
6) C_{2-6} alkynyl;
7) C_{1-6} alkoxy;
8) C_{1-6} haloalkyl;
9) -(C_{1-6} alkyl)-OH;
10) -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);
11) C_{3-6} cycloalkyl;
12) 3-12 membered heterocyclyl optionally substituted with one or more substituents selected from halogen, hydroxyl, oxo, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, C_{3-6} cycloalkyl, C_{2-6} alkynyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-OH, 4-6 membered heterocyclyl, 4-6 membered fluoroheterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl is optionally substituted with one or more -OH;
13) 5-6 membered monocyclic heteroaryl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2,

-(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;

14) phenyl optionally substituted with one or more substituents selected from halogen, -CN, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-OH, C_{1-6} alkyl, C_{3-6} cycloalkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O(C_{1-6} alkyl), -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and 4-6 membered heterocyclyl;

15) -NR_a'R_a'', wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, C_{3-6} cycloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents of -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -NR_e'R_e'', and R_e' and R_e'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl;

16) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more substituents selected from halogen, -OH, C_{1-6} alkyl, -(C_{1-6} alkyl)-NH_2, -(C_{1-6} alkyl)-NH(C_{1-6} alkyl), -(C_{1-6} alkyl)-N(C_{1-6} alkyl)$_2$, -(C_{1-6} alkyl)-NH(C_{3-6} cycloalkyl) and -(C_{1-6} alkyl)-OH; and

17) -C(O)R_c, wherein R_c is selected from hydrogen, C_{1-6} alkyl, C_{2-6} alkenyl, C_{2-6} alkynyl and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

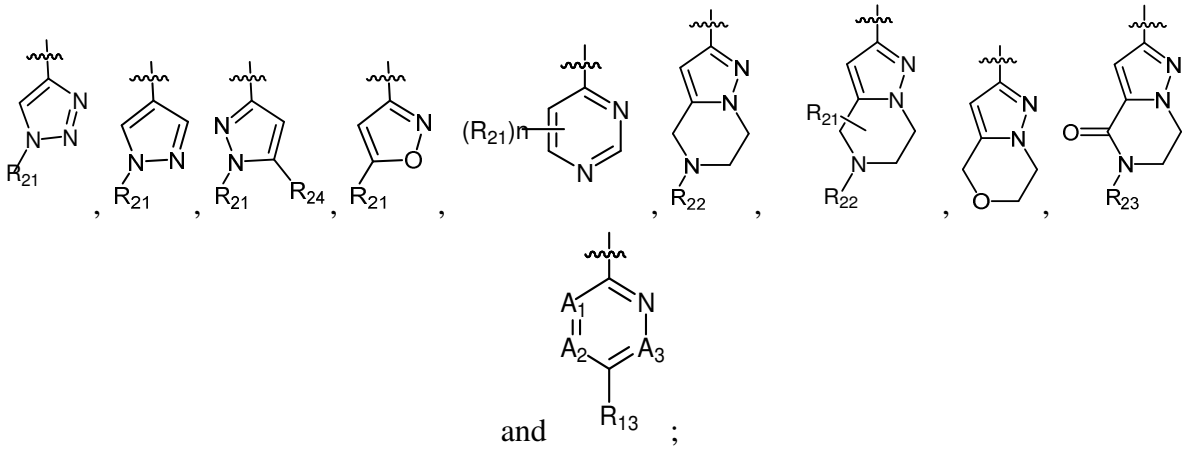
R_6 is halogen, C_{1-6} alkyl or hydroxyl;

m is 0, 1, 2 or 3; and

R_{11} is hydrogen, C_{1-6} alkyl or C_{1-6} deuteroalkyl.

24. The compound of any one of claims 22-23, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein Y_2 is CH.

25. The compound of any one of claims 22-24, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein R_5 is selected from:



and ;

wherein

R_{21} is selected from C_{1-6} alkyl, C_{1-6} haloalkyl and -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

n is 0, 1 or 2;

R_{22} and R_{23} are each independently selected from hydrogen, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), 4-6 membered heterocyclyl or -C(O)R_c, and R_c is selected from hydrogen, C_{1-6} alkyl or -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

R_{24} is selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), or -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl;

A_1, A_2 and A_3 are each independently CH or N; and

R_{13} is selected from:

1) hydrogen;

2) C_{1-6} alkyl;

3) C_{1-6} alkoxy;

4) halogen;

5) C_{3-6} cycloalkyl;

6) 4-8 membered heterocyclyl optionally substituted with one or more substituents selected from oxo, -CN, C_{1-6} alkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-CN, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), 4-6 membered heterocyclyl and deuterated 4-6 membered heterocyclyl, wherein the C_{1-6} alkyl is optionally substituted with one or more -OH;

7) phenyl optionally substituted with one or more substituents selected from 4-6 membered heterocyclyl;

8) -NR_a'R_a'', wherein R_a' and R_a'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more -(C_{1-6} alkyl)-OH, the C_{1-6} alkyl is optionally substituted with one or more -NR_e'R_e'', and R_e' and R_e'' are each independently selected from hydrogen, C_{1-6} alkyl, -(C_{1-6} alkyl)-OH and 4-6 membered heterocyclyl; and

9) -C(O)NR_b'R_b'', wherein R_b' and R_b'' together with the N atoms to which they are attached form 4-6 membered heterocyclyl, wherein the 4-6 membered heterocyclyl is optionally substituted with one or more C_{1-6} alkyl.

26. The compound of any one of claims 22-25, or a pharmaceutically acceptable salt thereof, or a solvate, a racemic mixture, an enantiomer, a diastereomer or a tautomer thereof, wherein

both X_1 and X_2 are CH;

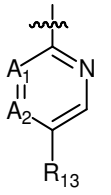
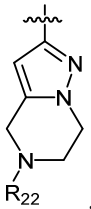
Y_2 is CH;

R_3 is hydrogen;

R_4 is -(C_{1-3} alkyl)-OH;

Z is CH;

U is CH, and V is N or CH;

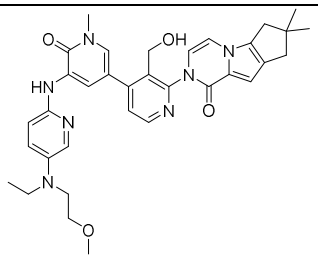
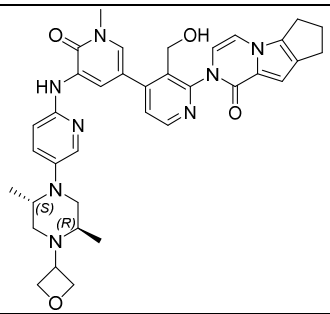
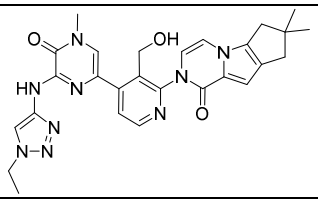
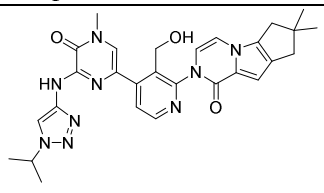
R_5 is  or , wherein A_1 and A_2 are each independently CH or N, and R_{13} is 4-6 membered heterocyclyl optionally substituted with one or more substituents selected from oxo, C_{1-6} alkyl, C_{1-6} alkoxy, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl) and 4-6 membered heterocyclyl; R_{22} is selected from hydrogen, -CN, C_{1-6} alkyl, C_{1-6} haloalkyl, -(C_{1-6} alkyl)-O-(C_{1-6} alkyl), 4-6 membered heterocyclyl or -C(O)R_c, and R_c is selected from hydrogen, C_{1-6} alkyl or -(C_{1-6} alkyl)-O-(C_{1-6} alkyl);

