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(54) Titre : INHIBITEURS DE PCSK9 ET LEURS PROCEDES D'UTILISATION

(54) Title: PCSK9 INHIBITORS AND METHODS OF USE THEREOF

(57) Abrégé/Abstract:

The invention relates to a novel inhibitor pharmacophore of PCSK9 and heteroaryl compounds that bind the PCSK9 protein.

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(54) Title: PCSK9 INHIBITORS AND METHODS OF USE THEREOF

(57) Abstract: The invention relates to a novel inhibitor pharmacophore of PCSK9 and heteroaryl compounds that bind the PCSK9 protein.

**WO 2020/150474 A1**

PCSK9 Inhibitors and Methods of Use Thereof**RELATED APPLICATIONS**

This application claims the benefit of priority to U.S. Provisional Patent Application No. 62/794,239, filed on January 18, 2019, which is hereby incorporated by reference in its entirety.

BACKGROUND

PCSK9, also referred to as “proprotein convertase subtilisin/kexin 9”, is a member of the secretory proprotein convertase family and plays an important role in cholesterol metabolism. PCSK9 increases the levels of circulating LDL cholesterol via the enhanced degradation of the LDL receptors independently of its catalytic activity. Secreted PCSK9 binds to the Epidermal Growth Factor domain A (EGFA) of the LDL receptor (LDLR) at the cell surface and the PCSK9/LDL receptor complex is internalized into endosomal/lysosomal compartments. The enhanced binding affinity of PCSK9 to the LDL receptor at the acidic pH of late endosomes/lysosomes reduces LDL receptor recycling and instead targets LDL receptors for lysosomal degradation. Genetic association studies have demonstrated that loss-of-function mutations in PCSK9 are associated with low plasma LDL-C levels and a reduction in the incidence of adverse cardiovascular events.

Another biological pathway involving the effect of PCSK9 on LDL receptors is the onset of septic shock. Septic shock is an often fatal complication of a severe microbial infection (sepsis) that triggers an uncontrolled systemic inflammatory response and subsequent organ failure. Sepsis originates with the microbial cell walls that contain pathogenic lipid moieties such as lipopolysaccharide (LPS; Gram-negative bacteria). LPS are potent ligands for mammalian innate immune receptors [Toll-like receptors (TLRs)] and thus figure prominently in the septic inflammatory response (septic shock, or sepsis).

PCSK9 reduces LPS uptake by the liver's LDL receptors, such that free LPS overstimulates the body's immune response to the pathogen leading to sepsis. Thus,

inhibiting PCSK9 is beneficial in retaining liver LDL receptors to effect systemic pathogen clearance and detoxification in response to sepsis. However, beyond antibiotic therapy, there are currently no effective treatments for sepsis or septic shock.

For cardiovascular disease, few options exist for inhibiting PCSK9. Statins actually upregulate PCSK9 in HepG2 cells and in human primary hepatocytes through the increased expression of SREBP-2, a transcription factor that upregulates both the LDLR and PCSK9 genes. Since an elevated level of PCSK9 decreases the abundance of LDL receptor on the cell surface, increasing doses of statins have failed to achieve proportional LDL-cholesterol lowering effects.

Two monoclonal antibodies (mAbs) that bind selectively to extracellular PCSK9 and prevent its interaction with the LDL receptor, alirocumab and evolocumab, have recently received FDA approval for lowering LDL-C levels. In clinical trials, alirocumab showed an about 50% decrease in LDL levels compared to placebo. Elbitar et al., *Expert Opin Therapeutic Patents* 2016 26:1377-1392. Patients taking evolocumab showed an about 60-75% decrease in LDL levels. The potency of these drugs demonstrates the potential for inhibitors of PCSK9 to be effective treatments for those with hypercholesterolemia and other cardiovascular diseases. However, both antibody drugs require intravenous administration and can cause allergic reactions or other deleterious immune responses in the body.

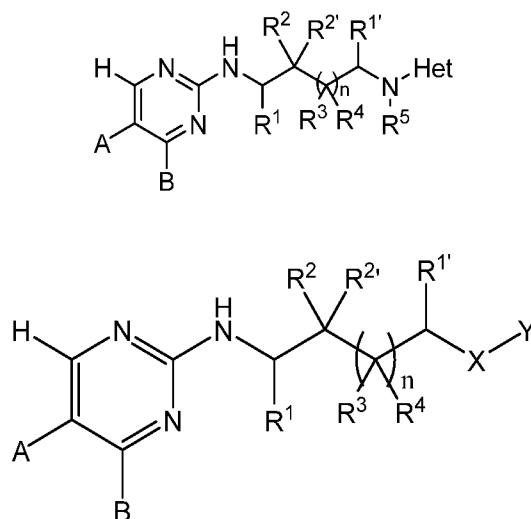
Designing and developing efficacious drugs is often aided by information about how a compound interacts with its biological target, such as PCSK9. Cunningham et al. have described the three-dimensional crystal structure of PCSK9 and identified different regions, such as the C-terminal domain which is more flexible than other sections of the protein. (Cunningham et al. *Nature Struct. Bio.* 2007 14:413-419). Thus, interest in inhibitors of PCSK9 has been focused on how various small molecules can interact with the surface or pockets in PCSK9.

Cardiovascular diseases often require management over a person's lifetime, unlike an infection that could be episodic. Thus, ease of dosing and administration become key factors to patient compliance with maintenance drug treatments. There is a

need for PCSK9 inhibitors with increased efficacy and greater ease of administration, which can be achieved with small molecule PCSK9 inhibitors.

SUMMARY

Disclosed herein are compounds of Formula (I):



(I)

wherein:

A is selected from H, halo, hydroxy, alkyl, thioalkyl, alkenyl, alkoxy, acyloxy, cyano, cycloalkyl, -C(O)OR⁶, and -C(O)NR⁶R⁷;

B is selected from H, alkyl, and halo, or

A and B are taken together with the carbon atoms to which they are attached to form a 5- or 6-membered heteroaryl;

X is NR⁵ or O;

R¹ and R^{1'} are each independently selected from H and alkyl; or

if n is 0, R¹ and R^{1'}, together with the atoms to which they are attached, form a 4-8 membered cycloalkyl or cycloalkenyl ring;

R² is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, hydroxyalkyl, alkylamino, cyano, and hydroxy; or

R^1 and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; or

$R^{1'}$ and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring;

$R^{2'}$ is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, and cyano, or

R^2 and $R^{2'}$, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring;

each R^3 and R^4 is independently H or alkyl; or

R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; and

R^5 is H or alkyl; or

R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclyl ring; or

R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclyl ring;

each R^6 and R^7 is independently H or alkyl;

Y is selected from aryl, heteroaryl and heterocyclyl;

and

n is 0 or 1. In certain embodiments, the present invention provides a pharmaceutical composition suitable for use in a subject in the treatment or prevention of cardiovascular diseases comprising an effective amount of any of the compounds described herein (e.g., a compound of the invention, such as a compound of formula (I)), and one or more pharmaceutically acceptable excipients. In certain embodiments, the pharmaceutical preparations may be for use in treating or preventing a condition or disease as described herein.

Disclosed herein are methods of treating diseases and conditions that benefit from the inhibition of PCSK9. These diseases include, but are not limited to cardiovascular diseases, such as hypercholesterolemia, hyperlipidemia, hyperlipoproteinemia, hypertriglyceridemia, dyslipidemia, dyslipoproteinemia, atherosclerosis, hepatic steatosis, metabolic syndrome and coronary artery disease.

Other diseases and conditions that can be treated using the methods described herein include, but are not limited to, sepsis and septic shock.

Provided herein are combination therapies of compounds of formula (I) with monoclonal antibodies, statins and other cardiovascular agents that can enhance the cardiovascular therapeutic benefit beyond the ability of the adjuvant therapy alone. Also provided herein are combination therapies of compounds of formula (I) with antibiotic agents that can reduce the occurrence and severity of sepsis and septic shock beyond the ability of the adjuvant therapy alone.

Also disclosed herein is a new binding site on PCSK9, that compounds of Formula I interact with. Certain features common to these compounds, such as a triad of H-bonds between the compounds disclosed herein and certain residues in the C-terminal domain of PCSK9, contribute to the selectivity and affinity of the compounds for PCSK9. This C-terminal binding site is distinct from the PCSK9 catalytic domain, which is understood to be the target of many previously identified inhibitors.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 depicts a crystal structure of PCSK9 showing the disordered segments in a dashed line.

FIG. 2 is a schematic of a crystal structure of PCSK9 bound to compound 152 showing H-bond donor and acceptors with dashed arrows. The pharmacophore spans the M2 and M3 domains.

FIG. 3 is a schematic of the pharmacophore H-bond triad, showing the distances between the Val589 acceptor (A), the Val589 donor (B), and the Ser636 acceptor (C).

FIG. 4 is a schematic of a crystal structure of PCSK9 bound to compound 162 showing H-bond donor and acceptors with dashed arrows.

FIG. 5 is a schematic of a crystal structure of PCSK9 bound to compound 43, showing H-bond donor and acceptors with dashed arrows.

FIG. 6 is a schematic of a crystal structure of PCSK9 bound to compound 60, showing H-bond donor and acceptors with dashed arrows and cation-pi bonding with pin dots.

FIG. 7 is a schematic of a crystal structure of PCSK9 bound to compound 5, showing H-bond donor and acceptors with dashed arrows and cation-pi bonding with pin dots.

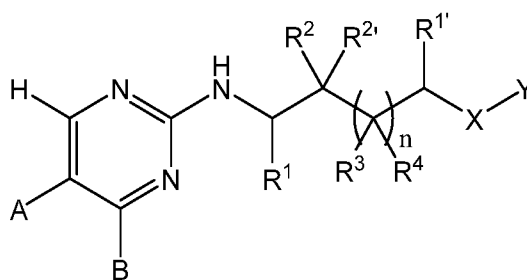
FIG. 8 is a schematic of a crystal structure of PCSK9 bound to compound 133, showing H-bond donor and acceptors with dashed arrows and cation-pi bonding with pin dots.

FIG. 9 is a schematic of a crystal structure of PCSK9 bound to compound 458B, showing the interaction with the N-H of glycine 640.

DETAILED DESCRIPTION

Compounds

Disclosed herein are compounds of Formula (I):



(I)

wherein:

A is selected from H, halo, hydroxy, alkyl, thioalkyl, alkenyl, alkoxy, acyloxy, cyano, cycloalkyl, $-C(O)OR^6$, and $-C(O)NR^6R^7$;

B is selected from H, alkyl, and halo, or

A and B are taken together with the carbon atoms to which they are attached to form a 5- or 6-membered heteroaryl;

X is NR^5 or O;

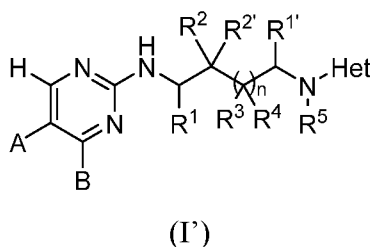
R^1 and $R^{1'}$ are each independently selected from H and alkyl; or

if n is 0, R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4-8 membered cycloalkyl or cycloalkenyl ring;

R^2 is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, hydroxyalkyl, alkylamino, cyano, and hydroxy; or

R^1 and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; or
 $R^{1'}$ and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring;
 $R^{2'}$ is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, and cyano, or
 R^2 and $R^{2'}$, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring;
each R^3 and R^4 is independently H or alkyl; or
 R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; and
 R^5 is H or alkyl; or
 R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclyl ring; or
 R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclyl ring;
each R^6 and R^7 is independently H or alkyl;
Y is selected from aryl, heteroaryl and heterocyclyl;
and
n is 0 or 1.

Disclosed herein are compounds of Formula (I')



wherein:

A is selected from H, halo, alkyl, thioalkyl, alkenyl, alkoxy, acyloxy, cyano, cycloalkyl, -C(O)OR⁶, and -C(O)NR⁶R⁷;
B is selected from H, alkyl, and halo;

R^1 and $R^{1'}$ are each independently selected from H and alkyl; or
 if n is 0, R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4-8 membered cycloalkyl ring;
 R^2 is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, hydroxyalkyl, alkylamino, cyano, and hydroxy; or
 R^1 and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; or
 $R^{1'}$ and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring;
 $R^{2'}$ is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, and cyano, ; or
 R^2 and $R^{2'}$, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring;
 each R^3 and R^4 is independently H or alkyl; or
 R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; and
 R^5 is H or alkyl; or
 R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclyl ring; or
 R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclyl ring;
 each R^6 and R^7 is independently H or alkyl;
 Het is heteroaryl or heterocyclyl; and
 n is 0 or 1.

All of the embodiments below and herein are understood to be embodiments of both Formula (I) and Formula (I').

In certain embodiments, The compound of claim 1, wherein A is selected from H, hydroxy, thioalkyl, alkyl, alkoxy, acyloxy, cyano, cycloalkyl, $-C(O)OR^6$, and $-C(O)NR^6R^7$.

In certain embodiments, A is H, while in other embodiments, A is alkyl, such as thioalkyl. In certain embodiments, A is selected from -SCH₃, -SCHF₂, and -OCHF₂. In some embodiments, A is alkoxy. In other embodiments, A is cycloalkyl. In certain embodiments, B is H.

In certain embodiments, A and B are taken together with the carbon atoms to which they are attached to form a pyrrolyl or thienyl ring, which is unsubstituted or substituted with one or more alkyl.

In certain embodiments, X is preferably NR⁵. In other embodiments, Y is preferably heteroaryl or heterocyclyl.

In certain embodiments, R¹ and R^{1'} are each H. However, when n is 0, R¹ and R^{1'}, together with the atoms to which they are attached, can form a 4- to 8-membered cycloalkyl ring. In some embodiments, the cycloalkyl is monocyclic or bicyclic. In other embodiments, R¹ and R^{1'}, together with the atoms to which they are attached, can form a 4- to 8-membered cycloalkenyl ring. In some embodiments, the cycloalkyl ring is a cyclopentyl ring, such as *S,S*-cyclopentyl. In some embodiments, the cycloalkyl ring is substituted with hydroxyl or hydroxyalkyl.

In certain embodiments, R² is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, alkylamino, cyano, and hydroxyl. In certain embodiments, R² is C₁₋₃alkyl. R² can be substituted with one or more substituents selected from amino, amido, cyano, hydroxy, and heterocyclyl. In some embodiments, R^{2'} is C₁₋₃alkyl, while in other embodiments, R^{2'} is H.

In certain embodiments, R¹ and R², together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring. In other embodiments, R^{1'} and R², together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring. In certain embodiments, R² and R^{2'}, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring.

In certain embodiments, R³ is C₁₋₃alkyl, while in other embodiments, R³ is H. In certain embodiments, R⁴ is H.

In certain embodiments, R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclcyl ring. In other embodiments, R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclcyl ring. In other embodiments, R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclcyl ring.

In certain embodiments, Y is monocyclic heteroaryl, such as, but not limited to, pyridinyl, pyrazinyl, pyrimidinyl, and thiazolyl. In other embodiments, Y is monocyclic heteroaryl, such as, but not limited to, pyridinyl, pyrazinyl, and pyrimidinyl. In some embodiments, Y is selected from triazenyl, oxazolyl, isoxazolyl, imidazolyl, pyrazolyl and triazolyl. The monocyclic heteroaryl can be unsubstituted, or substituted with one or more substituents selected from alkyl, thioalkyl alkoxy, alkoxycarbonyl, amido, carboxy, cyano, halo, heteroaryl, nitro, sulfonamido, and thioalkyl. In another embodiment, Y is a monocyclic heteroaryl can be unsubstituted, or substituted with one or more substituents selected from alkyl, thioalkyl, alkoxy, alkoxycarbonyl, amido, carboxy, cyano, halo, aryl, heteroaryl, heterocyclcyl, nitro, sulfonamido, and thioalkyl.

In certain embodiments, the monocyclic heteroaryl is substituted with an aryl, heteroaryl or heterocyclcyl selected from phenyl, pyridinyl, 2-hydroxypyridinyl, piperidinonyl, 2-hydroxy-1-methylpyridinyl, triazolyl, imidazolidinonyl, pyrimidonyl, 2-hydroxyisoquinolinyl, 3-hydroxypyridazinyl, pyrrolidinonyl, pyrazolyl, and morpholinonyl. In certain preferred embodiments, Y is a 6-membered monocyclic heteroaryl. In some embodiments, the monocyclic heteroaryl is substituted with an heteroaryl or heterocyclcyl that is substituted with one or more substituents selected from halo, CN, alkyl, alkoxy, hydroxy, carboxy, $-CO_2$ alkyl, and tetrazolyl. In certain preferred embodiments, the monocyclic heteroaryl is disposed on the para position of A relative to X.

In other embodiments, Y is bicyclic heteroaryl, such as, but not limited to, benzothiazolyl, benzimidazolyl, benzoxazolyl, triazolopyridinyl, thiazolopyrindinyl, quinolinyl, and quinoxalinyl. The bicyclic heteroaryl can be unsubstituted, or substituted with one or more substituents selected from alkyl, haloalkyl, hydroxyalkyl, thioalkyl, alkoxy, alkoxycarbonyl, amido, carboxy, cyano, halo, heteroaryl, nitro, and sulfonamido.

In certain embodiments, the bicyclic heteroaryl is unsubstituted, or substituted with one or more substituents selected from thioalkyl, alkoxycarbonyl, amido, carboxy, halo, and heteroaryl.

In certain embodiments, Y is substituted with an amido substituent of the formula $-C(O)NR^8R^9$ or $-NR^9C(O)R^{10}$, wherein

R^8 and R^9 are each independently selected from H, alkyl, heterocyclyl and heteroaryl; or R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a

4-, 5-, 6-, or 7-membered heterocyclic or heteroaryl ring; and

R^{10} is alkyl.

In certain embodiments, Y is substituted with a sulfonamido substituent of the formula $-S(O)_2NR^8R^9$ or $-NR^9S(O)_2R^{10}$; wherein

R^8 and R^9 are each independently selected from H, alkyl, and heteroaryl; or

R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a

4-, 5-, 6-, or 7-membered heterocyclic ring; and

R^{10} is alkyl.

All the foregoing embodiments of variable Y in Formula (I) are understood to also be embodiments of variable Het in Formula (I').

In certain embodiments, R^8 and R^9 are each independently selected from H, methyl, ethyl, triazolyl, and pyrazolyl. In embodiments where one or both of R^8 and R^9 are alkyl, each alkyl is independently unsubstituted, or substituted with one or more substituents selected from methyl, methoxy, carboxy, cyano, hydroxy, dimethylamino, ethoxycarbonyl, phenyl, methoxyphenyl, oxadiazolyl, tetrazolyl, 2-methyl-tetrazolyl, triazolyl, 1-methyltriazolyl, 4-methyltriazolyl, and 2,4-dihydro-3H-1,2,4-triazol-3-onyl. In certain embodiments, R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a heterocyclic ring selected from aziradine, isothiazolidine-1,1-dioxide, azetidine, thiazol-4(5Hn)-one, morpholine, piperidine, piperazine, pyrrolidine, thiomorpholine-1,1-dioxide, 2-oxa-6-azaspiro[3.3]heptane. In some embodiments, R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a heterocyclic ring selected from 2,8-diazaspiro[5,5]undecene, tetrahydroimidazo[1,2-a]pyrazine, octahydropyrazino[2,1-c][1,4]oxazine, tetrahydropyrido[3,4-d]pyrimidine, 2-

oxa-8-azaspiro[4.5]decane, tetrahydropyrrolo[3,4-c]pyrazole, thiomorpholine, 2-oxa-7-azaspiro[3.5]nonane, 2,8-diazaspiro[4.5]decan-3-one, tetrahydro-1,7-naphthyridine, 1-oxa-4,9-diazaspiro[5.5]undecan-3-one, tetrahydropyrrolo[3,4-d]imidazole, pyrimidine, 8-oxa-2-azaspiro[4.5]decane, hexahydro-3H-oxazolo[3,4-a]pyrazin-3-one, 1-oxa-7-azaspiro[3.5]nonane, octahydrocyclopenta[c]pyrrole, tetrahydro-[1,2,4]triazolo[4,3-a]pyrazine, 2,7-diazaspiro[4.4]nonane, 2,6-diazaspiro[3.4]octane, 7-oxa-2-azaspiro[3.5]nonane, 1-oxa-8 λ^2 -azaspiro[4.5]decane, 2-oxa-6-azaspiro[3.3]heptane, tetrahydrofuran, oxadiazole, triazole, pyridinone, tetrahydro-[1,2,4]triazolo[4,3-a]pyrazin-3(2H)-one, piperidinone, 3,6-diazabicyclo[3.1.1]heptane, 5-oxa-2,7-diazaspiro[3.5]nonane, pyrazole, and pyridazin-3(2H)-one.

In some embodiments, the heterocyclic ring is unsubstituted, or substituted with one or more substituents selected from alkyl, alkoxycarbonyl, halo, hydroxy, cyano, carboxy, and heterocyclyl. In certain embodiments, the heterocyclic ring is unsubstituted, or substituted with one or more substituents selected from methyl, ethoxycarbonyl, halo, hydroxy, cyano, carboxy, and oxetanyl.

In certain embodiments, the present invention provides a pharmaceutical preparation suitable for use in a human patient, comprising any of the compounds shown above (e.g., a compound of the invention, such as a compound of formula (I), and one or more pharmaceutically acceptable excipients. In certain embodiments, the pharmaceutical preparations may be for use in treating or preventing a condition or disease as described herein.

Any of the disclosed compounds may be used in the manufacture of medicaments for the treatment of any diseases or conditions disclosed herein.

Definitions

Unless defined otherwise, all technical and scientific terms used herein have the meaning commonly understood by a person skilled in the art of the present disclosure. The following references provide one of skill with a general definition of many of the terms used in this disclosure: Singleton et al., Dictionary of Microbiology and Molecular Biology (2nd ed. 1994); The Cambridge Dictionary of Science and Technology (Walker

ed., 1988); The Glossary of Genetics, 5th Ed., R. Rieger et al. (eds.), Springer Verlag (1991); and Hale & Marham, The Harper Collins Dictionary of Biology (1991). As used herein, the following terms have the meanings ascribed to them below, unless specified otherwise.

In this disclosure, "comprises," "comprising," "containing" and "having" and the like can have the meaning ascribed to them in U.S. Patent law and can mean "includes," "including," and the like; "consisting essentially of" or "consists essentially" likewise has the meaning ascribed in U.S. Patent law and the term is open-ended, allowing for the presence of more than that which is recited so long as basic or novel characteristics of that which is recited is not changed by the presence of more than that which is recited, but excludes prior art embodiments.

Unless specifically stated or obvious from context, as used herein, the term "or" is understood to be inclusive. Unless specifically stated or obvious from context, as used herein, the terms "a", "an", and "the" are understood to be singular or plural.

The term "acyl" is art-recognized and refers to a group represented by the general formula hydrocarbylC(O)-, preferably alkylC(O)-.

The term "acylamino" is art-recognized and refers to an amino group substituted with an acyl group and may be represented, for example, by the formula hydrocarbylC(O)NH-.

The term "acyloxy" is art-recognized and refers to a group represented by the general formula hydrocarbylC(O)O-, preferably alkylC(O)O-.

The term "alkoxy" refers to an alkyl group, preferably a lower alkyl group, having an oxygen attached thereto. Representative alkoxy groups include methoxy, ethoxy, propoxy, tert-butoxy and the like.

The term "alkoxyalkyl" refers to an alkyl group substituted with an alkoxy group and may be represented by the general formula alkyl-O-alkyl.

The term "alkenyl", as used herein, refers to an aliphatic group containing at least one double bond and is intended to include both "unsubstituted alkenyls" and "substituted alkenyls", the latter of which refers to alkenyl moieties having substituents replacing a hydrogen on one or more carbons of the alkenyl group. Such substituents may occur on

one or more carbons that are included or not included in one or more double bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed below, except where stability is prohibitive. For example, substitution of alkenyl groups by one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated.

An "alkyl" group or "alkane" is a straight chained or branched non-aromatic hydrocarbon which is completely saturated. Typically, a straight chained or branched alkyl group has from 1 to about 20 carbon atoms, preferably from 1 to about 10 unless otherwise defined. Examples of straight chained and branched alkyl groups include methyl, ethyl, n-propyl, iso-propyl, n-butyl, sec-butyl, tert-butyl, pentyl, hexyl, pentyl and octyl. A C₁-C₆ straight chained or branched alkyl group is also referred to as a "lower alkyl" group.

Moreover, the term "alkyl" (or "lower alkyl") as used throughout the specification, examples, and claims is intended to include both "unsubstituted alkyls" and "substituted alkyls", the latter of which refers to alkyl moieties having substituents replacing a hydrogen on one or more carbons of the hydrocarbon backbone. Such substituents, if not otherwise specified, can include, for example, a halogen, a hydroxyl, a carbonyl (such as a carboxyl, an alkoxycarbonyl, a formyl, or an acyl), a thiocarbonyl (such as a thioester, a thioacetate, or a thioformate), an alkoxy, a phosphoryl, a phosphate, a phosphonate, a phosphinate, an amino, an amido, an amidine, an imine, a cyano, a nitro, an azido, a sulfhydryl, an alkylthio, a sulfate, a sulfonate, a sulfamoyl, a sulfonamido, a sulfonyl, a heterocyclyl, an aralkyl, or an aromatic or heteroaromatic moiety. It will be understood by those skilled in the art that the moieties substituted on the hydrocarbon chain can themselves be substituted, if appropriate. For instance, the substituents of a substituted alkyl may include substituted and unsubstituted forms of amino, azido, imino, amido, phosphoryl (including phosphonate and phosphinate), sulfonyl (including sulfate, sulfonamido, sulfamoyl and sulfonate), and silyl groups, as well as ethers, alkylthios, carbonyls (including ketones, aldehydes, carboxylates, and esters), -CF₃, -CN and the like. Exemplary substituted alkyls are described below.

Cycloalkyls can be further substituted with alkyls, alkenyls, alkoxy, alkylthios, aminoalkyls, carbonyl-substituted alkyls, -CF₃, -CN, and the like.

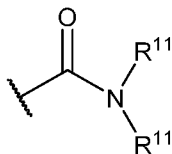
The term “C_{x-y}” when used in conjunction with a chemical moiety, such as, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy is meant to include groups that contain from x to y carbons in the chain. For example, the term “C_{x-y}alkyl” refers to substituted or unsubstituted saturated hydrocarbon groups, including straight-chain alkyl and branched-chain alkyl groups that contain from x to y carbons in the chain, including haloalkyl groups such as trifluoromethyl and 2,2,2-trifluoroethyl, etc. C₀ alkyl indicates a hydrogen where the group is in a terminal position, a bond if internal. The terms “C_{2-y}alkenyl” and “C_{2-y}alkynyl” refer to substituted or unsubstituted unsaturated aliphatic groups analogous in length and possible substitution to the alkyls described above, but that contain at least one double or triple bond respectively.

The term “alkylamino”, as used herein, refers to an amino group substituted with at least one alkyl group.

The term “alkylthio”, as used herein, refers to a thiol group substituted with an alkyl group and may be represented by the general formula alkylS-.

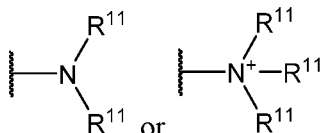
The term “alkynyl”, as used herein, refers to an aliphatic group containing at least one triple bond and is intended to include both "unsubstituted alkynyls" and "substituted alkynyls", the latter of which refers to alkynyl moieties having substituents replacing a hydrogen on one or more carbons of the alkynyl group. Such substituents may occur on one or more carbons that are included or not included in one or more triple bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed above, except where stability is prohibitive. For example, substitution of alkynyl groups by one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated.

The term “amide”, as used herein, refers to a group



wherein each R^{11} independently represents a hydrogen or hydrocarbonyl group, or two R^{11} are taken together with the N atom to which they are attached complete a heterocycle having from 4 to 8 atoms in the ring structure.

The terms “amine” and “amino” are art-recognized and refer to both unsubstituted and substituted amines and salts thereof, e.g., a moiety that can be represented by

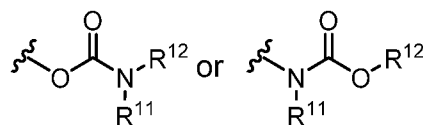


wherein each R^{11} independently represents a hydrogen or a hydrocarbonyl group, or two R^{11} are taken together with the N atom to which they are attached complete a heterocycle having from 4 to 8 atoms in the ring structure. The term “aminoalkyl”, as used herein, refers to an alkyl group substituted with an amino group.

The term “aralkyl”, as used herein, refers to an alkyl group substituted with an aryl group.

The term “aryl” as used herein include substituted or unsubstituted single-ring aromatic groups in which each atom of the ring is carbon. Preferably, the ring is a 5- to 7-membered ring, more preferably a 6-membered ring. The term “aryl” also includes polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is aromatic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls. Aryl groups include benzene, naphthalene, phenanthrene, phenol, aniline, and the like.

The term “carbamate” is art-recognized and refers to a group



wherein R^{11} and R^{12} independently represent hydrogen or a hydrocarbonyl group, such as an alkyl group, or R^{11} and R^{12} taken together with the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

The terms “carbocycle”, and “carbocyclic”, as used herein, refers to a saturated or unsaturated ring in which each atom of the ring is carbon. The term carbocycle includes both aromatic carbocycles and non-aromatic carbocycles. Non-aromatic carbocycles include both cycloalkane rings, in which all carbon atoms are saturated, and cycloalkene rings, which contain at least one double bond.

The term “carbocycle” includes 5-7 membered monocyclic and 8-12 membered bicyclic rings. Each ring of a bicyclic carbocycle may be selected from saturated, unsaturated and aromatic rings. Carbocycle includes bicyclic molecules in which one, two or three or more atoms are shared between the two rings. The term “fused carbocycle” refers to a bicyclic carbocycle in which each of the rings shares two adjacent atoms with the other ring. Each ring of a fused carbocycle may be selected from saturated, unsaturated and aromatic rings. In an exemplary embodiment, an aromatic ring, e.g., phenyl, may be fused to a saturated or unsaturated ring, e.g., cyclohexane, cyclopentane, or cyclohexene. Any combination of saturated, unsaturated and aromatic bicyclic rings, as valence permits, is included in the definition of carbocyclic. Exemplary “carbocycles” include cyclopentane, cyclohexane, bicyclo[2.2.1]heptane, 1,5-cyclooctadiene, 1,2,3,4-tetrahydronaphthalene, bicyclo[4.2.0]oct-3-ene, naphthalene and adamantane. Exemplary fused carbocycles include decalin, naphthalene, 1,2,3,4-tetrahydronaphthalene, bicyclo[4.2.0]octane, 4,5,6,7-tetrahydro-1H-indene and bicyclo[4.1.0]hept-3-ene. “Carbocycles” may be substituted at any one or more positions capable of bearing a hydrogen atom.

A “cycloalkyl” group is a cyclic hydrocarbon which is completely saturated. “Cycloalkyl” includes monocyclic and bicyclic rings. Typically, a monocyclic cycloalkyl group has from 3 to about 10 carbon atoms, more typically 3 to 8 carbon atoms unless otherwise defined. The second ring of a bicyclic cycloalkyl may be selected from saturated, unsaturated and aromatic rings. Cycloalkyl includes bicyclic molecules in which one, two or three or more atoms are shared between the two rings. The term “fused cycloalkyl” refers to a bicyclic cycloalkyl in which each of the rings shares two adjacent atoms with the other ring. The second ring of a fused bicyclic cycloalkyl may be selected

from saturated, unsaturated and aromatic rings. A “cycloalkenyl” group is a cyclic hydrocarbon containing one or more double bonds.

The term “carbocyclalkyl”, as used herein, refers to an alkyl group substituted with a carbocycle group.

The term “carbonate” is art-recognized and refers to a group $-\text{OCO}_2\text{-R}^{10}$, wherein R^{10} represents a hydrocarbyl group.

The term “carboxy”, as used herein, refers to a group represented by the formula $-\text{CO}_2\text{H}$.

The term “ester”, as used herein, refers to a group $-\text{C}(\text{O})\text{OR}^{10}$ wherein R^{10} represents a hydrocarbyl group.

The term “ether”, as used herein, refers to a hydrocarbyl group linked through an oxygen to another hydrocarbyl group. Accordingly, an ether substituent of a hydrocarbyl group may be hydrocarbyl-O-. Ethers may be either symmetrical or unsymmetrical. Examples of ethers include, but are not limited to, heterocycle-O-heterocycle and aryl-O-heterocycle. Ethers include “alkoxyalkyl” groups, which may be represented by the general formula alkyl-O-alkyl.

The terms “halo” and “halogen” as used herein means halogen and includes chloro, fluoro, bromo, and iodo.

The terms “hetaralkyl” and “heteroaralkyl”, as used herein, refers to an alkyl group substituted with a hetaryl group.

The term "heteroalkyl", as used herein, refers to a saturated or unsaturated chain of carbon atoms and at least one heteroatom, wherein no two heteroatoms are adjacent.

The terms “heteroaryl” and “hetaryl” include substituted or unsubstituted aromatic single ring structures, preferably 5- to 7-membered rings, more preferably 5- to 6-membered rings, whose ring structures include at least one heteroatom, preferably one to four heteroatoms, more preferably one or two heteroatoms. The terms “heteroaryl” and “hetaryl” also include polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is heteroaromatic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryl, and/or heterocyclyls. Heteroaryl groups include, for

example, pyrrole, furan, thiophene, imidazole, oxazole, thiazole, pyrazole, pyridine, pyrazine, pyridazine, and pyrimidine, and the like.

The term “heteroatom” as used herein means an atom of any element other than carbon or hydrogen. Preferred heteroatoms are nitrogen, oxygen, and sulfur.

The terms “heterocyclyl”, “heterocycle”, and “heterocyclic” refer to substituted or unsubstituted non-aromatic ring structures, preferably 3- to 10-membered rings, more preferably 3- to 7-membered rings, whose ring structures include at least one heteroatom, preferably one to four heteroatoms, more preferably one or two heteroatoms. The terms “heterocyclyl” and “heterocyclic” also include polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is heterocyclic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryl, and/or heterocyclyls. Heterocyclyl groups include, for example, piperidine, piperazine, pyrrolidine, morpholine, lactones, lactams, and the like.

The term “heterocyclylalkyl”, as used herein, refers to an alkyl group substituted with a heterocycle group.

The term “hydrocarbyl”, as used herein, refers to a group that is bonded through a carbon atom that does not have a =O or =S substituent, and typically has at least one carbon-hydrogen bond and a primarily carbon backbone, but may optionally include heteroatoms. Thus, groups like methyl, ethoxyethyl, 2-pyridyl, and trifluoromethyl are considered to be hydrocarbyl for the purposes of this application, but substituents such as acetyl (which has a =O substituent on the linking carbon) and ethoxy (which is linked through oxygen, not carbon) are not. Hydrocarbyl groups include, but are not limited to aryl, heteroaryl, carbocycle, heterocyclyl, alkyl, alkenyl, alkynyl, and combinations thereof.

The term “hydroxyalkyl”, as used herein, refers to an alkyl group substituted with a hydroxy group.

The term “lower” when used in conjunction with a chemical moiety, such as, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy is meant to include groups where there are ten or fewer non-hydrogen atoms in the substituent, preferably six or fewer. A “lower alkyl”,

for example, refers to an alkyl group that contains ten or fewer carbon atoms, preferably six or fewer. In certain embodiments, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy substituents defined herein are respectively lower acyl, lower acyloxy, lower alkyl, lower alkenyl, lower alkynyl, or lower alkoxy, whether they appear alone or in combination with other substituents, such as in the recitations hydroxyalkyl and aralkyl (in which case, for example, the atoms within the aryl group are not counted when counting the carbon atoms in the alkyl substituent).

The terms “polycyclyl”, “polycycle”, and “polycyclic” refer to two or more rings (e.g., cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls) in which two or more atoms are common to two adjoining rings, e.g., the rings are “fused rings”. Each of the rings of the polycycle can be substituted or unsubstituted. In certain embodiments, each ring of the polycycle contains from 3 to 10 atoms in the ring, preferably from 5 to 7.

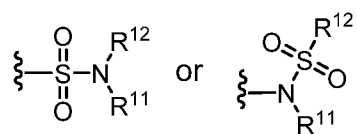
The term “silyl” refers to a silicon moiety with three hydrocarbyl moieties attached thereto.

The term “substituted” refers to moieties having substituents replacing a hydrogen on one or more carbons of the backbone. It will be understood that “substitution” or “substituted with” includes the implicit proviso that such substitution is in accordance with permitted valence of the substituted atom and the substituent, and that the substitution results in a stable compound, e.g., which does not spontaneously undergo transformation such as by rearrangement, cyclization, elimination, etc. As used herein, the term “substituted” is contemplated to include all permissible substituents of organic compounds. In a broad aspect, the permissible substituents include acyclic and cyclic, branched and unbranched, carbocyclic and heterocyclic, aromatic and non-aromatic substituents of organic compounds. The permissible substituents can be one or more and the same or different for appropriate organic compounds. For purposes of this invention, the heteroatoms such as nitrogen may have hydrogen substituents and/or any permissible substituents of organic compounds described herein which satisfy the valences of the heteroatoms. Substituents can include any substituents described herein, for example, a halogen, a hydroxyl, a carbonyl (such as a carboxyl, an alkoxycarbonyl, a formyl, or an

acyl), a thiocarbonyl (such as a thioester, a thioacetate, or a thioformate), an alkoxy, a phosphoryl, a phosphate, a phosphonate, a phosphinate, an amino, an amido, an amidine, an imine, a cyano, a nitro, an azido, a sulfhydryl, an alkylthio, a sulfate, a sulfonate, a sulfamoyl, a sulfonamido, a sulfonyl, a heterocyclyl, an aralkyl, or an aromatic or heteroaromatic moiety. It will be understood by those skilled in the art that substituents can themselves be substituted, if appropriate. Unless specifically stated as “unsubstituted,” references to chemical moieties herein are understood to include substituted variants. For example, reference to an “aryl” group or moiety implicitly includes both substituted and unsubstituted variants.

The term “sulfate” is art-recognized and refers to the group $-\text{OSO}_3\text{H}$, or a pharmaceutically acceptable salt thereof.

The term “sulfonamide” is art-recognized and refers to the group represented by the general formulae



wherein R^{11} and R^{12} independently represents hydrogen or hydrocarbyl, such as alkyl, or R^{11} and R^{12} taken together with the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

The term “sulfoxide” is art-recognized and refers to the group $-\text{S}(\text{O})\text{---}\text{R}^{10}$, wherein R^{10} represents a hydrocarbyl.

The term “sulfonate” is art-recognized and refers to the group SO_3H , or a pharmaceutically acceptable salt thereof.

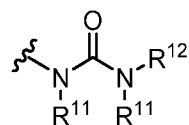
The term “sulfone” is art-recognized and refers to the group $-\text{S}(\text{O})_2\text{---}\text{R}^{10}$, wherein R^{10} represents a hydrocarbyl.

The term “thioalkyl”, as used herein, refers to an alkyl group substituted with a thiol group.

The term “thioester”, as used herein, refers to a group $-\text{C}(\text{O})\text{SR}^{10}$ or $-\text{SC}(\text{O})\text{R}^{10}$ wherein R^{10} represents a hydrocarbyl.

The term “thioether”, as used herein, is equivalent to an ether, wherein the oxygen is replaced with a sulfur.

The term “urea” is art-recognized and may be represented by the general formula



wherein R¹¹ and R¹² independently represent hydrogen or a hydrocarbyl, such as alkyl, or either occurrence of R¹¹ taken together with R¹² and the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

The term “protecting group” refers to a group of atoms that, when attached to a reactive functional group in a molecule, mask, reduce or prevent the reactivity of the functional group. Typically, a protecting group may be selectively removed as desired during the course of a synthesis. Examples of protecting groups can be found in Greene and Wuts, *Protective Groups in Organic Chemistry*, 3rd Ed., 1999, John Wiley & Sons, NY and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8, 1971-1996, John Wiley & Sons, NY. Representative nitrogen protecting groups include, but are not limited to, formyl, acetyl, trifluoroacetyl, benzyl, benzyloxycarbonyl (“CBZ”), tert-butoxycarbonyl (“Boc”), trimethylsilyl (“TMS”), 2-trimethylsilyl-ethanesulfonyl (“TES”), trityl and substituted trityl groups, allyloxycarbonyl, 9-fluorenylmethyloxycarbonyl (“Fmoc”), nitro-veratryloxycarbonyl (“NVOC”) and the like. Representative hydroxyl protecting groups include, but are not limited to, those where the hydroxyl group is either acylated (esterified) or alkylated such as benzyl and trityl ethers, as well as alkyl ethers, tetrahydropyranyl ethers, trialkylsilyl ethers (e.g., TMS or TIPS groups), glycol ethers, such as ethylene glycol and propylene glycol derivatives and allyl ethers.