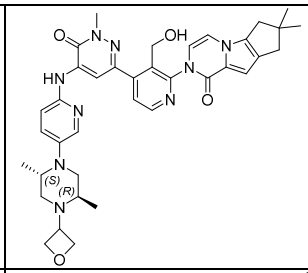
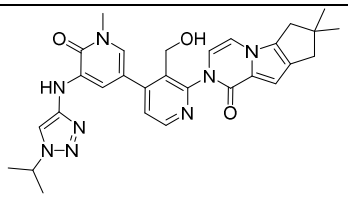
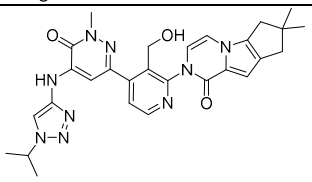
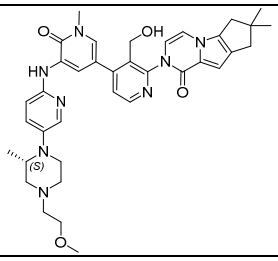
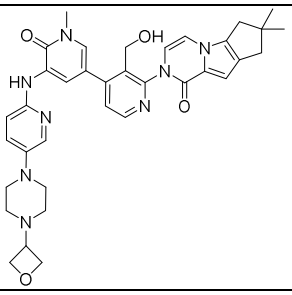
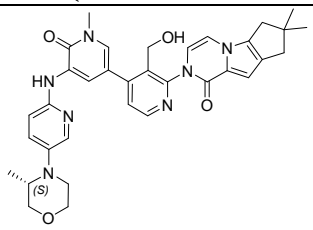
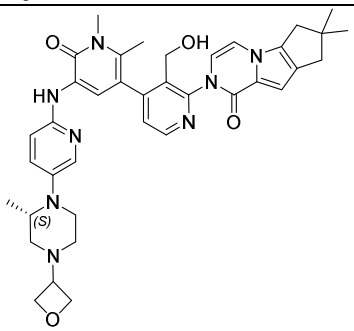
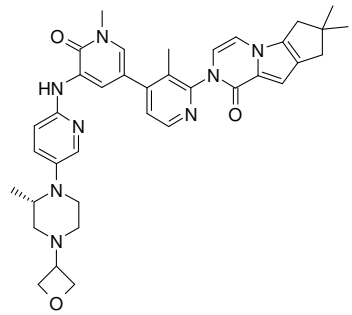
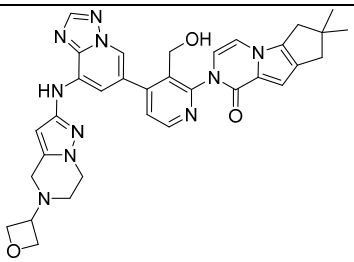
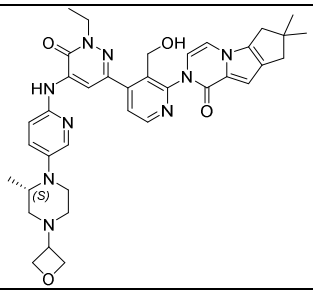
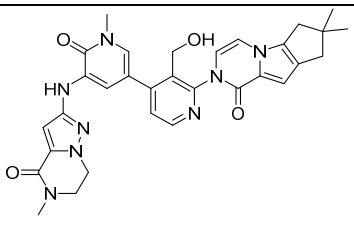
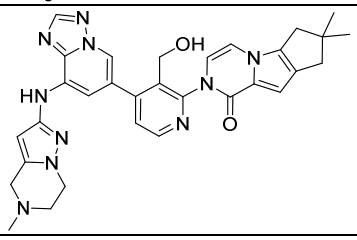
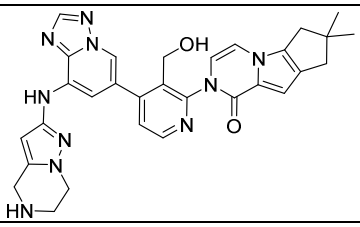
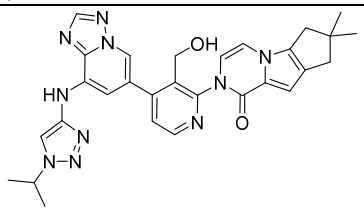
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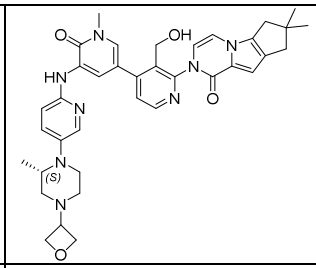
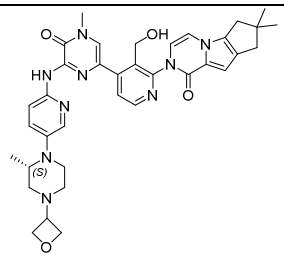
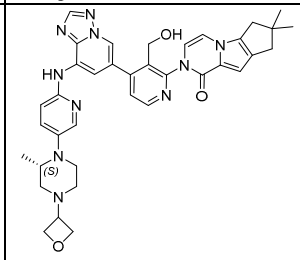
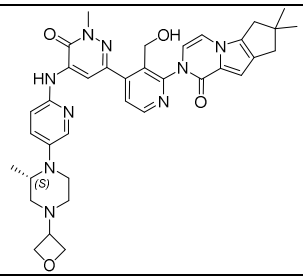
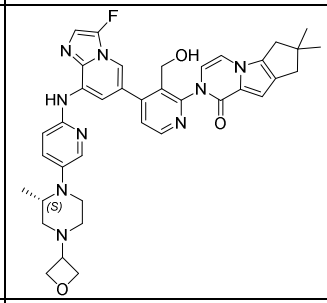
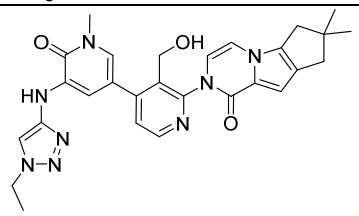
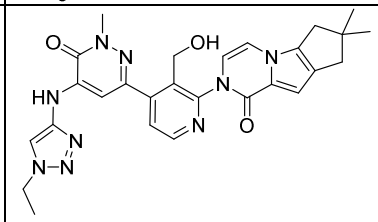
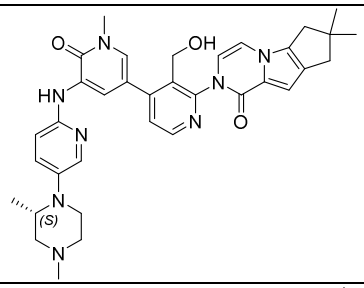
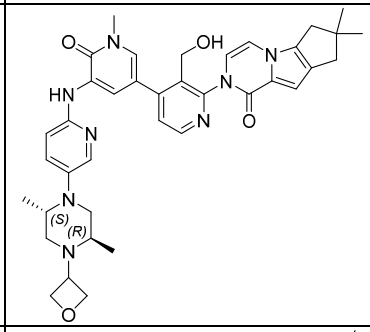
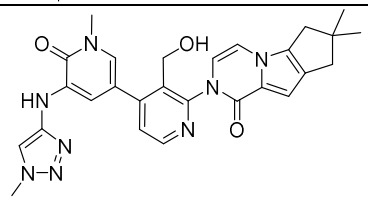
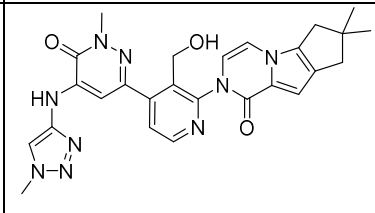
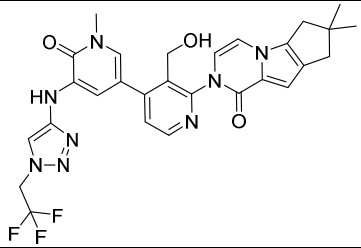
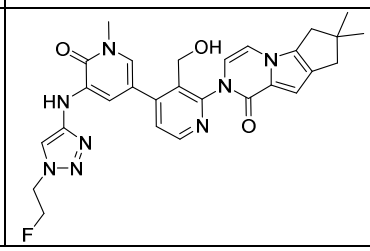
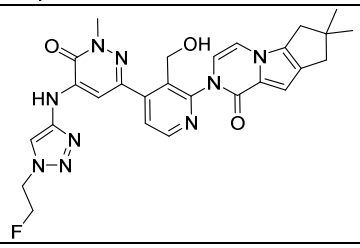
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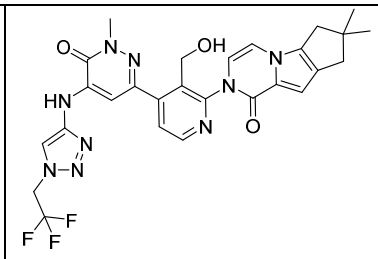
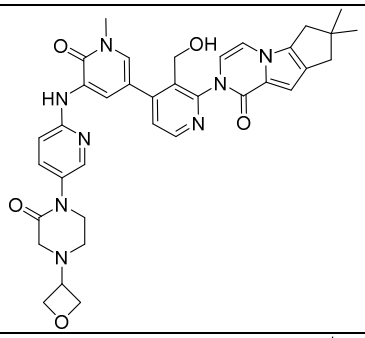
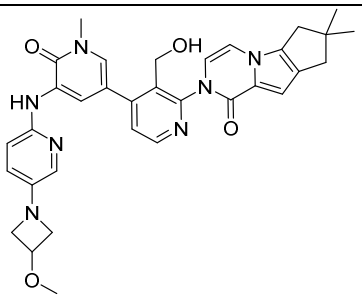
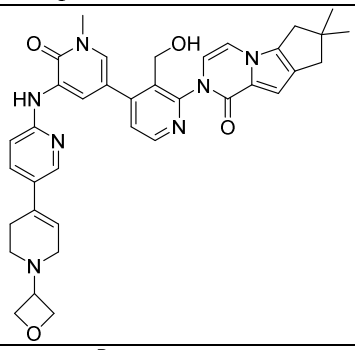
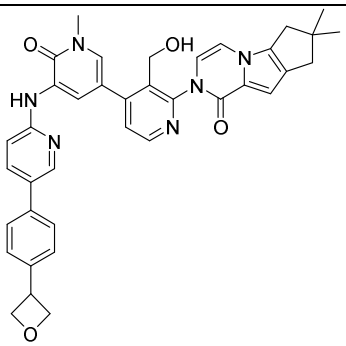
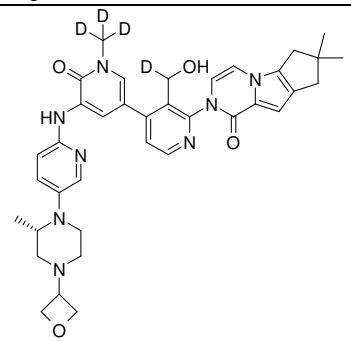
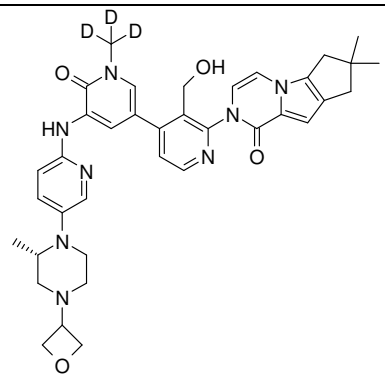
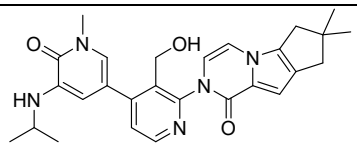
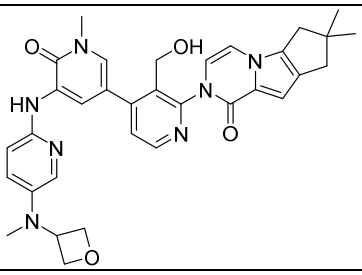
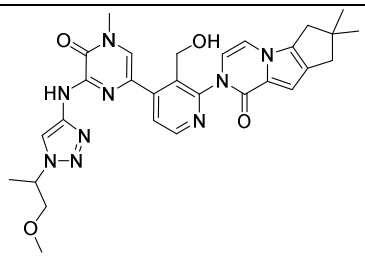
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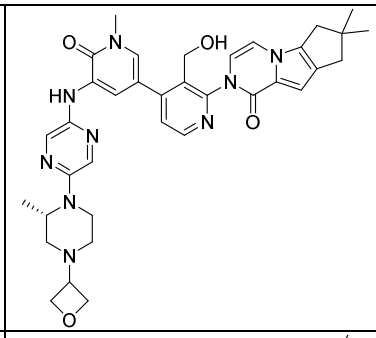
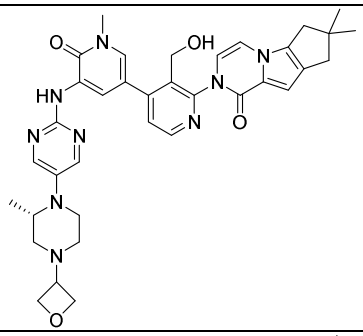
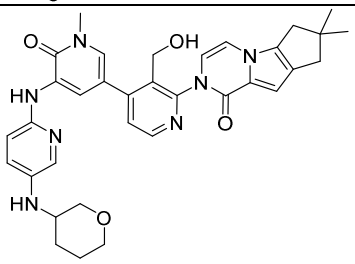
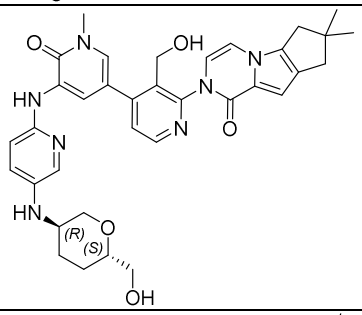
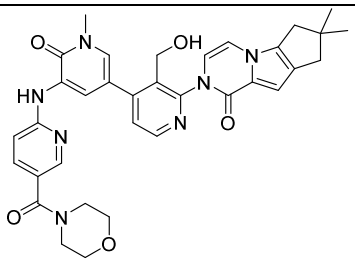
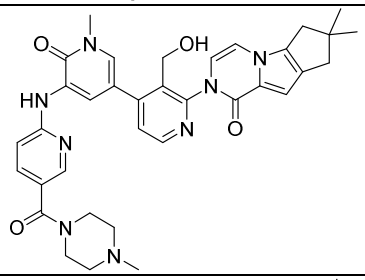
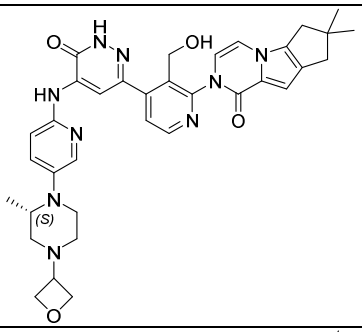
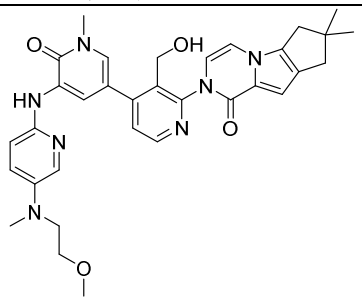
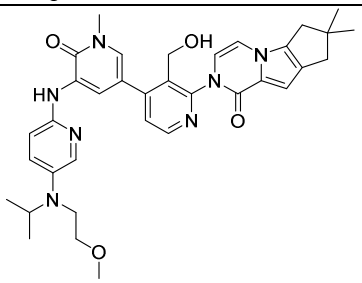
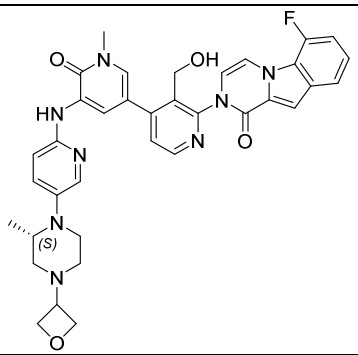
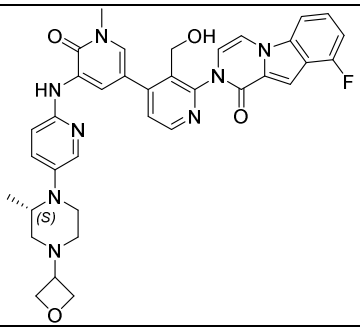
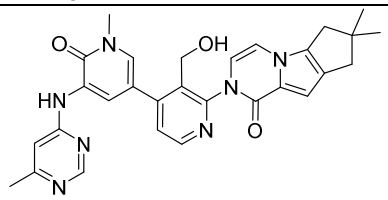
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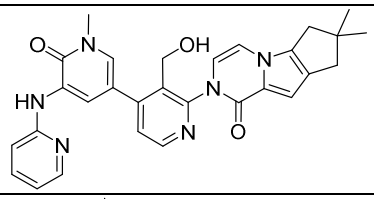
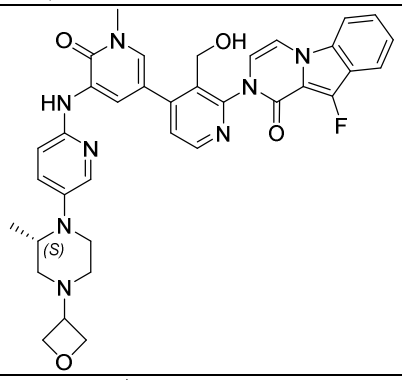
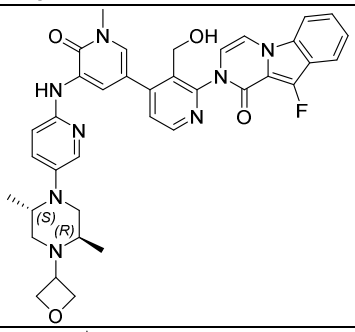
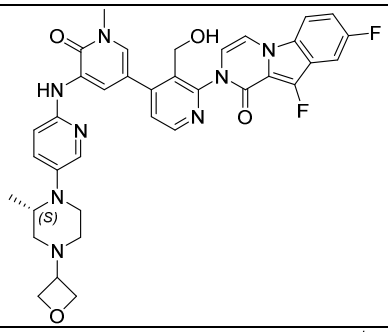
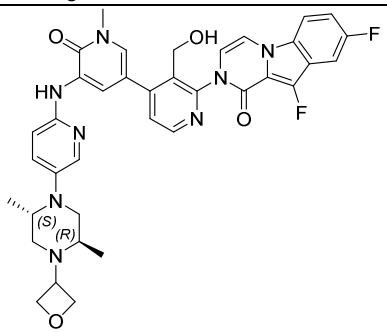
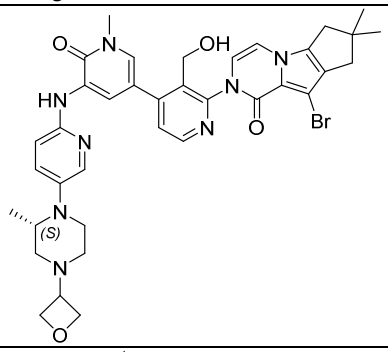
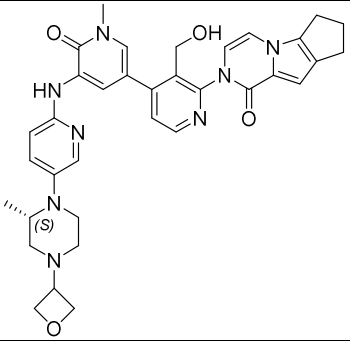
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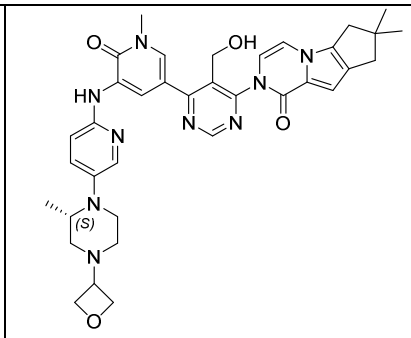
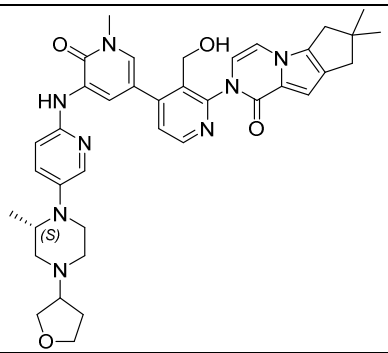
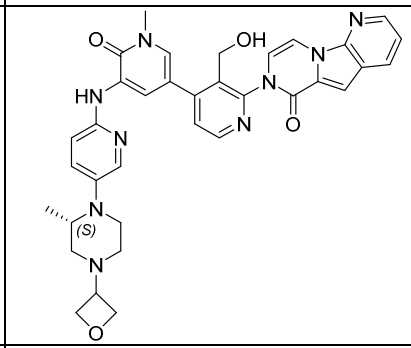
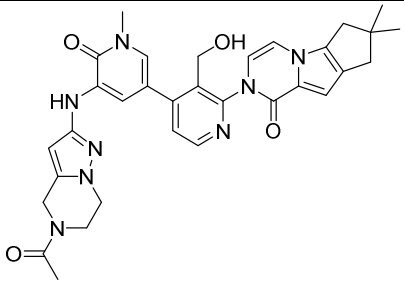
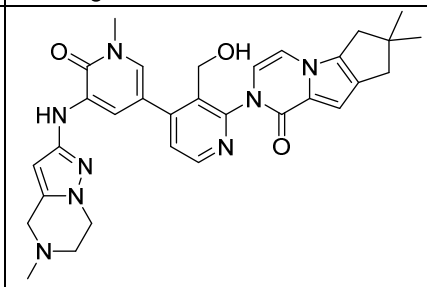
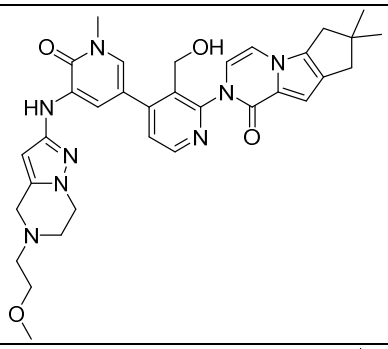
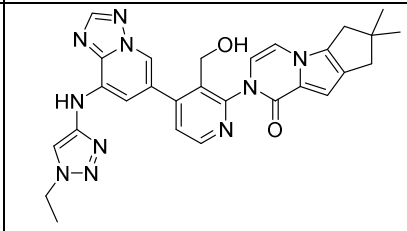
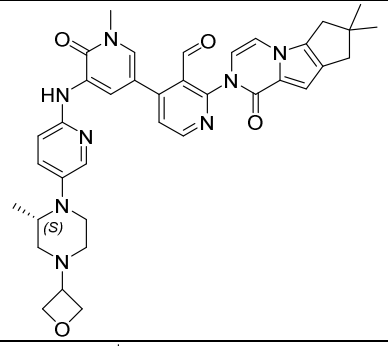
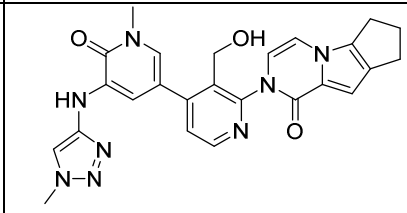
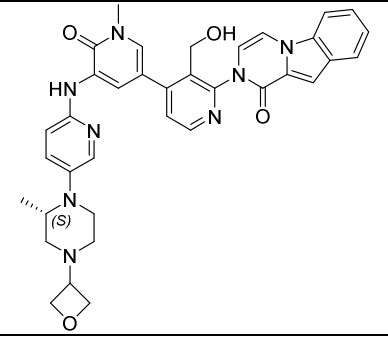
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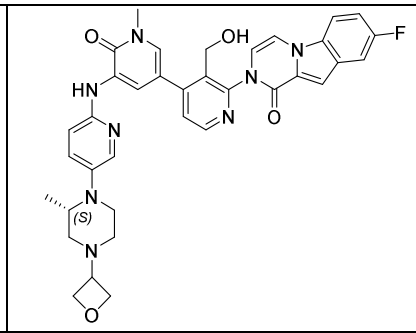
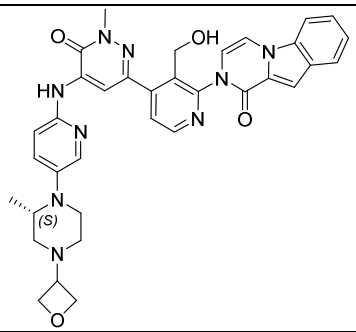
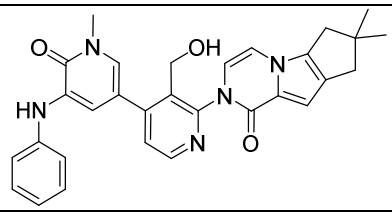
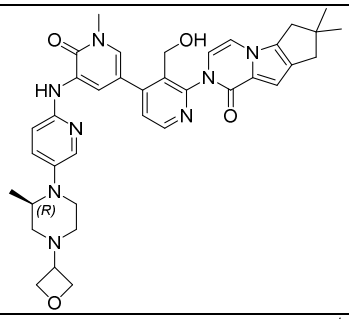
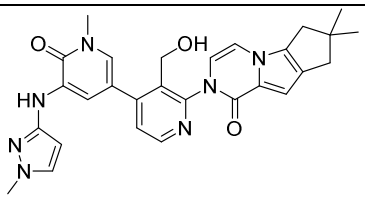
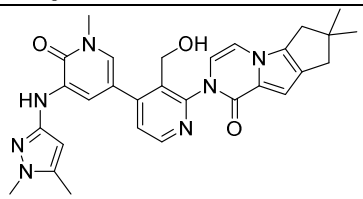
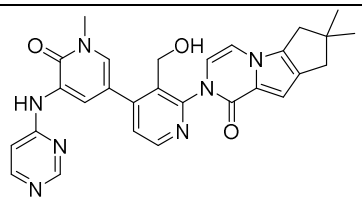
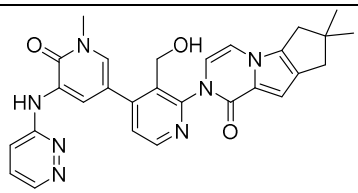
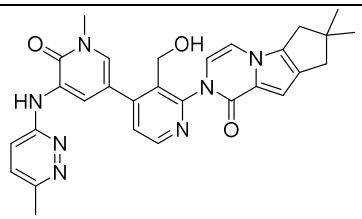
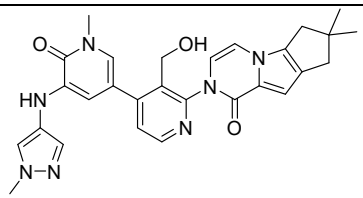
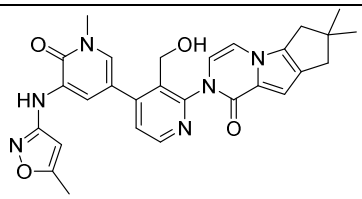
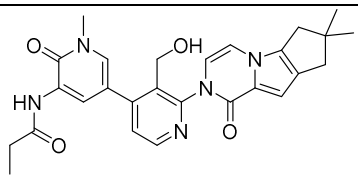
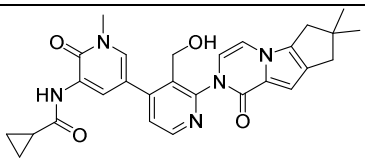
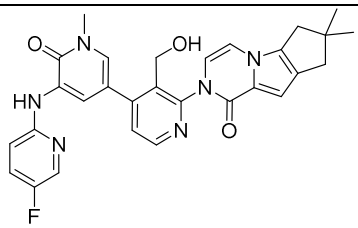
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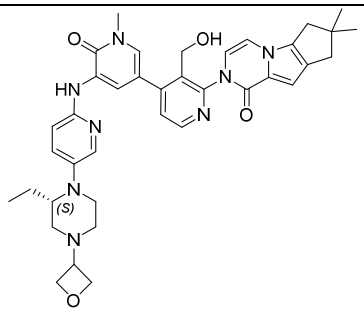
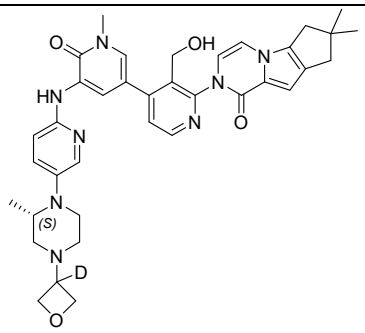
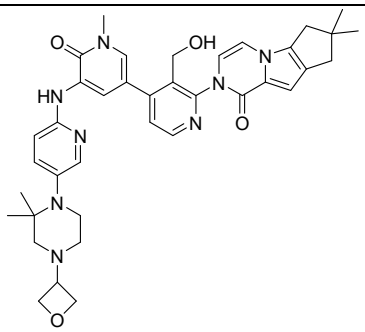
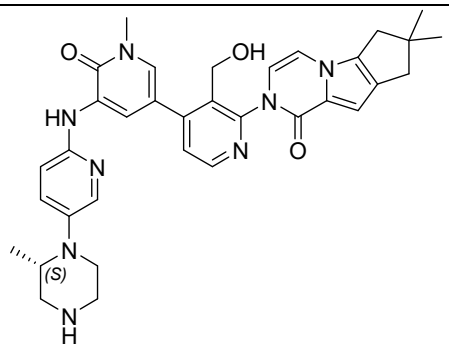
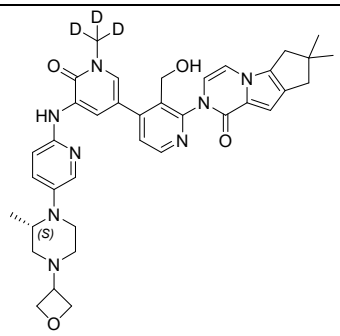
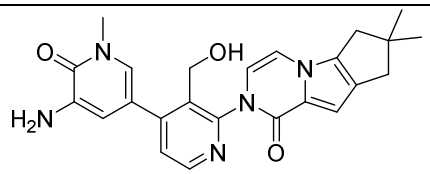