The present invention includes all pharmaceutically acceptable isotopically-labelled compounds as described herein wherein one or more atoms are replaced by atoms having the same atomic number, but an atomic mass or mass number different from the atomic mass or mass number usually found in nature.

Examples of isotopes suitable for inclusion in the compounds of the invention include isotopes of hydrogen, such as ^2H and ^3H carbon, such as ^{11}C , ^{13}C and ^{14}C , chlorine, such as ^{36}Cl , fluorine, such as ^{18}F , iodine, such as ^{123}I and ^{125}I , nitrogen, such as ^{13}N and ^{15}N , oxygen, such as ^{15}O , ^{17}O and ^{18}O , phosphorus, such as ^{32}P , and sulphur, such as ^{35}S .

Certain isotopically-labelled compounds as disclosed herein, for example, those incorporating a radioactive isotope, are useful in drug and/or substrate tissue distribution studies. The radioactive isotopes tritium, i.e. ^3H , and carbon-14, i.e. ^{14}C , are useful for this purpose in view of their ease of incorporation and ready means of detection.

Substitution with heavier isotopes such as deuterium, i.e. ^2H , may afford certain therapeutic advantages resulting from greater metabolic stability, for example, increased in vivo half-life or reduced dosage requirements, and hence may be preferred in some circumstances.

Substitution with positron emitting isotopes, such as ^{11}C , ^{18}F , ^{15}O and ^{13}N , can be useful in Positron Emission Tomography (PET) studies for examining substrate receptor occupancy.

In certain embodiments, compounds of the invention may be racemic. In certain embodiments, compounds of the invention may be enriched in one enantiomer. For example, a compound of the invention may have greater than about 30% ee, about 40% ee, about 50% ee, about 60% ee, about 70% ee, about 80% ee, about 90% ee, or even about 95% or greater ee. In certain embodiments, compounds of the invention may have more than one stereocenter. In certain such embodiments, compounds of the invention may be enriched in one or more diastereomer. For example, a compound of the invention may have greater than about 30% de, about 40% de, about 50% de, about 60% de, about 70% de, about 80% de, about 90% de, or even about 95% or greater de.

In certain embodiments, the therapeutic preparation may be enriched to provide predominantly one enantiomer of a compound (e.g., of Formula (I)). An enantiomerically enriched mixture may comprise, for example, at least about 60 mol percent of one enantiomer, or more preferably at least about 75, about 90, about 95, or even about 99 mol percent. In certain embodiments, the compound enriched in one

enantiomer is substantially free of the other enantiomer, wherein substantially free means that the substance in question makes up less than about 10%, or less than about 5%, or less than about 4%, or less than about 3%, or less than about 2%, or less than about 1% as compared to the amount of the other enantiomer, e.g., in the composition or compound mixture. For example, if a composition or compound mixture contains about 98 grams of a first enantiomer and about 2 grams of a second enantiomer, it would be said to contain about 98 mol percent of the first enantiomer and only about 2% of the second enantiomer.

In certain embodiments, the therapeutic preparation may be enriched to provide predominantly one diastereomer of a compound (e.g., of Formula (I)). A diastereomerically enriched mixture may comprise, for example, at least about 60 mol percent of one diastereomer, or more preferably at least about 75, about 90, about 95, or even about 99 mol percent.

The term "subject" to which administration is contemplated includes, but is not limited to, humans (i.e., a male or female of any age group, e.g., a pediatric subject (e.g., infant, child, adolescent) or adult subject (e.g., young adult, middle-aged adult or senior adult)) and/or other primates (e.g., cynomolgus monkeys, rhesus monkeys); mammals, including commercially relevant mammals such as cattle, pigs, horses, sheep, goats, cats, and/or dogs; and/or birds, including commercially relevant birds such as chickens, ducks, geese, quail, and/or turkeys. Preferred subjects are humans.

As used herein, a therapeutic that "prevents" a disorder or condition refers to a compound that, in a statistical sample, reduces the occurrence of the disorder or condition in the treated sample relative to an untreated control sample, or delays the onset or reduces the severity of one or more symptoms of the disorder or condition relative to the untreated control sample.

The term "treating" includes prophylactic and/or therapeutic treatments. The term "prophylactic or therapeutic" treatment is art-recognized and includes administration to the subject of one or more of the disclosed compositions. If it is administered prior to clinical manifestation of the unwanted condition (e.g., disease or other unwanted state of the subject) then the treatment is prophylactic (i.e., it protects the subject against developing the unwanted condition), whereas if it is administered after manifestation of

the unwanted condition, the treatment is therapeutic, (i.e., it is intended to diminish, ameliorate, or stabilize the existing unwanted condition or side effects thereof).

The term “prodrug” is intended to encompass compounds which, under physiologic conditions, are converted into the therapeutically active agents of the present invention (e.g., a compound of Formula (I)). A common method for making a prodrug is to include one or more selected moieties which are hydrolyzed under physiologic conditions to reveal the desired molecule. In other embodiments, the prodrug is converted by an enzymatic activity of the subject. For example, esters or carbonates (e.g., esters or carbonates of alcohols or carboxylic acids) are preferred prodrugs of the present invention. In certain embodiments, some or all of the compounds of Formula (I) in a formulation represented above can be replaced with the corresponding suitable prodrug, e.g., wherein a hydroxyl in the parent compound is presented as an ester or a carbonate or carboxylic acid.

An “effective amount”, as used herein, refers to an amount that is sufficient to achieve a desired biological effect. A “therapeutically effective amount”, as used herein refers to an amount that is sufficient to achieve a desired therapeutic effect. For example, a therapeutically effective amount can refer to an amount that is sufficient to improve at least one sign or symptom of cancer.

A “response” to a method of treatment can include a decrease in or amelioration of negative symptoms, a decrease in the progression of a disease or symptoms thereof, an increase in beneficial symptoms or clinical outcomes, a lessening of side effects, stabilization of disease, partial or complete remedy of disease, among others.

Allosteric Inhibitors of PCSK9

Applicants have identified and characterized a previously uncharacterized site of PCSK9, to which the compounds disclosed herein bind. As a result, Applicants have identified a set of chemical features, or a pharmacophore, that characterizes compounds that can interact with this site and inhibit the activity of PCSK9.

The concept of a 'pharmacophore' is not recent. It was first introduced by Paul Ehrlich in 1909 as "a molecular framework that carries (pharos) the essential features

responsible for a drug's (pharmakon's) biological activity". Ehrlich, *Über den jetzigen stand derchemotherapie*. *Chem. Ber.* 42:17. This definition was further updated in 1977 by Peter Gund to "a set of structural features in a molecule that is recognized at a receptor site and is responsible for that molecule's biological activity" Gund, *Three dimensional pharmacophoric pattern searching*. *Prog. Mol. Subcell. Biol.* 5:117-143. More recently, the official IUPAC recommendation from 1997 has summarized the concept as follows: "A pharmacophore is the ensemble of steric and electronic features that is necessary to ensure the optimal supramolecular interactions with a specific biological target and to trigger (or block) its biological response" Wermuth, C.-G. et al. 1998 *Glossary of terms used in medicinal chemistry (IUPAC Recommendations 1998)*. *Pure Appl. Chem.* 70:1129-1143. Thus, a pharmacophore does not represent a unique molecule or a specific association of functional groups, but an understanding that accounts for the common molecular interaction capacities of a group of compounds towards their target structure. The pharmacophore can be considered as the largest common denominator shared by a set of active molecules. Pharmacophores are normally defined by pharmacophoric descriptors which include H-bonding, hydrophobic and electrostatic interaction sites, defined by atoms, ring centers and virtual points.

Using the structure-activity relationships described below and herein, Applicants have identified a pharmacophore that binds PCSK9 and inhibits its activity. PCSK9 has three known domains: the prodomain, the catalytic domain, and the C-terminal domain. *Cunningham* at p. 414. In the active site of PCSK9, a serine protease catalytic triad of Ser386, His226 and Asp186 has been identified that interacts with LDLR and facilitates its internalization within the cell and eventual degradation. Studies of lack-of-function mutants have shown that the C-terminal domain is also necessary for degradation activity, but not may not bind LDLR. The binding site identified herein is located in the C-terminal domain. Without wishing to be bound by any theory, the disclosed inhibitors can act allosterically to modify the PCSK9 C-terminal domain conformation and function elsewhere, rather than binding directly at the catalytic domain site of the enzyme.

The C-terminal domain of PCSK9 has three modules, denoted M1, M2, and M3. The boundaries of the modules have been described as including slightly different ranges

of amino acid residues as research into PCSK9 has developed. The differences in the ranges serve mainly as location descriptors and do not connote any specific activity of one or more specific residues. In some embodiments, the M1 domain ranges from residues 457-527, the M2 domain ranges from residues 534-601, and the M3 domain ranges from residues 608-679. In other embodiments, the M1 domain ranges from residues 447-530, the M2 domain ranges from residues 531-604, and the M3 domain ranges from residues 608-683.

FIG. 1 provides a crystal structure of the C-terminal domain. Halgren et al., *J. Chem. Inf. Model.* 2009 49:377-389. In the crystal structure, the C-terminal domain had several disordered segments and a greater level of flexibility. *Cunningham* at p. 416. Experimental results in the art suggest that the C-terminal domain is involved in the secretion of PCSK9, which is needed for its activity in LDLR degradation. *Cunningham* at p. 417. The C-terminal domain also plays a role in targeting the PCSK9-LDLR complex to the endosomes/lysosome organelles inside cells for degradation. Saavedra et al. *J. Biol. Chem.* 2012 287:43492-43501. Mutant studies where the M2 domain of PCSK9 was removed resulted in loss of the enzyme's extracellular activity, but not its intracellular activity. *Saavedra* at p. 43500. Thus, the presently described binding site located in the C-terminal domain could influence PCSK9 activity in any of a number of known or undetermined pathways.

Key features of the binding site include a triad of hydrogen-bonded atom pairs that span the M2 and M3 domains as shown in FIG. 2. Based on crystal structures of PCSK9 bound to disclosed compounds, compounds of Formula I interact with the binding site as follows:

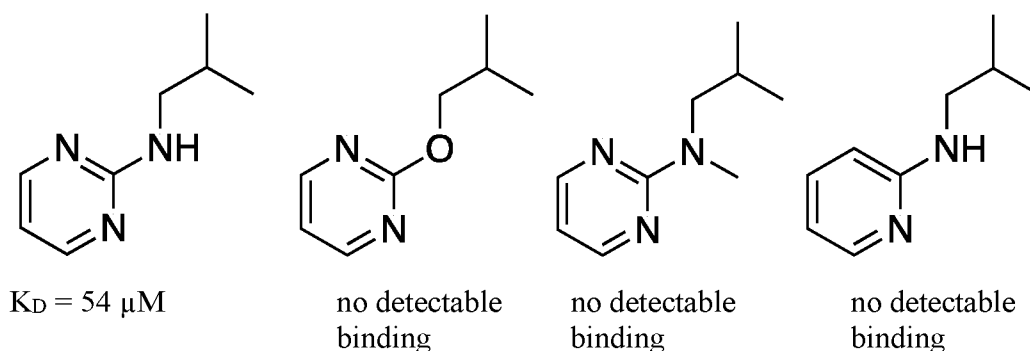
H-Bonding Type	PCSK9 Residue	2-aminopyrimidine atom
Acceptor A	Val 589	Acceptor is one pyrimidine N
Donor B	Val 589	Donor is 2-NH group
Acceptor C	Ser 636	Acceptor is the other pyrimidine N

The numbers of these residue positions are relative to the most common isoform of PCSK9. An isoform is a peptide or protein that has differences in its amino acid sequence, but is translated from the same gene. However, due to inclusion and deletion of

some residues during transcription and translation, the numbering of amino acids described herein may shift in a different isoform. Isoforms may also occur due to natural variations in genetic sequence. The present disclosure includes all isoforms of PCSK9 and their corresponding residue positions in isoforms or other mutant sequences. In some embodiments, isoforms of PCSK9 can have about 90%, about 91%, about 92%, about 93%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99%, about 99.2%, about 99.4%, about 99.6%, about 98.8%, or about 99.9% sequence homology with human PCSK9 having the sequence given in the Biological Assays section below. Isoform sequences (SEQID Nos 1-6) are given after the Biological Assays section.

Because the disclosed compounds acts as both an H-bond acceptor A at a pyrimidinyl nitrogen and a donor B at the 2-NH- of its 2-amino pyrimidinyl group with Val589, a bonding triad in the binding site is formed out of two PCSK9 residues. The other pyrimidinyl nitrogen binds as an H-bond acceptor C to Ser636. The bond distance between each triad atom of the pharmacophore as disclosed herein is about 2.3 Å to about 2.5 Å as shown in FIG. 3. For example, acceptor A is 2.3-2.4 Å from donor B and 2.3-2.5 Å from acceptor C. Donor B is 2.3-2.5 Å from acceptor C.

As shown below, the three nitrogen atoms of the 2-aminopyrimidinyl core of the disclosed compounds interact with the triad. Analogs lacking one of these bonding features do not exhibit detectable binding to human PCSK9.



As shown in FIG. 4, this H-bond triad is evident in fully elaborated compounds of the invention, such as compound 162.

Disclosed herein are methods of inhibiting PCSK9, comprising contacting PCSK9 with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues

Val589 and Ser636 of human PCSK9. In some embodiments, the inhibitor is of PCSK9 is an allosteric inhibitor. In some embodiments, the method comprises contacting the surface of a cell that secretes PCSK9 with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues Val589 and Ser636 of human PCSK9. In certain embodiments, the method comprises binding PCSK9 that is intracellular with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues Val589 and Ser636 of human PCSK9. In some embodiments, the method comprises contacting a cell that expresses PCSK9 with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues Val589 and Ser636 of human PCSK9. In other embodiments, the method comprises binding PCSK9 that is in plasma, with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues Val589 and Ser636 of human PCSK9.

In some embodiments, the inhibitor comprises an H-bond acceptor/donor group having two H-bond acceptor moieties and one H-bond donor moiety disposed to donate an H-bond to and accept an H-bond from the backbone amide functionality of residue Val589, and accept an H-bond from the hydroxymethyl sidechain of Ser636 of human PCSK9.

In certain embodiments, the inhibitor comprises an H-bond acceptor/donor group having two H-bond donor moieties and one H-bond acceptor moiety disposed to donate an H-bond to and accept an H-bond from the backbone amide functionality of residue Val589, and donate an H-bond to the hydroxymethyl sidechain of Ser636 of human PCSK9.

In certain embodiments, the inhibitor further comprises one or more of:

- a) an H-bond acceptor moiety disposed to bind with amino acid residues Ser642, His643 or Val 644,
- b) an H-bond donor moiety disposed to bind with amino acid residue Ala637 or Thr641, and
- c) a cation-pi stacking interaction moiety disposed to bind with amino acid residue Arg495 or His591,

wherein the H-bond acceptor/donor group is bound to amino acid residues Val589 and

Ser636 of human PCSK9. In certain embodiments, the inhibitor further comprises an H-bond acceptor moiety disposed to bind with amino acid residue Glu612. The binding may be a direct H-bond or indirect H-bond (e.g., where water-mediated H-bonding occurs).

While the triad H-bonding is common to the inhibitory compounds disclosed herein, some compounds have additional H-bonds to other residues in the pharmacophore. For example, as shown in FIG. 5, compound 43 forms the common 2-aminopyrimidine H-bond triad with the pharmacophore and the 2-aminobenzothiazole forms an H-bond with Ala637 and a molecule of water. Additional H-bonding occurs with the sulfonamido substituent on the benzothiazole ring. Residue Val644 is an H-bond donor and Ser642 is a H-bond acceptor.

The crystal structure of compound 60 bound to the pharmacophore, shown in FIG. 6, illustrates that, in addition to the H-bond triad, cation-pi stacking interactions occur between Arg495 in the M1 domain and the benzoxazole ring. These cation-pi stacking interactions can also occur with His591 (shown as HIE591) in the M2 domain as shown in compound 5 bound to the binding site in FIG. 7. Compound 5 has additional H-bonds between His643 and the carbonyl oxygen and between Thr641 and the hydroxyl group hydrogen.

The binding site's versatility to bind compounds of varying structure is further illustrated by compound 133. As shown in FIG. 8, compound 133 has two 2-aminopyrimidinyl functional groups that interact with the binding site. The pyrimidinyl ring with its thiomethyl substituent binds to the common H-bond triad formed from Ser 636 and Val 589. The pyrimidinyl ring substituted with a methyl ester forms five additional H-bonds with Ala637, Val644, and two molecules of water. A cation-pi stacking interaction occurs between His591 (shown as HIE591) and the pyrimidine ring. In addition, FIG. 9 illustrates the interaction of compound 458B with the N-H of glycine 640.

Substitution around the 2-aminopyrimidinyl core can be selected to engage a combination of these affinity features to foster increased H-bonding or cation-pi stacking, thereby increasing a compound's affinity for the binding site, thereby increasing its

inhibitory effect. The binding site engages residues from all three subdomains of the C-terminal domain. The flexibility of the pharmacophore that engages this binding site provides numerous opportunities to design compounds, such as compounds having the core 2-aminopyrimidyl group or a bioisosteric equivalent, with structures that hydrogen-bond to the triad (e.g., with two donor and one acceptor H-bonds) and engage one or more of the other affinity elements (e.g., the cation-pi stacking interaction and the additional H-bond sites).

As used herein, the term “interacts” in the context of an inhibitor in relation to one or more residues of PCSK9 refers to direct or indirect associations of the inhibitor with either the backbone of the enzyme or the side chain of any given residue. For example, interactions include covalent bonds, hydrogen bonds, hydrophobic attractions, cation-pi interactions, anion-pi interactions and others well known in the art.

The amino acids binding to the pharmacophore of the inhibitors, the triad formed between Val589 and Ser 636, can also be further interacting with amino acid residue(s) in the M1, M2, and M3 domains. In certain embodiments, the inhibitor interacts with at least one residue in the M2 C-terminal domain and at least one residue in the M3 C-terminal domain. In some embodiments, the inhibitor further interacts with at least one residue in the M1 C-terminal domain. In certain embodiments, the inhibitor interacts with at least one residue in the M1 C-terminal domain and at least one residue in the M3 C-terminal domain. In other embodiments, the inhibitor interacts with at least one residue in the M1 C-terminal domain and at least one residue in the M2 C-terminal domain. In certain embodiments, the inhibitor interacts with PCSK9 between amino acid residues 558-590 in the M2 C-terminal domain and amino acids residues 631-650 in the M3 C-terminal domain.

In certain embodiments, the inhibitor interacts with at least one residue in beta strand 3 and beta strand 5 of the M2 C-terminal domain and beta strand 3 and beta strand 4 of the M3 C-terminal domain. In certain embodiments, the inhibitor interacts with PCSK9 created between amino acid residues 558-566 in beta strand 3 of the M2 C-terminal domain and amino acids residues 587-590 in beta strand 5 of the M2 C-terminal domain. In other embodiments, the inhibitor interacts with a pocket in PCSK9 created

between amino acid residues 631-637 in beta strand 3 of the M3 C-terminal domain and amino acids residues 644-650 in beta strand 4 of the M3 C-terminal domain.

Structural evaluation of the PCSK9 binding site can be performed using a number of techniques well known to the skilled artisan. For instance, FIGS. 4-8 illustrate 3-D renderings of PCSK9-compound interactions as determined from X-ray crystal structures. Details on the preparation and analysis of the crystal structures are given in the examples below. Analysis of the X-ray data provides a 3D rendering of the compound bound to PCSK9 where atom orientation and distances can indicate the type of bonds present, such as covalent, H-bond, pi-stacking, and others.

Other methods include 3D computer modeling techniques that render a computer generated image of a compound interacting with a substrate. As with crystal structure data, computer modeling programs can present 3D information as a shell of the surface or in ball/stick format showing atoms in 3D array. In a non-limiting example, it is well within the skill in the art to use a computer model of a presently disclosed compound bound to PCSK9 to identify how and where the compound interacts with PCSK9.

Methods of Use

The PCSK9 gene was identified using genetic mapping techniques on DNA from subjects with autosomal dominant hypercholesterolemia (Abifadel, et al. *Nat. Genet.* 2003 34:154-6). The encoded protein is a serine protease that is mostly expressed in the liver, gut, kidney, and nervous system. While not wishing to be bound by any particular theory, studies on mutations in the gene indicated that its putative role was in reducing LDL receptors at the cell surface independently of its catalytic activity. (Abifadel, et al. *Expert Opin. Ther. Pat.* 2010 20:1547-71). Binding of PCSK9 to the receptors results in their lysosomal degradation. This enhanced degradation results in increases in the amount of circulating low-density lipoprotein LDL (LDL-c). PCSK9 is upregulated by statins, SREBP-1a and SREBP-2, LXR agonist, and insulin, but downregulated by dietary cholesterol, glucagon, ethinylestradiol, chenodeoxycholic acid and the bile acid-activated farnesoid X receptor (FXR) (Maxwell, et al. *J. Lipid Res.* 2003 44:2109-19; Persson et al. *Endocrinology* 2009 150:1140-6; Langhi et al. *FEBS Lett.* 2008 582:949-

55). Since an elevated level of PCSK9 decreases the abundance of LDL receptor on the cell surface, increasing doses of statins fail to achieve proportional LDL-cholesterol lowering results. Thus, disclosed herein are methods for treating a wide range of cardiovascular diseases and conditions that benefit from inhibiting PCSK9 thereby lowering LDL-c.

In certain embodiments, the disclosed methods of inhibiting PCSK9 occurs in a subject in need thereof, thereby treating a disease or disorder mediated by PCSK9. Also, disclosed herein are methods of treating or preventing a disease or a disorder mediated by PCSK9 comprising administering a compound of Formula (I) or a pharmaceutically acceptable salt thereof. In certain embodiments, disclosed herein are methods of treating a disease or a disorder mediated by PCSK9 comprising administering a compound of Formula (I) or a pharmaceutically acceptable salt thereof. In certain embodiments, disclosed herein are methods of preventing a disease or a disorder mediated by PCSK9 comprising administering a compound of Formula I or a pharmaceutically acceptable salt thereof. The prevention of cardiovascular events through the inhibition of PCSK9 has been described, e.g., in Robinson et al., *Arteriosclerosis* 2015 243:593-597.

Exemplary cardiovascular diseases and conditions include, but are not limited to, dyslipidemia, hypercholesterolemia, hypertriglyceridemia, hyperlipidemia, hypoalphalipoproteinemia, metabolic syndrome, diabetic complications, atherosclerosis, stroke, vascular dimensia, chronic kidney disease, coronary heart disease, coronary artery disease, retinopathy, inflammation, thrombosis, peripheral vascular disease or congestive heart failure.

In certain embodiments, exemplary cardiovascular diseases and conditions include, but are not limited to, hypercholesterolemia, hyperlipidemia, hyperlipoproteinemia, hypertriglyceridemia, dyslipidemia, dyslipoproteinemia, atherosclerosis, hepatic steatosis, metabolic syndrome and coronary artery disease. In certain embodiments, the disease is hypercholesterolemia, such as familial hypercholesterolemia or autosomal dominant hypercholesterolemia. In certain embodiments, the disease is hyperlipidemia. In certain embodiments, the disease is coronary artery disease.

In certain embodiments, the disclosed methods of treatment can decrease high levels of circulating serum cholesterol, such as LDL-cholesterol and VLDL-cholesterol. In addition, the disclosed methods are useful for decreasing circulating serum triglycerides, circulating serum lipoprotein A, circulating serum LDL and atherogenic lipoproteins. In certain embodiments, the diseases or conditions treated with the disclosed compounds and compositions include atherosclerosis and atherosclerotic plaque formation. Subjects having a gain-of-function mutation in the PCSK9 gene also benefit with treatment with the disclosed compounds and compositions counteracting the mutation through their inhibition of PCSK9.

Inhibition of PCSK9 has also shown therapeutic benefit in treating sepsis in a subject. Septic shock is an often fatal complication of a severe microbial infection (sepsis) that triggers an uncontrolled systemic inflammatory response and subsequent organ failure. Sepsis originates with the microbial cell walls that contain pathogenic lipid moieties such as lipopolysaccharide (LPS; Gram-negative bacteria). LPS are potent ligands for mammalian innate immune receptors [Toll-like receptors (TLRs)] and thus figure prominently in the septic inflammatory response (septic shock or sepsis). PCSK9 reduces LPS uptake by the liver's LDL receptors, such that free LPS overstimulates the body's immune response to the pathogen leading to sepsis. Inhibiting PCSK9 is beneficial in retaining liver LDL receptors to effect systemic pathogen clearance and detoxification in response to sepsis (See, e.g., Walley et al *Sci. Translat. Med.* 2014 6:1-10).

Disclosed herein are methods of treating sepsis or septic shock comprising administering a compound of Formula (I) or a pharmaceutically acceptable salt thereof. In certain embodiments, the disclosed methods of treatment are useful for increasing LPS uptake. Certain embodiments provide a method of decreasing the inflammatory response induced by sepsis or septic shock.

Pharmaceutical Compositions

The compositions and methods of the present invention may be utilized to treat a subject in need thereof. In certain embodiments, the subject is a mammal such as a

human, or a non-human mammal. When administered to subject, such as a human, the composition or the compound is preferably administered as a pharmaceutical composition comprising, for example, a compound of the invention and a pharmaceutically acceptable carrier. Pharmaceutically acceptable carriers are well known in the art and include, for example, aqueous solutions such as water or physiologically buffered saline or other solvents or vehicles such as glycols, glycerol, oils such as olive oil, or injectable organic esters. In a preferred embodiment, when such pharmaceutical compositions are for human administration, particularly for invasive routes of administration (i.e., routes, such as injection or implantation, that circumvent transport or diffusion through an epithelial barrier), the aqueous solution is pyrogen-free, or substantially pyrogen-free. The excipients can be chosen, for example, to effect delayed release of an agent or to selectively target one or more cells, tissues or organs. The pharmaceutical composition can be in dosage unit form such as tablet, capsule (including sprinkle capsule and gelatin capsule), granule, lyophile for reconstitution, powder, solution, syrup, suppository, injection or the like. The composition can also be present in a transdermal delivery system, e.g., a skin patch. The composition can also be present in a solution suitable for topical administration, such as an eye drop.

A pharmaceutically acceptable carrier can contain physiologically acceptable agents that act, for example, to stabilize, increase solubility or to increase the absorption of a compound such as a compound of the invention. Such physiologically acceptable agents include, for example, carbohydrates, such as glucose, sucrose or dextrans, antioxidants, such as ascorbic acid or glutathione, chelating agents, low molecular weight proteins or other stabilizers or excipients. The choice of a pharmaceutically acceptable carrier, including a physiologically acceptable agent, depends, for example, on the route of administration of the composition. The preparation or pharmaceutical composition can be a self-emulsifying drug delivery system or a self-microemulsifying drug delivery system. The pharmaceutical composition (preparation) also can be a liposome or other polymer matrix, which can have incorporated therein, for example, a compound of the invention. Liposomes, for example, which comprise phospholipids or other lipids, are

nontoxic, physiologically acceptable and metabolizable carriers that are relatively simple to make and administer.

The phrase "pharmaceutically acceptable" is employed herein to refer to those compounds, materials, compositions, and/or dosage forms which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of a subject without excessive toxicity, irritation, allergic response, or other problem or complication, commensurate with a reasonable benefit/risk ratio.

The phrase "pharmaceutically acceptable carrier" as used herein means a pharmaceutically acceptable material, composition or vehicle, such as a liquid or solid filler, diluent, excipient, solvent or encapsulating material. Each carrier must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not injurious to the subject. Some examples of materials which can serve as pharmaceutically acceptable carriers include: (1) sugars, such as lactose, glucose and sucrose; (2) starches, such as corn starch and potato starch; (3) cellulose, and its derivatives, such as sodium carboxymethyl cellulose, ethyl cellulose and cellulose acetate; (4) powdered tragacanth; (5) malt; (6) gelatin; (7) talc; (8) excipients, such as cocoa butter and suppository waxes; (9) oils, such as peanut oil, cottonseed oil, safflower oil, sesame oil, olive oil, corn oil and soybean oil; (10) glycols, such as propylene glycol; (11) polyols, such as glycerin, sorbitol, mannitol and polyethylene glycol; (12) esters, such as ethyl oleate and ethyl laurate; (13) agar; (14) buffering agents, such as magnesium hydroxide and aluminum hydroxide; (15) alginic acid; (16) pyrogen-free water; (17) isotonic saline; (18) Ringer's solution; (19) ethyl alcohol; (20) phosphate buffer solutions; and (21) other non-toxic compatible substances employed in pharmaceutical formulations.

A pharmaceutical composition (preparation) can be administered to a subject by any of a number of routes of administration including, for example, orally (for example, drenches as in aqueous or non-aqueous solutions or suspensions, tablets, capsules (including sprinkle capsules and gelatin capsules), boluses, powders, granules, pastes for application to the tongue); absorption through the oral mucosa (e.g., sublingually); anally, rectally or vaginally (for example, as a pessary, cream or foam); parenterally (including

intramuscularly, intravenously, subcutaneously or intrathecally as, for example, a sterile solution or suspension); nasally; intraperitoneally; subcutaneously; transdermally (for example as a patch applied to the skin); and topically (for example, as a cream, ointment or spray applied to the skin, or as an eye drop). The compound may also be formulated for inhalation. In certain embodiments, a compound may be simply dissolved or suspended in sterile water. Details of appropriate routes of administration and compositions suitable for same can be found in, for example, U.S. Pat. Nos. 6,110,973, 5,763,493, 5,731,000, 5,541,231, 5,427,798, 5,358,970 and 4,172,896, as well as in patents cited therein.

The formulations may conveniently be presented in unit dosage form and may be prepared by any methods well known in the art of pharmacy. The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will vary depending upon the subject being treated, the particular mode of administration. The amount of active ingredient that can be combined with a carrier material to produce a single dosage form will generally be that amount of the compound which produces a therapeutic effect. Generally, out of one hundred percent, this amount will range from about 1 percent to about ninety-nine percent of active ingredient, preferably from about 5 percent to about 70 percent, most preferably from about 10 percent to about 30 percent.

Methods of preparing these formulations or compositions include the step of bringing into association an active compound, such as a compound of the invention, with the carrier and, optionally, one or more accessory ingredients. In general, the formulations are prepared by uniformly and intimately bringing into association a compound of the present invention with liquid carriers, or finely divided solid carriers, or both, and then, if necessary, shaping the product.

Formulations of the invention suitable for oral administration may be in the form of capsules (including sprinkle capsules and gelatin capsules), cachets, pills, tablets, lozenges (using a flavored basis, usually sucrose and acacia or tragacanth), lyophile, powders, granules, or as a solution or a suspension in an aqueous or non-aqueous liquid, or as an oil-in-water or water-in-oil liquid emulsion, or as an elixir or syrup, or as pastilles (using an inert base, such as gelatin and glycerin, or sucrose and acacia) and/or

as mouth washes and the like, each containing a predetermined amount of a compound of the present invention as an active ingredient. Compositions or compounds may also be administered as a bolus, electuary or paste.

To prepare solid dosage forms for oral administration (capsules (including sprinkle capsules and gelatin capsules), tablets, pills, dragees, powders, granules and the like), the active ingredient is mixed with one or more pharmaceutically acceptable carriers, such as sodium citrate or dicalcium phosphate, and/or any of the following: (1) fillers or extenders, such as starches, lactose, sucrose, glucose, mannitol, and/or silicic acid; (2) binders, such as, for example, carboxymethylcellulose, alginates, gelatin, polyvinyl pyrrolidone, sucrose and/or acacia; (3) humectants, such as glycerol; (4) disintegrating agents, such as agar-agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates, and sodium carbonate; (5) solution retarding agents, such as paraffin; (6) absorption accelerators, such as quaternary ammonium compounds; (7) wetting agents, such as, for example, cetyl alcohol and glycerol monostearate; (8) absorbents, such as kaolin and bentonite clay; (9) lubricants, such as talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate, and mixtures thereof; (10) complexing agents, such as, modified and unmodified cyclodextrins; and (11) coloring agents. In the case of capsules (including sprinkle capsules and gelatin capsules), tablets and pills, the pharmaceutical compositions may also comprise buffering agents. Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugars, as well as high molecular weight polyethylene glycols and the like.

A tablet may be made by compression or molding, optionally with one or more accessory ingredients. Compressed tablets may be prepared using binder (for example, gelatin or hydroxypropylmethyl cellulose), lubricant, inert diluent, preservative, disintegrant (for example, sodium starch glycolate or cross-linked sodium carboxymethyl cellulose), surface-active or dispersing agent. Molded tablets may be made by molding in a suitable machine a mixture of the powdered compound moistened with an inert liquid diluent.

The tablets, and other solid dosage forms of the pharmaceutical compositions, such as dragees, capsules (including sprinkle capsules and gelatin capsules), pills and granules, may optionally be scored or prepared with coatings and shells, such as enteric coatings and other coatings well known in the pharmaceutical-formulating art. They may also be formulated so as to provide slow or controlled release of the active ingredient therein using, for example, hydroxypropylmethyl cellulose in varying proportions to provide the desired release profile, other polymer matrices, liposomes and/or microspheres. They may be sterilized by, for example, filtration through a bacteria-retaining filter, or by incorporating sterilizing agents in the form of sterile solid compositions that can be dissolved in sterile water, or some other sterile injectable medium immediately before use. These compositions may also optionally contain opacifying agents and may be of a composition that they release the active ingredient(s) only, or preferentially, in a certain portion of the gastrointestinal tract, optionally, in a delayed manner. Examples of embedding compositions that can be used include polymeric substances and waxes. The active ingredient can also be in micro-encapsulated form, if appropriate, with one or more of the above-described excipients.

Liquid dosage forms useful for oral administration include pharmaceutically acceptable emulsions, lyophiles for reconstitution, microemulsions, solutions, suspensions, syrups and elixirs. In addition to the active ingredient, the liquid dosage forms may contain inert diluents commonly used in the art, such as, for example, water or other solvents, cyclodextrins and derivatives thereof, solubilizing agents and emulsifiers, such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor and sesame oils), glycerol, tetrahydrofuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof.

Besides inert diluents, the oral compositions can also include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, coloring, perfuming and preservative agents.

Suspensions, in addition to the active compounds, may contain suspending agents as, for example, ethoxylated isostearyl alcohols, polyoxyethylene sorbitol and sorbitan

esters, microcrystalline cellulose, aluminum metahydroxide, bentonite, agar-agar and tragacanth, and mixtures thereof.

Formulations of the pharmaceutical compositions for rectal, vaginal, or urethral administration may be presented as a suppository, which may be prepared by mixing one or more active compounds with one or more suitable nonirritating excipients or carriers comprising, for example, cocoa butter, polyethylene glycol, a suppository wax or a salicylate, and which is solid at room temperature, but liquid at body temperature and, therefore, will melt in the rectum or vaginal cavity and release the active compound.

Formulations of the pharmaceutical compositions for administration to the mouth may be presented as a mouthwash, or an oral spray, or an oral ointment.

Alternatively or additionally, compositions can be formulated for delivery via a catheter, stent, wire, or other intraluminal device. Delivery via such devices may be especially useful for delivery to the bladder, urethra, ureter, rectum, or intestine.

Formulations which are suitable for vaginal administration also include pessaries, tampons, creams, gels, pastes, foams or spray formulations containing such carriers as are known in the art to be appropriate.

Dosage forms for the topical or transdermal administration include powders, sprays, ointments, pastes, creams, lotions, gels, solutions, patches and inhalants. The active compound may be mixed under sterile conditions with a pharmaceutically acceptable carrier, and with any preservatives, buffers, or propellants that may be required.

The ointments, pastes, creams and gels may contain, in addition to an active compound, excipients, such as animal and vegetable fats, oils, waxes, paraffins, starch, tragacanth, cellulose derivatives, polyethylene glycols, silicones, bentonites, silicic acid, talc and zinc oxide, or mixtures thereof.

Powders and sprays can contain, in addition to an active compound, excipients such as lactose, talc, silicic acid, aluminum hydroxide, calcium silicates and polyamide powder, or mixtures of these substances. Sprays can additionally contain customary propellants, such as chlorofluorohydrocarbons and volatile unsubstituted hydrocarbons, such as butane and propane.

Transdermal patches have the added advantage of providing controlled delivery of a compound of the present invention to the body. Such dosage forms can be made by dissolving or dispersing the active compound in the proper medium. Absorption enhancers can also be used to increase the flux of the compound across the skin. The rate of such flux can be controlled by either providing a rate controlling membrane or dispersing the compound in a polymer matrix or gel.

Ophthalmic formulations, eye ointments, powders, solutions and the like, are also contemplated as being within the scope of this invention. Exemplary ophthalmic formulations are described in U.S. Publication Nos. 2005/0080056, 2005/0059744, 2005/0031697 and 2005/004074 and U.S. Patent No. 6,583,124, the contents of which are incorporated herein by reference. If desired, liquid ophthalmic formulations have properties similar to that of lacrimal fluids, aqueous humor or vitreous humor or are compatible with such fluids. A preferred route of administration is local administration (*e.g.*, topical administration, such as eye drops, or administration via an implant).

The phrases "parenteral administration" and "administered parenterally" as used herein means modes of administration other than enteral and topical administration, usually by injection, and includes, without limitation, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intraorbital, intracardiac, intradermal, intraperitoneal, transtracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal and intrasternal injection and infusion. Pharmaceutical compositions suitable for parenteral administration comprise one or more active compounds in combination with one or more pharmaceutically acceptable sterile isotonic aqueous or nonaqueous solutions, dispersions, suspensions or emulsions, or sterile powders which may be reconstituted into sterile injectable solutions or dispersions just prior to use, which may contain antioxidants, buffers, bacteriostats, solutes which render the formulation isotonic with the blood of the intended recipient or suspending or thickening agents.

Examples of suitable aqueous and nonaqueous carriers that may be employed in the pharmaceutical compositions of the invention include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures

thereof, vegetable oils, such as olive oil, and injectable organic esters, such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of coating materials, such as lecithin, by the maintenance of the required particle size in the case of dispersions, and by the use of surfactants.

These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of the action of microorganisms may be ensured by the inclusion of various antibacterial and antifungal agents, for example, paraben, chlorobutanol, phenol sorbic acid, and the like. It may also be desirable to include isotonic agents, such as sugars, sodium chloride, and the like into the compositions. In addition, prolonged absorption of the injectable pharmaceutical form may be brought about by the inclusion of agents that delay absorption such as aluminum monostearate and gelatin.

In some cases, in order to prolong the effect of a drug, it is desirable to slow the absorption of the drug from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material having poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution, which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered drug form is accomplished by dissolving or suspending the drug in an oil vehicle.

Injectable depot forms are made by forming microencapsulated matrices of the subject compounds in biodegradable polymers such as polylactide-polyglycolide. Depending on the ratio of drug to polymer, and the nature of the particular polymer employed, the rate of drug release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are also prepared by entrapping the drug in liposomes or microemulsions that are compatible with body tissue.

For use in the methods of this invention, active compounds can be given per se or as a pharmaceutical composition containing, for example, 0.1 to 99.5% (more preferably, 0.5 to 90%) of active ingredient in combination with a pharmaceutically acceptable carrier.

Methods of introduction may also be provided by rechargeable or biodegradable devices. Various slow release polymeric devices have been developed and tested *in vivo* in recent years for the controlled delivery of drugs, including proteinaceous biopharmaceuticals. A variety of biocompatible polymers (including hydrogels), including both biodegradable and non-degradable polymers, can be used to form an implant for the sustained release of a compound at a particular target site.

Actual dosage levels of the active ingredients in the pharmaceutical compositions may be varied so as to obtain an amount of the active ingredient that is effective to achieve the desired therapeutic response for a particular patient, composition, and mode of administration, without being toxic to the patient.

The selected dosage level will depend upon a variety of factors including the activity of the particular compound or combination of compounds employed, or the ester, salt or amide thereof, the route of administration, the time of administration, the rate of excretion of the particular compound(s) being employed, the duration of the treatment, other drugs, compounds and/or materials used in combination with the particular compound(s) employed, the age, sex, weight, condition, general health and prior medical history of the subject being treated, and like factors well known in the medical arts.

A physician or veterinarian having ordinary skill in the art can readily determine and prescribe the therapeutically effective amount of the pharmaceutical composition required. For example, the physician or veterinarian could start doses of the pharmaceutical composition or compound at levels lower than that required in order to achieve the desired therapeutic effect and gradually increase the dosage until the desired effect is achieved. By “therapeutically effective amount” is meant the concentration of a compound that is sufficient to elicit the desired therapeutic effect. It is generally understood that the effective amount of the compound will vary according to the weight, sex, age, and medical history of the subject. Other factors which influence the effective amount may include, but are not limited to, the severity of the subject's condition, the disorder being treated, the stability of the compound, and, if desired, another type of therapeutic agent being administered with the compound of the invention. A larger total dose can be delivered by multiple administrations of the agent. Methods to determine

efficacy and dosage are known to those skilled in the art (Isselbacher *et al.* (1996) Harrison's Principles of Internal Medicine 13 ed., 1814-1882, herein incorporated by reference).