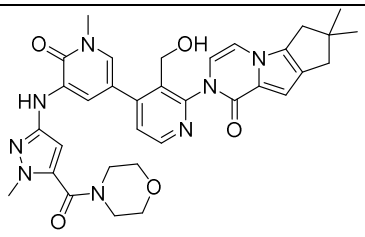
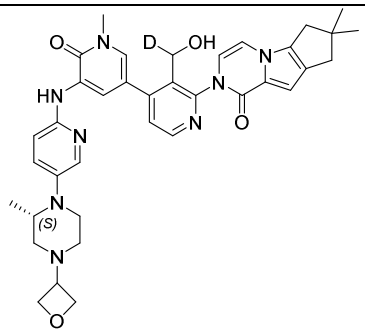
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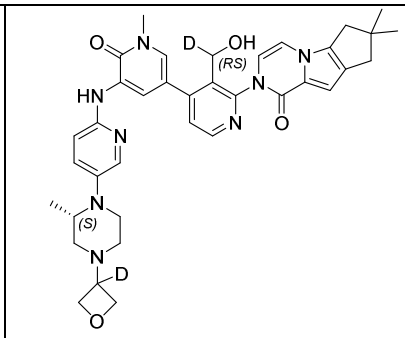
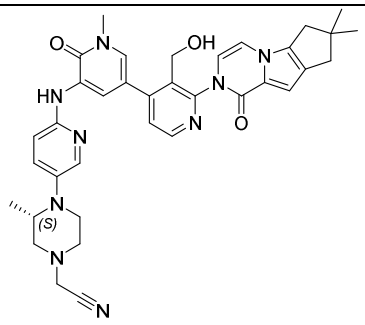
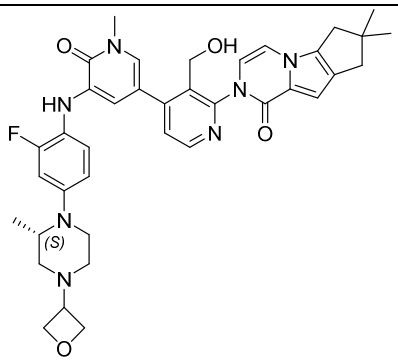
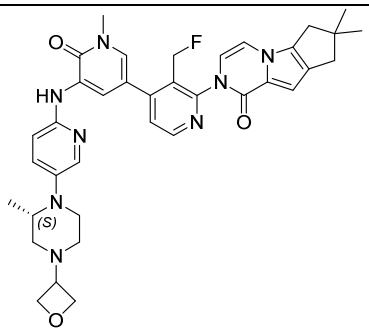
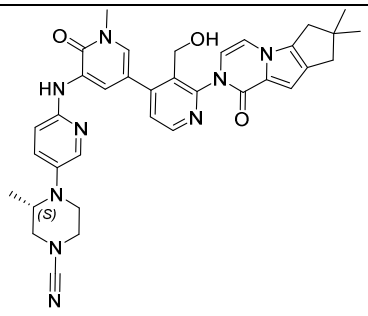
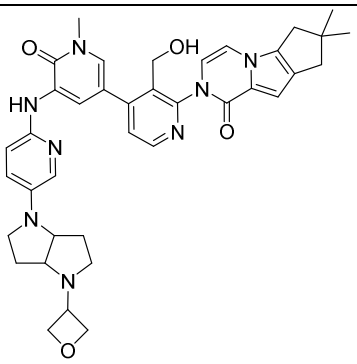
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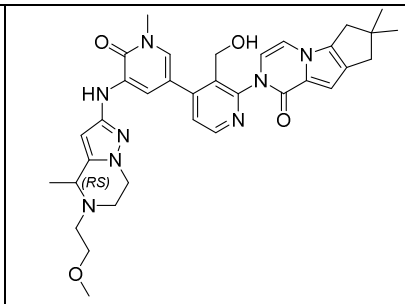
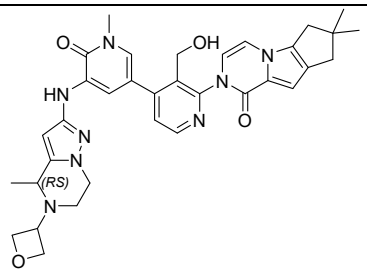
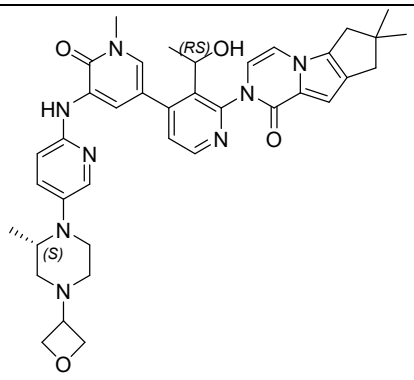
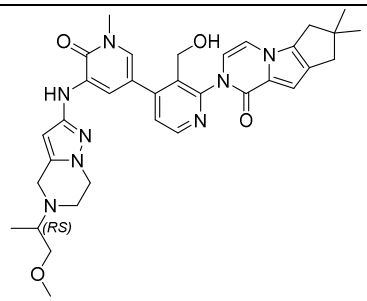
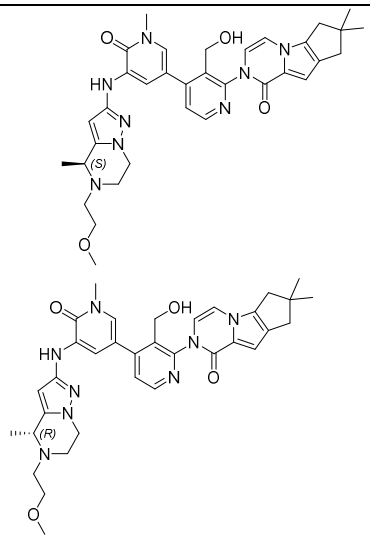
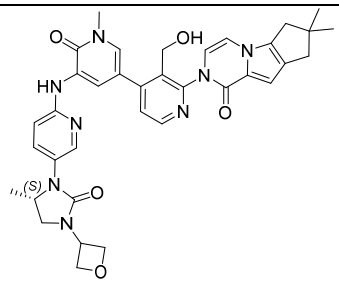
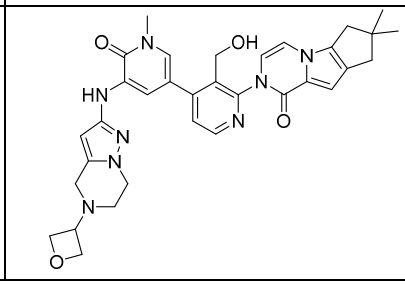
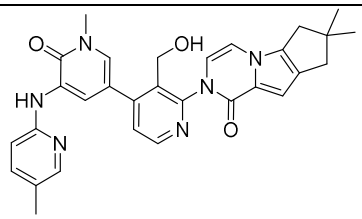
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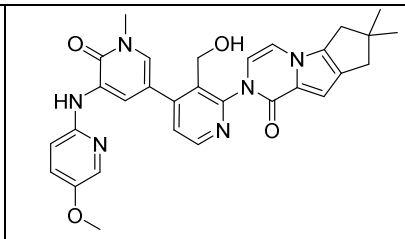
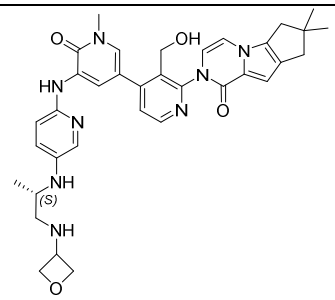
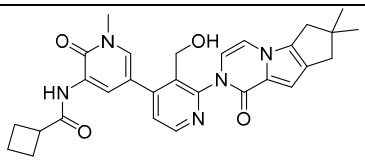
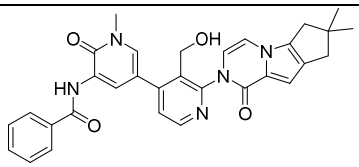
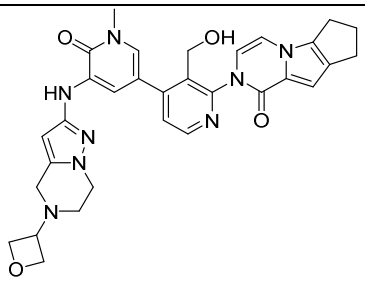
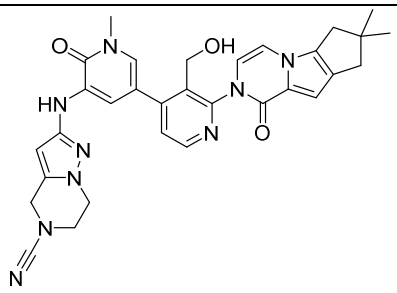
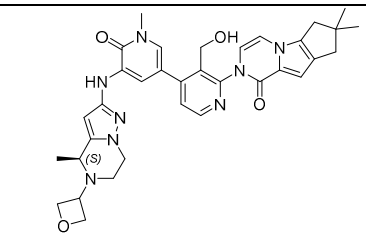
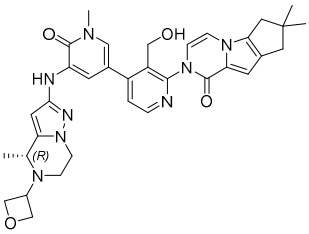
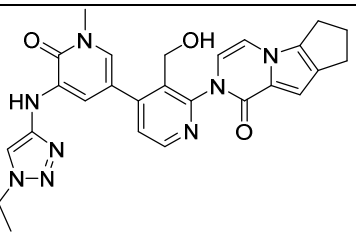
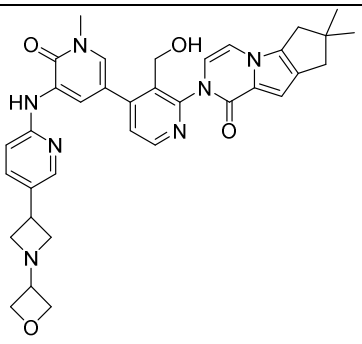
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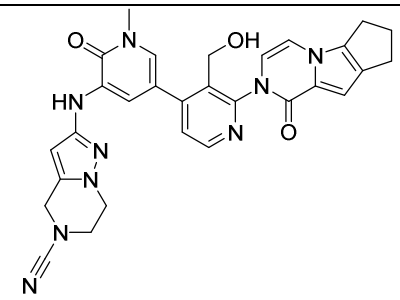
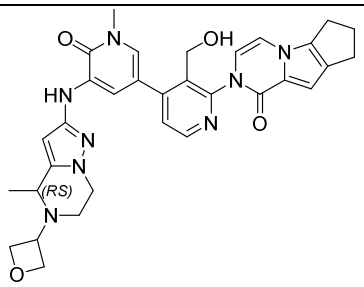
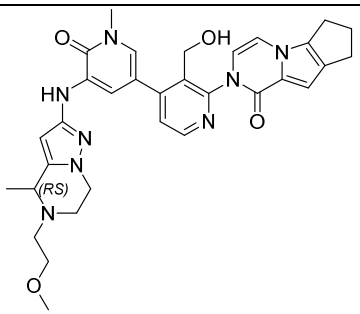
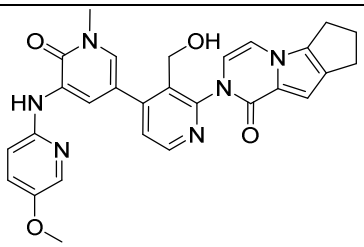
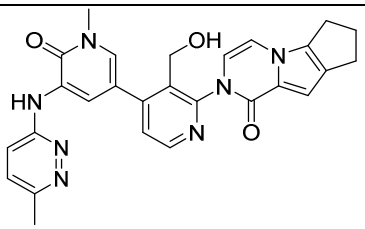
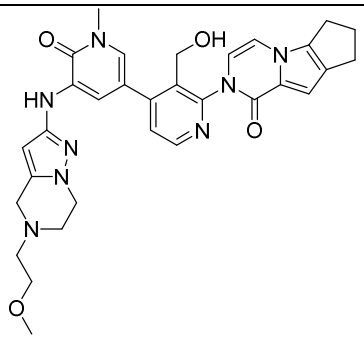
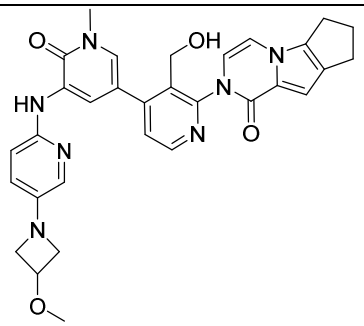
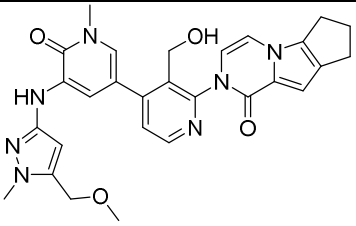
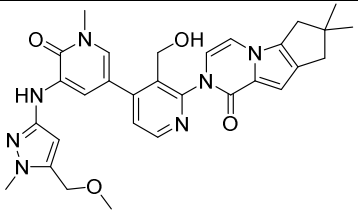
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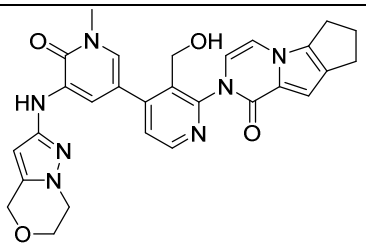
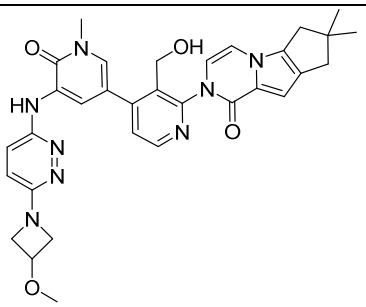
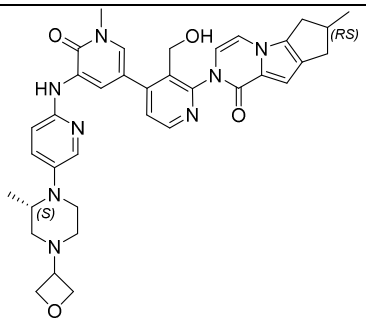
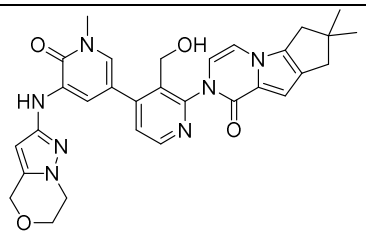
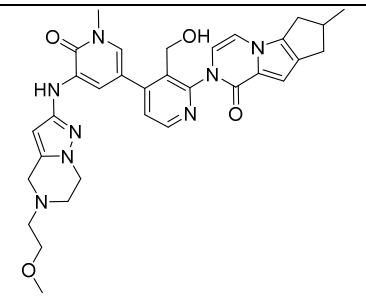
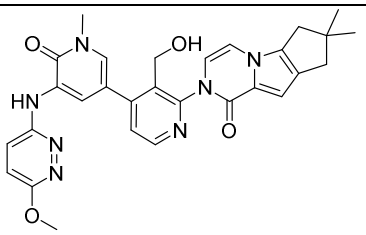
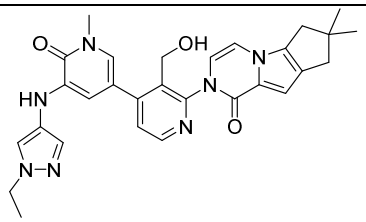