In general, a suitable daily dose of an active compound used in the compositions and methods of the invention will be that amount of the compound that is the lowest dose effective to produce a therapeutic effect. Such an effective dose will generally depend upon the factors described above.

If desired, the effective daily dose of the active compound may be administered as one, two, three, four, five, six or more sub-doses administered separately at appropriate intervals throughout the day, optionally, in unit dosage forms. In certain embodiments of the present invention, the active compound may be administered two or three times daily. In preferred embodiments, the active compound will be administered once daily.

In certain embodiments, compounds of the invention may be used alone or conjointly administered with another type of therapeutic agent. As used herein, the phrase "conjoint administration" refers to any form of administration of two or more different therapeutic compounds such that the second compound is administered while the previously administered therapeutic compound is still effective in the body (*e.g.*, the two compounds are simultaneously effective in the subject, which may include synergistic effects of the two compounds). For example, the different therapeutic compounds can be administered either in the same formulation or in a separate formulation, either concomitantly or sequentially. In certain embodiments, the different therapeutic compounds can be administered within one hour, 12 hours, 24 hours, 36 hours, 48 hours, 72 hours, or a week of one another. Thus, a subject who receives such treatment can benefit from a combined effect of different therapeutic compounds.

In certain embodiments, conjoint administration of compounds of the invention with one or more additional therapeutic agent(s) provides improved efficacy relative to each individual administration of the compound of the invention (*e.g.*, compound of formula I or Ia) or the one or more additional therapeutic agent(s). In certain such embodiments, the conjoint administration provides an additive effect, wherein an additive

effect refers to the sum of each of the effects of individual administration of the compound of the invention and the one or more additional therapeutic agent(s).

This invention includes the use of pharmaceutically acceptable salts of compounds of the invention in the compositions and methods of the present invention. In certain embodiments, contemplated salts of the invention include, but are not limited to, alkyl, dialkyl, trialkyl or tetra-alkyl ammonium salts. In certain embodiments, contemplated salts of the invention include, but are not limited to, L-arginine, benenthamine, benzathine, betaine, calcium hydroxide, choline, deanol, diethanolamine, diethylamine, 2-(diethylamino)ethanol, ethanolamine, ethylenediamine, N-methylglucamine, hydrabamine, 1H-imidazole, lithium, L-lysine, magnesium, 4-(2-hydroxyethyl)morpholine, piperazine, potassium, 1-(2-hydroxyethyl)pyrrolidine, sodium, triethanolamine, tromethamine, and zinc salts. In certain embodiments, contemplated salts of the invention include, but are not limited to, Na, Ca, K, Mg, Zn or other metal salts.

The pharmaceutically acceptable acid addition salts can also exist as various solvates, such as with water, methanol, ethanol, dimethylformamide, and the like. Mixtures of such solvates can also be prepared. The source of such solvate can be from the solvent of crystallization, inherent in the solvent of preparation or crystallization, or adventitious to such solvent.

Wetting agents, emulsifiers and lubricants, such as sodium lauryl sulfate and magnesium stearate, as well as coloring agents, release agents, coating agents, sweetening, flavoring and perfuming agents, preservatives and antioxidants can also be present in the compositions.

Examples of pharmaceutically acceptable antioxidants include: (1) water-soluble antioxidants, such as ascorbic acid, cysteine hydrochloride, sodium bisulfate, sodium metabisulfite, sodium sulfite and the like; (2) oil-soluble antioxidants, such as ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), lecithin, propyl gallate, alpha-tocopherol, and the like; and (3) metal-chelating agents, such as citric acid, ethylenediamine tetraacetic acid (EDTA), sorbitol, tartaric acid, phosphoric acid, and the like.

Examples

Examples of compounds of Formula (I), or pharmaceutically acceptable salts thereof, having useful biological activity are listed in Tables 1-10. ¹H NMR spectra were performed on a Varian MR-400 spectrometer operating at 400 MHz (proton frequency), equipped with: a self-shielded z-gradient coil 5 mm 1H/nX broad band probehead for reverse detection, deuterium digital lock channel unit, quadrature digital detection unit with transmitter offset frequency shift. Chemical shift are reported as δ values in ppm relative to trimethylsilane (TMS) as an internal standard. Coupling constants (J values) are given in hertz (Hz) and multiplicities are reported using the following abbreviation (s= singlet, d=doublet, t=triplet, q=quartet, m=multiplet, br=broad, nd=not determined).

A. Analytical methods

Method 1 (acid FA)

UPLC Setup

Solvents: - A Water (High purity via PureLab Option unit) with 0.1% formic acid
 B Acetonitrile (Far UV grade) with 0.1% (V/V) formic acid

Column: - Acquity UPLC HSS C18 1.8 μ m 100 x 2.1 mm. (Plus guard cartridge)

Flow Rate: - 0.5 mL/min

Gradient:

Time (min)	%A	%B
0.00	95	5
1.2	95	5
3.5	0	100
4.9	0	100
5	95	5
6	95	5

Injections 0.5-2 μ L

UV detection via Waters DAD

Start Range (nm) 210 End Range (nm) 400 Resolution (nm) 1.2

MS detection: Waters SQD2, single quadrapole UPLC-MS

Scan range for MS Data (m/z)

Start (m/z) 100

End (m/z) 700 or 1500 when required

With +ve / -ve switching

Ionisation is ESI.

ESI voltages and temperatures are:

Source 150C 3.5KV capillary 25V cone

Method 2 (basic FA)

UPLC Setup

Solvents: - Acetonitrile (Far UV grade)

Water (High purity via PureLab Option unit) with 10 mM ammonium bicarbonate (ammonium hydrogen carbonate)

Column: - Acquity UPLC BEH Shield RP18 1.7 μ m 100 x 2.1 mm. (Plus guard cartridge)

Flow Rate: - 0.5 mL/min

Gradient: - A: Water / Basic B: MeCN / Basic

Time	A%	B%
0.00	95	5
1.20	95	5
3.5	0	100
4.90	0	100
5.00	95	5
6.00	95	5

Typical Injections 0.5-2 μ L (concentration ~ 0.2 -1 mg/mL).

UV detection via Waters DAD

Start Range (nm) 210 End Range (nm) 400 Resolution (nm) 1.2

Other wavelength traces are extracted from the DAD data.

MS detection: Waters SQD2, single quadrupole UPLC-MS

Flow splitter gives approximately 300ul/min to mass spec

Scan range for MS Data (m/z)

Start (m/z) 100

End (m/z) 700 or 1500 when required

With +ve / -ve switching

Preparative reverse-phase HPLC conditions

Preparative HPLC

Waters Micromass ZQ/Sample manager 2767

Photodiode array detector 2996;

Column: XTerra Prep MS C18 Column (5 µm, 19 x 150 mm, Waters)

Flow rate: 20 mL/min with MS detection

UV wavelength: 254 nm.

Mobile phase: Solvent A (water:MeCN:HCO₂H 95:5:0.05); Solvent B (water:MeCN:HCO₂H 5:95:0.05)

Gradient:

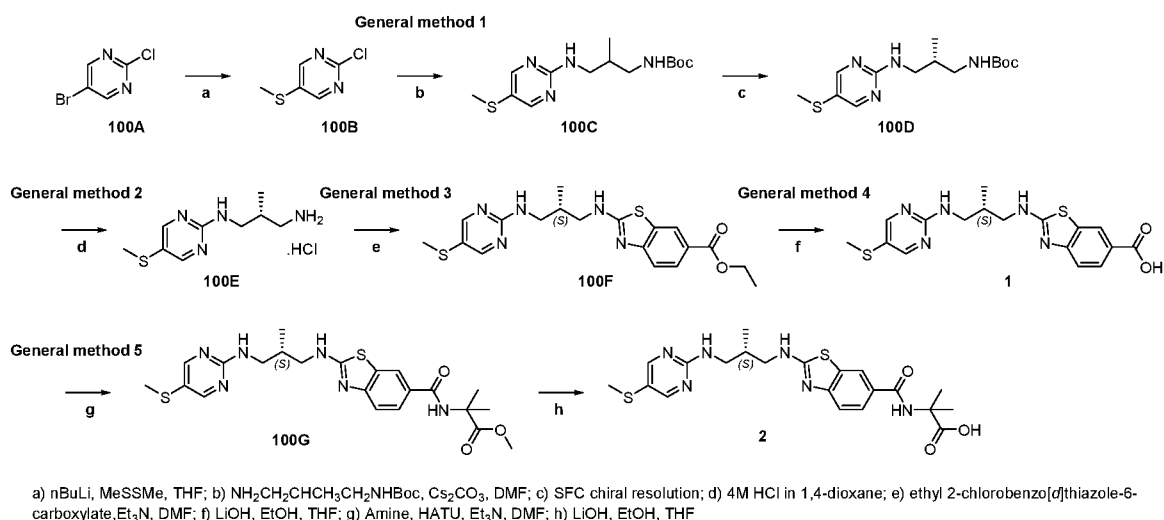
Time (min)	%A	%B
0.00	100.0	0.00
1.00	100	0.00
10.00	0.00	100.0
11.00	0.00	100.0
12.00	100.0	0.00

Flash chromatography is carried out using an Isolera MPLC system (manufactured by Biotage) using pre-packed silica gel or reverse-phase cartridges (supplied by Biotage or Interchim).

B. Chemical Syntheses

The general procedures used in the methods to prepare the compounds of the present invention are described below:

Scheme 1



2-Chloro-5-(methylthio)pyrimidine (100B)

Dimethyl disulphide (13.96 mL, 155.4 mmol, 1.0 eq) was added under nitrogen to a $-75\text{ }^\circ\text{C}$ cooled solution of 5-bromo-2-chloropyrimidine (100A) (30 g, 155.4 mmol, 1.0 eq) in anhydrous tetrahydrofuran (700 mL). To this mixture was added a solution of *n*-butyl lithium (2.5 M, 68.4 mL, 170.9 mmol, 1.0 eq) dropwise over 1.5 h, with the internal temperature maintained at $-70\text{ }^\circ\text{C}$ to $-75\text{ }^\circ\text{C}$ throughout the addition. After complete addition, the mixture was stirred at $-75\text{ }^\circ\text{C}$ for 4.5 h and was then quenched by the slow addition of a saturated solution of ammonium chloride (100 mL). The cooling bath was removed and the reaction was allowed to warm to room temperature under nitrogen over 18 h. The reaction mixture was diluted with ethyl acetate (500 mL), washed with water (50 mL) and then saturated brine (50 mL). The organic phase was dried over anhydrous magnesium sulfate, filtered and then concentrated under reduced pressure. The crude pale yellow oil obtained was purified by flash chromatography (eluting *iso*hexane to ethyl acetate, 0-50%) to give the desired product 2-chloro-5-(methylthio)pyrimidine as a waxy pale yellow solid (100B).

Yield: 7.39 g (29%). ^1H NMR (CDCl_3) δ 8.48 (2H, s), 2.54 (3H, s); MS (ESI+) m/z 161 ($\text{M}+\text{H}$) $^+$.

General Method 1

***tert*-Butyl (2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (100C)**

tert-Butyl(3-amino-2-methylpropyl)carbamate (4.79 g, 25.52 mmol, 1.05 eq) was added to a stirred suspension of 2-chloro-5-(methylthio)pyrimidine (100B) (3.89 g, 24.31 mmol, 1.0 eq) and cesium carbonate (11.85 g, 36.46 mmol, 1.4 eq) in anhydrous dimethylformamide (50 mL). The mixture was stirred at room temperature for 18 h and then concentrated under reduced pressure to ~20 mL. The liquor was diluted with ethyl acetate (100 mL), washed with water (75 mL) and brine (50 mL) and then dried over magnesium sulfate. The solvents were removed under vacuum to afford a crude residue that was purified by flash chromatography (eluting *iso*hexane to ethyl acetate, 0-50%) to give the desired product *tert*-butyl (2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) carbamate (100C) as a pale yellow oil.

Yield: 6.59 g (86%). MS (ESI+) m/z 313 ($\text{M}+\text{H}$) $^+$.

***tert*-Butyl (S)-(2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) carbamate (100D)**

Racemic *tert*-butyl (2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (100C) (5 g) was purified by chiral SFC using the following conditions: YMC amylose-C 30/70 MeOH / CO_2 , 100 mL/min, 120 bar, 40 $^\circ\text{C}$, GLS 40 psi, System 3900 psi, drop 140 bar, Stacker, DAD 245 nm.

First-eluting isomer, 1.3 minutes. *tert*-Butyl (*R*)-(2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate

Yield: 2.05 g. ^1H NMR (400 MHz, CDCl_3) δ 8.34 (s, 2H), 5.79 (dd, $J=6.7$, 6.7 Hz, 1H), 5.18 (dd, $J=5.8$, 5.8 Hz, 1H), 3.50 - 3.39 (m, 1H), 3.33 - 3.14 (m, 2H), 3.04 - 2.94 (m, 1H), 2.36 (s, 3H), 1.94 - 1.85 (m, 1H), 1.45 (s, 9H), 0.95 (d, $J=6.9$ Hz, 3H). MS (ESI+) m/z 313 ($\text{M}+\text{H}$) $^+$.

Second-eluting isomer, 1.7 minutes. *tert*-Butyl (*S*)-(2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (**100D**)

Yield: 2.48 g. ¹H NMR (400 MHz, CDCl₃) δ 8.34 (s, 2H), 5.77 - 5.69 (m, 1H), 5.15 (dd, *J* = 6.5, 6.5 Hz, 1H), 3.50 - 3.40 (m, 1H), 3.33 - 3.16 (m, 2H), 3.03 - 2.94 (m, 1H), 2.36 (s, 3H), 1.95 - 1.85 (m, 1H), 1.47 (s, 9H), 0.95 (d, *J* = 6.9 Hz, 3H); MS (ESI+) *m/z* 313 (M+H)⁺.

General Method 2

(*R*)-2-Methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (**100E**)

A solution of hydrogen chloride (15 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (*S*)-(2-ethyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (**100D**) (600 mg, 2.48 mmol) and the mixture was stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired product (*R*)-2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (**100E**) as a pale yellow semi-solid.

Yield: 548 mg (100%) HCl salt. ¹H NMR (400 MHz, DMSO) δ 8.39 (s, 2H), 8.00 - 7.96 (m, 3H), 7.72 - 7.72 (m, 1H), 3.32 - 3.18 (m, 2H), 2.88 - 2.80 (m, 1H), 2.66 - 2.55 (m, 1H), 2.38 (s, 3H), 2.13 - 2.00 (m, 1H), 0.96 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 213 (M+H)⁺.

General Method 3

Ethyl (*S*)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazole-6-carboxylate (**100F**)

Ethyl-2-chlorobenzothiazole-6-carboxylate (600 mg, 2.48 mmol, 1.0 eq) was added to a stirred solution of (*R*)-2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (**100E**) (548 mg, 2.48 mmol, 1.0 eq) and triethylamine (1.73 mL, 12.44 mmol, 5.0 eq) in anhydrous dimethylformamide (20 mL) under nitrogen. The mixture was stirred at room temperature for 48 h and then concentrated under vacuum to ~5 mL. Water (25 mL) was added and the mixture was extracted with ethyl acetate (3 x 50 mL). The combined organic phases were washed with water (20 mL) and brine (25

mL) then dried over magnesium sulfate. The solvents were removed under vacuum to give a crude yellow oil which was purified by flash chromatography (eluting *isohexane* to ethyl acetate, 0-100%) to give the desired ethyl (*S*)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazole-6-carboxylate (100F) as an off white solid.

Yield: 647 mg (62%). ¹H NMR (400 MHz, CDCl₃) δ 8.37 (s, 2H), 8.27 (d, *J*=1.5 Hz, 1H), 7.99 (dd, *J*=1.8, 8.5 Hz, 1H), 7.51 (d, *J*=8.4 Hz, 1H), 7.02 - 6.98 (m, 1H), 5.83 (dd, *J*=6.7, 6.7 Hz, 1H), 4.38 (q, *J*=7.2 Hz, 2H), 3.67 - 3.47 (m, 2H), 3.42 - 3.24 (m, 2H), 2.37 (s, 3H), 2.20 - 2.11 (m, 1H), 1.40 (dd, *J*=7.2, 7.2 Hz, 3H), 1.07 (d, *J*=7.0 Hz, 3H); MS (ESI+) *m/z* 418 (M+H)⁺.

General Method 4

(*S*)-2-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazole-6-carboxylic acid (Example 1)

Lithium hydroxide monohydrate (318 mg, 7.75 mmol, 5.0 eq) was added to a stirred solution of ethyl (*S*)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino) benzo[*d*]thiazole-6-carboxylate (100F) (647 mg, 1.55 mmol, 1.0 eq) in ethanol (7 mL) and water (5 mL). The mixture was stirred at ambient temperature for 18 h and then concentrated under reduced pressure. Water (5 mL) was added to the residue and this mixture was acidified to pH ~3 with a solution of aqueous hydrochloric acid (2M). A precipitate that formed was collected by filtration, washed with water and then dried under high vacuum to give the desired product (*S*)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo[*d*]thiazole-6-carboxylic acid (Example 1) as a pale yellow solid.

General Method 5

Methyl (*S*)-2-methyl-2-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo [*d*]thiazole-6-carboxamido)propanoate (100G)

1-[Bis(dimethylamino)methylene]-1*H*-1,2,3-triazolo[4,5-*b*]pyridinium 3-oxide hexafluorophosphate (HATU, 146 mg, 0.385 mmol, 1.5 eq) was added to a solution of

(*S*)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazole-6-carboxylic acid (1) (100 mg, 0.257 mmol, 1.0 eq), triethylamine (0.36 mL, 2.57 mmol, 10.0 eq) and methyl-2-amino-2-methylpropanoate hydrochloride (196 mg, 1.28 mmol, 4.9 eq) in dimethylformamide (5 mL) and the reaction mixture was stirred at room temperature for 18 h. The solvents were removed under reduced pressure and the crude residue obtained was purified by flash chromatography (eluting *iso*hexane to ethyl acetate, 0-75%) to give the desired methyl (*S*)-2-methyl-2-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo[*d*] thiazole-6-carboxamido)propanoate (G) as an off-white solid.

Yield: 120 mg (95%). ¹H NMR (400 MHz, MeOD) δ 8.34 (s, 2H), 8.10 (d, *J*=1.8 Hz, 1H), 7.77 (dd, *J*=1.9, 8.5 Hz, 1H), 7.47 (d, *J*=8.5 Hz, 1H), 3.74 (s, 3H), 3.45 (dd, *J*=6.3, 22.4 Hz, 4H), 2.34 (s, 3H), 2.29 - 2.16 (m, 1H), 1.59 (s, 6H), 1.08 (d, *J*=6.9 Hz, 3H) *NH* exchangeable protons not observed; MS (ESI+) *m/z* 489 (M+H)⁺.

(*S*)-2-Methyl-2-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo[*d*] thiazole-6-carboxamido)propanoic acid (Example 2)

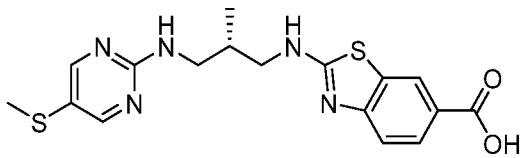
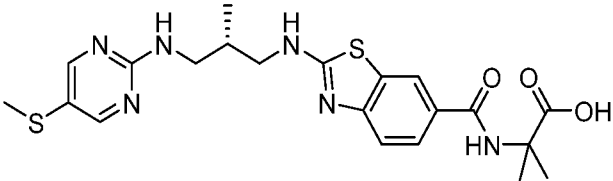
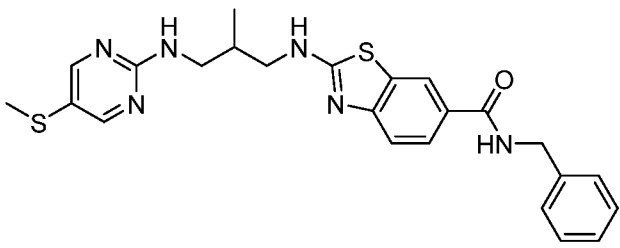
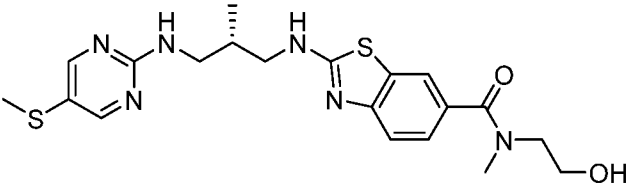
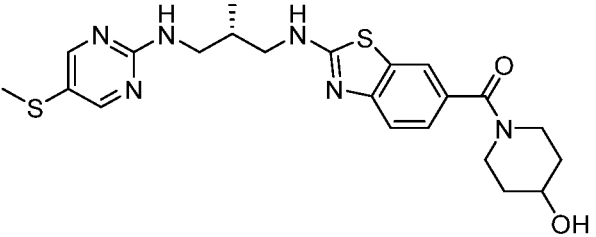
Method analogous to General Method 4

Lithium hydroxide mono-hydrate (50 mg, 1.22 mmol, 5.0 eq) was added to a stirred solution of methyl (*S*)-2-methyl-2-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*] thiazole-6-carboxamido)propanoate (100G) (120 mg, 0.245 mmol, 1.0 eq) in ethanol (5 mL) and water (5 mL) and the mixture was stirred at room temperature for 1 hour. The solvents were removed under vacuum and the residue was diluted with water (3 mL) and acidified to pH ~3 with aqueous solution of hydrochloride acid (2M). A precipitate that formed was collected by filtration, washed with water and then dried under high vacuum to give the title compound as an off-white solid.

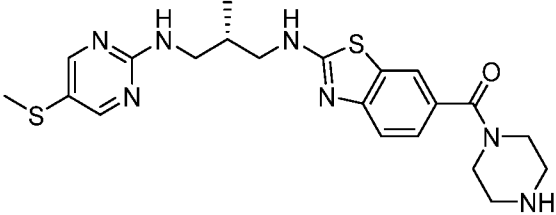
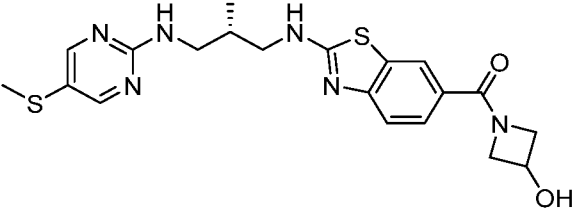
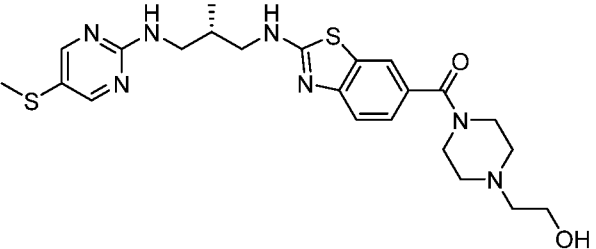
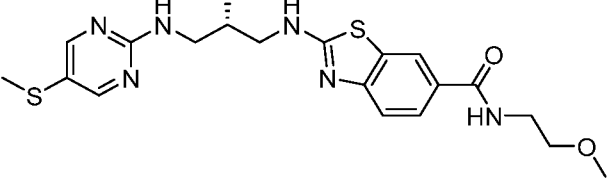
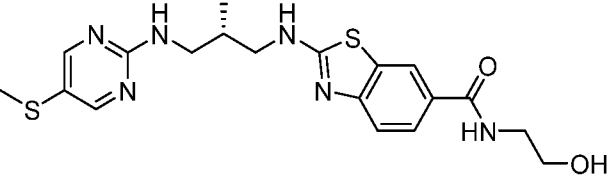
Using the above procedures, the following examples were synthesized:

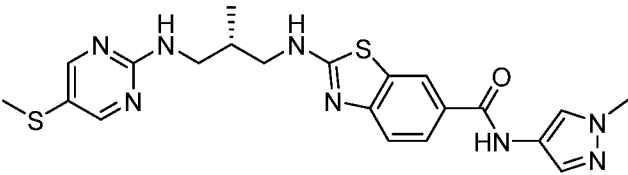
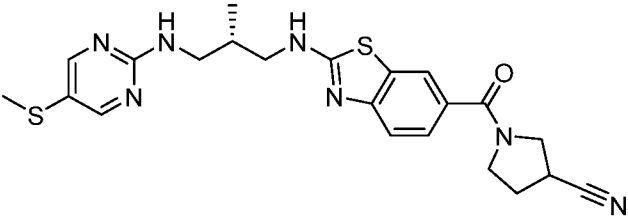
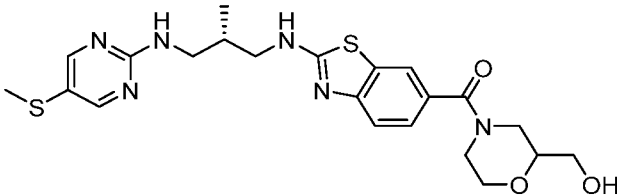
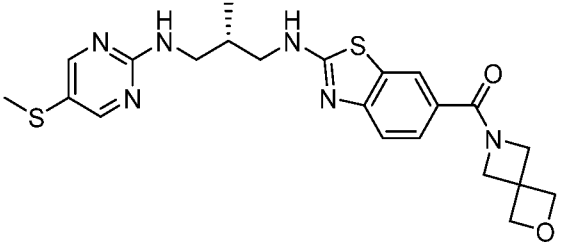
Table 1

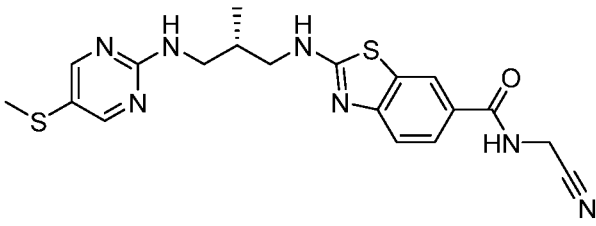
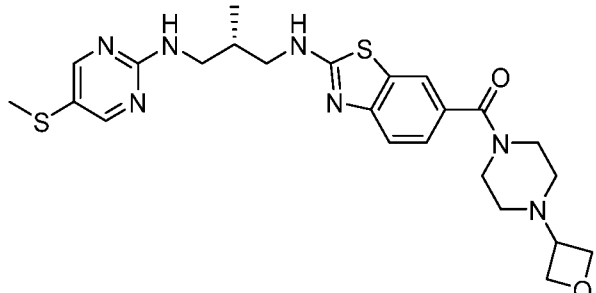
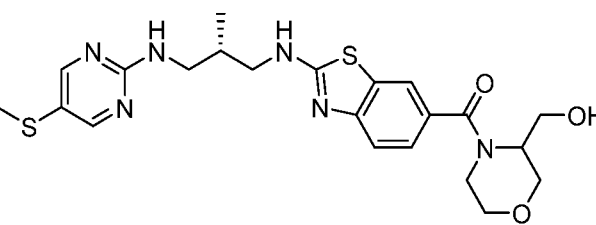
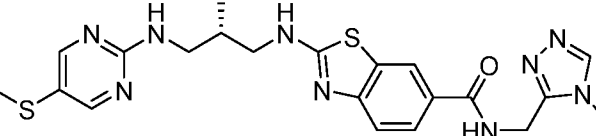
Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺

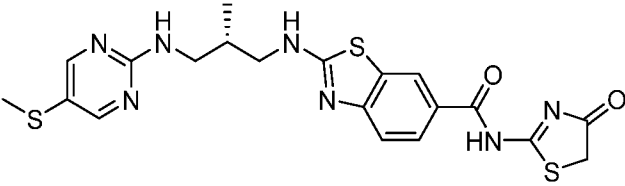
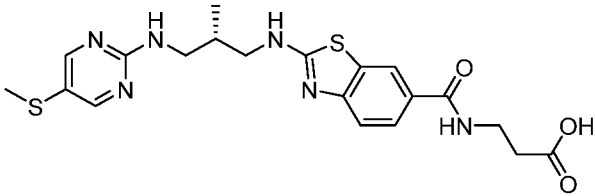
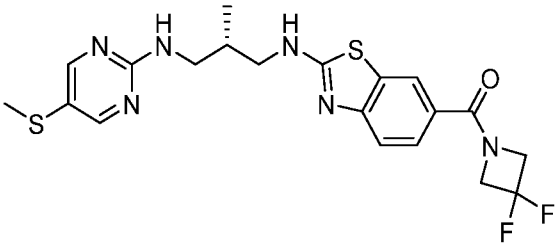
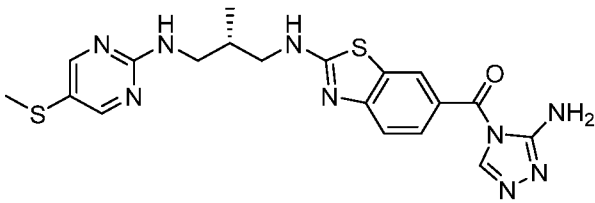
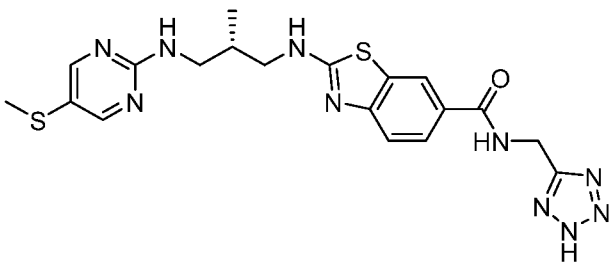
	1	¹ H NMR (400 MHz, DMSO) δ 8.43 (dd, <i>J</i> = 4.8, 4.8 Hz, 1H), 8.33 (s, 2H), 8.26 (d, <i>J</i> = 1.8 Hz, 1H), 7.81 (dd, <i>J</i> = 1.8, 8.5 Hz, 1H), 7.53 (dd, <i>J</i> = 5.6, 5.6 Hz, 1H), 7.38 (d, <i>J</i> = 8.4 Hz, 1H), 3.35 - 3.23 (m, 4H), 2.34 (s, 3H), 2.17 - 2.07 (m, 1H), 0.96 (d, <i>J</i> = 6.7 Hz, 3H).	390
	2	¹ H NMR (400 MHz, CDCl ₃) δ 8.34 (s, 2H), 8.00 (d, <i>J</i> = 1.1 Hz, 1H), 7.72 (d, <i>J</i> = 8.3 Hz, 1H), 7.32 (d, <i>J</i> = 8.5 Hz, 1H), 7.20 - 7.20 (m, 1H), 3.54 - 3.48 (m, 1H), 3.43 - 3.27 (m, 3H), 2.36 (s, 3H), 2.19 - 2.13 (m, 1H), 1.74 (d, <i>J</i> = 3.2 Hz, 6H), 1.03 (d, <i>J</i> = 6.9 Hz, 3H) <i>NH</i> protons not observed.	475
	3	¹ H NMR (400 MHz, DMSO) δ 8.90 (dd, <i>J</i> = 6.0, 6.0 Hz, 1H), 8.34 (s, 2H), 8.30 (dd, <i>J</i> = 5.5, 5.5 Hz, 1H), 8.21 (d, <i>J</i> = 1.6 Hz, 1H), 7.79 (dd, <i>J</i> = 1.8, 8.4 Hz, 1H), 7.52 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 7.38 (d, <i>J</i> = 8.4 Hz, 1H), 7.33 (d, <i>J</i> = 4.4 Hz, 4H), 7.27 - 7.22 (m, 1H), 4.48 (d, <i>J</i> = 6.0 Hz, 2H), 3.48 - 3.41 (m, 1H), 3.31 - 3.23 (m, 3H), 2.34 (s, 3H), 2.17 - 2.00 (m, 1H), 0.96 (d, <i>J</i> = 6.8 Hz, 3H).	479
	4	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.73 (d, <i>J</i> = 1.3 Hz, 1H), 7.51 (d, <i>J</i> = 8.3 Hz, 1H), 7.39 (dd, <i>J</i> = 1.5, 8.3 Hz, 1H), 6.77 (s, 1H), 5.77 - 5.74 (m, 1H), 3.89 - 3.85 (m, 2H), 3.71 (s, 2H), 3.63 - 3.47 (m, 2H), 3.42 - 3.25 (m, 2H), 3.12 (s, 3H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.06 (d, <i>J</i> = 6.8 Hz, 3H) <i>NH</i> protons not observed.	447
	5	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.67 (d, <i>J</i> = 1.5 Hz, 1H), 7.51 (d, <i>J</i> = 8.1 Hz, 1H), 7.32 (dd, <i>J</i> = 1.8, 8.1 Hz, 1H), 6.67 - 6.64 (m, 1H), 5.70 (dd, <i>J</i> = 6.8, 6.8 Hz, 1H), 4.02 - 3.95 (m, 2H), 3.63 - 3.49 (m, 2H), 3.42 - 3.29 (m, 4H), 2.37 (s, 3H), 2.20 - 2.09 (m, 1H), 1.95 - 1.88	473

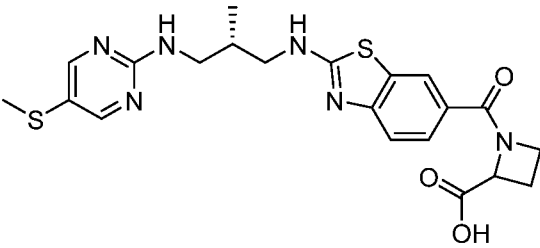
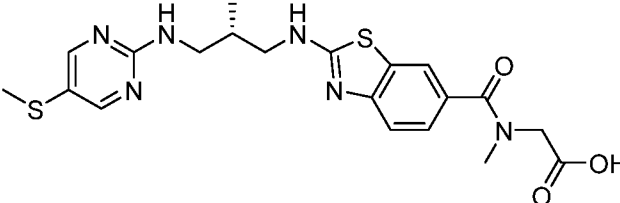
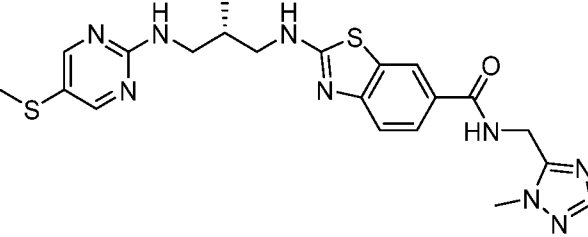
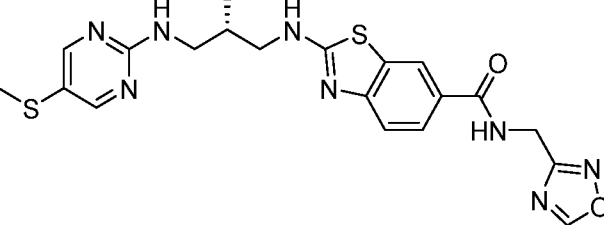
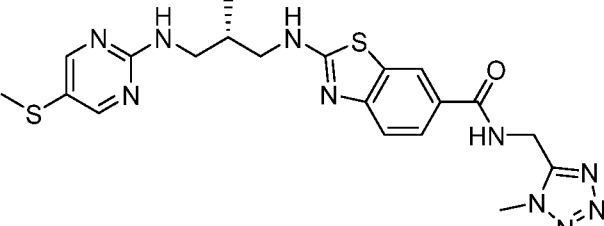
		(m, 2H), 1.06 (d, J = 6.8 Hz, 3H) <i>NH</i> protons not observed.	
	6	¹ H NMR (400 MHz, DMSO) δ 8.38 (s, 2H), 8.36 - 8.30 (m, 2H), 8.18 (d, J = 1.8 Hz, 1H), 7.76 (dd, J = 1.9, 8.5 Hz, 1H), 7.56 (dd, J = 6.1, 6.1 Hz, 1H), 7.40 (d, J = 8.6 Hz, 1H), 3.52 - 3.44 (m, 1H), 3.34 - 3.27 (m, 3H), 2.83 (d, J = 4.5 Hz, 3H), 2.39 (s, 3H), 2.22 - 2.10 (m, 1H), 1.00 (d, J = 6.8 Hz, 3H).	403
	7	¹ H NMR (400 MHz, DMSO) δ 8.34 (s, 2H), 8.26 (dd, J = 5.6, 5.6 Hz, 1H), 7.85 (s, 1H), 7.51 (dd, J = 5.8, 5.8 Hz, 1H), 7.37 (s, 2H), 3.94 - 3.83 (m, 4H), 3.48 - 3.40 (m, 1H), 3.31 - 3.24 (m, 8H), 2.34 (s, 3H), 2.14 - 1.99 (m, 1H), 0.96 (d, J = 6.8 Hz, 3H).	507
	8	¹ H NMR (400 MHz, DMSO) δ 8.34 (s, 2H), 8.31 (d, J = 5.6 Hz, 2H), 8.17 (d, J = 1.8 Hz, 1H), 7.73 (dd, J = 1.8, 8.4 Hz, 1H), 7.52 (dd, J = 5.9, 5.9 Hz, 1H), 7.37 (d, J = 8.4 Hz, 1H), 3.76 (d, J = 5.1 Hz, 2H), 3.49 - 3.40 (m, 1H), 3.33 - 3.22 (m, 3H), 2.34 (s, 3H), 2.17 - 2.07 (m, 1H), 0.96 (d, J = 6.8 Hz, 3H).	447
	9	¹ H NMR (400 MHz, CDCl ₃) δ 8.33 (s, 2H), 8.02 (s, 1H), 7.72 (dd, J = 1.4, 8.5 Hz, 1H), 7.55 (s, 1H), 7.45 (d, J = 8.3 Hz, 1H), 6.20 - 6.18 (m, 1H), 3.73 - 3.58 (m, 3H), 3.49 (dd, J = 4.2, 13.8 Hz, 1H), 3.40 - 3.20 (m, 2H), 3.01 - 2.91 (m, 2H), 2.59 (s, 6H), 2.36 (s, 4H), 2.20 - 2.13 (m, 1H), 1.07 (d, J = 6.8 Hz, 3H).	460
	10	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.69 (d, J = 1.5 Hz, 1H), 7.51 (d, J = 8.3 Hz, 1H), 7.36 (dd, J = 1.8, 8.3 Hz, 1H), 6.75 - 6.74 (m, 1H), 5.70 (dd, J = 6.4, 6.4 Hz, 1H), 3.63 - 3.47 (m, 2H), 3.42 - 3.25 (m, 2H), 3.08 (s, 6H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.06 (d, J = 6.9 Hz, 3H).	417

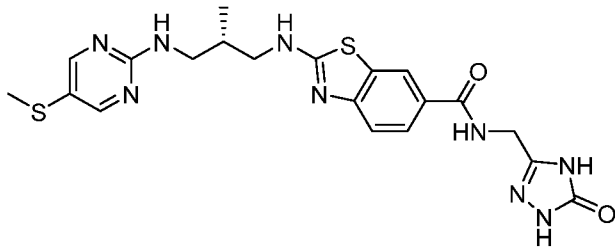
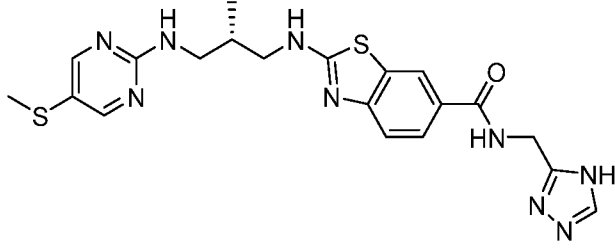
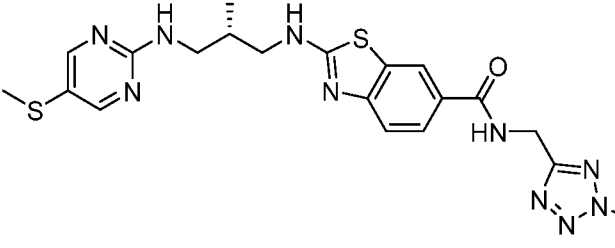
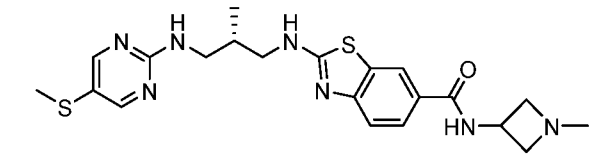
	11	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 8.32 (s, 1H), 7.68 (s, 1H), 7.50 (d, <i>J</i> = 8.3 Hz, 1H), 7.35 - 7.30 (m, 1H), 5.90 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 3.76 (s, 4H), 3.62 - 3.53 (m, 1H), 3.48 (dd, <i>J</i> = 4.8, 13.8 Hz, 1H), 3.43 - 3.35 (m, 1H), 3.29 (dd, <i>J</i> = 7.5, 13.7 Hz, 1H), 3.05 - 2.98 (m, 4H), 2.62 (s, 1H), 2.37 (s, 3H), 2.19 - 2.12 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	458
	12	¹ H NMR (400 MHz, CDCl ₃) δ 8.36 (s, 2H), 7.90 (s, 1H), 7.52 - 7.44 (m, 2H), 7.00 (s, 1H), 5.90 (s, 1H), 4.75 - 4.68 (m, 1H), 4.51 (dd, <i>J</i> = 8.0, 8.0 Hz, 2H), 4.15 - 4.15 (m, 2H), 3.65 - 3.57 (m, 1H), 3.55 - 3.48 (m, 1H), 3.41 - 3.33 (m, 1H), 3.30 - 3.24 (m, 1H), 2.61 (s, 1H), 2.37 (s, 3H), 2.20 - 2.12 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	455
	13	¹ H NMR (400 MHz, DMSO) δ 8.33 (s, 2H), 8.22 (dd, <i>J</i> = 5.4, 5.4 Hz, 1H), 8.15 (s, 1H), 7.74 (d, <i>J</i> = 1.5 Hz, 1H), 7.51 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 7.36 (d, <i>J</i> = 8.3 Hz, 1H), 7.25 (dd, <i>J</i> = 1.8, 8.3 Hz, 1H), 4.49 (s, 1H), 3.52 (dd, <i>J</i> = 6.0, 6.0 Hz, 5H), 3.47 - 3.40 (m, 2H), 3.29 - 3.19 (m, 4H), 2.48 (d, <i>J</i> = 7.5 Hz, 4H), 2.34 (s, 3H), 2.14 - 2.08 (m, 1H), 0.96 (d, <i>J</i> = 6.8 Hz, 3H).	502
	14	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 8.09 (d, <i>J</i> = 1.5 Hz, 1H), 7.66 (dd, <i>J</i> = 1.9, 8.5 Hz, 1H), 7.52 (d, <i>J</i> = 8.3 Hz, 1H), 6.80 (s, 1H), 6.50 (dd, <i>J</i> = 5.2, 5.2 Hz, 1H), 5.69 (dd, <i>J</i> = 6.7, 6.7 Hz, 1H), 3.69 - 3.55 (m, 5H), 3.40 (s, 6H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.07 (d, <i>J</i> = 6.8 Hz, 3H).	447
	15	¹ H NMR (400 MHz, DMSO) δ 8.34 (s, 2H), 8.29 (dd, <i>J</i> = 5.4, 5.4 Hz, 2H), 8.17 (d, <i>J</i> = 1.8 Hz, 1H), 7.74 (dd, <i>J</i> = 1.8, 8.5 Hz, 1H), 7.52 (dd, <i>J</i> = 6.0, 6.0 Hz, 1H), 7.36 (d, <i>J</i> = 8.4 Hz, 1H), 4.71 (dd, <i>J</i> = 5.4, 5.4 Hz, 1H), 3.55 - 3.41 (m, 3H), 3.31 - 3.23	433

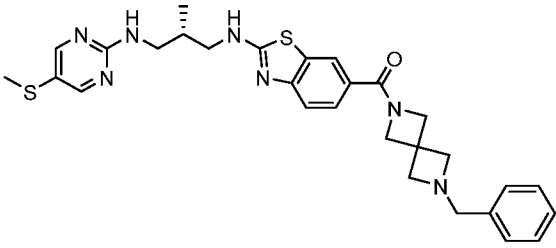
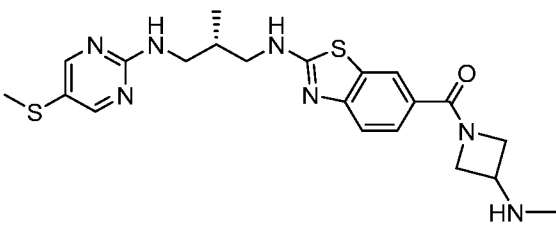
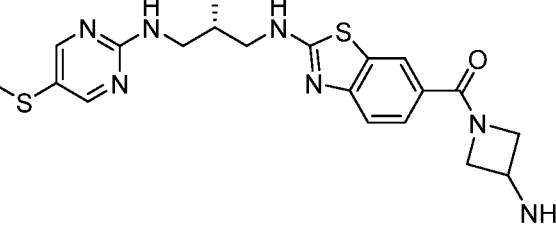
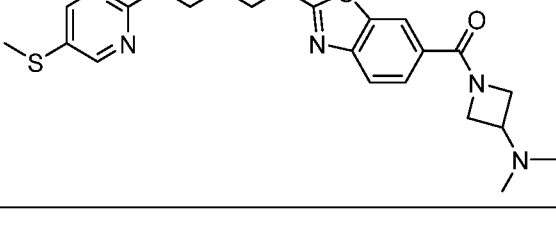
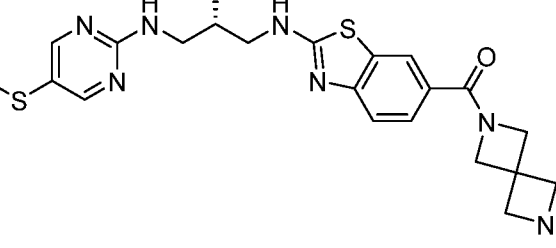
		(m, 5H), 2.34 (s, 3H), 2.17 - 2.06 (m, 1H), 0.96 (d, J = 6.8 Hz, 3H).	
	16	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 8.09 (s, 1H), 8.06 (s, 1H), 7.90 - 7.90 (m, 1H), 7.72 (dd, J = 1.9, 8.4 Hz, 1H), 7.52 (d, J = 9.0 Hz, 2H), 7.14 (s, 1H), 5.99 (s, 1H), 3.91 (s, 3H), 3.62 (ddd, J = 4.4, 6.9, 14.3 Hz, 1H), 3.51 (d, J = 13.4 Hz, 1H), 3.41 - 3.33 (m, 1H), 3.29 - 3.22 (m, 1H), 2.37 (s, 3H), 2.21 - 2.13 (m, 1H), 1.08 (d, J = 6.9 Hz, 3H).	469
	17	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.80 (s, 1H), 7.52 (d, J = 8.3 Hz, 1H), 7.46 (d, J = 7.9 Hz, 1H), 6.79 - 6.78 (m, 1H), 5.67 (dd, J = 6.5, 6.5 Hz, 1H), 3.95 - 3.81 (m, 3H), 3.73 (s, 1H), 3.64 - 3.56 (m, 1H), 3.55 - 3.48 (m, 1H), 3.42 - 3.34 (m, 1H), 3.32 - 3.25 (m, 1H), 3.19 (s, 1H), 2.37 (s, 3H), 2.30 (d, J = 6.0 Hz, 2H), 2.20 - 2.10 (m, 1H), 1.07 (d, J = 6.9 Hz, 3H).	468
	18	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.69 (d, J = 1.5 Hz, 1H), 7.52 (d, J = 8.3 Hz, 1H), 7.33 (dd, J = 1.6, 8.3 Hz, 1H), 6.77 (s, 1H), 5.69 (dd, J = 6.5, 6.5 Hz, 1H), 3.96 (d, J = 9.9 Hz, 1H), 3.67 (d, J = 13.4 Hz, 1H), 3.64 - 3.55 (m, 5H), 3.51 (dd, J = 4.5, 13.7 Hz, 1H), 3.42 - 3.34 (m, 1H), 3.29 (dd, J = 7.5, 14.2 Hz, 1H), 3.18 (s, 1H), 3.03 (s, 1H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.07 (d, J = 6.9 Hz, 3H).	489
	19	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 7.92 (d, J = 1.1 Hz, 1H), 7.52 - 7.50 (m, 2H), 6.87 - 6.87 (m, 1H), 5.73 (dd, J = 6.1, 6.1 Hz, 1H), 4.82 (s, 4H), 4.43 - 4.43 (m, 4H), 3.64 - 3.48 (m, 2H), 3.42 - 3.26 (m, 2H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.07 (d, J = 6.9 Hz, 3H).	471

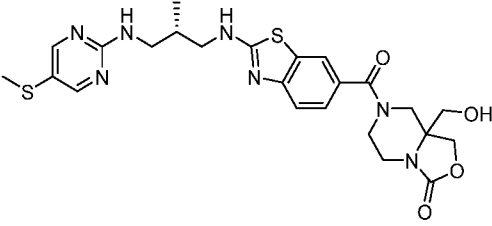
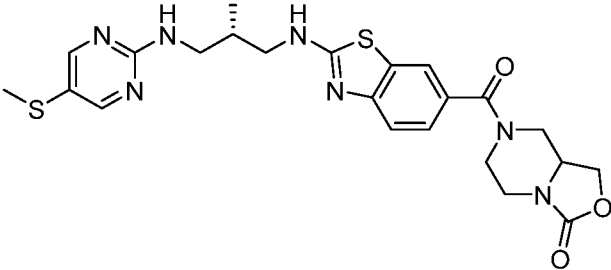
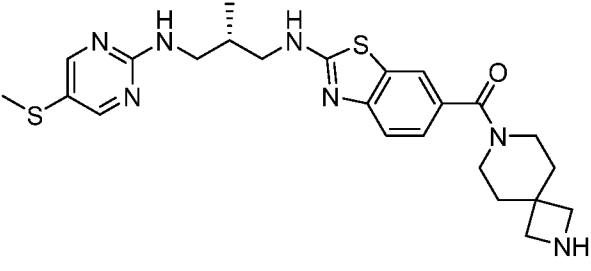
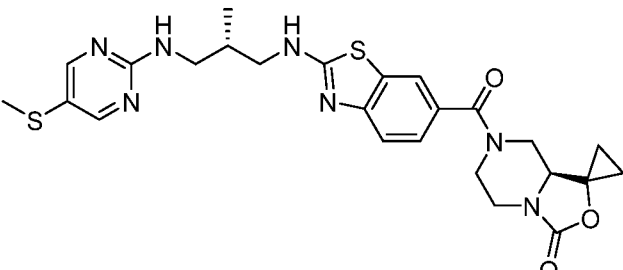
	20	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 8.03 (s, 1H), 7.64 (dd, <i>J</i> = 1.9, 8.4 Hz, 1H), 7.49 (d, <i>J</i> = 8.4 Hz, 1H), 6.53 - 6.53 (m, 1H), 6.01 - 5.99 (m, 1H), 4.41 (d, <i>J</i> = 5.8 Hz, 2H), 3.62 (ddd, <i>J</i> = 4.3, 6.7, 14.3 Hz, 1H), 3.51 (dd, <i>J</i> = 4.3, 13.8 Hz, 1H), 3.41 - 3.22 (m, 2H), 2.37 (s, 3H), 2.20 - 2.13 (m, 1H), 1.08 (d, <i>J</i> = 6.9 Hz, 3H) <i>NH</i> protons not observed.	428
	21	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.68 (d, <i>J</i> = 1.6 Hz, 1H), 7.51 (d, <i>J</i> = 8.3 Hz, 1H), 7.33 (dd, <i>J</i> = 1.6, 8.3 Hz, 1H), 6.87 - 6.86 (m, 1H), 5.77 (dd, <i>J</i> = 6.2, 6.2 Hz, 1H), 4.70 - 4.60 (m, 4H), 3.70 (s, 3H), 3.63 - 3.47 (m, 3H), 3.42 - 3.25 (m, 2H), 2.37 (s, 6H), 2.20 - 2.12 (m, 2H), 1.06 (d, <i>J</i> = 6.9 Hz, 3H) <i>NH</i> protons not observed. ¹ H NMR (400 MHz, DMSO) δ 8.33 (s, 2H), 8.23 (dd, <i>J</i> = 5.5, 5.5 Hz, 1H), 7.75 (s, 1H), 7.51 (dd, <i>J</i> = 5.9, 5.9 Hz, 1H), 7.36 (d, <i>J</i> = 8.2 Hz, 1H), 7.27 - 7.23 (m, 1H), 4.58 - 4.51 (m, 2H), 4.45 (dd, <i>J</i> = 5.7, 5.7 Hz, 2H), 3.53 - 3.53 (m, 4H), 3.47 - 3.39 (m, 2H), 3.29 - 3.22 (m, 3H), 2.34 (s, 3H), 2.29 (s, 4H), 2.17 - 2.06 (m, 1H), 0.95 (d, <i>J</i> = 6.7 Hz, 3H). <i>NH</i> protons not observed	514
	22	¹ H NMR (400 MHz, DMSO) δ 8.34 (s, 2H), 8.22 (dd, <i>J</i> = 5.5, 5.5 Hz, 1H), 7.76 (d, <i>J</i> = 1.5 Hz, 1H), 7.52 (dd, <i>J</i> = 5.9, 5.9 Hz, 1H), 7.36 (d, <i>J</i> = 8.2 Hz, 1H), 7.29 (dd, <i>J</i> = 1.6, 8.3 Hz, 1H), 4.90 - 4.90 (m, 1H), 3.79 - 3.79 (m, 3H), 3.65 (s, 1H), 3.59 - 3.40 (m, 4H), 3.31 - 3.20 (m, 4H), 2.34 (s, 3H), 2.17 - 2.05 (m, 1H), 0.95 (d, <i>J</i> = 6.7 Hz, 3H) <i>NH</i> protons not observed.	489
	23	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 8.10 (s, 1H), 8.05 (s, 1H), 7.72 (dd, <i>J</i> = 1.9, 8.5 Hz, 1H), 7.49 - 7.45 (m, 2H), 7.18 - 7.17 (m, 1H), 6.04 (d, <i>J</i> = 4.9 Hz, 1H), 4.83 (d, <i>J</i> = 5.5 Hz, 2H), 3.80 (s, 3H), 3.64 - 3.48 (m, 2H),	484

		3.41 - 3.26 (m, 2H), 2.36 (s, 3H), 2.21 - 2.13 (m, 1H), 1.06 (d, J = 6.9 Hz, 3H).	
	24	¹ H NMR (400 MHz, DMSO) δ 12.42 - 12.42 (m, 1H), 8.48 (s, 1H), 8.41 (d, J = 1.6 Hz, 1H), 8.33 (s, 2H), 8.03 (dd, J = 1.6, 8.5 Hz, 1H), 7.51 (dd, J = 5.9, 5.9 Hz, 1H), 7.41 (d, J = 8.4 Hz, 1H), 3.95 (s, 2H), 3.49 - 3.38 (m, 2H), 3.29 - 3.20 (m, 2H), 2.34 (s, 3H), 2.17 - 2.08 (m, 1H), 0.96 (d, J = 6.8 Hz, 3H).	488
	25	¹ H NMR (400 MHz, DMSO) δ 12.21 (s, 1H), 8.39 (dd, J = 5.5, 5.5 Hz, 1H), 8.34 (s, 3H), 8.15 (d, J = 1.6 Hz, 1H), 7.72 (dd, J = 1.8, 8.5 Hz, 1H), 7.52 (dd, J = 5.3, 5.3 Hz, 1H), 7.36 (d, J = 8.4 Hz, 1H), 3.48 - 3.43 (m, 4H), 3.33 - 3.23 (m, 4H), 2.34 (s, 3H), 2.17 - 2.06 (m, 1H), 0.96 (d, J = 6.8 Hz, 3H).	461
	26	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (s, 2H), 7.95 (s, 1H), 7.52 (s, 2H), 6.93 - 6.93 (m, 1H), 5.65 (dd, J = 6.6, 6.6 Hz, 1H), 4.56 (dd, J = 12.0, 12.0 Hz, 4H), 3.60 (ddd, J = 4.5, 7.2, 14.4 Hz, 1H), 3.51 (s, 1H), 3.42 - 3.26 (m, 2H), 2.38 (s, 3H), 2.20 - 2.11 (m, 1H), 1.07 (d, J = 6.9 Hz, 3H).	465
	27	¹ H NMR (400 MHz, DMSO) δ 8.55 - 8.52 (m, 2H), 8.34 (s, 2H), 8.05 (dd, J = 1.8, 8.6 Hz, 1H), 7.65 (s, 3H), 7.51 (dd, J = 5.8, 5.8 Hz, 1H), 7.43 (d, J = 8.5 Hz, 1H), 3.52 - 3.44 (m, 1H), 3.30 - 3.20 (m, 3H), 2.34 (s, 3H), 2.16 - 2.08 (m, 1H), 0.97 (d, J = 6.8 Hz, 3H).	456
	28	¹ H NMR (400 MHz, DMSO) δ 9.13 (dd, J = 5.3, 5.3 Hz, 1H), 8.57 - 8.57 (m, 1H), 8.34 (s, 2H), 8.24 (s, 1H), 7.83 - 7.79 (m, 1H), 7.57 - 7.57 (m, 1H), 7.42 (d, J = 8.4 Hz, 1H), 4.76 (d, J = 5.6 Hz, 2H), 3.50 - 3.43 (m, 1H), 3.35 - 3.23 (m, 3H), 2.34 (s, 3H), 2.17 - 2.08 (m, 1H), 0.97 (d, J = 6.8 Hz, 3H) <i>NH</i> protons not observed.	471

	29	¹ H NMR (400 MHz, DMSO) δ 8.29 (s, 2H), 8.03 (s, 1H), 7.93 (d, <i>J</i> = 1.5 Hz, 1H), 7.49 (dd, <i>J</i> = 1.8, 8.4 Hz, 1H), 7.33 (d, <i>J</i> = 8.4 Hz, 1H), 7.12 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 4.82 (dd, <i>J</i> = 5.3, 9.4 Hz, 1H), 4.33 - 4.25 (m, 1H), 4.14 - 4.07 (m, 1H), 3.47 - 3.23 (m, 4H), 2.66 - 2.55 (m, 1H), 2.33 (s, 3H), 2.21 - 2.08 (m, 2H), 0.97 (d, <i>J</i> = 6.8 Hz, 3H) <i>NH</i> protons not observed, VT @ 85°C.	473
	30	¹ H NMR (400 MHz, DMSO) δ 8.32 (s, 2H), 7.85 (s, 1H), 7.71 (d, <i>J</i> = 1.4 Hz, 1H), 7.37 (d, <i>J</i> = 8.3 Hz, 1H), 7.29 (dd, <i>J</i> = 1.6, 8.2 Hz, 1H), 7.02 (s, 1H), 3.97 (s, 2H), 3.50 - 3.30 (m, 4H), 3.01 (s, 3H), 2.36 (s, 3H), 2.22 - 2.13 (m, 1H), 1.01 (d, <i>J</i> = 6.8 Hz, 3H) <i>NH</i> protons not observed, VT @ 125°C.	461
	31	¹ H NMR (400 MHz, DMSO) δ 9.03 (dd, <i>J</i> = 5.6, 5.6 Hz, 1H), 8.38 (s, 3H), 8.24 (d, <i>J</i> = 1.8 Hz, 1H), 7.88 (s, 1H), 7.81 (dd, <i>J</i> = 1.9, 8.5 Hz, 1H), 7.57 (dd, <i>J</i> = 5.9, 5.9 Hz, 1H), 7.41 (d, <i>J</i> = 8.3 Hz, 1H), 4.64 (d, <i>J</i> = 5.6 Hz, 2H), 3.94 (s, 3H), 3.53 - 3.44 (m, 1H), 3.35 - 3.27 (m, 3H), 2.38 (s, 3H), 2.21 - 2.10 (m, 1H), 1.00 (d, <i>J</i> = 6.8 Hz, 3H).	484
	32	¹ H NMR (400 MHz, DMSO) δ 9.60 (1H, s), 9.09 (1H, dd, <i>J</i> = 5.7, 5.7 Hz), 8.38 (3H, s), 8.24 (1H, d, <i>J</i> = 1.8 Hz), 7.81 (1H, dd, <i>J</i> = 1.8, 8.3 Hz), 7.58 (1H, dd, <i>J</i> = 5.9, 5.9 Hz), 7.43 (1H, d, <i>J</i> = 8.3 Hz), 4.67 (2H, d, <i>J</i> = 5.8 Hz), 3.54 - 3.45 (2H, m), 3.36 - 3.27 (2H, m), 2.38 (3H, s), 2.21 - 2.10 (1H, m), 1.01 (3H, d, <i>J</i> = 6.8 Hz).	471
	33	¹ H NMR (400 MHz, DMSO) δ 9.16 (dd, <i>J</i> = 5.6, 5.6 Hz, 1H), 8.41 (d, <i>J</i> = 5.6 Hz, 1H), 8.38 (s, 2H), 8.23 (d, <i>J</i> = 1.8 Hz, 1H), 7.80 (dd, <i>J</i> = 1.8, 8.6 Hz, 1H), 7.57 (dd, <i>J</i> = 5.9, 5.9 Hz, 1H), 7.42 (d, <i>J</i> = 8.6 Hz, 1H), 4.80 (d, <i>J</i> = 5.6 Hz, 2H), 4.15 (s, 3H),	485

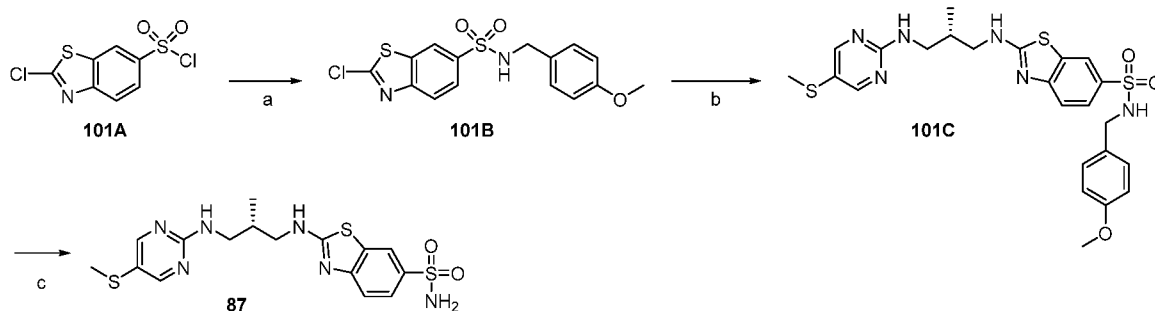
		3.53 - 3.45 (m, 1H), 3.36 - 3.27 (m, 3H), 2.38 (s, 3H), 2.21 - 2.10 (m, 1H), 1.00 (d, J = 6.6 Hz, 3H).	
	34	¹ H NMR (400 MHz, DMSO) δ 11.30 (2H, s), 8.80 (1H, dd, J = 5.3, 5.3 Hz), 8.38 (3H, s), 8.24 (1H, d, J = 1.5 Hz), 7.81 (1H, dd, J = 1.6, 8.5 Hz), 7.58 (1H, dd, J = 5.9, 5.9 Hz), 7.42 (1H, d, J = 8.3 Hz), 4.30 (2H, d, J = 5.3 Hz), 3.53 - 3.45 (1H, m), 3.35 - 3.27 (3H, m), 2.39 (3H, s), 2.21 - 2.11 (1H, m), 1.00 (3H, d, J = 6.6 Hz).	486
	35	¹ H NMR (400 MHz, DMSO) δ 8.94 (s, 1H), 8.38 (s, 2H), 8.36 (d, J = 5.6 Hz, 1H), 8.25 (d, J = 1.5 Hz, 1H), 7.83 (dd, J = 1.8, 8.3 Hz, 1H), 7.58 (dd, J = 5.9, 5.9 Hz, 1H), 7.42 (d, J = 8.3 Hz, 1H), 4.59 (d, J = 4.8 Hz, 2H), 3.53 - 3.45 (m, 1H), 3.36 - 3.27 (m, 3H), 2.39 (s, 3H), 2.21 - 2.11 (m, 1H), 1.00 (d, J = 6.8 Hz, 3H) <i>NH</i> protons not observed.	470
	36	¹ H NMR (400 MHz, DMSO) δ 9.09 (dd, J = 5.8, 5.8 Hz, 1H), 8.38 (s, 3H), 8.23 (d, J = 1.5 Hz, 1H), 7.81 (dd, J = 1.8, 8.6 Hz, 1H), 7.58 (dd, J = 5.9, 5.9 Hz, 1H), 7.42 (d, J = 8.3 Hz, 1H), 4.74 (d, J = 5.6 Hz, 2H), 4.38 (s, 3H), 3.53 - 3.45 (m, 1H), 3.36 - 3.27 (m, 3H), 2.39 (s, 3H), 2.21 - 2.11 (m, 1H), 1.00 (d, J = 6.8 Hz, 3H).	485
	37	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 8.14 (d, J = 1.6 Hz, 1H), 7.93 - 7.93 (m, 1H), 7.79 (dd, J = 1.7, 8.5 Hz, 1H), 7.52 (d, J = 8.4 Hz, 1H), 6.92 (s, 1H), 5.82 - 5.81 (m, 1H), 4.94 - 4.87 (m, 1H), 3.88 - 3.82 (m, 2H), 3.61 (ddd, J = 4.5, 7.0, 14.4 Hz, 2H), 3.53 - 3.50 (m, 1H), 3.41 - 3.24 (m, 3H), 2.56 (s, 3H), 2.37 (s, 3H), 2.20 - 2.11 (m, 1H), 1.07 (d, J = 6.9 Hz, 3H).	458

	38	¹ H NMR (400 MHz, DMSO) δ 8.41 (s, 2H), 8.38 (d, J = 5.5 Hz, 1H), 8.40 - 8.37 (m, 1H), 8.04 (d, J = 1.6 Hz, 1H), 7.61 - 7.54 (m, 2H), 7.49 (d, J = 6.9 Hz, 5H), 7.43 (d, J = 8.3 Hz, 2H), 4.57 - 4.57 (m, 2H), 4.26 - 4.25 (m, 3H), 3.55 - 3.45 (m, 2H), 3.33 (dd, J = 6.8, 13.3 Hz, 3H), 2.42 (s, 3H), 2.24 - 2.16 (m, 1H), 1.03 (d, J = 6.7 Hz, 3H).	560
	39	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (2H, s), 7.94 (1H, d, J = 1.4 Hz), 7.56 - 7.53 (1H, m), 7.50 (1H, d, J = 8.3 Hz), 6.76 (1H, s), 5.68 (1H, dd, J = 6.6, 6.6 Hz), 4.42 (2H, s), 4.04 - 3.92 (2H, m), 3.68 - 3.49 (3H, m), 3.42 - 3.26 (2H, m), 2.40 (6H, d, J = 18.1 Hz), 2.25 - 2.11 (1H, m), 1.06 (3H, d, J = 6.9 Hz); One NH proton not observed	458
	40	¹ H NMR (400 MHz, DMSO) δ 8.33 (2H, s), 8.30 (1H, dd, J = 5.6, 5.6 Hz), 7.96 (1H, d, J = 1.6 Hz), 7.54 - 7.47 (2H, m), 7.34 (1H, d, J = 8.3 Hz), 4.45 (1H, s), 4.17 (1H, s), 3.92 (1H, s), 3.76 - 3.69 (2H, m), 3.47 - 3.40 (2H, m), 3.29 - 3.23 (3H, m), 2.34 (3H, s), 2.17 - 2.06 (1H, m), 0.96 (3H, d, J = 6.8 Hz); One NH proton not observed	444
	41	¹ H NMR (400 MHz, MeOD) δ 8.33 (2H, s), 7.97 (1H, d, J = 1.6 Hz), 7.60 (1H, dd, J = 1.8, 8.4 Hz), 7.48 (1H, d, J = 8.5 Hz), 4.59 - 4.10 (4H, m), 3.52 - 3.40 (6H, m), 2.45 (6H, s), 2.34 (3H, s), 2.24 - 2.16 (1H, m), 1.08 (3H, d, J = 6.8 Hz); One NH proton not observed	472
	42	¹ H NMR (400 MHz, DMSO) δ 8.49 - 8.47 (m, 3H), 8.34 (s, 1H), 7.98 (d, J = 1.6 Hz, 1H), 7.54 (s, 1H), 7.49 (dd, J = 1.8, 8.4 Hz, 1H), 7.37 (d, J = 8.4 Hz, 1H), 4.52 - 4.52 (m, 2H), 4.21 (s, 2H), 4.14 - 4.06 (m, 4H), 3.97 (s, 1H), 3.33 - 3.26 (m, 3H), 2.34 (s, 3H), 2.09 (s, 1H), 0.96 (d, J = 6.8 Hz, 3H). Formate salt. One NH not observed.	470

	43	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.75 (s, 1H), 7.54 (d, <i>J</i> = 8.3 Hz, 1H), 7.39 (dd, <i>J</i> = 1.6, 8.3 Hz, 1H), 6.89 - 6.89 (m, 1H), 5.69 - 5.66 (m, 1H), 4.80 (s, 1H), 4.43 (d, <i>J</i> = 9.2 Hz, 1H), 4.10 - 4.08 (m, 2H), 3.80 - 3.49 (m, 6H), 3.43 - 3.25 (m, 3H), 2.95 (d, <i>J</i> = 12.8 Hz, 2H), 2.38 (s, 3H), 2.20 - 2.10 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	544
	44	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.70 (d, <i>J</i> = 1.5 Hz, 1H), 7.53 (d, <i>J</i> = 8.4 Hz, 1H), 7.33 (dd, <i>J</i> = 1.8, 8.3 Hz, 1H), 6.85 - 6.85 (m, 1H), 5.71 (dd, <i>J</i> = 6.6, 6.6 Hz, 1H), 4.72 - 4.12 (m, 3H), 3.98 (d, <i>J</i> = 7.8 Hz, 1H), 3.90 - 3.81 (m, 2H), 3.63 - 3.48 (m, 2H), 3.43 - 3.25 (m, 2H), 3.08 - 3.06 (m, 2H), 2.89 - 2.83 (m, 1H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	514
	45	¹ H NMR (400 MHz, CDCl ₃) δ 8.55 - 8.54 (m, 1H), 8.37 (s, 2H), 7.64 (s, 1H), 7.50 (d, <i>J</i> = 8.3 Hz, 1H), 6.86 - 6.86 (m, 1H), 5.80 (dd, <i>J</i> = 6.5, 6.5 Hz, 1H), 3.74 (s, 4H), 3.63 - 3.46 (m, 6H), 3.42 - 3.24 (m, 2H), 2.37 (s, 3H), 2.20 - 2.09 (m, 1H), 1.83 - 1.86 (m, 4H), 1.06 (d, <i>J</i> = 6.9 Hz, 3H), <i>NH</i> proton not observed.	498
	46	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.69 (d, <i>J</i> = 1.5 Hz, 1H), 7.53 (d, <i>J</i> = 8.4 Hz, 1H), 7.32 (dd, <i>J</i> = 1.7, 8.3 Hz, 1H), 6.95 (s, 1H), 5.71 (dd, <i>J</i> = 6.6, 6.6 Hz, 1H), 4.18 - 4.18 (m, 2H), 3.91 (d, <i>J</i> = 9.7 Hz, 1H), 3.79 - 3.74 (m, 1H), 3.63 - 3.48 (m, 2H), 3.43 - 3.26 (m, 2H), 3.10 (d, <i>J</i> = 8.8 Hz, 2H), 2.91 - 2.88 (m, 1H), 2.38 (s, 3H), 2.20 - 2.10 (m, 1H), 1.26 - 1.12 (m, 2H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H), 0.78 - 0.75 (m, 2H).	540

	47	¹ H NMR (400 MHz, CDCl ₃) δ 8.42 (s, 1H), 8.38 (s, 2H), 7.64 (d, <i>J</i> = 1.4 Hz, 1H), 7.52 - 7.49 (m, 1H), 7.30 (dd, <i>J</i> = 1.8, 8.3 Hz, 1H), 5.72 (dd, <i>J</i> = 6.7, 6.7 Hz, 1H), 3.63 - 3.47 (m, 9H), 3.43 - 3.25 (m, 3H), 2.96 - 2.89 (m, 1H), 2.37 (s, 3H), 2.20 - 2.12 (m, 1H), 1.87 (t, <i>J</i> = 6.1 Hz, 4H), 1.20 (d, <i>J</i> = 6.4 Hz, 6H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	540
	48	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.67 (s, 1H), 7.51 (d, <i>J</i> = 8.3 Hz, 1H), 7.31 (d, <i>J</i> = 8.0 Hz, 1H), 6.75 - 6.68 (m, 1H), 5.75 (dd, <i>J</i> = 6.7, 6.7 Hz, 1H), 3.63 - 3.46 (m, 4H), 3.42 - 3.26 (m, 2H), 2.92 - 2.91 (m, 2H), 2.39 (d, <i>J</i> = 18.2 Hz, 6H), 2.20 - 2.09 (m, 1H), 1.70 (s, 4H), 1.06 (d, <i>J</i> = 6.9 Hz, 3H), 0.69 (s, 2H).	498
	49	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 7.68 (d, <i>J</i> = 1.4 Hz, 1H), 7.52 (d, <i>J</i> = 8.3 Hz, 1H), 7.33 (dd, <i>J</i> = 1.5, 8.3 Hz, 1H), 5.86 (dd, <i>J</i> = 6.6, 6.6 Hz, 1H), 4.78 (d, <i>J</i> = 6.8 Hz, 2H), 4.25 (s, 2H), 3.89 - 3.84 (m, 2H), 3.70 - 3.26 (m, 6H), 2.58 (s, 3H), 2.51 (dd, <i>J</i> = 4.7, 4.7 Hz, 2H), 2.37 (s, 3H), 2.20 - 2.11 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H), <i>NH</i> proton not observed.	514
	50	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.68 (d, <i>J</i> = 1.4 Hz, 1H), 7.53 - 7.50 (m, 1H), 7.33 (td, <i>J</i> = 1.4, 8.5 Hz, 1H), 6.68 (s, 1H), 5.69 (t, <i>J</i> = 6.6 Hz, 1H), 3.62 - 3.47 (m, 2H), 3.42 - 3.26 (m, 2H), 2.37 (s, 3H), 2.20 - 2.08 (m, 1H), 1.06 (d, <i>J</i> = 6.9 Hz, 3H), <i>NH</i> not observed.	466

Scheme 2



a) (4-Methoxyphenyl)methanamine, Et₃N, THF, b) Et₃N, DMF, **100E**, c) TFA, DCM

General Method 6

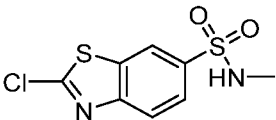
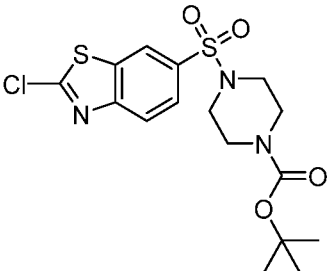
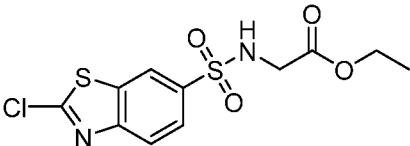
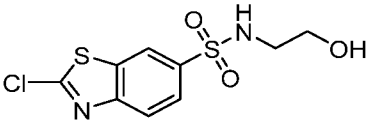
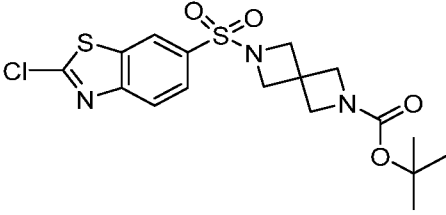
2-Chloro-*N*-(4-methoxybenzyl)benzo[*d*]thiazole-6-sulfonamide (**101B**).

(4-Methoxyphenyl)methanamine (134 mg, 0.97 mmol, 1.05 eq) was added dropwise to an ice cooled solution of 2-chlorobenzothiazole-6-sulfonyl chloride (**101A**) (250 mg, 0.932 mmol, 1.0 eq), triethylamine (0.39 mL, 2.79 mmol, 3.0 eq) in tetrahydrofuran (10 mL), and the mixture stirred at 0°C for 1 hour. The reaction mixture was concentrated under reduced pressure to give a solid which was washed with ice cold water (10 mL), ice cold tetrahydrofuran (10 mL) and then dried under vacuum to give the desired 2-chloro-*N*-(4-methoxybenzyl)benzo[*d*]thiazole-6-sulfonamide as a white solid (**101B**). Yield: 295 mg (85%). ¹H NMR (400 MHz, DMSO) δ 8.56 (d, *J* = 1.6 Hz, 1H), 8.24 (s, 1H), 8.11 (d, *J* = 8.7 Hz, 1H), 7.90 (dd, *J* = 1.9, 8.7 Hz, 1H), 7.10 (d, *J* = 8.8 Hz, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 3.98 (s, 2H), 3.67 (s, 3H); MS (ESI+) *m/z* 369 (M+H)⁺.

The intermediates in **Table 2** were synthesized using conditions analogous to those described for intermediate **101B**:

Table 2

Structure	Compound No.	¹ H NMR	LC-MS (M+H) ⁺
	Intermediate	¹ H NMR (400 MHz, CDCl ₃) δ 8.33 (1H, d, <i>J</i> = 1.6 Hz), 8.12 (1H, d, <i>J</i> = 8.5 Hz), 7.95 (1H, dd, <i>J</i> = 1.8, 8.6 Hz), 4.55 (1H, d, <i>J</i> = 3.9 Hz), 4.08 (2H, dd, <i>J</i> = 6.5, 9.3 Hz),	305

		3.64 (2H, dd, $J=5.3, 9.2$ Hz), 2.13 - 2.13 (1H, m).	
	Intermediate	Not acquired	263
	Intermediate	Not acquired	418
	Intermediate	^1H NMR (400 MHz, CDCl_3) δ 8.36 (d, $J=1.8$ Hz, 1H), 8.07 (d, $J=8.7$ Hz, 1H), 7.96 (dd, $J=1.8, 8.6$ Hz, 1H), 5.13 (dd, $J=5.3, 5.3$ Hz, 1H), 4.07 (q, $J=7.2$ Hz, 2H), 3.82 (d, $J=5.5$ Hz, 2H), 1.17 (dd, $J=7.2, 7.2$ Hz, 3H).	335
	Intermediate	^1H NMR (400 MHz, CDCl_3) δ 8.38 (d, $J=1.8$ Hz, 1H), 8.07 (d, $J=8.5$ Hz, 1H), 7.97 (dd, $J=1.8, 8.6$ Hz, 1H), 5.18 (s, 1H), 3.73 (dd, $J=4.3, 4.3$ Hz, 2H), 3.15 (dd, $J=5.8, 10.4$ Hz, 2H), 2.01 - 2.01 (m, 1H).	293
	Intermediate	Not acquired	430

(S)-N-(4-Methoxybenzyl)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo[d]thiazole-6-sulfonamide (101C)

Methodology applied was analogous to that described in **General method 3**.

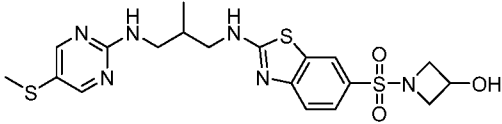
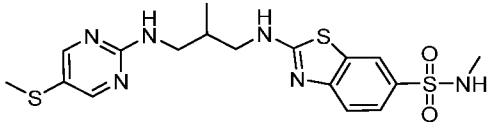
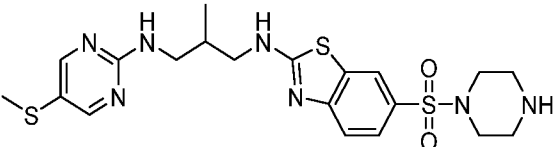
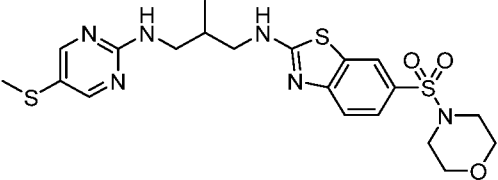
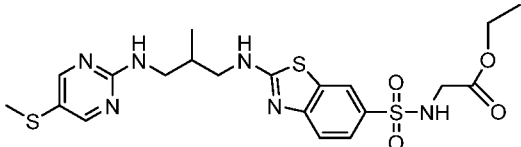
Yield: 298 mg, (69%). ¹H NMR (400 MHz, DMSO) δ 8.56 (1H, d, *J* = 1.6 Hz), 8.24 (1H, s), 8.11 (1H, d, *J* = 8.7 Hz), 7.90 (1H, dd, *J* = 1.9, 8.7 Hz), 7.10 (2H, d, *J* = 8.8 Hz), 6.76 (2H, d, *J* = 8.8 Hz), 3.98 (2H, s), 3.67 (3H, s); MS (ESI+) *m/z* 545 (M+H)⁺.