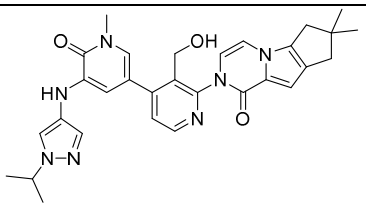
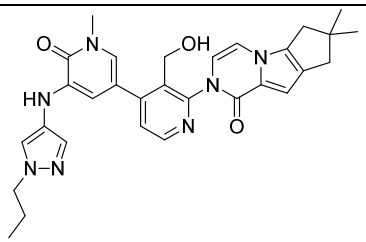
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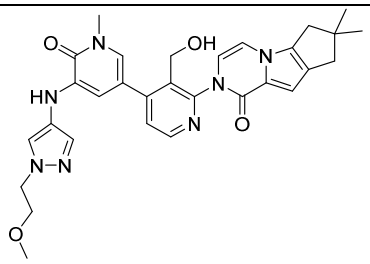
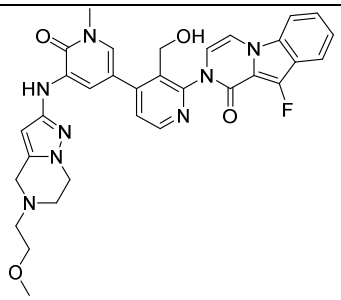
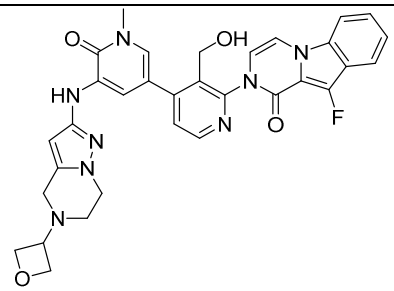
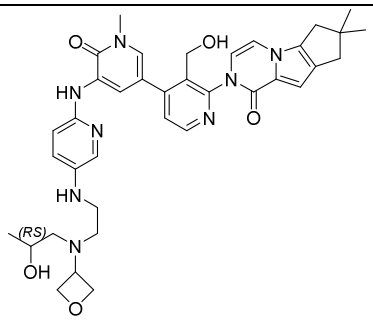
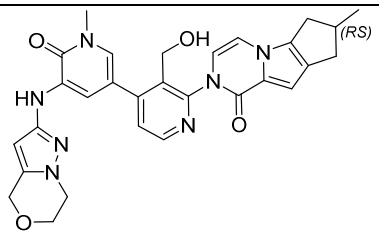
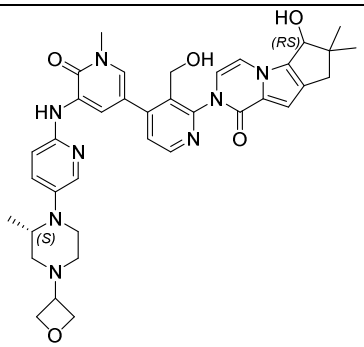
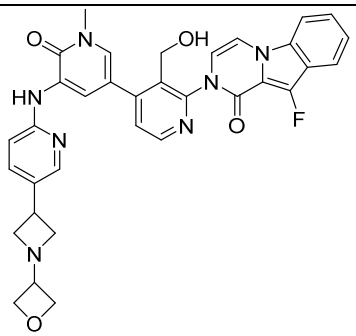
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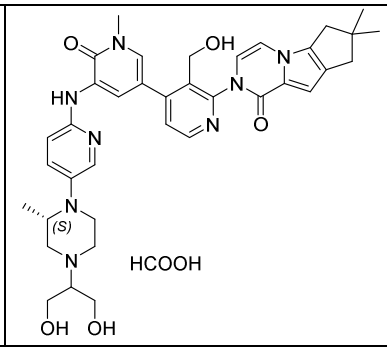
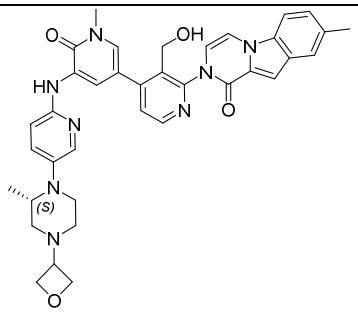
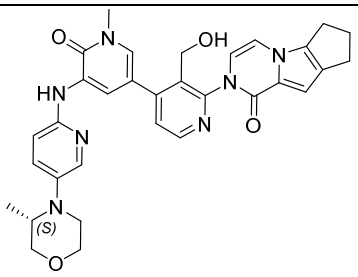
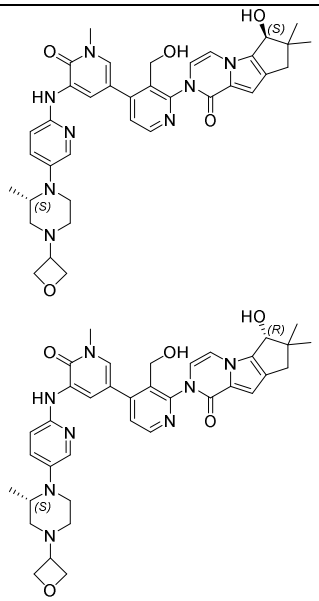
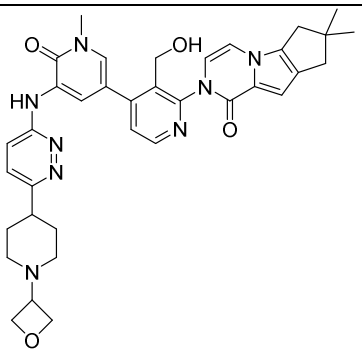
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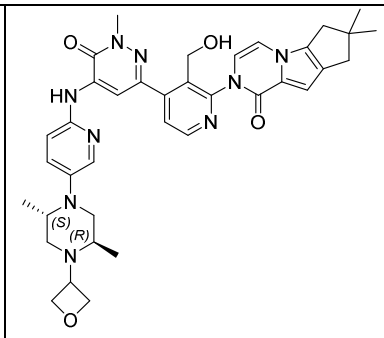
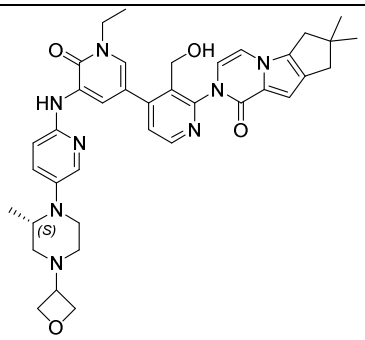
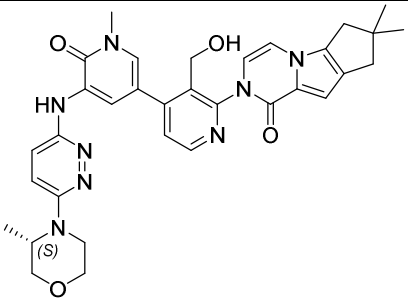
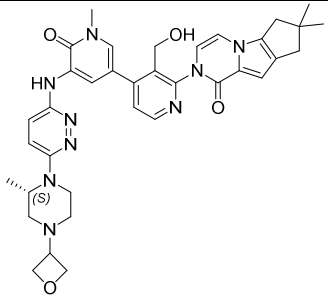
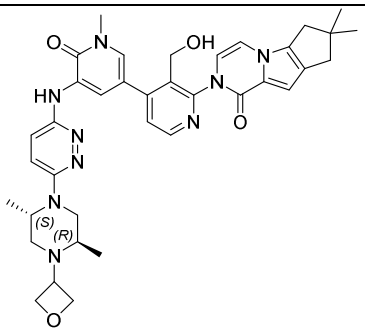
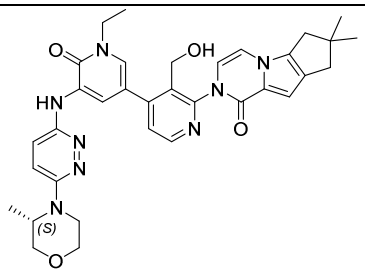
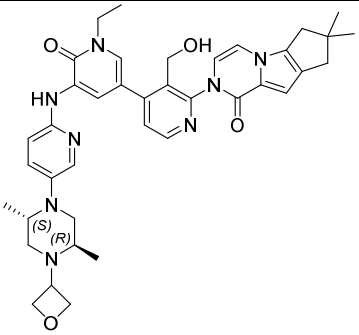
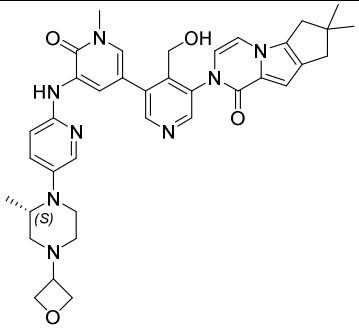
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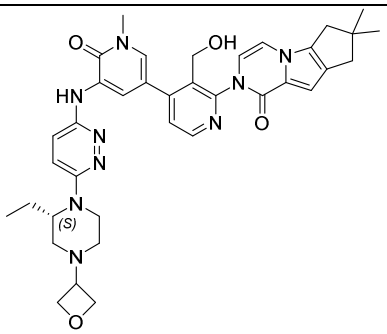
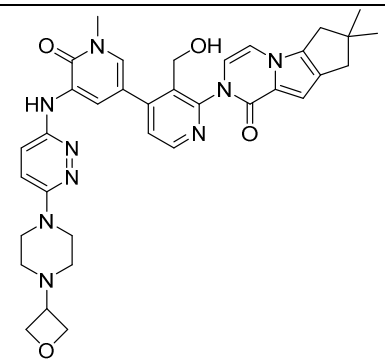
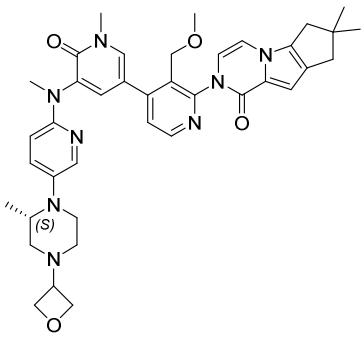
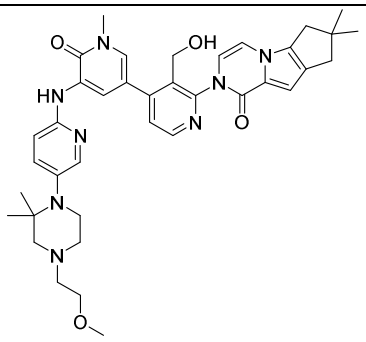
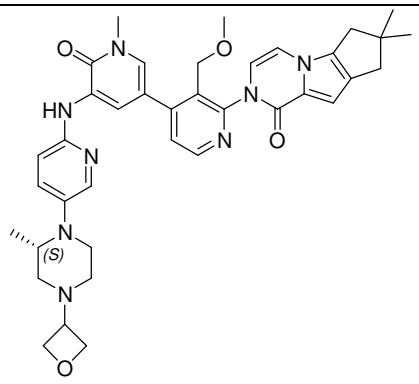
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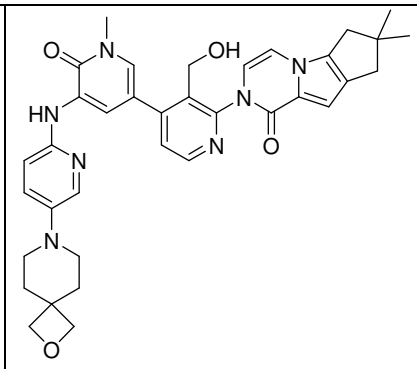
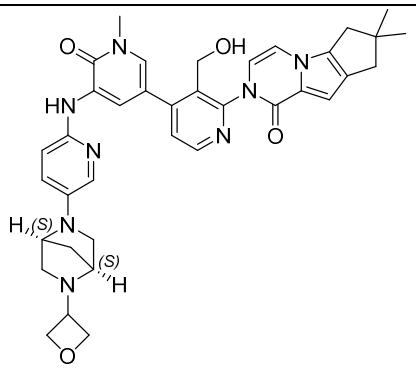
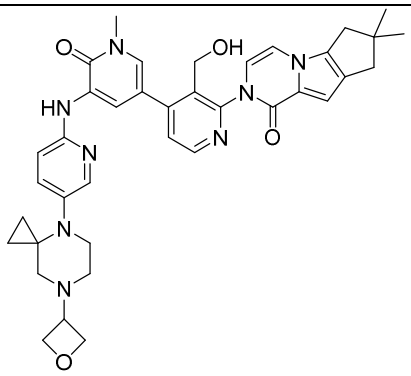
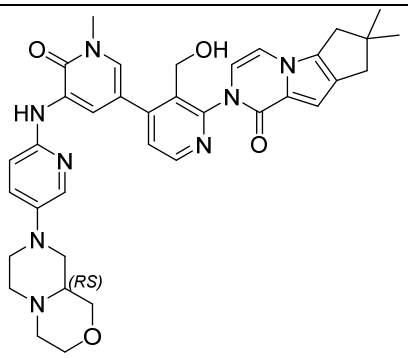
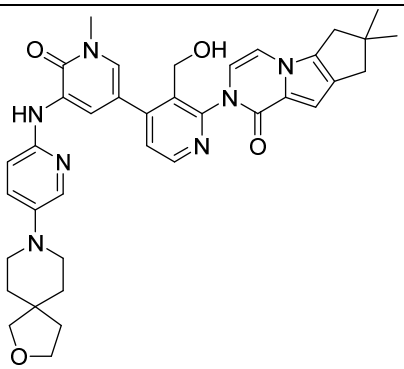
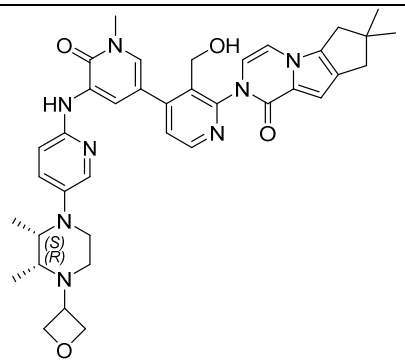
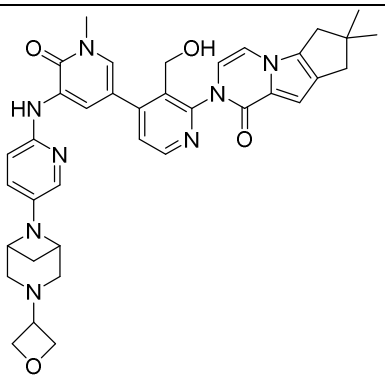
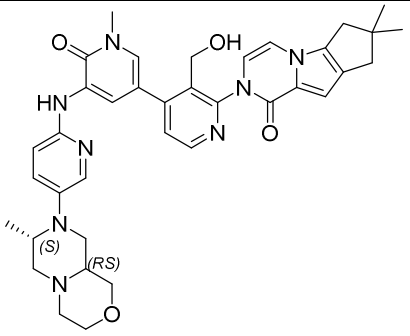
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28. A pharmaceutical composition, comprising the compound of any one of claims 1-27 and/or a pharmaceutically acceptable salt thereof, and optionally comprising a pharmaceutically acceptable excipient.