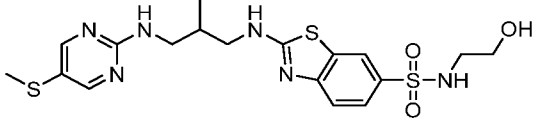
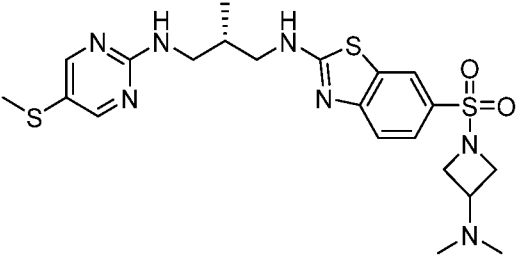
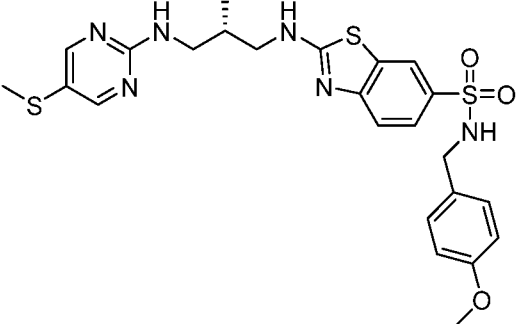
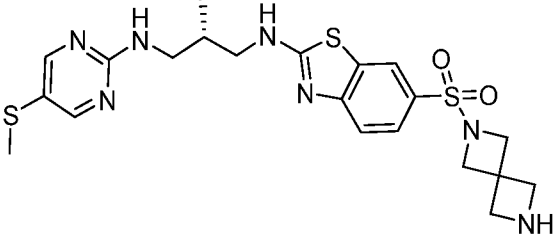
(S)-2-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazole-6-sulfonamide (Example 87)

Trifluoroacetic acid (5 mL) was added dropwise to an ice cooled solution of *N*-(4-methoxybenzyl)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)benzo [d]thiazole-6-sulfonamide (101C) (250 mg, 0.459 mmol, 1.0 eq) in anhydrous dichloromethane (5 mL). The mixture was stirred on ice for 30 minutes and then allowed to warm to ambient temperature over 18 h. The reaction mixture was diluted with dichloromethane (15 mL) and saturated sodium hydrogen carbonate (15 mL) was added slowly. The organic phase was separated, washed with brine (5 mL), dried over magnesium sulphate and then concentrated to dryness under reduced pressure. The crude residue obtained was purified by flash chromatography (eluting DCM to methanol, 0-10%) give the desired (S)-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino) benzo[d] thiazole-6-sulfonamide (Example 87) as a white solid. Yield: 190 mg (97%). ¹H NMR (400 MHz, DMSO) δ 8.40 (dd, *J* = 5.5, 5.5 Hz, 1H), 8.34 (s, 2H), 8.12 (d, *J* = 1.6 Hz, 1H), 7.66 (dd, *J* = 2.0, 8.4 Hz, 1H), 7.51 (dd, *J* = 6.0, 6.0 Hz, 1H), 7.44 (d, *J* = 8.5 Hz, 1H), 7.21 (s, 2H), 3.49 - 3.42 (m, 1H), 3.31 - 3.23 (m, 3H), 2.34 (s, 3H), 2.17 - 2.07 (m, 1H), 0.96 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 425 (M+H)⁺. Using the procedures described in **Scheme 2**, following **General Method 3**, the following examples were prepared:

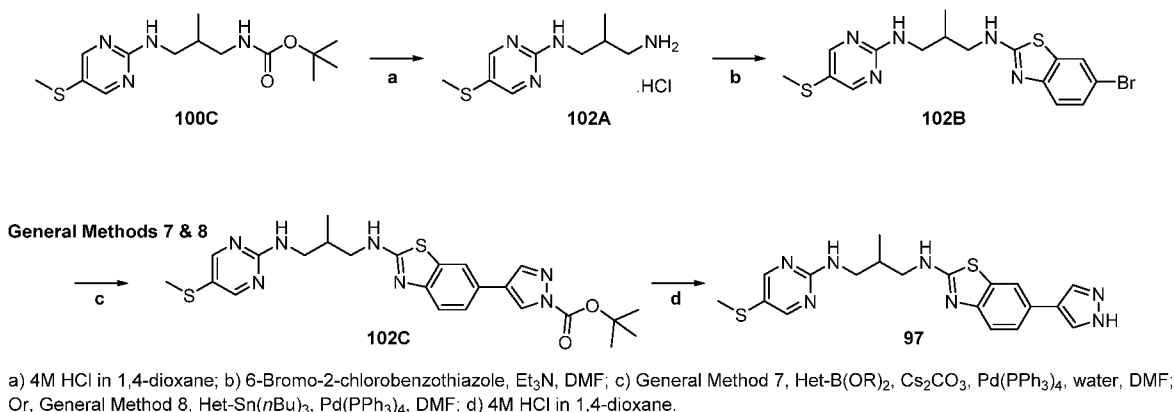
Table 3

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺

	88	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 8.05 (d, <i>J</i> = 1.5 Hz, 1H), 7.74 (dd, <i>J</i> = 1.9, 8.5 Hz, 1H), 7.60 (d, <i>J</i> = 8.5 Hz, 1H), 7.16 (s, 1H), 5.70 (dd, <i>J</i> = 6.8, 6.8 Hz, 1H), 4.50 - 4.45 (m, 1H), 4.05 - 4.01 (m, 2H), 3.62 - 3.57 (m, 3H), 3.54 (dd, <i>J</i> = 4.1, 13.6 Hz, 1H), 3.43 - 3.26 (m, 2H), 2.38 (s, 3H), 2.21 - 2.05 (m, 1H), 1.08 (d, <i>J</i> = 6.9 Hz, 3H).	481
	89	¹ H NMR (400 MHz, DMSO) δ 8.45 (dd, <i>J</i> = 5.4, 5.4 Hz, 1H), 8.33 (s, 2H), 8.11 (d, <i>J</i> = 1.9 Hz, 1H), 7.60 (dd, <i>J</i> = 1.9, 8.5 Hz, 1H), 7.51 (dd, <i>J</i> = 5.7, 5.7 Hz, 1H), 7.47 (d, <i>J</i> = 8.5 Hz, 1H), 7.26 (q, <i>J</i> = 5.1 Hz, 1H), 3.50 - 3.42 (m, 1H), 3.31 - 3.20 (m, 3H), 2.41 - 2.34 (m, 6H), 2.29 - 2.07 (m, 1H), 0.96 (d, <i>J</i> = 6.8 Hz, 3H).	439
	90	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.96 (d, <i>J</i> = 1.6 Hz, 1H), 7.64 (dd, <i>J</i> = 1.8, 8.5 Hz, 1H), 7.57 (d, <i>J</i> = 8.5 Hz, 1H), 5.86 (t, <i>J</i> = 13.1 Hz, 1H), 3.64 - 3.26 (m, 6H), 3.08 - 2.95 (m, 8H), 2.38 (s, 3H), 2.21 - 2.11 (m, 1H), 1.08 (d, <i>J</i> = 6.9 Hz, 3H).	494
	91	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (2H, s), 7.97 (1H, d, <i>J</i> = 1.8 Hz), 7.65 (1H, dd, <i>J</i> = 1.8, 8.5 Hz), 7.59 (1H, d, <i>J</i> = 8.5 Hz), 7.11 (1H, s), 5.63 (1H, t, <i>J</i> = 10.5 Hz), 3.77 - 3.73 (4H, m), 3.65 - 3.52 (2H, m), 3.43 - 3.26 (2H, m), 3.04 - 2.95 (4H, m), 2.38 (3H, s), 2.21 - 2.10 (1H, m), 1.08 (3H, d, <i>J</i> = 6.9 Hz);	495
	92	¹ H NMR (400 MHz, MeOD) δ 8.33 (2H, s), 8.11 (1H, d, <i>J</i> = 1.6 Hz), 7.74 (1H, dd, <i>J</i> = 2.0, 8.5 Hz), 7.52 (1H, d, <i>J</i> = 8.5 Hz), 4.00 (2H, q, <i>J</i> = 7.2 Hz), 3.77 (2H, s), 3.49 (2H, d, <i>J</i> = 6.1 Hz), 3.42 - 3.40 (2H, m), 2.35 (3H, s), 2.25 - 2.16 (1H, m), 1.15 - 1.06 (6H, m); N-CH ₃ obscured by MeOH peak	511

	93	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 8.07 (d, J = 1.6 Hz, 1H), 7.74 (dd, J = 1.9, 8.5 Hz, 1H), 7.54 (d, J = 8.5 Hz, 1H), 7.18 (s, 1H), 5.80 (dd, J = 6.5, 6.5 Hz, 1H), 5.02 (dd, J = 6.1, 6.1 Hz, 1H), 3.73 - 3.70 (m, 2H), 3.64 - 3.50 (m, 2H), 3.43 - 3.25 (m, 2H), 3.13 (dd, J = 5.9, 10.4 Hz, 2H), 2.38 (s, 3H), 2.21 - 2.10 (m, 1H), 1.07 (d, J = 7.0 Hz, 3H).	469
	94	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (2H, s), 8.05 (1H, d, J = 1.6 Hz), 7.74 (1H, dd, J = 1.9, 8.5 Hz), 7.61 (1H, d, J = 8.5 Hz), 5.68 (1H, dd, J = 6.7, 6.7 Hz), 3.81 (2H, dd, J = 7.6, 7.6 Hz), 3.64 - 3.53 (4H, m), 3.43 - 3.26 (2H, m), 3.06 - 2.98 (1H, m), 2.38 (3H, s), 2.21 - 2.11 (1H, m), 2.02 (6H, s), 1.33 - 1.24 (1H, m), 1.08 (3H, d, J = 6.9 Hz).	508
	95	¹ H NMR (400 MHz, DMSO) δ 8.44 (dd, J = 5.5, 5.5 Hz, 1H), 8.34 (s, 2H), 8.07 (d, J = 1.9 Hz, 1H), 7.88 (dd, J = 6.0, 6.0 Hz, 1H), 7.62 (dd, J = 2.0, 8.5 Hz, 1H), 7.52 (dd, J = 6.0, 6.0 Hz, 1H), 7.43 (d, J = 8.5 Hz, 1H), 7.14 (d, J = 8.8 Hz, 2H), 6.81 (d, J = 8.8 Hz, 2H), 3.89 (d, J = 5.8 Hz, 2H), 3.70 (s, 3H), 3.52 - 3.42 (m, 1H), 3.32 - 3.23 (m, 3H), 2.34 (s, 3H), 2.17 - 2.07 (m, 1H), 0.97 (d, J = 6.7 Hz, 3H).	545
	96	¹ H NMR (400 MHz, DMSO) δ 8.63 (s, 1H), 8.55 - 8.46 (m, 2H), 8.35 (s, 2H), 8.20 (d, J = 1.9 Hz, 1H), 7.61 (dd, J = 1.9, 8.5 Hz, 1H), 7.52 (d, J = 8.4 Hz, 1H), 3.94 - 3.85 (m, 9H), 3.38 - 3.21 (m, 3H), 2.35 (s, 3H), 2.18 - 2.08 (m, 1H), 0.97 (d, J = 6.8 Hz, 3H).	505

Scheme 3



2-Methyl-N¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (102A)

Methodology applied was analogous to **General Method 2**.

A solution of hydrogen chloride (54 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (100C) (4.25 g, 13.60 mmol) and the mixture stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired 2-methyl-N¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (102A) as a pale yellow semi-solid. The semi-crude sample was taken on into the next reaction without further purification.

N¹-(6-Bromobenzo[d]thiazol-2-yl)-2-methyl-N³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (102B)

Methodology applied was analogous to **General Method 3**.

6-Bromo-2-chlorobenzothiazole (828 mg, 3.33 mmol, 0.95 eq) was added to a stirred suspension of 2-methyl-N¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (102A) (1.00 g, 3.51 mmol, 1.0 eq) and cesium carbonate (3.43 g, 10.52 mmol, 3.0 eq) in anhydrous dimethylformamide (25 mL) under nitrogen. The mixture was stirred at room temperature for 72 h and was then concentrated under vacuum to ~3 mL. Water (25 mL) was added and the mixture was extracted with ethyl acetate (3 x 50 mL). The combined organic phases were washed with water (20 mL) and brine (25 mL) then dried over magnesium sulfate. The solvents were removed under vacuum to give a

crude yellow oil which was purified by flash chromatography (eluting *isohexane* to ethyl acetate, 0-100%) to give the desired *N*¹-(6-bromobenzo[*d*]thiazol-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (102B) as a sticky yellow solid.

Yield: 266 mg (18%). ¹H NMR (400 MHz, CDCl₃) δ 8.37 (s, 2H), 7.66 (d, *J* = 0.6 Hz, 1H), 7.37 (d, *J* = 1.9 Hz, 2H), 6.58 (s, 1H), 5.69 (dd, *J* = 6.3, 6.3 Hz, 1H), 3.67 - 3.23 (m, 4H), 2.37 (s, 3H), 2.17 - 2.09 (m, 1H), 1.06 (d, *J* = 6.9 Hz, 3H).

General Method 7

***tert*-Butyl 4-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazol-6-yl)-1*H*-pyrazole-1-carboxylate (102C)**

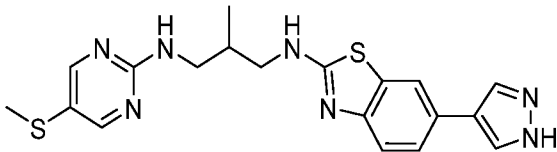
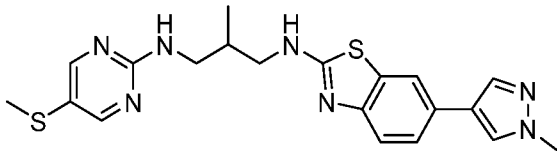
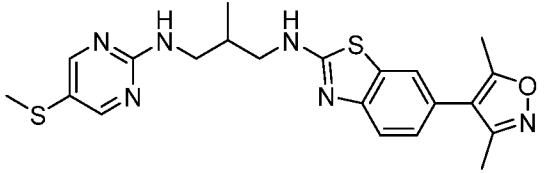
A solution of *N*¹-(6-bromobenzo[*d*]thiazol-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (102B) (50 mg, 0.12 mmol, 1.0 eq) was added to a solution of (1-(*tert*-butoxycarbonyl)-1*H*-pyrazol-4-yl)boronic acid (27.8 mg, 0.13 mmol, 1.0 eq), cesium carbonate (58 mg, 0.18 mmol, 1.5 eq) and tetrakis(triphenylphosphine)palladium (0) (7 mg, 0.01 mmol, 0.05 eq) in water (0.20 mL) and *N,N*-dimethylformamide (0.80 mL) under nitrogen. The reaction mixture was heated to 90°C for 16 h. An additional aliquot of (1-(*tert*-butoxycarbonyl)-1*H*-pyrazol-4-yl)boronic acid (27.8 mg, 0.13 mmol, 1.0 eq) and tetrakis(triphenylphosphine) palladium (0) (7 mg, 0.01 mmol, 0.05 eq) was added to the reaction and the mixture was heated to 90°C under nitrogen for a further 16 h. The solvents were removed under reduced pressure; water (2 mL) was added and the mixture was extracted with ethyl acetate (3 x 5 mL). The combined organic phases were washed with water (2 mL) and brine (2 mL), dried by passing through a phase separator and then concentrated under vacuum. The crude residue obtained was purified by flash chromatography (eluting *isohexane* to ethyl acetate, 0-75%) to give the desired *tert*-butyl 4-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazol-6-yl)-1*H*-pyrazole-1-carboxylate (102C) as an off-white solid. The semi-crude product was taken through to the next reaction without further purification.

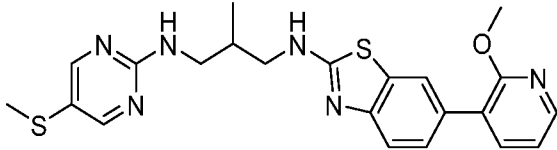
***N*¹-(6-(1*H*-Pyrazol-4-yl)benzo[*d*]thiazol-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 97)**

A solution of hydrogen chloride (2 mL, 4M in 1,4-dioxane) was added to *tert*-butyl 4-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazol-6-yl)-1*H*-pyrazole-1-carboxylate (102C) (100 mg, 0.12 mmol) and the mixture stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired *N*¹-(6-(1*H*-pyrazol-4-yl)benzo[*d*]thiazol-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 97) as an off-white solid.

Using the procedures described in **Scheme 3**, according to **General Method 7**, the following examples were prepared:

Table 4

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	97	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 7.84 (s, 2H), 7.69 (d, <i>J</i> = 1.6 Hz, 1H), 7.53 (d, <i>J</i> = 8.3 Hz, 1H), 7.43 (dd, <i>J</i> = 1.8, 8.4 Hz, 1H), 6.00 - 5.91 (m, 1H), 3.63 - 3.26 (m, 4H), 2.36 (s, 3H), 2.21 - 2.11 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H). NH exchangeable proton not observed.	412
	98	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.74 (s, 1H), 7.66 (d, <i>J</i> = 1.3 Hz, 1H), 7.58 (s, 1H), 7.52 (d, <i>J</i> = 8.4 Hz, 1H), 7.39 (dd, <i>J</i> = 1.7, 8.3 Hz, 1H), 6.61 - 6.61 (m, 1H), 5.76 (dd, <i>J</i> = 6.3, 6.3 Hz, 1H), 3.95 (s, 3H), 3.63 - 3.47 (m, 2H), 3.43 - 3.26 (m, 2H), 2.36 (s, 3H), 2.19 - 2.11 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	426
	99	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (s, 2H), 7.59 (d, <i>J</i> = 8.3 Hz, 1H), 7.43 (d, <i>J</i> = 1.6 Hz, 1H), 7.16 (dd, <i>J</i> = 1.8, 8.3 Hz, 1H), 6.64 - 6.64 (m, 1H), 5.74 (dd, <i>J</i> = 6.2, 6.2 Hz, 1H), 3.64 - 3.49 (m, 2H), 3.43 - 3.27 (m, 2H), 2.41 (s, 3H), 2.37 (s, 3H).	441

		2.27 (s, 3H), 2.18 - 2.14 (m, 1H), 1.08 (d, $J=6.8$ Hz, 3H).	
	100	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (s, 2H), 8.14 (dd, $J=1.8$, 5.0 Hz, 1H), 7.79 (d, $J=1.8$ Hz, 1H), 7.64 - 7.57 (m, 2H), 7.47 (dd, $J=1.7$, 8.3 Hz, 1H), 6.97 (dd, $J=5.0$, 7.3 Hz, 1H), 6.61 - 6.61 (m, 1H), 5.74 (dd, $J=6.3$, 6.3 Hz, 1H), 3.98 (s, 3H), 3.63 - 3.50 (m, 2H), 3.43 - 3.27 (m, 2H), 2.37 (s, 3H), 2.20 - 2.11 (m, 1H), 1.07 (d, $J=6.9$ Hz, 3H).	453

General Method 8

2-Methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)-*N*³-(6-(oxazol-2-yl)benzo[d]thiazol-2-yl)propane-1,3-diamine (Example 101)

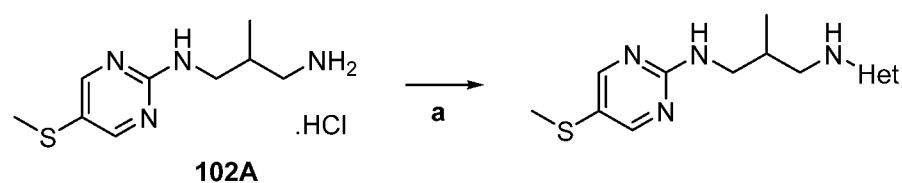
*N*¹-(6-Bromobenzo[d]thiazol-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (102B) (90 mg, 0.21 mmol, 1.0 eq) was added to a solution of 2-(tri-*n*-butylstannyl)oxazole (0.044 mL, 0.21 mmol, 1.0 eq) and tetrakis(triphenylphosphine) palladium (0) (23 mg, 0.02 mmol, 0.1 eq) in *N,N*-dimethylformamide (0.80 mL) under nitrogen. The reaction mixture was heated to 90°C for 16 h. A further aliquot of 2-(tri-*n*-butylstannyl)oxazole (0.044 mL, 0.21 mmol, 1.0 eq) and tetrakis(triphenylphosphine) palladium (0) (23 mg, 0.02 mmol, 0.1 eq) were added to the reaction mixture, heating to 110°C for 18 h. The reaction was cooled to room temperature, diluted with water (2 mL) and extracted with ethyl acetate (3 x 5 mL). The combined organic phase was washed with water (2 mL) and brine (2 mL), filtered through a celite pad, and dried by passing through a phase separator before concentrating to dryness under vacuum. The crude residue obtained was twice purified by flash chromatography (first eluting *iso*hexane to ethyl acetate, 0-100%, then ethyl acetate to methanol, 0-10%) to give a semi-crude residue which was further purified by reverse phase preparative HPLC to give the desired 2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)-*N*³-(6-(oxazol-2-yl)benzo[d]thiazol-2-yl)propane-1,3-diamine (101) as an off-white solid.

Using the procedures described in **Scheme 3**, according to **General Method 8**, the following examples were prepared:

Table 5

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	101	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 (s, 2H), 8.26 (d, <i>J</i> = 1.6 Hz, 1H), 7.98 (dd, <i>J</i> = 1.8, 8.5 Hz, 1H), 7.68 (s, 1H), 7.58 (d, <i>J</i> = 8.4 Hz, 1H), 7.21 (s, 1H), 6.75 - 6.75 (m, 1H), 5.68 (dd, <i>J</i> = 6.3, 6.3 Hz, 1H), 3.65 - 3.57 (m, 1H), 3.56 - 3.50 (m, 1H), 3.43 - 3.28 (m, 2H), 2.37 (s, 3H), 2.17 (s, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	413
	102	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (s, 2H), 7.80 (s, 1H), 7.53 (s, 2H), 7.13 (s, 1H), 6.76 (s, 1H), 5.84 (t, <i>J</i> = 6.9 Hz, 1H), 3.64 - 3.48 (m, 2H), 3.43 - 3.25 (m, 2H), 2.52 (s, 3H), 2.36 (s, 3H), 2.19 - 2.10 (m, 1H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	427

Scheme 4

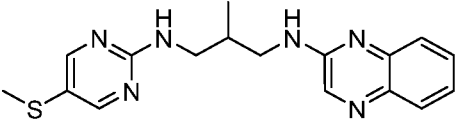
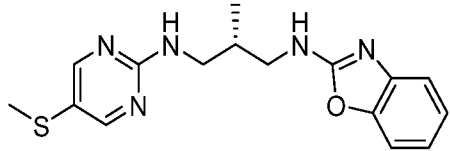
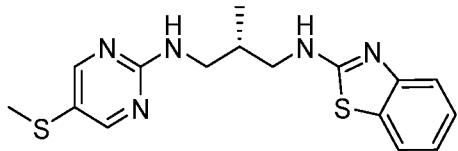
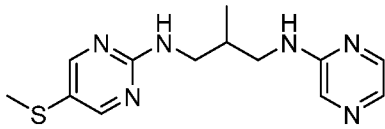


a) Het-Cl, or Het Br; Et₃N, DMF; RT to 80°C

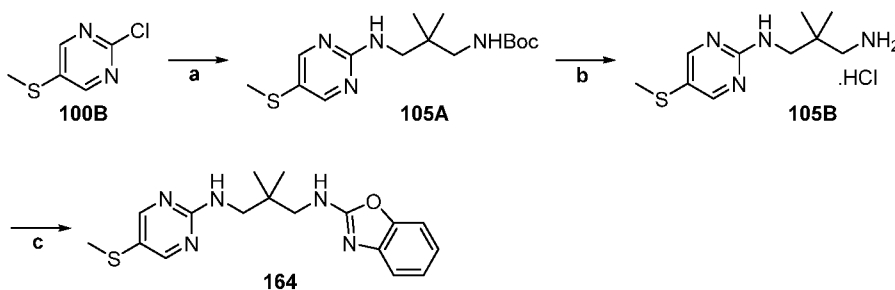
Using the procedures described in **Scheme 4**, according to **General Method 3**, the following examples were prepared:

Table 6

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	103	¹ H NMR (400 MHz, DMSO) δ 9.10 (s, 1H), 8.34 (s, 2H), 7.79 (d, <i>J</i> = 7.8 Hz, 1H), 7.71 - 7.66 (m, 1H), 7.59 (s, 1H), 7.46 (d, <i>J</i> = 8.4 Hz, 2H), 7.22 (dd, <i>J</i> = 7.4, 7.4 Hz, 1H), 3.43 - 3.35 (m, 2H), 3.31 - 3.25 (m, 2H), 2.34 (s, 3H), 2.12 - 2.08 (m, 1H), 0.94 (d, <i>J</i> = 6.8 Hz, 3H).	341

	104	¹ H NMR (400 MHz, DMSO) δ 8.33 (s, 3H), 7.75 (d, <i>J</i> = 7.9 Hz, 1H), 7.64 (dd, <i>J</i> = 5.6, 5.6 Hz, 1H), 7.59 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 7.53 (d, <i>J</i> = 3.8 Hz, 2H), 7.34 - 7.28 (m, 1H), 3.45 - 3.35 (m, 2H), 3.28 (t, <i>J</i> = 6.2 Hz, 2H), 2.34 (s, 3H), 2.16 - 2.08 (m, 1H), 0.98 (d, <i>J</i> = 6.8 Hz, 3H).	341
	105	¹ H NMR (400 MHz, DMSO) δ 8.32 (s, 2H), 7.92 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 7.48 (dd, <i>J</i> = 5.7, 5.7 Hz, 1H), 7.32 (d, <i>J</i> = 7.7 Hz, 1H), 7.22 (d, <i>J</i> = 7.4 Hz, 1H), 7.10 (dd, <i>J</i> = 7.4, 7.4 Hz, 1H), 6.99 - 6.94 (m, 1H), 3.30 - 3.16 (m, 4H), 2.34 (s, 3H), 2.13 - 2.05 (m, 1H), 0.94 (d, <i>J</i> = 6.7 Hz, 3H).	330
	106	¹ H NMR (400 MHz, DMSO) δ 8.26 (s, 2H), 7.96 (dd, <i>J</i> = 5.6, 5.6 Hz, 1H), 7.57 (d, <i>J</i> = 7.1 Hz, 1H), 7.46 (dd, <i>J</i> = 5.9, 5.9 Hz, 1H), 7.28 (d, <i>J</i> = 7.3 Hz, 1H), 7.16 - 7.11 (m, 1H), 6.95 - 6.90 (m, 1H), 3.37 - 3.30 (m, 1H), 3.23 - 3.14 (m, 3H), 2.26 (s, 3H), 2.09 - 1.97 (m, 1H), 0.87 (d, <i>J</i> = 6.8 Hz, 3H).	346
	107	¹ H NMR (400 MHz, DMSO) δ 8.33 (s, 2H), 7.93 (s, 1H), 7.89 (d, <i>J</i> = 2.6 Hz, 1H), 7.61 (d, <i>J</i> = 2.8 Hz, 1H), 7.44 (dd, <i>J</i> = 5.8, 5.8 Hz, 1H), 7.05 (dd, <i>J</i> = 5.7, 5.7 Hz, 1H), 3.31 - 3.14 (m, 4H), 2.35 (s, 3H), 2.09 - 1.99 (m, 1H), 0.92 (d, <i>J</i> = 6.8 Hz, 3H).	291

Scheme 7



a) $\text{NH}_2\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{NHBoc}$, Cs_2CO_3 , DMF; b) 4M HCl in 1,4-dioxane; c) 2-chlorobenzo[d]oxazole, Cs_2CO_3 , DMF

***tert*-Butyl (2,2-dimethyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (105A)**

Methodology applied was analogous to those described in **General Method 1** except additional heating was required.

tert-Butyl (3-amino-2,2-dimethylpropyl)carbamate (0.13 g, 0.65 mmol, 1.05 eq) was added to a stirred suspension of 2-chloro-5-(methylthio)pyrimidine (100B) (0.10 g, 0.62 mmol, 1.0 eq) and cesium carbonate (0.24 g, 0.75 mmol, 1.2 eq) in anhydrous *N,N*-dimethylformamide (1.5 mL) and the mixture stirred at 80°C for 4 h. The reaction mixture was concentrated under vacuum, diluted with ethyl acetate (20 mL), washed with water (7.5 mL) and brine (5.0 mL) then dried through a phase separator. The solvents were removed under vacuum to give the desired *tert*-butyl (2,2-dimethyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (**105A**) as a pale yellow oil. Yield: 0.163 g (81%). ¹H NMR (400 MHz, DMSO) δ 8.37 (s, 2H), 7.24 (dd, *J* = 6.6, 6.6 Hz, 1H), 6.93 (dd, *J* = 6.3, 6.3 Hz, 1H), 3.20 (d, *J* = 6.8 Hz, 2H), 2.85 (d, *J* = 8.7 Hz, 2H), 2.40 (s, 3H), 1.43 (d, *J* = 3.3 Hz, 9H), 0.83 (s, 6H).

2,2-Dimethyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (105B)

Methodology applied was analogous to those described in **General Method 2**.

A solution of hydrogen chloride (5 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (2,2-dimethyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)carbamate (**105A**) (0.16 g, 0.50 mmol) and the mixture was stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired 2,2-dimethyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (**105B**) as a pale yellow semi solid.

Yield: 0.13 g (100%) HCl salt. ¹H NMR (400 MHz, DMSO) δ 8.39 (s, 2H), 7.95 (s, 3H), 7.70 (s, 1H), 3.25 (d, *J* = 5.5 Hz, 2H), 2.68 - 2.61 (m, 2H), 2.38 (s, 3H), 0.96 (s, 6H).

***N*¹-(Benzo[*d*]oxazol-2-yl)-2,2-dimethyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 164)**

Methodology applied was analogous to those described in **General Method 3** except cesium carbonate was used as a general base.

2-Chlorobenzoxazole (0.06 mL, 0.54 mmol, 0.1 eq) was added to a stirred solution of 2,2-dimethyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (**105B**) (0.13 g, 0.49 mmol, 1.0 eq) and cesium carbonate (0.48 g, 1.48 mmol, 3.0 eq) in anhydrous *N,N*-dimethylformamide (2.0 mL) under nitrogen. The mixture was stirred at either 80°C or room temperature for 16 h and was then concentrated under vacuum.

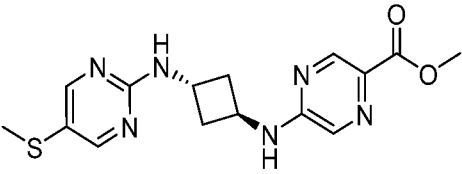
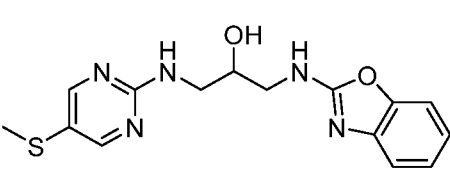
Water (2.5 mL) was added and the mixture extracted with ethyl acetate (3 x 5 mL). The combined organic phases were washed with water (2 mL) and brine (2 mL) then dried through a phase separator. The solvents were removed under vacuum to give a crude yellow oil which was purified by preparative HPLC to give the desired *N*¹-(benzo[*d*]oxazol-2-yl)-2,2-dimethyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 164) as an off-white solid.

Using the procedures described in **Scheme 7**, according to **General Method 3**, the following examples were prepared:

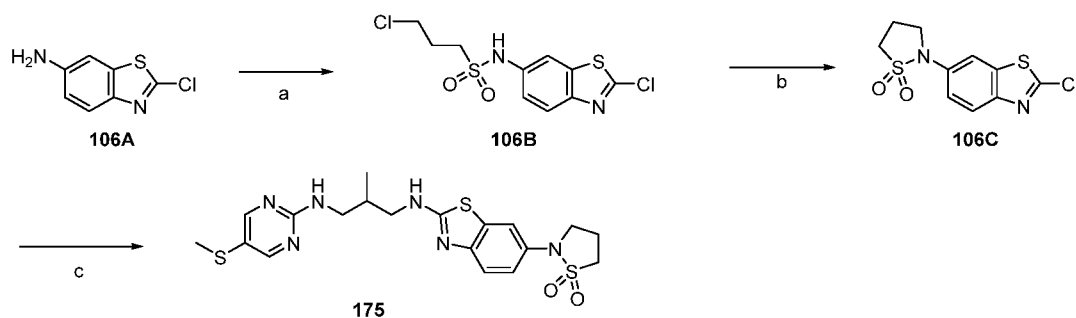
Table 9

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	164	¹ H NMR (400 MHz, DMSO) δ 8.33 (s, 2H), 8.21 (s, 1H), 7.53 - 7.51 (m, 1H), 7.37 (d, <i>J</i> = 7.8 Hz, 1H), 7.24 (d, <i>J</i> = 7.4 Hz, 1H), 7.14 (dd, <i>J</i> = 7.4, 7.4 Hz, 1H), 7.02 (dd, <i>J</i> = 7.3, 7.3 Hz, 1H), 3.30 - 3.23 (m, 4H), 2.34 (s, 3H), 0.93 (s, 6H).	344
	165	¹ H NMR (400 MHz, CDCl ₃) δ 8.36 (s, 2H), 7.34 (d, <i>J</i> = 7.5 Hz, 1H), 7.23 (d, <i>J</i> = 7.8 Hz, 1H), 7.15 (dd, <i>J</i> = 7.2, 7.2 Hz, 1H), 7.01 (dd, <i>J</i> = 7.3, 7.3 Hz, 1H), 6.28 - 6.27 (m, 1H), 5.73 (dd, <i>J</i> = 6.3, 6.3 Hz, 1H), 3.47 - 3.38 (m, 4H), 2.36 (s, 3H), 0.69 - 0.65 (m, 2H), 0.58 - 0.54 (m, 2H).	342
	166	¹ H NMR (400 MHz, DMSO) δ 8.36 (s, 2H), 8.35 - 8.29 (m, 1H), 7.84 (d, <i>J</i> = 6.7 Hz, 1H), 7.35 (d, <i>J</i> = 7.8 Hz, 1H), 7.25 (d, <i>J</i> = 7.4 Hz, 1H), 7.12 (dd, <i>J</i> = 7.4, 7.4 Hz, 1H), 6.99 (dd, <i>J</i> = 7.3, 7.3 Hz, 1H), 4.47 - 4.40 (m, 1H), 4.29 (dd, <i>J</i> = 6.5, 12.9 Hz, 1H).	328

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	173	¹ H NMR (400 MHz, CDCl ₃) δ 8.79 (1H, s), 8.36 (2H, s), 7.89 (1H, s), 5.46 (1H, d, <i>J</i> = 5.9 Hz), 5.38 (1H, d, <i>J</i> = 4.9 Hz), 4.61 - 4.48 (2H, m), 3.96 (3H, s), 2.49 (3H, dd, <i>J</i> = 6.6, 6.6 Hz), 2.37 (3H, s).	347
	174	¹ H NMR (400 MHz, CDCl ₃) δ 8.36 (s, 2H), 7.37 (d, <i>J</i> = 7.7 Hz, 1H), 7.17 (dd, <i>J</i> = 7.4, 7.4 Hz, 1H), 7.07 - 7.02 (m, 1H), 5.80 (dd, <i>J</i> = 5.7, 5.7 Hz, 1H), 5.63 (s, 1H), 4.82 - 4.81 (m, 1H), 4.12 - 4.06 (m, 1H), 3.74 - 3.49 (m, 4H), 2.38 (s, 3H).	332

Scheme 8



a) ClS(O₂)CH₂CH₂CH₂Cl, NaH, DMF b) NaH, DMF c) **102A**, Et₃N, Cs₂CO₃

3-Chloro-*N*-(2-chlorobenzo[*d*]thiazol-6-yl)propane-1-sulfonamide (106B)

Sodium hydride (60% dispersion in mineral oil) (326 mg, 8.15 mmol, 3.0 eq) was added portion-wise to an ice cooled solution of 2-chlorobenzothiazole-6-amine (500 mg, 2.71 mmol, 1.0 eq) in *N,N*-dimethylformamide (25 mL) and the mixture stirred for 1 hour under ice cooling. A solution of 3-chloropropane-1-sulfonyl chloride (673 mg, 3.80 mmol, 1.4 eq) in *N,N*-dimethylformamide (3 mL) was added dropwise and the reaction mixture was then allowed to warm to ambient temperature over 3 h. The reaction mixture was diluted with brine (20 mL) and extracted with ethyl acetate (2 x 25 mL). The combined organic fractions were combined and concentrated under reduced pressure to give a pale yellow oil that was purified by flash chromatography (eluting *iso*-hexanes to ethyl acetate, 0-100%) to give the desired product 3-chloro-*N*-(2-chlorobenzo[*d*]thiazol-6-yl)propane-1-sulfonamide **106B** as an off-white gum.

Yield: 427 mg (48%). ¹H NMR (400 MHz, MeOD) δ 7.87 - 7.84 (m, 2H), 7.38 (dd, J = 2.3, 8.8 Hz, 1H), 3.67 (dd, J = 6.3, 6.3 Hz, 2H), 2.27 - 2.19 (m, 2H). **Note** CH₂ protons obscured by MeOD.

2-(2-Chlorobenzo[*d*]thiazol-6-yl)isothiazolidine 1,1-dioxide (106C)

Sodium hydride (60% dispersion in mineral oil) (98 mg, 2.46 mmol, 2.0 eq) was added to an ice cooled solution of 3-chloro-*N*-(2-chlorobenzo[*d*]thiazol-6-yl)propane-1-sulfonamide (106B) (400 mg, 1.23 mmol, 1.0 eq) in *N,N*-dimethylformamide (5 mL). The reaction mixture was stirred for 1 hour under ice cooling and then quenched by the careful addition of a saturated solution of ammonium chloride (20 mL). The resulting mixture was extracted with ethyl acetate (3 x 20 mL) and the combined organic phases were washed with water (20 mL), brine (20 mL) and then concentrated under vacuum to give a gum. The crude product was purified by flash chromatography (eluting *iso*hexane to ethyl acetate, 0-100%) to give the desired product (106C) as an off-white gum.

Yield: 220 mg (62%). ¹H NMR (400 MHz, CDCl₃) δ 7.92 (d, J = 8.9 Hz, 1H), 7.72 (d, J = 2.1 Hz, 1H), 7.38 (dd, J = 2.4, 8.9 Hz, 1H), 3.84 (dd, J = 6.5, 6.5 Hz, 2H), 3.43 (dd, J = 7.5, 7.5 Hz, 2H), 2.63 - 2.55 (m, 2H).

2-(2-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazol-6-yl)isothiazolidine 1,1-dioxide (Example 175)

Methodology applied was analogous to those described in **General Method 3**.

Yield: 25 mg (15%). ¹H NMR (400 MHz, DMSO) δ 8.34 (s, 2H), 8.03 (dd, J = 5.6, 5.6 Hz, 1H), 7.57 (d, J = 2.3 Hz, 1H), 7.51 (dd, J = 5.9, 5.9 Hz, 1H), 7.35 (d, J = 8.8 Hz, 1H), 7.14 (dd, J = 2.4, 8.7 Hz, 1H), 3.72 (dd, J = 6.5, 6.5 Hz, 2H), 3.47 (dd, J = 7.5, 7.5 Hz, 2H), 3.45 - 3.38 (m, 1H), 3.30 - 3.22 (m, 3H), 2.44 - 2.36 (m, 2H), 2.35 (s, 3H), 2.13 - 2.06 (m, 1H), 0.95 (d, J = 6.8 Hz, 3H); MS (ESI+) m/z 465 (M+H)⁺.

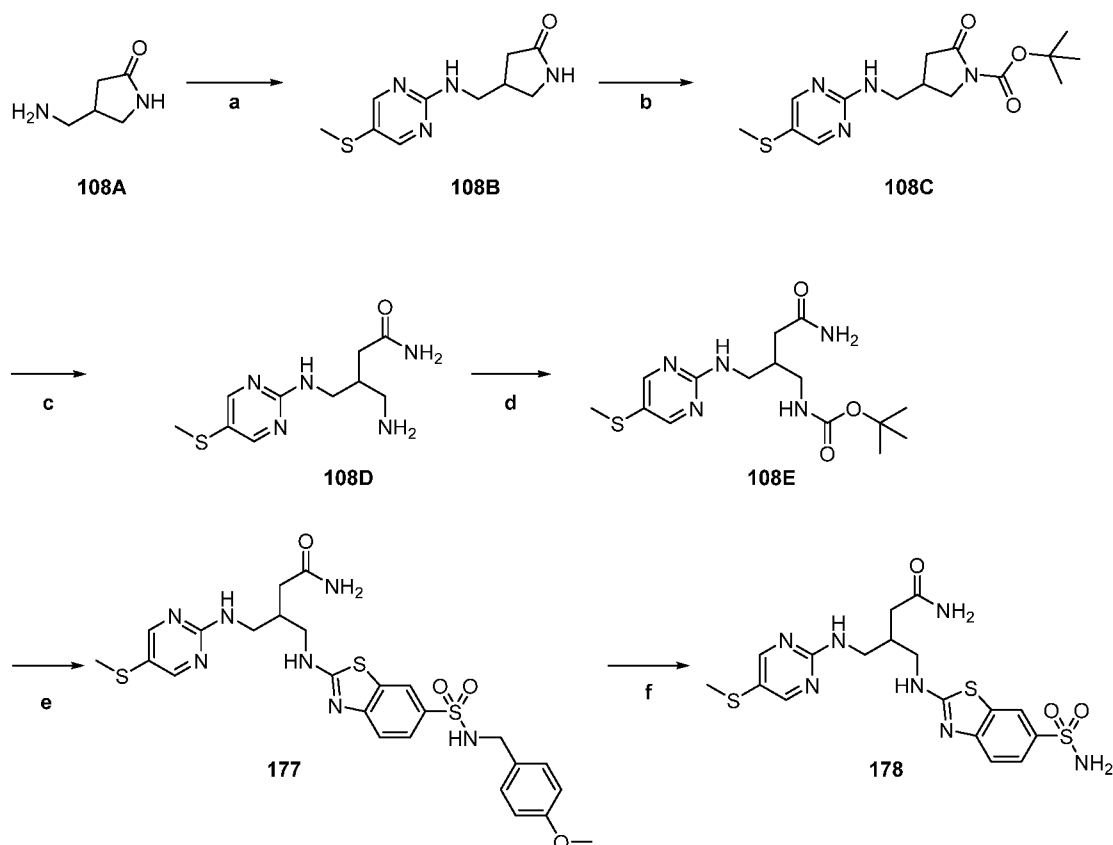
removed under high vacuum to give a pale yellow gum that was purified by flash chromatography (eluting *iso*-hexanes to ethyl acetate, 0-100%) to give the desired *N*-(2-chlorobenzo[*d*]thiazol-6-yl)-*N*-methylmethanesulfonamide (107C) as a pale yellow gum. Yield: 100 mg (70%) ¹H NMR (400 MHz, CDCl₃) δ 7.95 (d, *J* = 8.8 Hz, 1H), 7.86 (d, *J* = 2.1 Hz, 1H), 7.48 (dd, *J* = 2.3, 8.8 Hz, 1H), 3.39 (s, 3H), 2.88 (s, 3H).

***N*-Methyl-*N*-(2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazol-6-yl)methanesulfonamide (Example 176)**

Methodology applied was analogous to those described in **General Method 3**.

Yield: 89 mg (60%) ¹H NMR (400 MHz, CDCl₃) δ 8.38 (s, 2H), 7.62 (d, *J* = 2.0 Hz, 1H), 7.51 (d, *J* = 8.7 Hz, 1H), 7.24 (d, *J* = 3.2 Hz, 1H), 5.74 (dd, *J* = 6.5, 6.5 Hz, 1H), 3.34 - 3.33 (m, 6H), 2.86 (s, 3H), 2.37 (s, 3H), 2.20 - 2.10 (m, 1H), 1.06 (d, *J* = 6.9 Hz, 3H). Not all *NH* exchangeable protons observed; MS (ESI+) *m/z* 453 (M+H)⁺.

Scheme 10



a) **100B**, Cs₂CO₃, DMF; b) BOC₂O, Et₃N, DMAP, DCM; c) 1. NH₄OH, 2. HCl; d) **101B**, Et₃N, DMF; e) TFA, DCM

4-(((5-(Methylthio)pyrimidin-2-yl)amino)methyl)pyrrolidin-2-one (**108B**)

Methodology applied was analogous to those described in **General Method 1**.

5-Aminomethyl-pyrrolidin-2-one (**108A**) (1.0 g, 8.76 mmol, 1.0 eq) was added to a stirred suspension of 2-chloro-5-(methylthio)pyrimidine (**100B**) (1.4 g, 8.76 mmol, 1.0 eq) and cesium carbonate (8.56 g, 26.28 mmol, 3.0 eq) in anhydrous dimethylformamide (10 mL). The mixture was heated to 50°C for 18 h and then concentrated under reduced pressure. The liquor obtained was diluted with ethyl acetate (50 mL), washed with water (10 mL) and brine (10 mL) and then dried through a phase separator. The solvents were removed under reduced pressure to afford a crude residue that was purified by trituration in methanol to give the desired product 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)pyrrolidin-2-one (**108B**) as a yellow solid. The aqueous phase was concentrated under reduced pressure, combined with the filtrate and purified by flash

chromatography (eluting dichloromethane to methanol, 0-10%) to give the desired product 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)pyrrolidin-2-one (108B) as a yellow solid. Both crops were combined and used in the next step.

Yield: 0.74 g (36%). ¹H NMR (400 MHz, CDCl₃) δ 8.35 (s, 2H), 5.79 - 5.76 (m, 1H), 5.48 (dd, *J* = 5.5, 5.5 Hz, 1H), 3.57 - 3.50 (m, 3H), 3.20 (dd, *J* = 5.3, 9.5 Hz, 1H), 2.89 - 2.84 (m, 1H), 2.53 - 2.46 (m, 1H), 2.37 (s, 3H), 2.16 (dd, *J* = 6.4, 17.1 Hz, 1H).

***tert*-Butyl 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-2-oxopyrrolidine-1-carboxylate (108C)**

4-Dimethylaminopyridine (5 mg, 0.04 mmol, 0.1 eq) was added to a stirred suspension of 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)pyrrolidin-2-one (108B) (100 mg, 0.4 mmol, 1.0 eq), di-*tert*-butyl dicarbonate (229 mg, 1.0 mmol, 2.5 eq) and triethylamine (0.146 mL, 1.00 mmol, 2.5 eq) in dichloromethane (4.2 mL). The mixture was stirred at room temperature for 72 h and then water (3.0 mL) was added. The mixture was extracted with ethyl acetate (3 x 5.0 mL) and the combined organic phases were washed with brine (2.5 mL) then dried passing through a phase separator. The solvents were removed under reduced pressure to afford a crude residue which was purified by reverse phase chromatography (eluting 0.1% formic solution to acetonitrile, 5-100%) to give the desired product *tert*-butyl 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-2-oxopyrrolidine-1-carboxylate (108C).

Yield: 72 mg (53%). ¹H NMR (400 MHz, DMSO) δ 8.35 (s, 2H), 7.62 (t, *J* = 6.1 Hz, 1H), 3.73 (dd, *J* = 7.8, 10.4 Hz, 1H), 3.50 - 3.44 (m, 1H), 3.29 (d, *J* = 6.4 Hz, 2H), 2.60 - 2.55 (m, 2H), 2.36 (s, 3H), 2.28 (dd, *J* = 9.6, 20.9 Hz, 1H), 1.44 (s, 9H).

***tert*-Butyl (4-amino-2-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-4-oxobutyl)carbamate (108D)**

A solution of ammonium hydroxide (2.2 mL) was added to *tert*-butyl 4-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-2-oxopyrrolidine-1-carboxylate (108C) (72 mg, 0.21 mmol) and the mixture was heated at 80°C for 1.5 h. The mixture was cooled to room temperature then extracted with dichloromethane (3 x 5 mL). The organic solvents

were dried passing through a phase separator then removed under reduced pressure to afford the desired product *tert*-butyl (4-amino-2-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-4-oxobutyl)carbamate (108D).

Yield: 61 mg (86%). ¹H NMR (400 MHz, DMSO) δ 8.33 (s, 2H), 7.32 (s, 1H), 7.25 (dd, J = 6.0, 6.0 Hz, 1H), 6.81 (s, 2H), 3.24 (dd, J = 6.2, 6.2 Hz, 2H), 2.97 (dd, J = 6.0, 6.0 Hz, 2H), 2.36 (s, 3H), 2.18 - 2.08 (m, 1H), 2.04 (d, J = 6.4 Hz, 2H), 1.38 (s, 9H).

4-Amino-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide dihydrochloride salt (108E)

Methodology applied was analogous to those described in **General Method 2**.

A solution of hydrogen chloride (0.7 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (4-amino-2-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)-4-oxobutyl)carbamate (108D) (61 mg, 0.17 mmol) and the mixture was stirred at room temperature for 2 h. The solvents were removed under reduced pressure to afford the desired product 4-amino-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide dihydrochloride salt (108E) as a pale yellow solid.

Yield: 56 mg (100%) HCl salt.

4-((6-(*N*-(4-Methoxybenzyl)sulfamoyl)benzo[*d*]thiazol-2-yl)amino)-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide (177)

Methodology applied was analogous to those described in **General Method 3**.

2-Chloro-*N*-(4-methoxybenzyl)benzo[*d*]thiazole-6-sulfonamide (101B) (70 mg, 0.19 mmol, 1.10 eq) was added to a stirred solution of 4-amino-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide dihydrochloride salt (108E) (56 mg, 0.17 mmol, 1.0 eq) and triethylamine (0.072 mL, 0.51 mmol, 3.0 eq) in anhydrous dimethylformamide (2.0 mL) under nitrogen. The mixture was stirred at room temperature for 72 h and then concentrated under reduced pressure. Water (2.5 mL) was added and the resulting precipitate was collected by filtration, then washed with methanol. The organic filtrate was concentrated under reduced pressure to give a crude residue which was purified by flash chromatography (eluting dichloromethane to methanol, 0-25%) to give the desired

product 4-((6-(*N*-(4-methoxybenzyl)sulfamoyl)benzo[*d*]thiazol-2-yl)amino)-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide (Example 177) as an off white solid.

Yield: 25 mg (25%). ¹H NMR (400 MHz, DMSO) δ 8.45 (dd, *J* = 5.6, 5.6 Hz, 1H), 8.33 (s, 2H), 8.08 (d, *J* = 1.8 Hz, 1H), 7.88 (dd, *J* = 6.1, 6.1 Hz, 1H), 7.62 (dd, *J* = 1.9, 8.5 Hz, 1H), 7.49 - 7.42 (m, 2H), 7.39 - 7.37 (m, 1H), 7.14 (d, *J* = 8.7 Hz, 2H), 6.87 - 6.87 (m, 1H), 6.81 (d, *J* = 8.7 Hz, 2H), 3.89 (d, *J* = 6.0 Hz, 2H), 3.70 (s, 3H), 3.48 (d, *J* = 1.1 Hz, 2H), 3.37 (dd, *J* = 6.1, 6.1 Hz, 2H), 2.43 - 2.37 (m, 1H), 2.34 (s, 3H), 2.22 - 2.17 (m, 2H).

4-((5-(Methylthio)pyrimidin-2-yl)amino)-3-(((6-sulfamoylbenzo[*d*]thiazol-2-yl)amino)methyl)butanamide (178)

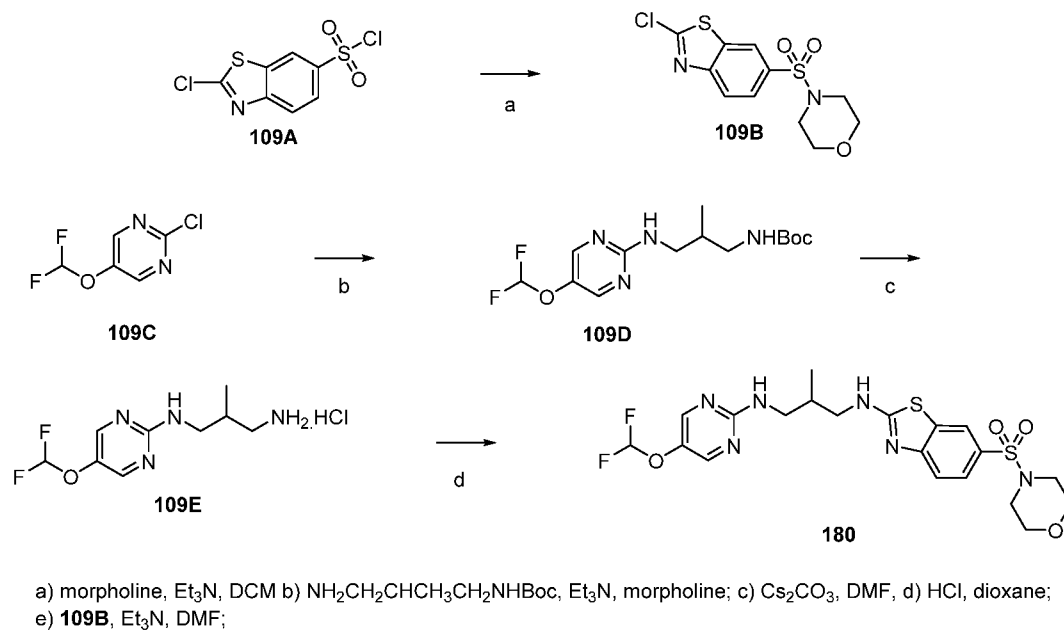
Trifluoroacetic acid (0.3 mL) was added dropwise to a 0°C cooled solution of 4-((6-(*N*-(4-methoxybenzyl)sulfamoyl)benzo[*d*]thiazol-2-yl)amino)-3-(((5-(methylthio)pyrimidin-2-yl)amino)methyl)butanamide (177) (20 mg, 0.03 mmol, 1.0 eq) in anhydrous dichloromethane (0.3 mL). The mixture was stirred for 30 minutes and then allowed to warm to room temperature over 8 h. A further aliquot of trifluoroacetic acid (1 mL) was added and the mixture was stirred for 16 h. The reaction mixture was concentrated under pressure then carefully made basic with the addition of a saturated aqueous solution of sodium hydrogen carbonate (3 mL). The mixture was extracted with ethyl acetate (3 x 5 mL). The combined organic phase was washed with brine (3 mL), dried over anhydrous magnesium sulphate and then concentrated under reduced pressure. The crude residue obtained was purified by flash chromatography (eluting dichloromethane to methanol, 0-20%) to give the desired product 4-((5-(methylthio)pyrimidin-2-yl)amino)-3-(((6-sulfamoylbenzo[*d*]thiazol-2-yl)amino)methyl)butanamide (Example 178) as a white solid.

Yield: 12 mg (75%). ¹H NMR (400 MHz, DMSO) δ 8.41 (dd, *J* = 5.5, 5.5 Hz, 1H), 8.33 (s, 2H), 8.13 (d, *J* = 1.8 Hz, 1H), 7.67 (dd, *J* = 1.9, 8.5 Hz, 1H), 7.47 - 7.43 (m, 2H), 7.38 (s, 1H), 7.21 (s, 2H), 6.86 (s, 1H), 3.46 - 3.46 (m, 2H), 3.36 (dd, *J* = 6.2, 6.2 Hz, 2H), 2.39 - 2.38 (m, 1H), 2.34 (s, 3H), 2.21 - 2.17 (m, 2H).

Table 10

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	179	¹ H NMR (400 MHz, DMSO) δ 8.45 (dd, J = 5.4, 5.4 Hz, 1H), 8.33 (s, 2H), 8.08 (d, J = 1.9 Hz, 1H), 7.88 (dd, J = 6.0, 6.0 Hz, 1H), 7.81 (q, J = 4.5 Hz, 1H), 7.62 (dd, J = 1.9, 8.5 Hz, 1H), 7.47 - 7.41 (m, 2H), 7.14 (d, J = 8.8 Hz, 2H), 6.81 (d, J = 8.8 Hz, 2H), 3.89 (d, J = 4.8 Hz, 2H), 3.70 (s, 3H), 3.52 - 3.42 (m, 2H), 3.38 - 3.31 (m, 2H), 2.59 (d, J = 4.5 Hz, 3H), 2.48 - 2.35 (m, 1H), 2.34 (s, 3H), 2.22 - 2.17 (m, 2H).	602

Scheme 11



4-((2-Chlorobenzo[d]thiazol-6-yl)sulfonyl)morpholine (109B)

Methodology applied was analogous to those described in General Method 6 using dichloromethane as solvent instead of tetrahydrofuran.

Yield: 686 mg. ^1H NMR (400 MHz, CDCl_3) δ 8.25 (d, J = 1.8 Hz, 1H), 8.10 (d, J = 8.6 Hz, 1H), 7.85 (dd, J = 1.3, 8.6 Hz, 1H), 3.75 (dd, J = 4.7, 4.7 Hz, 4H), 3.04 (dd, J = 4.7, 4.7 Hz, 4H); MS (ESI+) m/z 319 (M+H)+.

tert-Butyl (3-((5-(difluoromethoxy)pyrimidin-2-yl)amino)-2-methylpropyl)carbamate (109D)

Methodology applied was analogous to those described in General Method 1.

Yield: 433 mg. ^1H NMR (400 MHz, CDCl_3) δ 8.16 - 8.15 (m, 2H), 5.05 - 5.05 (m, 1H), 3.47 - 3.38 (m, 1H), 3.31 - 3.17 (m, 2H), 3.04 - 2.95 (m, 1H), 1.96 - 1.86 (m, 1H), 1.60 - 1.58 (m, 1H), 0.96 - 0.94 (m, 3H); MS (ESI+) m/z 333 (M+H)+.

N1-(5-(Difluoromethoxy)pyrimidin-2-yl)-2-methylpropane-1,3-diamine hydrochloride (109E)

A solution of hydrogen chloride (2.7 mL, 4M in 1,4-dioxane) was added to tert-butyl (3-((5-(difluoromethoxy)pyrimidin-2-yl)amino)-2-methylpropyl)carbamate (109D) (300 mg, 0.903 mmol) and stirred at room temperature for 15 minutes. The solvents were removed under vacuum to give the crude title compound N1-(5-(difluoromethoxy)pyrimidin-2-yl)-2-methylpropane-1,3-diamine hydrochloride (109E) was taken on to next step without further purification.

Yield: 225 mg (Quant.). MS (ESI+) m/z 233 (M+H)+.

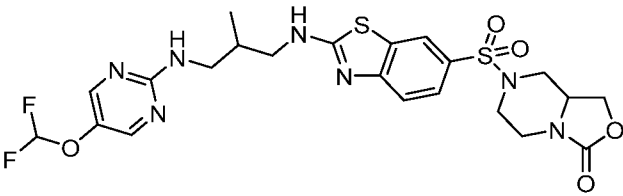
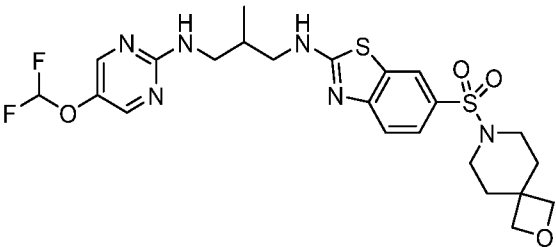
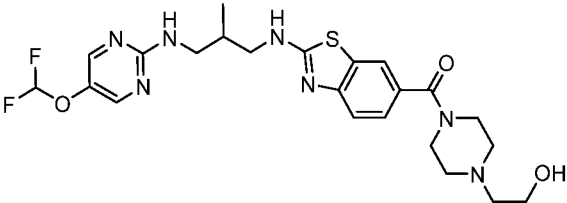
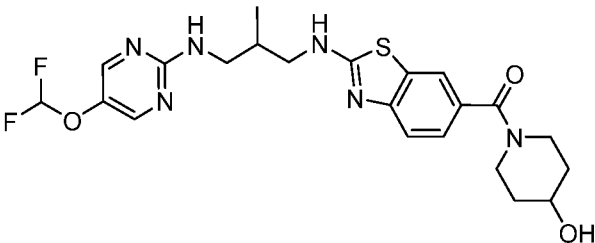
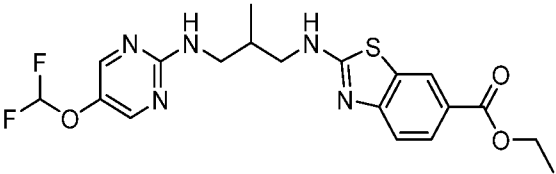
N1-(5-(Difluoromethoxy)pyrimidin-2-yl)-2-methyl-N3-(6-(morpholinosulfonyl)benzo[d]thiazol-2-yl)propane-1,3-diamine (180)

Methodology applied was analogous to those described in General Method 3.

Yield: 225 mg. ^1H NMR (400 MHz, CDCl_3) δ 8.21 (s, 2H), 7.97 (d, J = 1.5 Hz, 1H), 7.65 (dd, J = 1.8, 8.5 Hz, 1H), 7.59 (d, J = 8.5 Hz, 1H), 6.91 (s, 1H), 6.43 (t, J = 71.6 Hz, 1H), 5.72 (dd, J = 6.6, 6.6 Hz, 1H), 3.77 - 3.73 (m, 4H), 3.62 - 3.51 (m, 2H), 3.43 - 3.29 (m, 2H), 3.01 (dd, J = 4.6, 4.6 Hz, 4H), 2.21 - 2.12 (m, 1H), 1.08 (d, J = 6.9 Hz, 3H); (ESI+) m/z 515 (M+H)+.

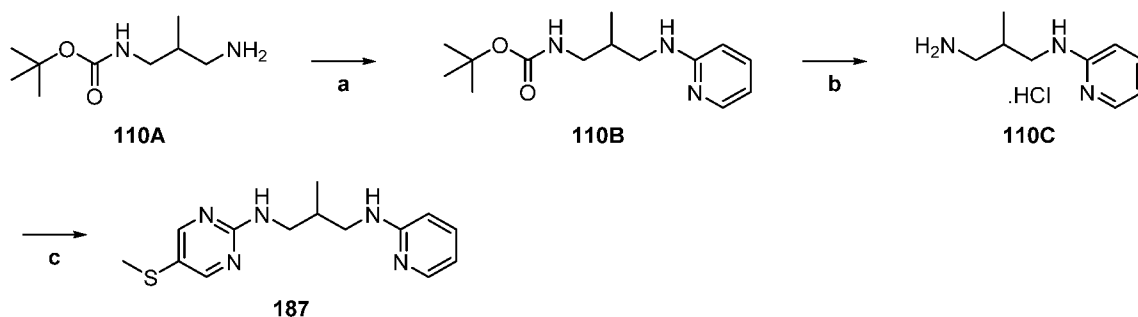
Following the procedures described in **Scheme 11**, the following examples were synthesized:

Table 11

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	181	¹ H NMR (400 MHz, CDCl ₃) δ 8.21 (s, 2H), 7.94 (d, <i>J</i> = 1.5 Hz, 1H), 7.64 - 7.60 (m, 2H), 6.93 (s, 1H), 6.44 (t, <i>J</i> = 72.8 Hz, 1H), 5.66 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 4.44 - 4.39 (m, 1H), 3.88 (tt, <i>J</i> = 7.5, 7.8 Hz, 3H), 3.80 - 3.74 (m, 1H), 3.62 - 3.51 (m, 2H), 3.42 - 3.17 (m, 3H), 2.37 - 2.29 (m, 1H), 2.23 - 2.14 (m, 2H), 1.08 (d, <i>J</i> = 6.9 Hz, 3H).	570
	182	¹ H NMR (400 MHz, CDCl ₃) δ 8.22 (s, 2H), 7.96 - 7.95 (m, 1H), 7.65 - 7.57 (m, 2H), 6.88 - 6.83 (m, 1H), 5.68 - 5.62 (m, 1H), 4.31 (s, 4H), 3.62 - 3.49 (m, 2H), 3.42 - 3.28 (m, 2H), 2.97 - 2.92 (m, 4H), 2.19 - 2.10 (m, 1H), 1.98 - 1.93 (m, 4H), 1.08 (d, <i>J</i> = 6.9 Hz, 3H).	555
	183	¹ H NMR (400 MHz, CDCl ₃) δ 8.21 - 8.20 (2H, m), 7.68 (1H, d, <i>J</i> = 1.5 Hz), 7.54 - 7.51 (1H, m), 7.33 (1H, dd, <i>J</i> = 1.5, 8.3 Hz), 6.42 - 6.42 (1H, m), 5.69 (1H, t, <i>J</i> = 6.4 Hz), 3.69 - 3.48 (6H, m), 3.42 - 3.28 (2H, m), 2.63 - 2.56 (6H, m), 2.18 - 2.09 (1H, m), 1.08 - 1.05 (3H, m);	522
	184	¹ H NMR (400 MHz, DMSO) δ 8.16 - 8.15 (m, 3H), 7.65 - 7.64 (m, 1H), 7.42 (t, <i>J</i> = 5.9 Hz, 1H), 7.29 - 7.26 (m, 1H), 7.17 - 7.13 (m, 1H), 4.72 - 4.65 (m, 1H), 3.71 - 3.63 (m, 2H), 2.45 - 2.42 (m, 12H), 2.08 - 1.98 (m, 1H), 1.67 - 1.25 (m, 4H), 0.88 (d, <i>J</i> = 6.8 Hz, 3H).	493
	185	¹ H NMR (400 MHz, DMSO) δ 8.44 (t, <i>J</i> = 5.5 Hz, 1H), 8.30 - 8.23 (m, 3H), 7.82 (dd, <i>J</i> = 1.9, 8.4 Hz, 1H), 7.50 (t, <i>J</i> = 5.9 Hz, 1H), 7.41 - 7.38 (m, 1H), 4.30 (q, <i>J</i> = 7.1 Hz, 2H), 2.17 - 2.07	438

		(m, 1H), 1.35 - 1.30 (m, 3H), 0.98 - 0.95 (m, 3H).	
	186	¹ H NMR (400 MHz, DMSO) δ 8.43 - 8.39 (m, 1H), 8.25 - 8.24 (m, 2H), 8.12 (d, J = 1.9 Hz, 1H), 7.66 (dd, J = 1.9, 8.5 Hz, 1H), 7.51 - 7.43 (m, 2H), 7.21 (d, J = 4.8 Hz, 2H), 2.16 - 2.07 (m, 1H), 0.98 - 0.95 (m, 3H).	445

Scheme 12



a) 2-Bromopyridine, NaOtBu, Pd₂(dba)₃, XPhos, 1,4-dioxane; b) 4M HCl in 1,4-dioxane; c) **100B**, Cs₂CO₃, DMF

***tert*-Butyl (2-methyl-3-(pyridin-2-ylamino)propyl)carbamate (110B)**

A solution of *tert*-butyl 3-amino-2-methylpropylcarbamate (**110A**) (150 mg, 0.80 mmol, 1.0 eq) in 1,4-dioxane (2 mL) was added to a solution of 2-bromopyridine (0.076 mL, 0.80 mmol, 1.0 eq), sodium *tert*-butoxide (383 mg, 3.98 mmol, 5.0 eq), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl (38 mg, 0.08 mmol, 0.1 eq) and tris(dibenzylideneacetone)dipalladium (0) (73 mg, 0.08 mmol, 0.1 eq) in 1,4-dioxane (10 mL) under nitrogen. The reaction mixture was heated to 70°C for 72 h. The solvents were removed under reduced pressure and the residue obtained was partitioned between water (2 mL) and ethyl acetate (5 mL). The mixture was filtered through celite and the aqueous phase was then removed and extracted with ethyl acetate (3 x 5 mL). The combined organic phases were washed with water (2 mL) and brine (2 mL) then dried by passing through a phase separator before concentrating to dryness under vacuum. The crude residue obtained was purified by reverse phase chromatography (eluting 10 mM ammonium bicarbonate aqueous solution to acetonitrile, 5-95%) to give the semi-pure

desired *tert*-butyl (2-methyl-3-(pyridin-2-ylamino)propyl)carbamate (110B) as an off-white solid that was used in the next step without further purification.

Yield: 27 mg (12%). MS (ESI+) m/z 266 (M+H)⁺.

2-Methyl-*N*¹-(pyridin-2-yl)propane-1,3-diamine hydrochloride (110C)

Methodology applied was analogous to those described in **General Method 2**.

A solution of hydrogen chloride (0.4 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (2-methyl-3-(pyridin-2-ylamino)propyl)carbamate (108B) (27 mg, 0.10 mmol) and the mixture was stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired product 2-methyl-*N*¹-(pyridin-2-yl)propane-1,3-diamine hydrochloride (110C) as a pale yellow semi-solid. The semi-crude sample was taken on into the next reaction without further purification.

Yield: 25 mg (assumed quant. %).

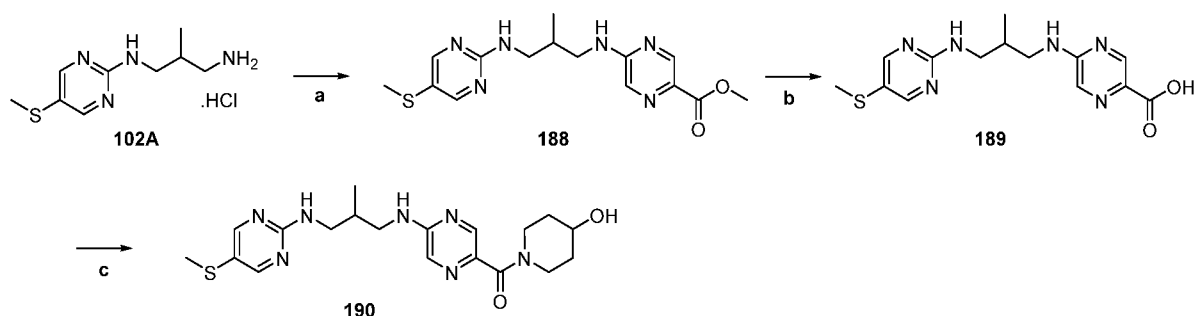
2-Methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)-*N*³-(pyridin-2-yl)propane-1,3-diamine (Example 187)

Methodology applied was analogous to those described in **General Method 3**.

2-Chloro-5-methylsulfanyl-pyrimidine (100B) (17 mg, 0.11 mmol, 1.05 eq) was added to a stirred solution of 2-methyl-*N*¹-(pyridin-2-yl)propane-1,3-diamine hydrochloride (110C) (24 mg, 0.10 mmol, 1.0 eq) and cesium carbonate (99 mg, 0.30 mmol, 3.0 eq) in anhydrous *N,N*-dimethylformamide (0.5 mL) under nitrogen. The mixture was heated to 50°C for 16 h and was then concentrated under vacuum. Water (2 mL) was added and the mixture was extracted with ethyl acetate (3 x 5 mL). The combined organic phases were washed with water (2 mL) and brine (2 mL) then dried by passing through a phase separator. The solvents were removed under vacuum to give a crude yellow oil which was purified by reverse phase chromatography (eluting 10 mM ammonium bicarbonate aqueous solution to acetonitrile, 5-95%) to give the desired 2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)-*N*³-(pyridin-2-yl)propane-1,3-diamine (Example 187) as a sticky yellow solid.

Yield: 1.5 mg (5%). ^1H NMR (400 MHz, CDCl_3) δ 8.35 (s, 2H), 8.10 (dd, $J = 0.6, 3.6$ Hz, 1H), 7.41 - 7.35 (m, 1H), 6.54 (dd, $J = 5.3, 6.8$ Hz, 1H), 6.38 (d, $J = 8.4$ Hz, 1H), 5.93 - 5.93 (m, 1H), 4.96 - 4.96 (m, 1H), 3.53 - 3.21 (m, 4H), 2.35 (s, 3H), 2.10 - 2.01 (m, 1H), 1.03 (d, $J = 6.9$ Hz, 3H); MS (ESI+) m/z 290 ($\text{M} + \text{H}$) $^+$.

Scheme 13



a) Methyl 5-bromopyrazine-2-carboxylate, Cs_2CO_3 , DMF; c) LiOH, EtOH, THF; d) piperidin-4-ol, HATU, Et_3N , DMF.

Methyl 5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazine-2-carboxylate (188)

Methodology applied was analogous to those described in **General Method 3**.

Methyl 5-bromopyrazine-2-carboxylate (114 mg, 0.53 mmol, 1.0 eq) was added to a stirred solution of 2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (102A) (150 mg, 0.53 mmol, 1.0 eq) and cesium carbonate (514 mg, 1.58 mmol, 3.0 eq) in anhydrous *N,N*-dimethylformamide (2.0 mL) under nitrogen. The mixture was stirred at room temperature for 16 h and then concentrated under vacuum. Water (2.5 mL) was added and the mixture was extracted with ethyl acetate (3 x 5 mL). The combined organic phases were washed with water (2 mL) and brine (2.5 mL) then dried passing through a phase separator. The solvents were removed under vacuum to give a brown oil which was purified by flash chromatography (eluting *iso*-hexanes to ethyl acetate, 0-100%). The semi-crude product obtained was further purified by flash chromatography (eluting dichloromethane to methanol, 0-10%) to give the desired methyl 5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazine-2-carboxylate (Example 188) as a white solid.

Yield: 60 mg (32%). ¹H NMR (400 MHz, CDCl₃) δ 8.76 (s, 1H), 8.37 (s, 2H), 7.91 (d, *J* = 1.4 Hz, 1H), 6.36 - 6.36 (m, 1H), 5.56 (dd, *J* = 6.0, 6.0 Hz, 1H), 3.95 (s, 3H), 3.60 - 3.51 (m, 2H), 3.40 - 3.26 (m, 2H), 2.38 (s, 3H), 2.10 - 2.03 (m, 1H), 1.04 (d, *J* = 6.9 Hz, 3H). MS (ESI+) *m/z* 349 (M+H)⁺.

5-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazine-2-carboxylic acid (189)

Methodology applied was analogous to those described in **General Method 4**.

Lithium hydroxide monohydrate (23 mg, 55 mmol, 5.0 eq) was added to a stirred solution of methyl 5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino) pyrazine-2-carboxylate (188) (38 mg, 0.11 mmol, 1.0 eq) in ethanol (0.4 mL) and water (0.4 mL). The mixture was stirred at ambient temperature for 72 h and then concentrated under reduced pressure. Water (0.5 mL) was added to the residue and this mixture was acidified to pH ~3 with a solution of aqueous hydrochloric acid (2M). A sticky precipitate was collected under filtration and then extracted with ethyl acetate (3 x 3 mL), washed with water (1 mL) and then dried by passing through a phase separator. The solvents were removed under vacuum to give the desired 5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazine-2-carboxylic acid (Example 189) as a pale yellow solid. Yield: 34 mg (94%); ¹H NMR (400 MHz, DMSO) δ 8.52 (s, 1H), 8.36 (s, 2H), 7.99 (s, 2H), 7.65 - 7.64 (m, 1H), 3.39 - 3.20 (m, 4H), 2.36 (s, 3H), 2.12 - 2.03 (m, 1H), 0.94 (d, *J* = 6.8 Hz, 3H), One NH proton not observed; MS (ESI+) *m/z* 335 (M+H)⁺.

(4-Hydroxypiperidin-1-yl)(5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino) pyrazin-2-yl)methanone (Example 190)

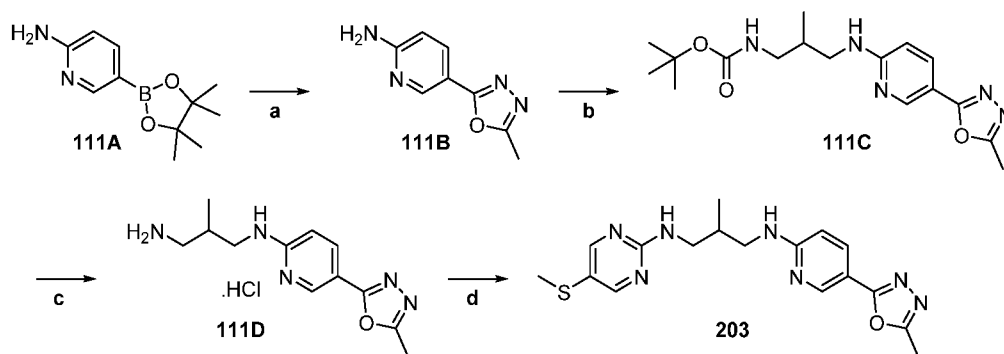
Methodology applied was analogous to those described in **General Method 5**.

1-[Bis(dimethylamino)methylene]-1*H*-1,2,3-triazolo[4,5-*b*]pyridinium 3-oxide hexafluoro phosphate (HATU, 58 mg, 0.15 mmol, 1.5 eq) was added to a solution of 5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazine-2-carboxylic acid (189) (34 mg, 0.10 mmol, 1.0 eq) and 4-hydroxypiperidine (103 mg, 1.02 mmol, 10 eq) in *N,N*-dimethylformamide (1 mL) and the reaction mixture was stirred at room

temperature for 18 h. The solvents were removed under reduced pressure and the crude residue obtained was purified by reverse phase preparative HPLC to give the desired (4-hydroxypiperidin-1-yl)(5-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazin-2-yl)methanone (Example 190) as an off-white solid.

Yield: 22 mg (53%). ¹H NMR (400 MHz, CDCl₃) δ 8.46 (s, 1H), 8.37 (s, 2H), 7.79 (s, 1H), 5.97 - 5.97 (m, 1H), 5.71 - 5.71 (m, 1H), 4.15 - 4.15 (m, 2H), 4.01 - 3.94 (m, 1H), 3.58 - 3.47 (m, 2H), 3.42 - 3.25 (m, 4H), 2.37 (s, 3H), 2.08 (ddd, *J* = 11.5, 11.5, 5.1 Hz, 1H), 2.00 - 1.94 (m, 2H), 1.62 - 1.60 (m, 3H), 1.04 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 418 (M+H)⁺.

Scheme 16



a) Cs₂CO₃, Pd(PPh₃)₄, 2-bromo-5-methyl-1,3,4-oxadiazole, water, 1,4-dioxane; b) *tert*-Butyl *N*-(2-methyl-3-oxopropyl)carbamate, acetic acid, mol sieves, Na(CH₃COO)₃BH, DCM; c) 4M HCl in 1,4-dioxane; d) **100B**, Cs₂CO₃, DMF.

5-(5-Methyl-1,3,4-oxadiazol-2-yl)pyridin-2-amine (111B)

Methodology applied was analogous to those described in **General Method 7**.

2-Bromo-5-methyl-1,3,4-oxadiazole (0.58 g, 3.58 mmol, 1.05 eq) was added to a solution of 5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridin-2-amine (111A) (0.75 g, 3.41 mmol, 1.0 eq), cesium carbonate (3.33 g, 10.22 mmol, 3.0 eq) and tetrakis(triphenylphosphine)palladium (0) (0.39 g, 0.34 mmol, 0.10 eq) in water (5.5 mL) and 1,4-dioxane (22.5 mL) under nitrogen. The reaction mixture was heated to 100°C for 16 h. The solvents were removed under vacuum, water (20 mL) was added and the mixture extracted with ethyl acetate (6 x 50 mL). The combined organic phases were washed with water (10 mL) and brine (10 mL), dried by passing through a phase

separator and then concentrated under vacuum. The crude residue obtained was purified by reverse phase chromatography (eluting 10 mM ammonium bicarbonate solution to acetonitrile, 5-30%) to give the desired 5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-amine (111B) as an off-white solid.

Yield: 153 mg (25%). ¹H NMR (400 MHz, DMSO) δ 8.49 (d, J = 2.0 Hz, 1H), 7.87 (dd, J = 2.4, 8.8 Hz, 1H), 6.75 (s, 2H), 6.57 (d, J = 8.8 Hz, 1H), 2.53 (s, 3H).

***tert*-Butyl (2-methyl-3-((5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)amino)propyl) carbamate (111C)**

tert-Butyl *N*-(2-methyl-3-oxopropyl)carbamate (111B) (225 mg, 1.21 mmol, 1.2 eq) was added to a solution of 5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-amine (114B) (153 mg, 1.00 mmol, 1.0 eq), acetic acid (0.230 mL, 4.02 mmol, 4.0 eq) and molecular sieves (type 4Å, 250 mg) in anhydrous dichloromethane (20 mL). The reaction mixture was stirred at room temperature for 5 minutes and then sodium triacetoxyborohydride (532 mg, 2.51 mmol, 2.5 eq) was added in one portion. The mixture was stirred at room temperature for 40 h. *tert*-Butyl *N*-(2-methyl-3-oxopropyl)carbamate (225 mg, 1.21 mmol, 1.2 eq) was added and the reaction mixture stirred at room temperature for a further 72 h. The reaction was quenched by the careful addition of a saturated aqueous solution of sodium hydrogen carbonate (30 mL). The mixture was stirred vigorously for 30 minutes and the dichloromethane layer was then isolated and concentrated under reduced pressure to give a gum. The crude product was purified by flash chromatography (eluting *isohexane* to ethyl acetate, 0-100%) to give the desired *tert*-butyl (2-methyl-3-((5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)amino)propyl) carbamate (111C) as an off-white gum. The crude sample was taken on into the next reaction without further purification.

Yield: 101 mg (29%).

2-Methyl-*N*¹-(5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)propane-1,3-diamine hydrochloride (111D)

Methodology applied was analogous to those described in **General Method 2**.

A solution of hydrogen chloride (1.2 mL, 4M in 1,4-dioxane) was added to *tert*-butyl (2-methyl-3-((5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)amino)propyl)carbamate (110C) (101 mg, 0.29 mmol) and the mixture stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford the desired 2-methyl-*N*¹-(5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)propane-1,3-diamine hydrochloride (111D) as an off-white solid. The crude sample was taken on into the next reaction without further purification.

Yield: 93 mg (assumed quant. %).