29. A method of *in vitro* inhibiting the activity of BTK, comprising contacting BTK with an effective amount of the compound of any one of claims 1-27, and/or a pharmaceutically acceptable salt thereof.

30. Use of the compound of any one of claims 1-27 and/or a pharmaceutically acceptable salt thereof in the manufacture of a medicament for treating or preventing cancer, an inflammatory disease or autoimmune disease, wherein the cancer is preferably solid tumor or hematologic malignancy, including lymphoma, leukemia and myeloma; the cancer is more preferably selected from B cell malignancy, diffuse large B-cell lymphoma (DLBCL), large B-cell lymphoma (LBCL), B-cell lymphoma, mantle cell lymphoma, follicular lymphoma, non-Hodgkin's lymphoma, Hodgkin's lymphoma, Waldenstrom macroglobulinemia, marginal zone lymphoma, Burkitt's lymphoma, non-Burkitt's high-grade B cell malignant lymphoma, extranodal marginal-zone B-cell lymphoma, small lymphotic lymphoma (SLL), lymphoblastic lymphoma, lymphocytic leukemia, myelogenous leukemia, acute myelogenous leukemia (AML), chronic myelogenous leukemia (CML), human acute monocytic leukemia, acute lymphocytic leukemia (ALL), B cell acute lymphocytic leukemia (B-ALL), hairy cell leukemia, chronic lymphocytic leukemia (CLL) (such as high risk CLL), myelodysplastic syndrome, acute lymphoblastic leukemia, myeloma (such as multiple myeloma) or graft versus host disease; and the inflammatory disease or autoimmune disease is preferably selected from: systemic inflammation and local inflammation, arthritis, rheumatoid arthritis, inflammation associated with immunosuppression, organ-graft rejection, allergic disease, ulcerative colitis, Crohn's disease, dermatitis, asthma, lupus erythematosus, Sjogren syndrome, multiple sclerosis, scleroderma, osteoporosis, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, antineutrophil cytoplasmatic antibody vasculitis, chronic obstructive pulmonary disease, psoriasis, sicca syndrome, pemphigus vulgaris, and diseases associated with kidney transplantation.