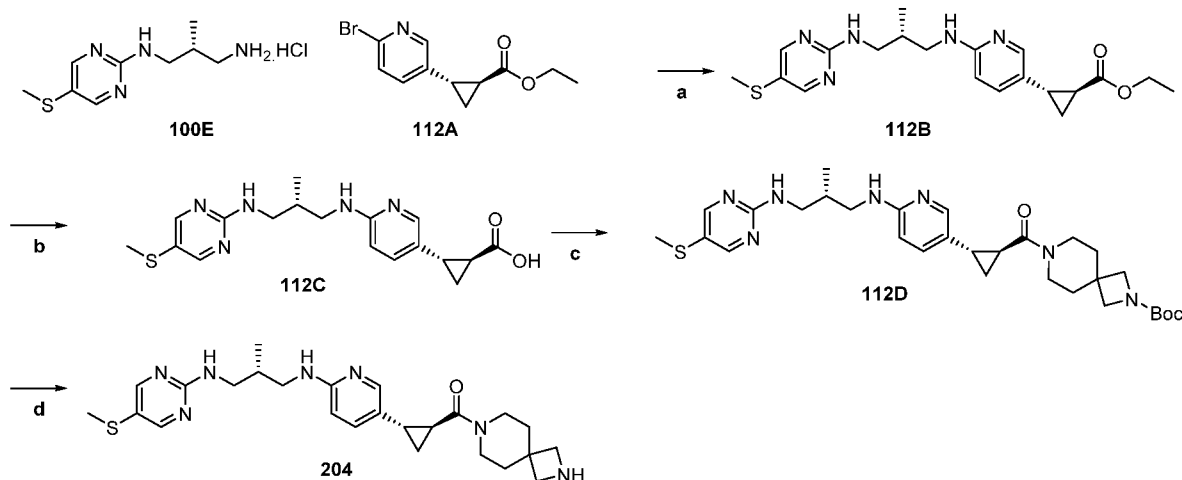
2-Methyl-*N*¹-(5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 203)

Methodology applied was analogous to those described in **General Method 3**.

2-Chloro-5-methylsulfanyl-pyrimidine (100B, 51 mg, 0.32 mmol, 1.1 eq) was added to a stirred suspension of 2-methyl-*N*¹-(5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)propane-1,3-diamine hydrochloride (111D) (93 mg, 0.29 mmol, 1.0 eq) and cesium carbonate (283 mg, 0.87 mmol, 3.0 eq) in anhydrous *N,N*-dimethylformamide (2.9 mL) under nitrogen. The mixture was stirred at room temperature for 16 h, heated to 40°C for a further 16 h and then concentrated under vacuum. Water (10 mL) was added and the mixture was extracted with ethyl acetate (3 x 50 mL). The combined organic phases were washed with water (10 mL) and brine (10 mL) then dried passing through a phase separator. The solvents were removed under vacuum to give a yellow oil which was purified by flash chromatography (eluting *iso*hexane to ethyl acetate, 0-100%) to give a crude residue which was further purified by reverse phase preparative HPLC to give the desired 2-methyl-*N*¹-(5-(5-methyl-1,3,4-oxadiazol-2-yl)pyridin-2-yl)-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (Example 203) as a yellow solid.

Yield: 3.5 mg (3%). ¹H NMR (400 MHz, CDCl₃) δ 8.70 (d, *J* = 1.8 Hz, 1H), 8.37 (s, 2H), 8.00 (dd, *J* = 2.3, 8.8 Hz, 1H), 6.47 (d, *J* = 8.1 Hz, 1H), 5.79 - 5.69 (m, 2H), 3.55 - 3.25 (m, 4H), 2.59 (s, 3H), 2.37 (s, 3H), 2.12 - 2.04 (m, 1H), 1.05 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 372 (M+H)⁺.

Scheme 17



a) Cu(I), L-Proline, K₃PO₄, DMSO; b) LiOH·H₂O, EtOH, H₂O; c) *tert*-butyl 2,7-diazaspiro[3.5]nonane-2-carboxylate, HATU, Et₃N, DMF; d) TFA, DCM

Ethyl 2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carboxylate (112B)

To a reaction tube was added (*R*)-2-methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (100E) (544 mg, 2.19 mmol), ethyl 2-(6-bromopyridin-3-yl)cyclopropane-1-carboxylate (650 mg, 2.41 mmol), L-Proline (101 mg, 0.875 mmol) potassium phosphate (928 mg, 4.37 mmol) and dimethylsulfoxide (5 mL) and the mixture was sparged with nitrogen for 2 minutes before copper (I) iodide (83 mg, 0.437 mmol) was added. The tube was sealed under nitrogen and heated at 90°C overnight. The reaction was cooled, diluted with ethyl acetate (20 mL), passed through a celite pad and the filtrate concentrated under vacuum. The resulting residue was diluted with ethyl acetate (30 mL) and water (20 mL) and the aqueous phase was separated and extracted with ethyl acetate (2 x 30 mL). The combined organics were washed with water (2 x 40 mL) and then brine (2 x 50 mL), dried over magnesium sulfate and then concentrated under vacuum to give the crude title compound ethyl 2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carboxylate (112B) as a pale brown oil.

(N.B. Purification *via* normal phase chromatography could not resolve several close running impurities).

Yield: 284 mg. ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.21 (dd, *J* = 2.1, 6.2 Hz, 1H), 7.95 (s, 1H), 7.26 - 7.19 (m, 1H), 7.12 (d, *J* = 8.1 Hz, 1H), 6.33 (d, *J* = 8.6 Hz, 1H), 4.22 - 4.15 (m, 2H), 3.53 - 3.46 (m, 1H), 3.39 - 3.31 (m, 2H), 3.23 - 3.17 (m, 1H), 2.49 (ddd, *J* = 11.8, 11.8, 11.8 Hz, 1H), 2.33 (s, 3H), 2.12 - 2.02 (m, 1H), 1.79 - 1.74 (m, 1H), 1.55 - 1.48 (m, 1H), 1.32 - 1.24 (m, 3H), 1.24 - 1.17 (m, 1H), 1.02 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 402 (M+H)⁺.

2-(6-(((*R*)-2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carboxylic acid (112C)

To a solution of ethyl 2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)pyridin-3-yl)cyclopropane-1-carboxylate (112B, 274 mg, 0.682 mmol) in ethanol (6 mL) and water (4 mL) was added lithium hydroxide monohydrate (143 mg, 3.41 mmol) and the resulting mixture was stirred at room temperature for 1 hour. The mixture was concentrated under vacuum and the residue obtained was diluted with water (8 mL). The solution was adjusted to pH ~ 2 with a 2M aqueous solution of hydrochloric acid and was then extracted with dichloromethane/methanol (20% methanol in dichloromethane, 2 x 10 mL). The combined organic layers were passed through a phase separator cartridge and then concentrated under vacuum to give the crude title compound 2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carboxylic acid (112C) as a brown oil which was used directly without further purification.

Yield: 280 mg. MS (ESI+) *m/z* 374 (M+H)⁺.

***tert*-Butyl 7-(2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl) amino)pyridin-3-yl)cyclopropane-1-carbonyl)-2,7-diazaspiro[3.5]nonane-2-carboxylate (112D)**

tert-Butyl 2,7-diazaspiro[3.5]nonane-2-carboxylate (65 mg, 0.281 mmol) was added to a solution of 2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)

pyridin-3-yl)cyclopropane-1-carboxylic acid (112C, 70 mg, 0.187 mmol), 1-[bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 3-oxid hexafluorophosphate (HATU, 86 mg, 0.225 mmol) and triethylamine (0.26 mL, 1.87 mmol) in dimethylformamide (2 mL) and the resulting mixture was stirred at room temperature for 18 h. Once complete the reaction mixture was concentrated under vacuum and the residue obtained was diluted with ethyl acetate (5 mL) and water (3 mL). The aqueous phase was separated and extracted with ethyl acetate (2 x 5 mL). The combined organics were washed with water (5 mL), brine (2 x 10 mL), dried over magnesium sulfate and then concentrated under vacuum. The crude residue obtained was purified using column chromatography (eluting 0-10% methanol in dichloromethane) to give the title compound *tert*-butyl 7-(2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carbonyl)-2,7-diazaspiro[3.5]nonane-2-carboxylate (112D) as an off white solid.

Yield: 69 mg. ¹H NMR (400 MHz, CDCl₃) δ 8.35 (s, 2H), 7.92 (d, *J* = 1.5 Hz, 1H), 7.15 (dd, *J* = 2.1, 8.5 Hz, 1H), 6.34 (d, *J* = 8.6 Hz, 1H), 5.96 (dd, *J* = 6.2, 6.2 Hz, 1H), 5.00 (s, 1H), 3.73 - 3.63 (m, 5H), 3.49 (s, 4H), 3.38 - 3.29 (m, 2H), 3.26 - 3.18 (m, 2H), 2.37 - 2.30 (m, 4H), 2.10 - 1.98 (m, 1H), 1.89 - 1.82 (m, 1H), 1.61 - 1.53 (m, 2H), 1.44 (s, 9H), 1.29 - 1.23 (m, 2H), 1.21 - 1.14 (m, 1H), 1.02 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* (M+H)⁺.

(2-(6-(((*R*)-2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropyl)(2,7-diazaspiro[3.5]nonan-7-yl)methanone (Example 204)

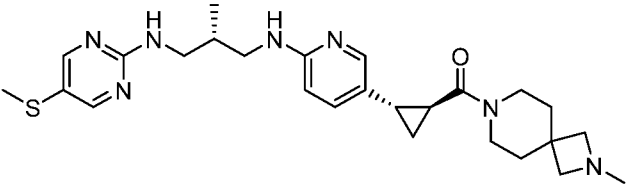
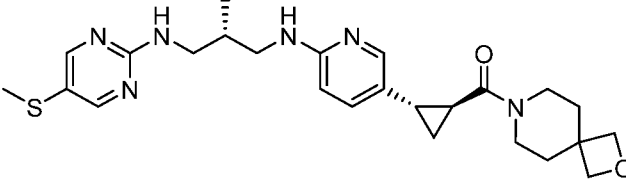
Trifluoroacetic acid (0.2 mL) was added to a stirred solution of *tert*-butyl 7-(2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropane-1-carbonyl)-2,7-diazaspiro[3.5]nonane-2-carboxylate (112D, 69 mg, 0.119 mmol) in dichloromethane (2 mL) and the mixture was stirred at room temperature for 30 minutes. The solvents were removed under vacuum and then azeotroped with dichloromethane (3 x 5 mL). The crude residue obtained was dissolved in dimethylsulfoxide (1.5 mL) and purified by preparative HPLC. The liquors obtained were dried under vacuum then freeze-dried from an acetonitrile/water mix to afford the

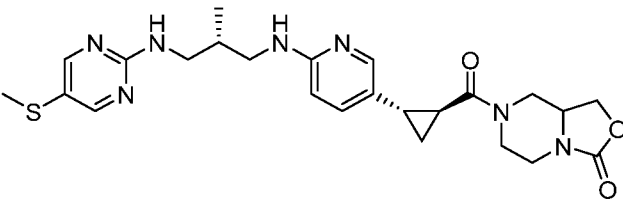
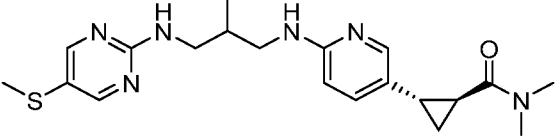
title compound (2-(6-(((*R*)-2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyridin-3-yl)cyclopropyl)(2,7-diazaspiro[3.5]nonan-7-yl) methanone (204) as a fluffy white solid.

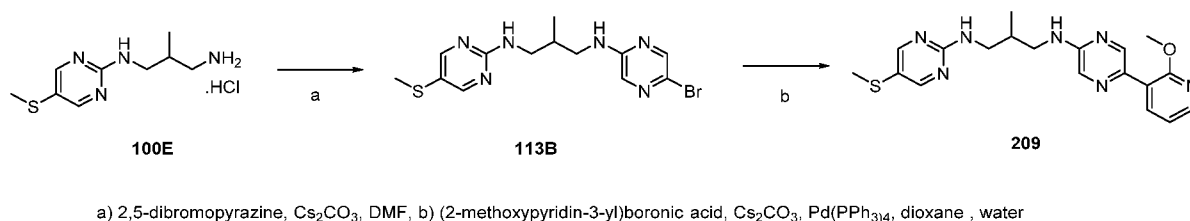
Yield: 15 mg. ¹H NMR (400 MHz, CDCl₃) δ 8.54 (s, 1H), 8.35 (s, 2H), 7.89 - 7.86 (m, 1H), 7.16 (dd, *J* = 2.0, 8.6 Hz, 1H), 6.36 (d, *J* = 8.6 Hz, 1H), 5.98 (dd, *J* = 6.9, 6.9 Hz, 1H), 5.49 - 5.49 (m, 1H), 3.76 (s, 4H), 3.51 - 3.43 (m, 2H), 3.39 - 3.30 (m, 3H), 3.22 (dd, *J* = 6.6, 13.4 Hz, 2H), 2.38 - 2.31 (m, 4H), 2.11 - 2.01 (m, 1H), 1.89 - 1.79 (m, 5H), 1.59 - 1.52 (m, 1H), 1.27 - 1.14 (m, 1H), 1.03 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 482 (M+H)⁺.

Following the procedures described in **Scheme 17**, the following examples were synthesized:

Table 14

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	205	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 7.93 (d, <i>J</i> = 2.0 Hz, 1H), 7.14 (dd, <i>J</i> = 2.3, 8.6 Hz, 1H), 6.33 (d, <i>J</i> = 8.6 Hz, 1H), 5.97 - 5.90 (m, 1H), 4.90 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 3.57 - 3.11 (m, 10H), 3.06 (d, <i>J</i> = 6.1 Hz, 2H), 2.36 (d, <i>J</i> = 7.1 Hz, 7H), 2.09 - 1.99 (m, 1H), 1.89 - 1.82 (m, 2H), 1.82 - 1.76 (m, 3H), 1.59 - 1.48 (m, 1H), 1.19 - 1.12 (m, 1H), 1.02 (d, <i>J</i> = 6.8 Hz, 3H).	496
	206	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 7.91 (d, <i>J</i> = 1.8 Hz, 1H), 7.16 (dd, <i>J</i> = 2.3, 8.6 Hz, 1H), 6.35 (d, <i>J</i> = 8.6 Hz, 1H), 5.94 - 5.91 (m, 1H), 5.14 (s, 1H), 4.46 (d, <i>J</i> = 2.8 Hz, 4H), 3.53 - 3.44 (m, 6H), 3.39 - 3.30 (m, 2H), 3.25 - 3.19 (m, 1H), 2.35 (s, 4H), 2.09 - 2.01 (m, 1H), 1.90 - 1.85 (m, 5H), 1.20 - 1.14 (m, 1H), 1.03 (d, <i>J</i> = 6.8 Hz, 3H).	483

	207	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 7.91 (s, 1H), 7.20 (s, 1H), 6.38 (d, <i>J</i> = 7.3 Hz, 1H), 5.91 - 5.91 (m, 1H), 5.44 - 5.18 (m, 1H), 4.72 (dd, <i>J</i> = 20.0, 62.4 Hz, 1H), 4.49 - 4.43 (m, 1H), 4.13 - 4.13 (m, 1H), 4.03 - 3.97 (m, 1H), 3.87 - 3.87 (m, 2H), 3.53 - 3.45 (m, 1H), 3.38 - 3.31 (m, 2H), 3.22 (dd, <i>J</i> = 6.4, 6.4 Hz, 2H), 3.10 - 3.00 (m, 2H), 2.64 (tt, <i>J</i> = 22.1, 20.6 Hz, 2H), 2.42 - 2.38 (m, 1H), 2.36 (s, 4H), 2.09 - 2.01 (m, 1H), 1.87 - 1.82 (m, 1H), 1.28 - 1.22 (m, 1H), 1.03 (d, <i>J</i> = 6.8 Hz, 3H).	498
	208	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 7.95 (d, <i>J</i> = 2.4 Hz, 1H), 7.16 (dd, <i>J</i> = 2.4, 8.6 Hz, 1H), 6.33 (d, <i>J</i> = 8.5 Hz, 1H), 5.95 - 5.92 (m, 1H), 4.88 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 3.52 - 3.17 (m, 4H), 3.14 (s, 3H), 2.99 (s, 3H), 2.36 (s, 4H), 2.06 - 2.00 (m, 1H), 1.90 - 1.85 (m, 1H), 1.59 - 1.53 (m, 1H), 1.17 (ddd, <i>J</i> = 4.5, 6.2, 8.3 Hz, 1H), 1.02 (d, <i>J</i> = 6.8 Hz, 3H).	401

Scheme 18

***N*¹-(5-Bromopyrazin-2-yl)-2-methyl-*N*3-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (113B)**

A solution of crude 2-methyl-*N*-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine hydrochloride (100E) (340 mg, 1.60 mmol, 1.0 eq) in dimethylformamide (8 mL) was added to a suspension of 2,5-dibromopyrazine (457 mg, 1.92 mmol, 1.2 eq) and cesium carbonate (1.56 g, 4.80 mmol, 3.0 eq) in dimethylformamide (2 mL). The reaction mixture was heated to 90°C for 18 h. The solvents were removed under reduced pressure

and the residue obtained was partitioned between water (20 mL) and dichloromethane (50 mL). The layers were separated and the aqueous phase was extracted with dichloromethane (3 x 25 mL). The combined organic phases were washed with brine (25 mL), dried by passing through a phase separator and then concentrated to dryness under vacuum. The crude residue was purified by flash chromatography (eluting with *iso*-hexanes to ethyl acetate, 0-100%) to give the title compound *N*¹-(5-bromopyrazin-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (113B) as a pale yellow gum.

Yield: 230 mg (38%). ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.06 (d, *J* = 1.3 Hz, 1H), 7.67 (d, *J* = 1.4 Hz, 1H), 5.67 - 5.51 (m, 2H), 3.55 - 3.31 (m, 3H), 3.25 - 3.12 (m, 1H), 2.37 (s, 3H), 2.04 (s, 1H), 1.03 (d, *J* = 6.9 Hz, 3H).

***N*¹-(5-(2-Methoxypyridin-3-yl)pyrazin-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (209)**

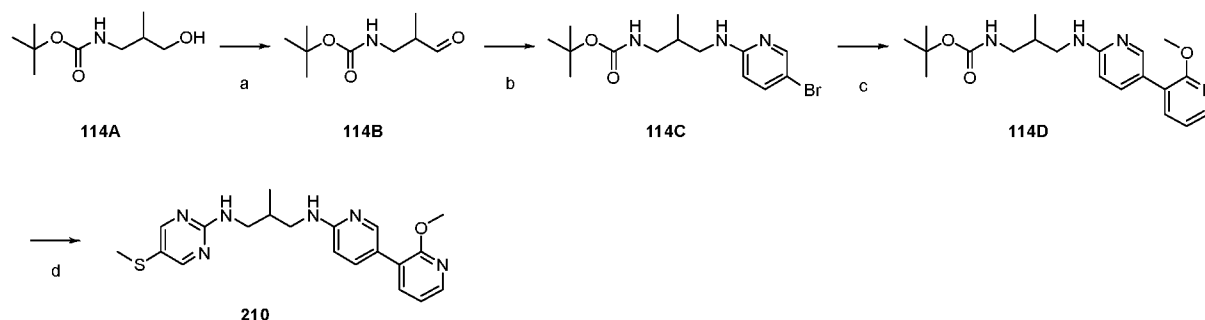
Methodology applied was analogous to those described in **General Method 7**, (N.B. used 1,4-dioxane instead of dimethylformamide).

A solution of *N*¹-(5-bromopyrazin-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (113B) (50 mg, 0.135 mmol, 1.0 eq) was added to a solution of 2-methoxy-3-phenylboronic acid (23 mg, 0.149 mmol, 1.1 eq), cesium carbonate (132 mg, 0.406 mmol, 3 eq) and tetrakis(triphenylphosphine)palladium (0) (15.6 mg, 0.0135 mmol, 0.1 eq) in water (1 mL) and 1,4-dioxane (2 mL) under an atmosphere of nitrogen. The reaction mixture was heated to 80°C for 1 hour. The solvents were removed under reduced pressure, water (2 mL) was added and the mixture was extracted with ethyl acetate (3 x 15 mL). The combined organic phases were washed with brine (10 mL) and concentrated under vacuum. The crude residue obtained was purified by preparative HPLC to give the desired *N*¹-(5-(2-methoxypyridin-3-yl)pyrazin-2-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (154) as an off white solid.

Yield: 24 mg (44%). ¹H NMR (400 MHz, CDCl₃) δ 8.77 (d, *J* = 1.4 Hz, 1H), 8.37 (s, 2H), 8.18 - 8.13 (m, 2H), 7.99 (d, *J* = 1.5 Hz, 1H), 7.01 (dd, *J* = 4.9, 7.4 Hz, 1H), 5.69 (dd, *J* = 6.5, 6.5 Hz, 1H), 5.55 (dd, *J* = 6.1, 6.1 Hz, 1H), 4.04 (s, 3H), 3.59 - 3.48 (m, 2H), 3.42

- 3.25 (m, 2H), 2.37 (s, 3H), 2.19 - 2.06 (m, 1H), 1.06 (d, $J = 6.9$ Hz, 3H); MS (ESI+) m/z 398 (M+H)⁺.

Scheme 19



a) Dess-Martin periodinane, DCM, b) Na(AcO)₃BH, AcOH, mole sieves, 5-bromopyridin-2-amine, c) 2-methoxy-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridine, Cs₂CO₃, Pd(PPh₃)₄, dioxane, water, d) 4M HCl in dioxane, 2-chloro-5-(methylthio)pyrimidine, Cs₂CO₃, Et₃N, DMF

tert-Butyl (2-methyl-3-oxopropyl)carbamate (114B)

Caution - exothermic reaction; Dess-Martin periodinane (2.94 g, 6.94 mmol, 1.3 eq) was added portion-wise over 20 minutes to a solution of *tert*-butyl (3-hydroxy-2-methylpropyl)carbamate (1.0 g, 5.34 mmol, 1.0 eq) in dichloromethane (50 mL) and the mixture was stirred at room temperature for 2 h. The mixture was diluted with dichloromethane (25 mL) and washed with 1M aqueous sodium dithionite solution (2 x 10 mL) and saturated aqueous sodium bicarbonate solution (2 x 10 mL). The organic phase dried passing through a phase separator and then concentrated under vacuum to give crude *tert*-butyl (2-methyl-3-oxopropyl)carbamate (114B) which was used immediately in the next step without further purification.

tert-Butyl (3-((5-bromopyridin-2-yl)amino)-2-methylpropyl)carbamate (114C)

Methodology applied was analogous to method described in Scheme 13 (for the generation of 109D).

The crude product was purified by flash chromatography (eluting *iso*-hexanes to ethyl acetate, 0-100%) to give the desired *tert*-butyl (3-((5-bromopyridin-2-yl)amino)-2-methylpropyl)carbamate (114C) as a pale yellow gum

Yield: 875 mg (47%) (MS (ESI+) m/z 345 (M+H)⁺).

tert-Butyl(3-((2'-methoxy-[3,3'-bipyridin]-6-yl)amino)-2-methylpropyl)carbamate (114D)

Methodology applied was analogous to those described in **General Method 7**.

Crude *tert*-butyl(3-((2'-methoxy-[3,3'-bipyridin]-6-yl)amino)-2-methylpropyl)carbamate (114D) was used immediately in the next step without further purification.

Yield: 110 mg, MS (ESI+) m/z 373 (M+H)⁺.

N¹-(2'-Methoxy-[3,3'-bipyridin]-6-yl)-2-methylpropane-1,3-diamine (114E)

Methodology applied was analogous to those described in **General Method 2**.

Crude N¹-(2'-methoxy-[3,3'-bipyridin]-6-yl)-2-methylpropane-1,3-diamine (114E) was taken on immediately to the next step without further purification.

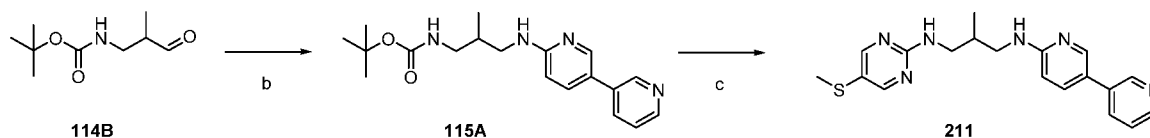
Crude yield: 75 mg MS (ESI+) m/z 273 (M+H)⁺.

N¹-(2'-Methoxy-[3,3'-bipyridin]-6-yl)-2-methyl-N³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (210)

Methodology applied was analogous to those described in **General Method 1**.

The crude residue obtained was purified by preparative HPLC to give the desired product, N¹-(2'-methoxy-[3,3'-bipyridin]-6-yl)-2-methyl-N³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine as an off white solid (155)

Yield: 8 mg (7%). ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.30 (d, J = 2.1 Hz, 1H), 8.11 (dd, J = 1.9, 5.0 Hz, 1H), 7.67 (dd, J = 2.4, 8.7 Hz, 1H), 7.57 (dd, J = 1.9, 7.3 Hz, 1H), 6.95 (dd, J = 5.0, 7.3 Hz, 1H), 6.45 (d, J = 8.4 Hz, 1H), 5.90 (dd, J = 6.3, 6.3 Hz, 1H), 5.11 (dd, J = 6.0, 6.0 Hz, 1H), 3.97 (s, 3H), 3.56 - 3.23 (m, 4H), 2.36 (s, 3H), 2.13 - 2.04 (m, 1H), 1.05 (d, J = 6.9 Hz, 3H); MS (ESI+) m/z 397 (M+H)⁺.

Scheme 20

a) Dess-Martin periodinane, DCM, b) Na(AcO)₃BH, AcOH, mole sieves, [3,3'-bipyridin]-6-amine, c) 4M HCl dioxane, 2-chloro-5-(methylthio)pyrimidine, Cs₂CO₃, Et₃N, DMF

tert-Butyl (3-([3,3'-bipyridin]-6-ylamino)-2-methylpropyl)carbamate (115A)

Methodology applied was analogous to scheme 19 (example 115B) to generate the aldehyde (114B), and then using methodology analogous to **general method 7**.

The crude *N*¹-([3,3'-bipyridin]-6-yl)-2-methylpropane-1,3-diamine (**115A**) was immediately taken on the next step.

Yield: 253 mg (63%) ¹H NMR (400 MHz, DMSO) δ 8.82 (d, *J* = 1.8 Hz, 1H), 8.48 (dd, *J* = 1.6, 4.8 Hz, 1H), 8.36 (d, *J* = 2.1 Hz, 1H), 8.00 - 7.96 (m, 1H), 7.76 (dd, *J* = 2.6, 8.7 Hz, 1H), 7.44 - 7.40 (m, 1H), 6.90 - 6.76 (m, 2H), 6.62 - 6.59 (m, 1H), 4.10 (q, *J* = 5.3 Hz, 1H), 3.19 - 3.18 (m, 4H), 3.03 - 2.94 (m, 1H), 2.88 - 2.80 (m, 1H), 1.93 - 1.82 (m, 1H), 1.40 - 1.38 (m, 9H).

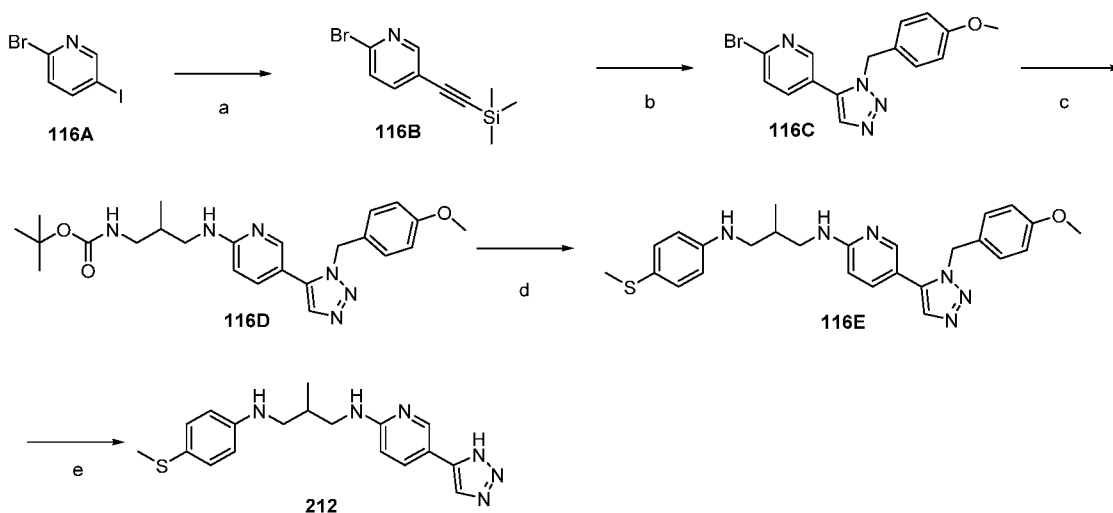
***N*¹-([3,3'-bipyridin]-6-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (211)**

Methodology applied was analogous to method described in Scheme 13 (for the generation of 109D).

The crude residue obtained was purified by reverse phase chromatography (eluting 10 mM ammonium bicarbonate aqueous solution to acetonitrile, 5-95%) to give the desired product, *N*¹-([3,3'-bipyridin]-6-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (211) as an off white solid.

Yield: 32 mg (14%). ¹H NMR (400 MHz, CDCl₃) δ 8.77 (1H, d, *J* = 2.1 Hz), 8.53 (1H, dd, *J* = 1.6, 4.8 Hz), 8.37 - 8.35 (3H, m), 7.81 - 7.77 (1H, m), 7.63 (1H, dd, *J* = 2.5, 8.7 Hz), 7.33 (1H, dd, *J* = 4.6, 7.8 Hz), 6.50 (1H, d, *J* = 8.7 Hz), 5.93 (1H, dd, *J* = 6.1, 6.1 Hz), 5.25 (1H, dd, *J* = 6.1, 6.1 Hz), 3.56 - 3.25 (4H, m), 2.36 (3H, s), 2.18 - 2.00 (1H, m), 1.06 (3H, d, *J* = 6.9 Hz); MS (ESI⁺) *m/z* 367 (M+H)⁺.

Scheme 21



a) Trimethylsilylacetylene, TEA, Pd(PPh)₃Cl₂, CuI, b) 1-(azidomethyl)-4-methoxybenzene, EtOH, TBAF
 c) tert-butyl(3-amino-2-methylpropyl)carbamate, K₃PO₄, L-proline, CuI, DMSO
 d) 4M HCl in dioxane, 2-chloro-5-(methylthio)pyrimidine, Cs₂CO₃, DMF e) TFA, DCM

2-Bromo-5-((trimethylsilyl)ethynyl)pyridine (116B)

Triethylamine (49 mL, 352.25 mmol, 25 eq) was added to 2-bromo-5-iodopyridine (4.0 g, 14.09 mmol, 1.0 eq) followed by ethynyltrimethylsilane (2.9 mL, 21.13 mmol, 1.5 eq), copper (I) iodide (270 mg, 1.41 mmol, 0.1 eq), bis(triphenylphosphine)palladium (II) dichloride (99 mg, 0.14 mmol, 0.01 eq) and the mixture was stirred at room temperature for 17 h. The mixture was concentrated under vacuum to give a crude gum which was purified by flash chromatography (eluting with *iso*-hexane to ethyl acetate, 0-40%) to give the intermediate 2-bromo-5-((trimethylsilyl)ethynyl)pyridine (116B) as a white solid.

Yield: 2.5 g (69%). MS (ESI+) *m/z* 254/256 (M+H)⁺.

2-Bromo-5-(1-(4-methoxybenzyl)-1H-1,2,3-triazol-5-yl)pyridine (116C)

To a solution of 2-bromo-5-((trimethylsilyl)ethynyl)pyridine (116B) (250 mg, 0.983 mmol, 1.0 eq) in ethanol (20 mL) was added 1-(azidomethyl)-4-methoxybenzene (177 mg, 1.08 mmol, 1.1 eq) and the mixture was stirred at room temperature for 1 hour. A solution of 1M tetrabutylammonium fluoride in tetrahydrofuran (0.54 mL, 1.08 mmol, 1.1 eq) was added and the mixture was stirred at room temperature for 18 h. The reaction

mixture was concentrated under vacuum and then purified by flash chromatography (eluting with *iso*-hexane to ethyl acetate, 0-100%) to give 2-bromo-5-(1-(4-methoxybenzyl)-1*H*-1,2,3-triazol-5-yl)pyridine (116C) as an off white solid. Yield: 0.21 g (61%). MS (ESI+) m/z 347 (M+H)⁺.

***tert*-Butyl (3-((5-(1-(4-methoxybenzyl)-1*H*-1,2,3-triazol-5-yl)pyridin-2-yl)amino)-2-methylpropyl)carbamate (116D)**

To a de-gassed solution of 2-bromo-5-(1-(4-methoxybenzyl)-1*H*-1,2,3-triazol-5-yl)pyridine (116C) (135 mg, 0.391, 1.0 eq) in dimethyl sulfoxide (5 mL) was added *tert*-butyl(3-amino-2-methylpropyl)carbamate (96 mg, 0.508 mmol, 1.3 eq), L-proline (18 mg, 0.156 mmol, 0.4 eq), potassium phosphate (1.6.5 mg, 0.078 mmol, 0.2 eq) and copper (I) iodide (15 mg, 0.782 mmol, 0.2 eq). The mixture was stirred at 90°C for 28 h, diluted with water (20 mL) and extracted with dichloromethane (3 x 20 mL). The organic phases were combined and concentrated under vacuum and the crude residue was purified by flash chromatography (eluting with *iso*-hexane to ethyl acetate, 0-100%) to give 2-bromo-5-(1-(4-methoxybenzyl)-1*H*-1,2,3-triazol-5-yl)pyridine (116D) as a pale brown solid.

Yield: 0.080 g (45%). MS (ESI+) m/z 453 (M+H)⁺.

***tert*-Butyl (3-((5-(1-(4-methoxybenzyl)-1*H*-1,2,3-triazol-5-yl)pyridin-2-yl)amino)-2-methylpropyl)carbamate (116E)**

Methodology applied was analogous to those described in **General Method 2**.

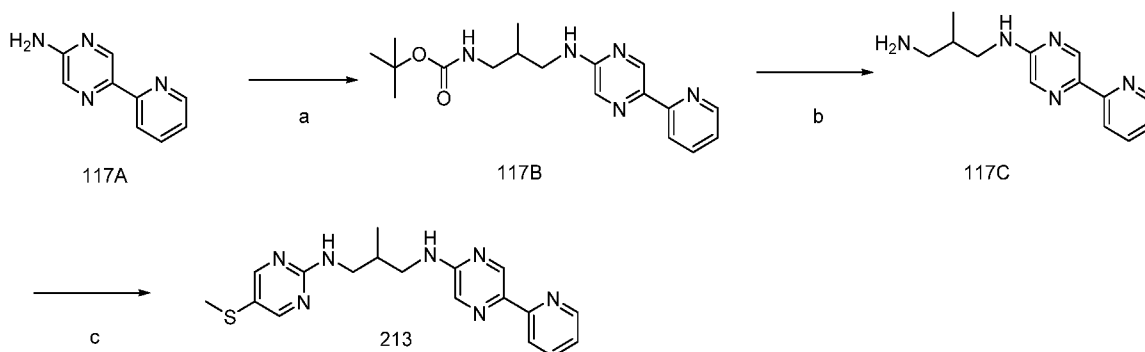
Yield: 25 mg (29%). ¹H NMR (400 MHz, CDCl₃) δ 8.42 (d, J = 2.0 Hz, 1H), 8.35 (s, 2H), 7.90 (dd, J = 2.4, 8.7 Hz, 1H), 7.52 (s, 1H), 6.94 - 6.90 (m, 2H), 6.44 (d, J = 9.0 Hz, 1H), 5.94 (dd, J = 6.1, 6.1 Hz, 1H), 5.49 (s, 2H), 5.09 (dd, J = 6.3, 6.3 Hz, 1H), 3.81 (s, 4H), 3.53 - 3.22 (m, 4H), 2.35 (s, 3H), 2.10 - 2.01 (m, 1H), 1.03 (d, J = 6.9 Hz, 3H), (NH not observed).

***N*¹-(5-(1*H*-1,2,3-Triazol-5-yl)pyridin-2-yl)-2-methyl-*N*3-(4-(methylthio)phenyl)propane-1,3-diamine (212)**

Methodology applied was analogous to those described in **General Method 3**.

Yield: 18 mg (96%). ¹H NMR (400 MHz, CDCl₃) δ 8.53 (d, *J* = 2.1 Hz, 1H), 8.38 (s, 2H), 7.84 (s, 1H), 7.82 (dd, *J* = 2.3, 8.7 Hz, 1H), 6.45 (d, *J* = 8.4 Hz, 1H), 6.17 (dd, *J* = 6.3, 6.3 Hz, 1H), 5.31 (dd, *J* = 6.0, 6.0 Hz, 1H), 3.57 - 3.26 (m, 4H), 2.36 (s, 3H), 2.19 - 2.06 (m, 1H), 1.06 (d, *J* = 6.8 Hz, 3H), (NH not observed); MS (ESI+) *m/z* 457 (M+H)⁺.

Scheme 22



a) **102b**, acetic acid, mol sieves, Na(CH₃COO)₃BH, DCM; b) 4M HCl in 1,4-dioxane; c) **100B**, Cs₂CO₃, DMF.

tert-Butyl (2-methyl-3-((5-(pyridin-2-yl)pyrazin-2-yl)amino)propyl)carbamate (117B)

To a solution of 5-(pyridin-2-yl)pyrazin-2-amine (200 mg, 1.16 mmol, 1.0 eq) in dichloromethane (10 mL) was added *tert*-butyl (2-methyl-3-oxopropyl)carbamate (117B) (221 mg, 1.17 mmol, 1.0 eq), 3 Å molecular sieves (750 mg), acetic acid (0.266 mL, 4.65 mmol) and sodium triacetoxymethylborohydride (616 mg, 2.9 mmol) and the mixture was stirred at room temperature for 18 h. The reaction mixture was diluted with dichloromethane (25 mL) and filtered. The organic phase was washed with water (25 mL) and brine (25 mL) then passed through a phase separator cartridge. The solvents were removed under vacuum to afford crude *tert*-butyl (2-methyl-3-((5-(pyridin-2-yl)pyrazin-2-yl)amino)propyl)carbamate (117B) which was used in the next step without further purification.

Yield: 310 mg (78%).

2-Methyl-*N*¹-(5-(pyridin-2-yl)pyrazin-2-yl)propane-1,3-diamine (117C)

Methodology applied was analogous to those described in **General Method 2**.

Yield: 200 mg (100%).

2-Methyl-*N*¹-(5-(methylthio)pyrimidin-2-yl)-*N*3-(5-(pyridin-2-yl)pyrazin-2-yl)propane-1,3-diamine (213)

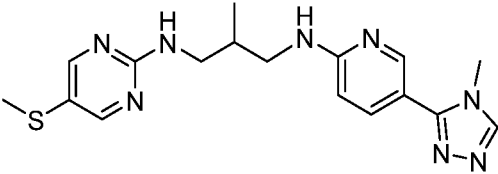
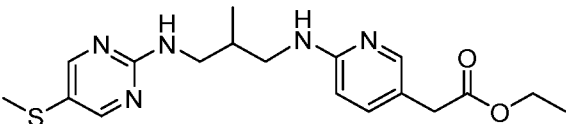
Methodology applied was analogous to those described in **General Method 1**.

Yield: 20 mg (10%). ¹H NMR (400 MHz, CDCl₃) δ 9.04 (d, *J* = 1.4 Hz, 1H), 8.62 - 8.61 (m, 1H), 8.37 (s, 2H), 8.10 (d, *J* = 8.0 Hz, 1H), 7.94 (d, *J* = 1.4 Hz, 1H), 7.77 - 7.72 (m, 1H), 7.20 (dd, *J* = 4.8, 6.5 Hz, 1H), 5.75 - 5.63 (m, 2H), 3.58 - 3.50 (m, 2H), 3.42 - 3.28 (m, 2H), 2.37 (s, 3H), 2.19 - 2.06 (m, 1H), 1.06 (d, *J* = 6.9 Hz, 3H); MS (ESI+) *m/z* 368 (M+H)⁺.