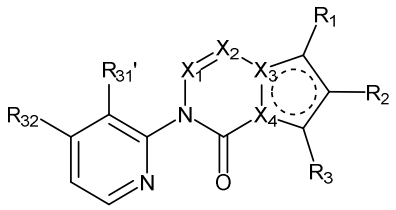
31. The compound of any one of claims 1-27 and/or a pharmaceutically acceptable salt thereof, for use as a medicament.

32. The compound of any one of claims 1-27 and/or a pharmaceutically acceptable salt thereof, for use in treating or preventing cancer, an inflammatory disease or autoimmune disease, wherein the cancer is preferably solid tumor or hematologic malignancy, including lymphoma, leukemia and myeloma; the cancer is more preferably selected from B cell malignancy, diffuse large B-cell lymphoma (DLBCL), large B-cell lymphoma (LBCL), B-cell lymphoma, mantle cell lymphoma, follicular lymphoma, non-Hodgkin's lymphoma, Hodgkin's lymphoma, Waldenstrom macroglobulinemia, marginal zone lymphoma, Burkitt's lymphoma, non-Burkitt's high-grade B cell malignant lymphoma, extranodal marginal-zone B-cell lymphoma, small lymphotic lymphoma (SLL), lymphoblastic lymphoma, lymphocytic leukemia, myelogenous leukemia, acute myelogenous leukemia (AML), chronic myelogenous leukemia (CML), human acute monocytic leukemia, acute lymphocytic leukemia (ALL), B cell acute lymphocytic leukemia (B-ALL), hairy cell leukemia, chronic lymphocytic leukemia (CLL) (such as high risk CLL), myelodysplastic syndrome, acute lymphoblastic leukemia, myeloma (such as multiple myeloma) or graft versus host disease; and the inflammatory disease or autoimmune disease is preferably

selected from: systemic inflammation and local inflammation, arthritis, rheumatoid arthritis, inflammation associated with immunosuppression, organ-graft rejection, allergic disease, ulcerative colitis, Crohn's disease, dermatitis, asthma, lupus erythematosus, Sjogren syndrome, multiple sclerosis, scleroderma, osteoporosis, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, antineutrophil cytoplasmatic antibody vasculitis, chronic obstructive pulmonary disease, psoriasis, sicca syndrome, pemphigus vulgaris, and diseases associated with kidney transplantation.

33. A pharmaceutical combination, comprising the compound of any one of claims 1-27 and/or a pharmaceutically acceptable salt thereof, and at least one additional therapeutic agent, wherein the therapeutic agent is preferably selected from: an anti-inflammatory agent, an immunomodulator or an anti-tumor active agent, wherein the anti-tumor active agent includes a chemotherapeutic agent, an immune checkpoint inhibitor or agonist, and a targeted therapeutic agent.

34. A compound of formula (VI):

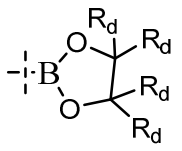
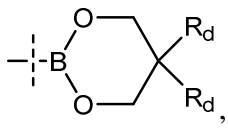


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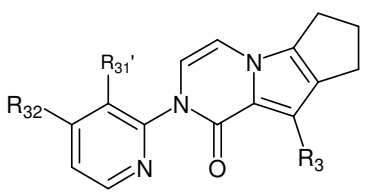
or a solvate, a racemic mixture, an enantiomer, a diastereomer and a tautomer thereof, wherein

X_1, X_2, X_3, X_4, R_1, R_2 and R_3 are as defined in any one of claims 1-27;

$R_{31'}$ is -CHO, -C_{1-3} alkyl-OH, -C_{1-3} alkyl-OAc, C_{1-3} alkyl, -C(O)-C_{1-3} alkyl or C_{1-3} haloalkyl, and

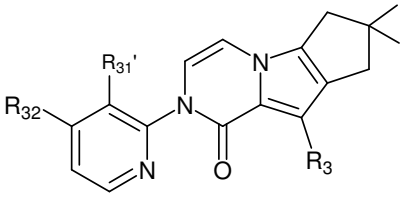
R_{32} is halogen, -$B(OH)_2$, -$B(OC_{1-6}$ alkyl$)_2$,  or , and R_d is hydrogen or C_{1-6} alkyl.

35. The compound of claim 34, which is



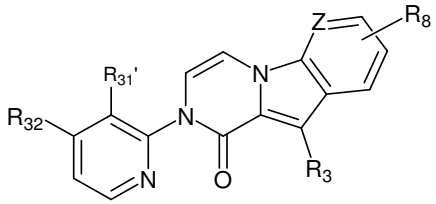
(V-1)

,



(V-2)

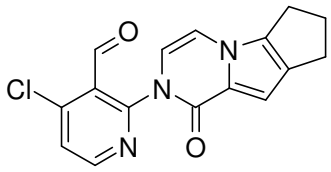
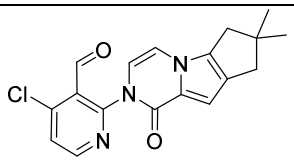
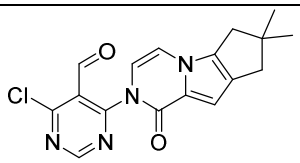
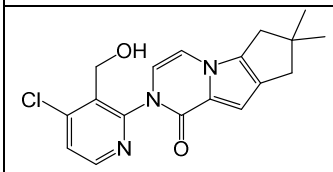
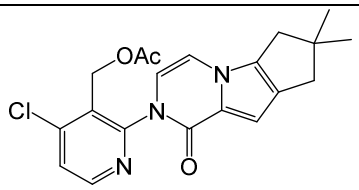
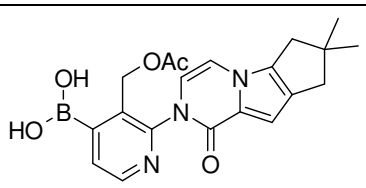
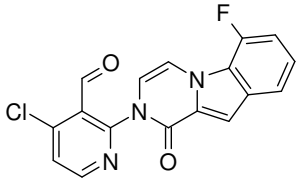
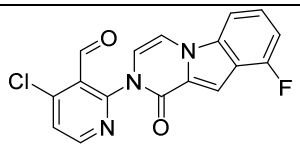
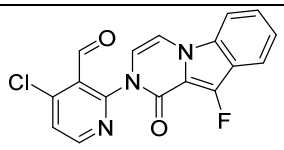
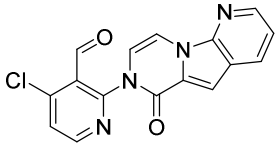
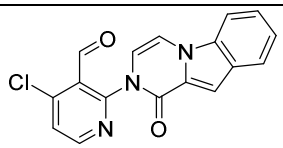
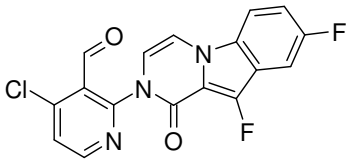
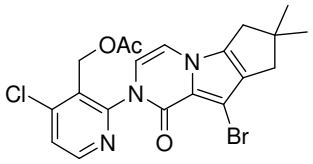
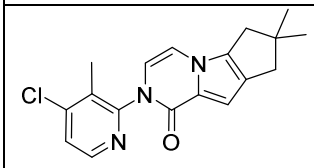
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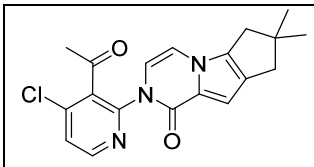
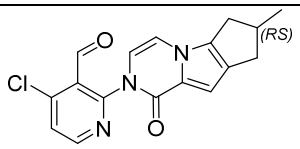
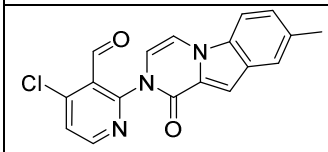
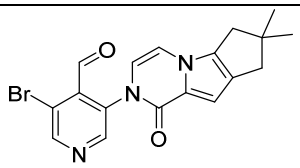
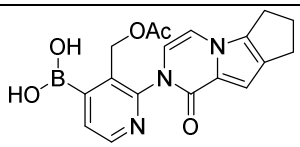
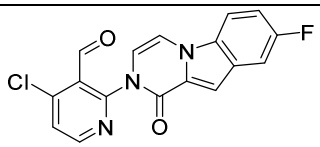
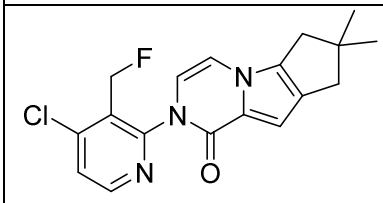


(V-3)

, wherein Z is N or CR_7; R_7 and R_8 are each independently hydrogen or halogen; R_9 is halogen or C_{1-6} alkyl; and n is 1 or 2.

36. A compound, which is selected from:

.