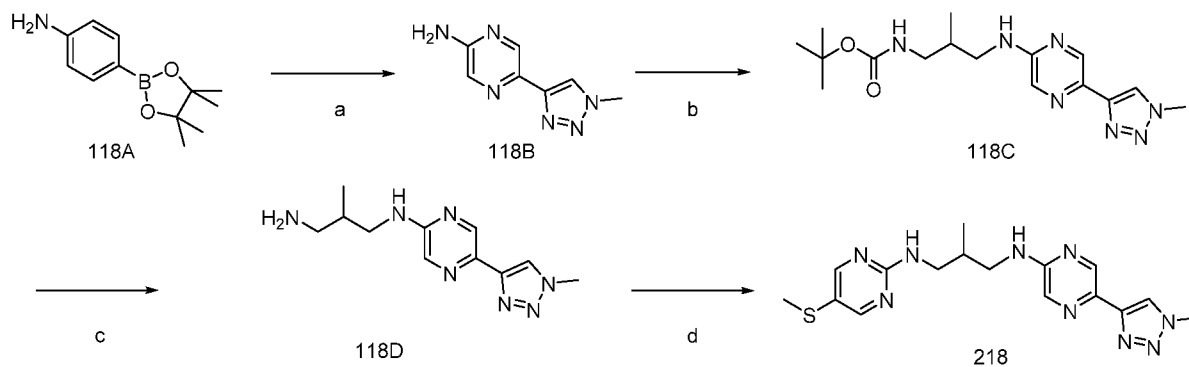
Following the procedures described in **Scheme 22**, the following examples were synthesized:

Table 15

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	214	¹ H NMR (400 MHz, CDCl ₃) δ 8.70 (d, <i>J</i> = 1.4 Hz, 1H), 8.37 (s, 2H), 8.27 (d, <i>J</i> = 2.3 Hz, 1H), 7.69 (dd, <i>J</i> = 1.4, 7.0 Hz, 2H), 6.45 - 6.43 (m, 1H), 5.65 (dd, <i>J</i> = 6.3, 6.3 Hz, 1H), 5.53 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 3.57 - 3.24 (m, 4H), 2.36 (s, 3H), 2.14 - 2.04 (m, 1H), 1.06 (d, <i>J</i> = 6.9 Hz, 3H).	357
	215	¹ H NMR (400 MHz, CDCl ₃) δ 9.20 (d, <i>J</i> = 2.0 Hz, 1H), 8.71 (d, <i>J</i> = 4.9 Hz, 2H), 8.40 (dd, <i>J</i> = 2.3, 8.8 Hz, 1H), 8.37 (s, 2H), 7.08 (dd, <i>J</i> = 4.8, 4.8 Hz, 1H), 6.47 (d, <i>J</i> = 8.5 Hz, 1H), 5.88 (dd, <i>J</i> = 6.0, 6.0 Hz, 1H), 5.43 (dd, <i>J</i> = 6.1, 6.1 Hz, 1H), 3.56 - 3.27 (m, 4H), 2.36	368

		(s, 3H), 2.14 - 2.00 (m, 1H), 1.06 (d, $J = 6.9$ Hz, 3H).	
	216	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 - 8.36 (m, 3H), 8.16 (s, 1H), 7.78 (dd, $J = 2.4, 8.7$ Hz, 1H), 6.51 (d, $J = 8.4$ Hz, 1H), 5.83 - 5.78 (m, 1H), 5.57 (dd, $J = 5.8, 5.8$ Hz, 1H), 3.76 (s, 3H), 3.57 - 3.24 (m, 4H), 2.36 (s, 3H), 2.14 - 1.99 (m, 1H).	371
	217	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (s, 2H), 7.99 (d, $J = 2.1$ Hz, 1H), 7.36 (dd, $J = 2.4, 8.5$ Hz, 1H), 6.37 (d, $J = 8.5$ Hz, 1H), 5.94 (dd, $J = 6.0, 6.0$ Hz, 1H), 4.96 (dd, $J = 5.8, 5.8$ Hz, 1H), 4.14 (q, $J = 7.2$ Hz, 2H), 3.52 - 3.45 (m, 3H), 3.42 - 3.31 (m, 2H), 3.26 - 3.20 (m, 1H), 2.35 (s, 3H), 2.09 - 2.00 (m, 1H), 1.25 (dd, $J = 7.2, 7.2$ Hz, 3H), 1.03 (d, $J = 6.9$ Hz, 3H).	376

Scheme 23



a) 4-bromo-1-methyl-1H-1,2,3-triazole, Cs₂CO₃, Pd(PPh₃)₄, dioxane/water; b) acetic acid, mol sieves, Na(CH₃COO)₃BH, DCM; c) 4M HCl in dioxane; d) **100B**, Cs₂CO₃, DMF

5-(1-Methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-amine (118B)

Methodology applied was analogous to those described in **General Method 7**, (N.B. used 1,4-dioxane/water used as solvent instead of dimethylformamide)

Yield: 158 mg (73%) m/z 176 (M+H)⁺.

***tert*-Butyl (2-methyl-3-((5-(1-methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-yl)amino)propyl)carbamate (118C)**

Methodology applied was analogous to the method described in **Scheme 13** (for the generation of **109D**).

Crude *tert*-butyl (2-methyl-3-((5-(1-methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-yl)amino)propyl)carbamate (118C) was taken on immediately to the next step.

Yield: 101 mg (34%) MS (ESI+) m/z 347 (M+H)⁺.

2-Methyl-*N*1-(5-(1-methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-yl)propane-1,3-diamine (118D)

Methodology applied was analogous to those described in **General Method 2**.

Crude 2-methyl-*N*¹-(5-(1-methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-yl)propane-1,3-diamine (106D) was taken on immediately to the next step.

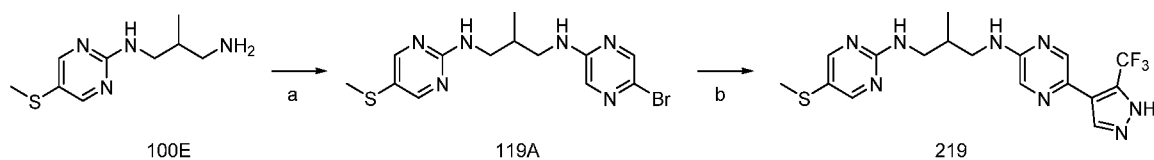
Yield: 71 mg (assumed) MS (ESI+) m/z 367 (M+H)⁺.

2-Methyl-*N*1-(5-(1-methyl-1*H*-1,2,3-triazol-4-yl)pyrazin-2-yl)-*N*3-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (218)

Methodology applied was analogous to those described in **General Method 1**.

Yield: 25 mg (23%). ¹H NMR (400 MHz, CDCl₃) δ 8.35 (s, 3H), 8.30 (s, 1H), 8.05 (dd, J = 2.3, 8.9 Hz, 1H), 7.67 (s, 1H), 6.56 (d, J = 9.2 Hz, 1H), 6.11 - 6.06 (m, 1H), 4.14 (s, 3H), 2.63 (s, 4H), 2.35 (s, 3H), 2.19 - 2.10 (m, 1H), 1.07 (d, J = 6.8 Hz, 3H); MS (ESI+) m/z 371(M+H)⁺.

Scheme 24



a) 2,5-dibromopyrazine, Et₃N, DMF; b) 2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyrazine, Cs₂CO₃, Pd(PPh₃)₄, 1,4-dioxane, water

N¹-(5-Bromopyrazin-2-yl)-2-methyl-N³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (119a)

Methodology applied was analogous to those described in **General Method 3**.

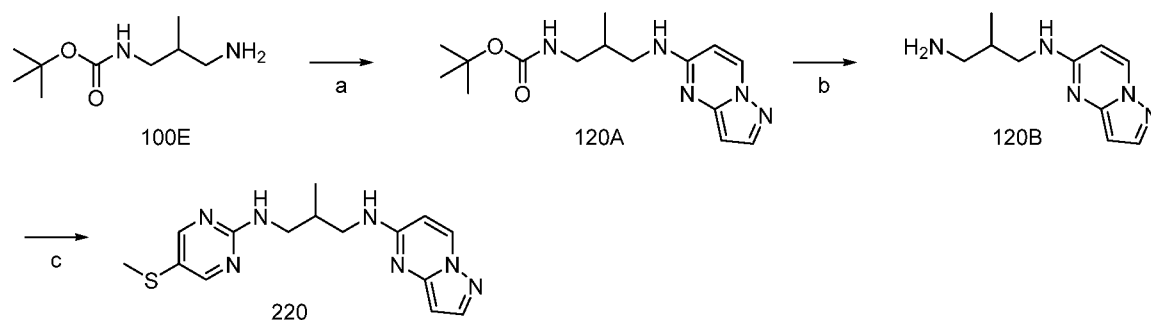
Yield: 230 mg (38%). ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.06 (d, *J* = 1.3 Hz, 1H), 7.67 (d, *J* = 1.4 Hz, 1H), 5.67 - 5.51 (m, 2H), 5.30 (s, 2H), 3.55 - 3.31 (m, 3H), 3.25 - 3.12 (m, 1H), 2.37 (s, 3H), 2.04 (s, 1H), 1.03 (d, *J* = 6.9 Hz, 3H).

2-Methyl-N¹-(5-(methylthio)pyrimidin-2-yl)-N³-(5-(5-(trifluoromethyl)-1H-pyrazol-4-yl)pyrazin-2-yl)propane-1,3-diamine (219)

Methodology applied was analogous to those described in **General Method 7**, (N.B. used 1,4-dioxane/water and no additional aliquots of reagents were added)

Yield: 18 mg (31%). ¹H NMR (400 MHz, DMSO) δ 13.70 (s, 1H), 8.35 - 8.34 (m, 2H), 8.26 (d, *J* = 1.0 Hz, 1H), 8.13 - 8.12 (m, 1H), 8.00 (d, *J* = 1.5 Hz, 1H), 7.55 - 7.44 (m, 1H), 7.23 - 7.18 (m, 1H), 3.35 - 3.18 (m, 4H), 2.35 (s, 3H), 2.11 - 2.02 (m, 1H), 0.95 (d, *J* = 6.8 Hz, 3H); MS (ESI+) *m/z* 426 (M+H)⁺.

Scheme 25



a) 5-chloropyrazolo[1,5-*c*]pyrimidine, microwave 140°C, 30min; b) 4M HCl in 1,4-dioxane; c) **100B**, Cs₂CO₃, DMF

***tert*-Butyl (2-methyl-3-(pyrazolo[1,5-*a*]pyrimidin-5-ylamino)propyl)carbamate (120A).**

A microwave vial containing 5-chloropyrazolo[1,5-*c*]pyrimidine (500 mg, 3.26 mmol, 1 eq) and *tert*-butyl (3-amino-2-methylpropyl)carbamate (100E) (6.13 g, 32.56 mmol, 10 eq) was heated to 140°C for 30 minutes under microwave irradiation. The crude reaction mixture was purified by flash chromatography (eluting with *iso*-hexane to ethyl acetate, 0-100%) to give *tert*-butyl (2-methyl-3-(pyrazolo[1,5-*a*]pyrimidin-5-ylamino)propyl)carbamate (120A)

Yield: 700 mg (70%). MS (ESI+) *m/z* 306 (M+H)⁺.

2-Methyl-*N*¹-(pyrazolo[1,5-*a*]pyrimidin-5-yl)propane-1,3-diamine (120B)

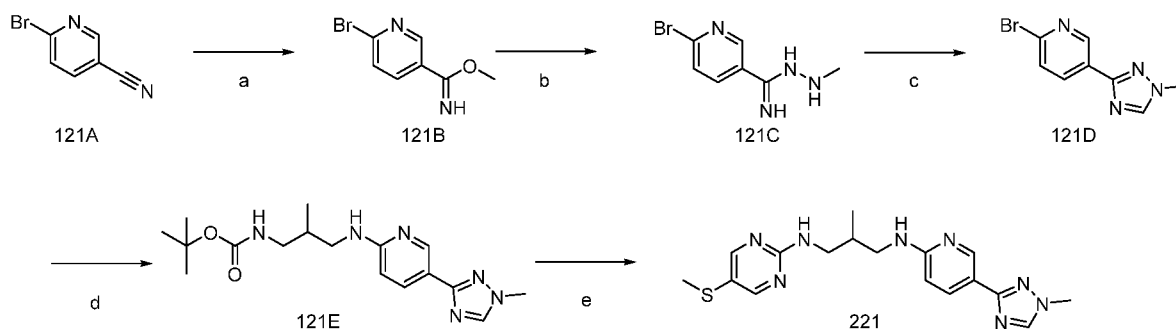
Methodology applied was analogous to those described in **General Method 2**.

MS (ESI+) *m/z* 229 (M+H)⁺.

***tert*-Butyl (2-methyl-3-(pyrazolo[1,5-*a*]pyrimidin-5-ylamino)propyl)carbamate (220)**

Methodology applied was analogous to those described in **General Method 3**.

Yield: 20 mg (14%). ¹H NMR (400 MHz, DMSO) δ 7.34 (s, 2H), 7.27 (d, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 1.8 Hz, 1H), 5.29 (d, *J* = 7.6 Hz, 1H), 5.08 (d, *J* = 1.5 Hz, 1H), 2.44 - 2.37 (m, 4H), 1.36 (s, 3H), 1.20 - 1.11 (m, 1H), (2 × NH not observed); MS (ESI+) *m/z* 330 (M+H)⁺.

Scheme 26

a) sodium methoxide, MeOH, dioxane, RT; b) Methyl hydrazine, pyridine RT; c) Formic acid, reflux; d) *tert*-butyl (3-amino-2-methylpropyl) carbamate, Pd(PPh₃)₄, Cs₂CO₃, dioxane, water 80°C overnight; e) i) 4M HCl in dioxane, ii) Cs₂CO₃, TEA, DMF, 50°C

Methyl 6-bromonicotinimidate (121B)

Sodium methoxide (0.71 g, 13.22 mmol, 1.1 eq) was added to an ice cooled solution of 6-bromonicotinonitrile (121A) (2.2 g, 12.02 mmol, 1.0 eq) in dioxane/water (20 mL/20 mL). The mixture was stirred under ice cooling for 30 minutes and then allowed to warm to room temperature. After 1 hour the mixture was diluted with ethyl acetate (200 mL) and water (200 mL). The organic phase was separated and the aqueous phase was further extracted with ethyl acetate (50 mL). The organics were combined and the solvents were removed under vacuum to afford crude methyl 6-bromonicotinimidate (121B) which was used in the next step without further purification.

Yield: 2.5 g (96%).

6-Bromo-N'-methylnicotinimidohydrazide (121C)

Methyl hydrazine (0.73 mL, 13.96 mmol, 1.2 eq) was added to a solution of 6-bromonicotinimidate (121B) (2.5 g, 11.63 mmol, 1.0 eq) and the mixture was stirred at room temperature for 1 hour. The solvents were removed under vacuum to afford crude 6-bromo-N'-methylnicotinimidohydrazide (121C) which was used in the next step without further purification.

Yield: 2 g (75%).

2-Bromo-5-(1-methyl-1*H*-1,2,4-triazol-3-yl)pyridine (121D)

Formic acid (10 mL, 265 mmol, 30.4 eq) was added to 6-bromo-*N*-methylnicotinimidohydrazide (121C) (2.0 g, 8.73 mmol, 1.0 eq) and the mixture was heated to reflux for 1 hour. The reaction mixture was diluted with water (100 mL) and then extracted with ethyl acetate (3 x 50 mL). The combined organic phases were washed with a saturated aqueous solution of sodium hydrogen carbonate (50 mL), dried over sodium sulphate and filtered. The solvents were removed under vacuum to afford crude a brown residue which was purified by flash chromatography (eluting with 0-10% methanol in dichloromethane/dichloromethane to give 2-bromo-5-(1-methyl-1*H*-1,2,4-triazol-3-yl) pyridine (121D) as an off white solid.

Yield: 500 mg (23%). MS (ESI+) *m/z* 240 (M+H)⁺.

***tert*-Butyl (2-methyl-3-((5-(1-methyl-1*H*-1,2,4-triazol-3-yl)pyridin-2-yl)amino)propyl)carbamate (121E)**

Methodology applied was analogous to those described in **General Method 7**, (N.B. used 1,4-dioxane/water and no additional aliquots of reagents were added).

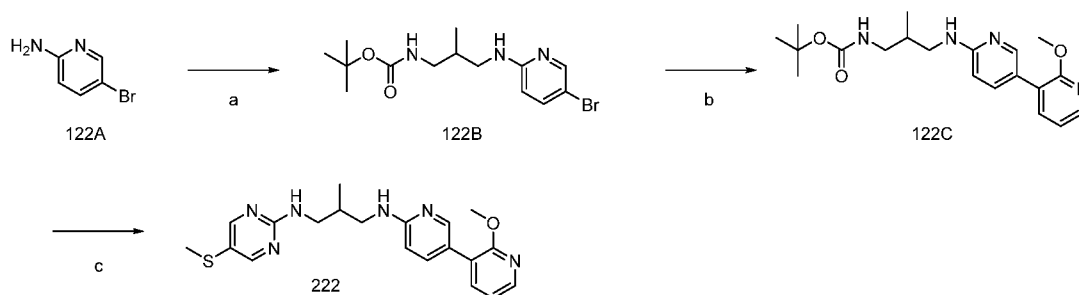
Yield: 125 mg

2-Methyl-*N*¹-(5-(1-methyl-1*H*-1,2,4-triazol-3-yl)pyridin-2-yl)-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (221)

Methodology applied was analogous to those described in **General Method 2** for the deprotection and then **General Method 1**.

Yield: 25 mg (18%). ¹H NMR (400 MHz, DMSO) δ 8.42 (d, *J* = 2.0 Hz, 1H), 8.34 (s, 2H), 8.04 (s, 1H), 7.76 (dd, *J* = 2.4, 8.8 Hz, 1H), 7.48 (dd, *J* = 6.0, 6.0 Hz, 1H), 6.82 (dd, *J* = 5.8, 5.8 Hz, 1H), 6.57 (d, *J* = 8.4 Hz, 1H), 4.16 (s, 3H), 3.32 - 3.17 (m, 4H), 2.35 (s, 3H), 2.09 - 1.99 (m, 1H), 0.93 (d, *J* = 6.7 Hz, 3H); MS (ESI+) *m/z* 371 (M+H)⁺.

Scheme 27



a) *tert*-butyl *N*-(2-methyl-3-oxopropyl)carbamate, acetic acid, mol sieves, Na(CH₃COO)₃BH, DCM; b) (2-methoxypyridin-3-yl)boronic acid, Pd(PPh₃)₄, Cs₂CO₃, dioxane, water 80°C overnight; c) i) 4M HCl in dioxane, ii) Cs₂CO₃, TEA, DMF 50°C overnight.

***tert*-Butyl (3-((5-bromopyridin-2-yl)amino)-2-methylpropyl)carbamate (122B)**

tert-Butyl *N*-(2-methyl-3-oxopropyl)carbamate (100E) (1.0 g, 5.34 mmol, 1.0 eq) was added to a solution of 5-bromopyridin-2-amine (122A) (920 mg, 5.34 mmol, 1.0 eq), acetic acid (1.2 mL, 21.36 mmol, 4.0 eq) and molecular sieves (type 4Å, 1.0 g) in anhydrous dichloromethane (50 mL). The reaction mixture was stirred at room temperature for 5 minutes and then sodium triacetoxyborohydride (2.83 g, 13.35 mmol, 2.5 eq) was added in one portion. The mixture was stirred at room temperature for 5 h. The reaction was quenched by the careful addition of a saturated aqueous solution of sodium hydrogen carbonate (30 mL). The mixture was stirred vigorously for 30 minutes and the dichloromethane layer was then separated and washed with an aqueous solution of sodium thiosulphate (1M, 15 mL). The organic phase was isolated and concentrated under reduced pressure to give semi-crude *tert*-butyl (3-((5-bromopyridin-2-yl)amino)-2-methylpropyl)carbamate (122B) as a pale brown gum which was used in the next reaction without further purification.

Yield: 875 mg (47%).

***tert*-Butyl (3-((2'-methoxy-[3,3'-bipyridin]-6-yl)amino)-2-methylpropyl)carbamate (122C)**

Methodology applied was analogous to those described in **General Method 7**.

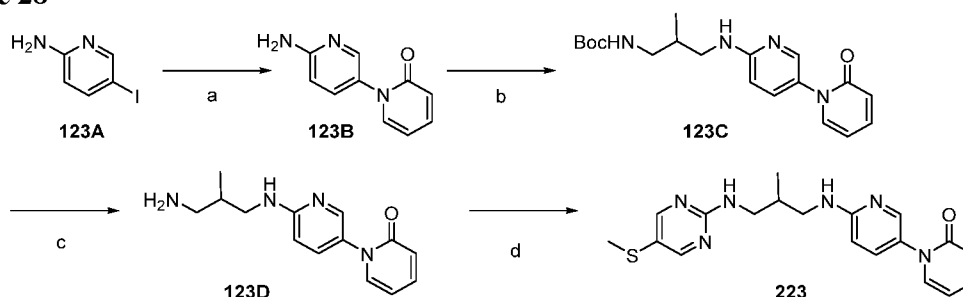
Yield: 138 mg.

***N*¹-(2'-Methoxy-[3,3'-bipyridin]-6-yl)-2-methyl-*N*³-(5-(methylthio)pyrimidin-2-yl)propane-1,3-diamine (222)**

Methodology applied was analogous to those described for **General Method 2** for the deprotection and then **General Method 1**.

Yield: 57 mg. ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.23 (d, *J* = 2.0 Hz, 1H), 7.68 (dd, *J* = 2.3, 8.7 Hz, 1H), 7.32 - 7.27 (m, 2H), 7.03 - 6.95 (m, 2H), 6.48 (d, *J* = 8.7 Hz, 1H), 5.94 - 5.90 (m, 2H), 3.82 (s, 3H), 3.56 - 3.47 (m, 1H), 3.44 - 3.35 (m, 2H), 3.28 (dd, *J* = 6.6, 13.4 Hz, 1H), 2.35 (s, 3H), 2.18 - 2.07 (m, 1H), 1.06 (d, *J* = 6.9 Hz, 3H); MS (ESI+) *m/z* 396 (M+H)⁺.

Scheme 28



a) 2-Hydroxypyridine, CuI, 8-Quinolol, K₂CO₃, DMSO, 130 °C; b) *tert*-butyl (2-methyl-3-oxopropyl)carbamate, 4A molecular sieves, NaBH(OAc)₃, AcOH, DCM, RT; c) 4M HCl in 1,4-dioxane, H₂O, RT; d) 2-chloro-5-(methylthio)pyrimidine, Et₃N, Cs₂CO₃, DMF, RT

6'-Chloro-2H-[1,3'-bipyridin]-2-one (123B)

2-Amino-5-iodopyridine (123A) (1.12 g, 5.00 mmol, 1.0 eq) was combined with 2-hydroxypyridine (582 mg, 6.00 mmol, 1.2 eq), potassium carbonate (760 mg, 5.50 mmol, 1.1 eq), copper (I) iodide (143 mg, 0.75 mmol, 0.15 eq) and 8-hydroxyquinoline (110 mg, 0.75 mmol, 0.15 eq) in anhydrous dimethylsulfonamide (5 mL). The mixture was degassed under a stream of nitrogen and then heated at 130°C for 21 h. The reaction mixture was allowed to cool to room temperature then poured into a mixture of 10% aqueous ammonium hydroxide solution (100 mL) and ethyl acetate (50 mL). Activated charcoal (1 g) was added and the mixture was filtered through a pad of celite, washing with ethyl acetate (2 x 50 mL). The layers were separated and the aqueous phase was extracted with ethyl acetate (2 x 50 mL). The combined organic extracts were washed with saturated brine (50 mL), dried over anhydrous magnesium sulfate, filtered and then concentrated under reduced pressure. The crude pale yellow solid was purified by flash

chromatography (eluting dichloromethane to methanol, 0-10%) to give the desired product 6'-chloro-2*H*-[1,3'-bipyridin]-2-one as an off white solid (123B).

Yield: 245 mg, (26%). ¹H NMR (400 MHz, DMSO) δ 7.88 (1H, d, J = 2.5 Hz), 7.60 (1H, ddd, J = 0.7, 2.1, 6.8 Hz), 7.49 (1H, ddd, J = 2.2, 6.7, 9.1 Hz), 7.41 (1H, dd, J = 2.7, 8.7 Hz), 6.52 (1H, dd, J = 0.4, 8.8 Hz), 6.45 (1H, ddd, J = 0.7, 1.3, 9.2 Hz), 6.28 (1H, ddd, J = 6.7, 6.7, 1.3 Hz), 6.23 (2H, s); MS (ESI+) m/z 188 (M+H)⁺.

***tert*-Butyl (2-methyl-3-((2-oxo-2*H*-[1,3'-bipyridin]-6'-yl)amino)propyl)carbamate (123C)**

Methodology applied was analogous to those described in **Scheme 19**.

6'-Chloro-2*H*-[1,3'-bipyridin]-2-one (123B) was used in excess (245 mg, 1.31 mmol, 1.1 eq). 4Å Molecular sieves were used in the reaction. The crude product was purified by flash chromatography (eluting dichloromethane to methanol, 0-7%) to give the desired product *tert*-butyl (2-methyl-3-((2-oxo-2*H*-[1,3'-bipyridin]-6'-yl)amino)propyl)carbamate (123C) as a pale brown solid.

Yield: 249 mg, (58%). MS (ESI+) m/z 359 (M+H)⁺.

6'-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)-2*H*-[1,3'-bipyridin]-2-one (223)

Methodology applied was analogous to those described in **General Method 2** using a (4:1) ratio of 4M HCl in 1,4-dioxane-water, followed by **General Method 3** using cesium carbonate (3.0 eq) in combination with triethylamine (2.0 eq).

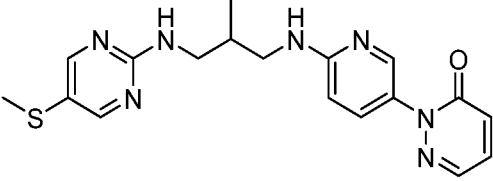
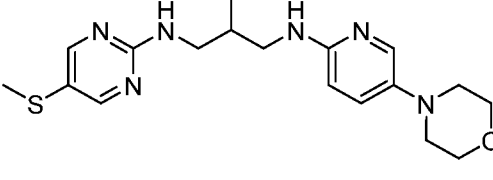
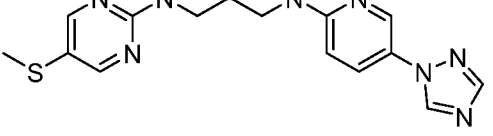
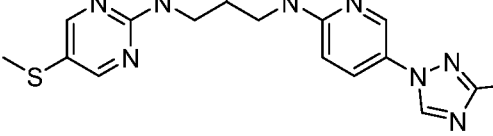
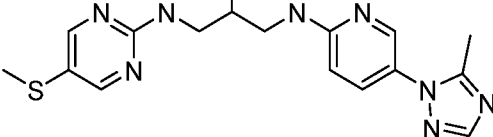
Yield: 152 mg (57% over 2 steps).

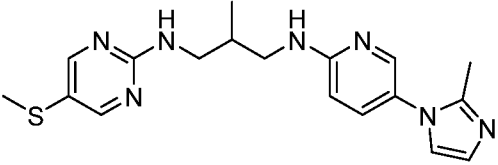
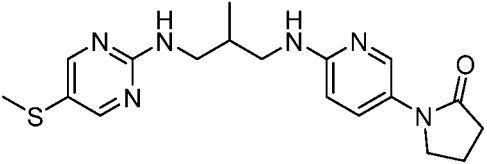
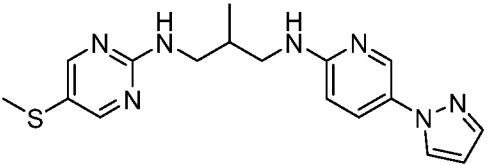
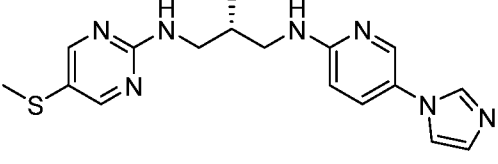
¹H NMR (400 MHz, DMSO) δ 8.35 (2H, s), 7.91 (1H, d, J = 2.6 Hz), 7.61 (1H, ddd, J = 0.6, 2.1, 6.8 Hz), 7.52 - 7.45 (2H, m), 7.40 (1H, dd, J = 2.7, 8.9 Hz), 6.90 (1H, dd, J = 5.8, 5.8 Hz), 6.57 (1H, dd, J = 0.5, 8.9 Hz), 6.45 (1H, ddd, J = 0.7, 1.2, 9.2 Hz), 6.28 (1H, ddd, J = 6.7, 6.7, 1.4 Hz), 3.33 - 3.14 (4H, m), 2.35 (3H, s), 2.10 - 2.00 (1H, m), 0.94 (3H, d, J = 6.8 Hz); MS (ESI+) m/z 383 (M+H)⁺.

Using the procedures described in **Scheme 28**, the following examples were synthesized:

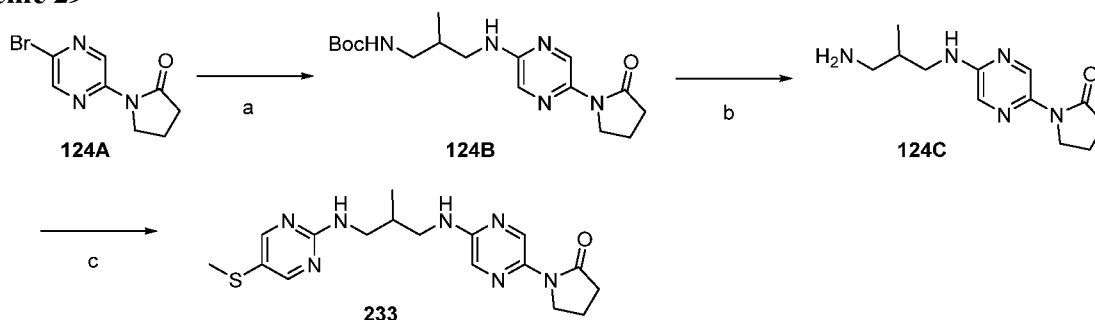
Table 16

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺

	224	¹ H NMR (400 MHz, DMSO) δ 8.34 (2H, s), 8.18 (0.5H, s), 8.10 (1H, dd, J = 0.4, 2.6 Hz), 8.03 (1H, dd, J = 1.6, 3.9 Hz), 7.52 (1H, dd, J = 2.7, 9.0 Hz), 7.50 - 7.45 (2H, m), 7.04 (1H, dd, J = 1.6, 9.4 Hz), 6.91 (1H, dd, J = 5.8, 5.8 Hz), 6.57 (1H, dd, J = 0.5, 9.0 Hz), 3.35 - 3.15 (4H, m), 2.35 (3H, s), 2.10 - 2.00 (1H, m), 0.94 (3H, d, J = 6.8 Hz). Partial formate salt.	384
	225	¹ H NMR (400 MHz, DMSO) δ 8.34 (2H, s), 8.16 (1H, s), 7.64 (1H, d, J = 2.8 Hz), 7.47 (1H, dd, J = 6.0, 6.0 Hz), 7.19 (1H, dd, J = 2.9, 9.0 Hz), 6.46 (1H, d, J = 8.9 Hz), 6.11 (1H, dd, J = 5.1, 5.1 Hz), 3.75 - 3.68 (4H, m), 3.30 - 3.05 (4H, m), 2.94 - 2.87 (4H, m), 2.35 (3H, s), 2.05 - 1.92 (1H, m), 0.91 (3H, d, J = 6.8 Hz). Formate salt.	375
	226	¹ H NMR (400 MHz, CDCl ₃) δ 8.40 - 8.31 (4H, m), 8.09 (1H, s), 7.65 (1H, dd, J = 2.5, 8.8 Hz), 6.49 (1H, d, J = 8.8 Hz), 5.77 (1H, dd, J = 6.2, 6.2 Hz), 5.44 (1H, dd, J = 5.7, 5.7 Hz), 3.57 - 3.23 (4H, m), 2.36 (3H, s), 2.13 - 2.02 (1H, m), 1.05 (3H, d, J = 6.8 Hz).	357
	227	¹ H NMR (400 MHz, DMSO) δ 9.04 (1H, s), 8.41 - 8.33 (3H, m), 8.10 (1H, dd, J = 2.0, 9.3 Hz), 7.59 (4H, br s), 7.03 (1H, d, J = 9.3 Hz), 3.44 - 3.23 (4H, m), 2.41 (3H, s), 2.39 (3H, s), 2.20 - 2.09 (1H, m), 1.01 (3H, d, J = 6.6 Hz). Bis(trifluoroacetate) salt.	371
	228	¹ H NMR (400 MHz, DMSO) δ 8.39 (2H, s), 8.23 (1H, d, J = 2.3 Hz), 8.10 (1H, s), 7.78 (1H, dd, J = 2.0, 9.1 Hz), 7.57 (1H, br s), 6.91 (1H, d, J = 9.1 Hz), 5.11 (3H, br s), 3.43 - 3.24 (4H, m), 2.46 (3H, s), 2.40 (3H, s), 2.19 - 2.09 (1H, m), 1.01 (3H, d, J = 6.8 Hz). Bis(trifluoroacetate) salt.	371

	229	¹ H NMR (400 MHz, DMSO) δ 8.34 (2H, s), 8.16 (1H, s), 7.98 (1H, d, <i>J</i> = 2.4 Hz), 7.47 (1H, dd, <i>J</i> = 6.0, 6.0 Hz), 7.43 (1H, dd, <i>J</i> = 2.7, 8.9 Hz), 7.16 (1H, d, <i>J</i> = 1.4 Hz), 6.92 (1H, dd, <i>J</i> = 5.8, 5.8 Hz), 6.87 (1H, d, <i>J</i> = 1.1 Hz), 6.60 (1H, dd, <i>J</i> = 0.6, 8.9 Hz), 3.35 - 3.26 (3H, m), 3.26 - 3.14 (2H, m), 2.35 (2H, s), 2.21 (3H, s), 2.10 - 2.00 (1H, m), 0.94 (3H, d, <i>J</i> = 6.8 Hz). Formate salt.	370
	230	¹ H NMR (400 MHz, CDCl ₃) δ 8.35 (2H, s), 8.05 (1H, d, <i>J</i> = 2.4 Hz), 7.92 (1H, dd, <i>J</i> = 2.8, 9.0 Hz), 6.43 (1H, dd, <i>J</i> = 0.5, 9.1 Hz), 5.96 (1H, dd, <i>J</i> = 5.8, 5.8 Hz), 3.80 (2H, ddt, <i>J</i> = 3.5, 3.5, 3.5 Hz), 3.53 - 3.44 (1H, m), 3.39 - 3.30 (2H, m), 3.22 (1H, dd, <i>J</i> = 6.8, 13.6 Hz), 2.63 - 2.53 (3H, m), 2.36 (3H, s), 2.22 - 2.01 (3H, m), 1.03 (3H, d, <i>J</i> = 6.9 Hz).	373
	231	¹ H NMR (400 MHz, CDCl ₃) δ 8.39 - 8.34 (3H, m), 7.77 - 7.74 (1H, m), 7.73 (1H, d, <i>J</i> = 2.7 Hz), 7.70 (1H, d, <i>J</i> = 1.5 Hz), 6.47 (1H, dd, <i>J</i> = 0.5, 9.0 Hz), 6.44 (1H, dd, <i>J</i> = 2.1, 2.1 Hz), 5.84 (1H, dd, <i>J</i> = 6.1, 6.1 Hz), 5.19 (1H, dd, <i>J</i> = 6.1, 6.1 Hz), 3.56 - 3.33 (3H, m), 3.31 - 3.23 (1H, m), 2.36 (3H, s), 2.12 - 2.03 (1H, m), 1.05 (3H, d, <i>J</i> = 6.9 Hz).	356
	232	¹ H NMR (400 MHz, CDCl ₃) δ 8.37 (2H, s), 8.16 (1H, d, <i>J</i> = 2.5 Hz), 7.87 - 7.76 (1H, m), 7.41 (1H, dd, <i>J</i> = 2.6, 8.9 Hz), 7.22 - 7.11 (1H, m), 6.48 (1H, d, <i>J</i> = 8.8 Hz), 5.81 (1H, br s), 5.52 (1H, br s), 3.57 - 3.48 (1H, m), 3.47 - 3.34 (2H, m), 3.27 (1H, dd, <i>J</i> = 7.2, 13.7 Hz), 2.36 (3H, s), 2.15 - 2.04 (2H, m), 1.06 (3H, d, <i>J</i> = 6.9 Hz).	356

Scheme 29



a) *tert*-Butyl *N*-(3-amino-2-methylpropyl)carbamate, CuI, L-Proline, K₃PO₄, DMSO, 90 °C; b) 4M HCl in 1,4-dioxane, H₂O, RT; c) 2-chloro-5-(methylthio)pyrimidine, Et₃N, Cs₂CO₃, DMF, RT

***tert*-Butyl (2-methyl-3-((5-(2-oxopyrrolidin-1-yl)pyrazin-2-yl)amino)propyl)carbamate (124B)**

A solution of *tert*-butyl *N*-(3-amino-2-methylpropyl)carbamate (100E) (436 mg, 2.20 mmol, 1.1 eq) in anhydrous dimethylsulfonamide (10 mL) was added to 2-bromo-5-(pyrrolidin-1-yl)pyrazine (124A) (510 mg, 2.00 mmol, 1.0 eq), potassium phosphate tribasic (866 mg, 4.00 mmol, 2 eq), L-proline (94 mg, 0.80 mmol, 0.4 eq) and copper (I) iodide (76 mg, 0.40 mmol, 0.2 eq). The mixture was degassed and kept under a stream of nitrogen, then heated at 90 °C with stirring for 20 h. The reaction mixture was allowed to cool to room temperature then poured into a mixture of water (50 mL) and ethyl acetate (50 mL). The layers were separated and the aqueous phase was extracted with ethyl acetate (2 x 50 mL). The combined organic extracts were washed with saturated brine (50 mL), dried over anhydrous magnesium sulfate, filtered and then concentrated under reduced pressure. The crude product was purified by flash chromatography (eluting dichloromethane to methanol, 0-6%) to give the desired product *tert*-butyl (2-methyl-3-((5-(2-oxopyrrolidin-1-yl)pyrazin-2-yl)amino)propyl)carbamate (124B) as a yellow solid. Yield: 375 mg, (54%). MS (ESI+) *m/z* 350 (M+H)⁺.

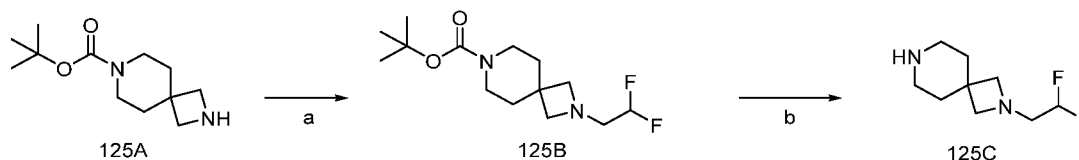
1-(5-((2-Methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)pyrazin-2-yl)pyrrolidin-2-one (233)

Methodology applied was analogous to those described in **General Method 2** using a [4:1] ratio of 4M HCl in 1,4-dioxane-water, followed by **General Method 3**.

Yield: 71 mg (18% over 2 steps).

¹H NMR (400 MHz, CDCl₃) δ 9.02 (1H, d, *J* = 1.5 Hz), 8.35 (2H, s), 7.64 (1H, d, *J* = 1.5 Hz), 5.63 (1H, dd, *J* = 6.2, 6.2 Hz), 5.24 (1H, dd, *J* = 5.7, 5.7 Hz), 3.97 (2H, t, *J* = 7.1 Hz), 3.55 - 3.46 (1H, m), 3.45 - 3.32 (2H, m), 3.28 - 3.19 (1H, m), 2.62 (2H, t, *J* = 8.1 Hz), 2.36 (3H, s), 2.20 - 2.02 (3H, m), 1.03 (3H, d, *J* = 6.8 Hz); MS (ESI+) *m/z* 374 (M+H)⁺.

Scheme 30



a) RX, K₂CO₃, DMF, b) TFA, DCM

***tert*-Butyl 2-(2,2-difluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (125B).**

1,1-Difluoro-2-iodo-ethane (128 mg, 0.67 mmol, 1.2 eq) was added to a suspension of *tert*-butyl 2,7-diazaspiro[3.5]nonane-7-carboxylate (125A) (126 mg, 0.56 mmol, 1.0 eq), potassium carbonate (231 mg, 1.67 mmol, 3.0 eq) in dimethylformamide (1.0 mL) and the mixture was stirred at 60°C for 2 h. The reaction mixture was cooled to room temperature, diluted with water and extracted with ethyl acetate. The organic phase was washed with brine, dried by passing through a phase separator and then concentrated under reduced pressure to afford the desired *tert*-butyl 2-(2,2-difluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (125B) as a pale yellow oil.

Yield: 73 mg (45%). ¹H NMR (400 MHz, CDCl₃) δ 5.87 - 5.57 (m, 1H), 3.41 - 3.30 (m, 4H), 3.14 (s, 4H), 2.89 - 2.77 (m, 2H), 1.76 - 1.67 (m, 4H), 1.46 (s, 9H).

2-(2,2-Difluoroethyl)-2,7-diazaspiro[3.5]nonane (125C)

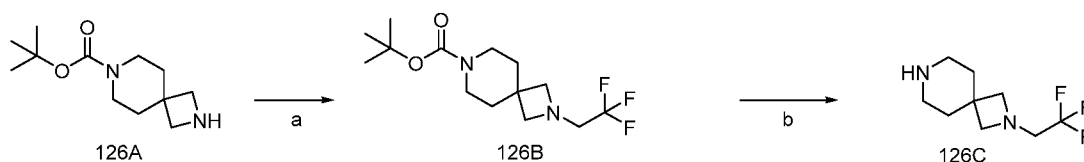
Trifluoroacetic acid (1.3 mL) was added dropwise to a solution of *tert*-butyl 2-(2,2-difluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (125B) (73 mg, 0.25 mmol, 1.0 eq) in dichloromethane (1.3 mL). The mixture was stirred for 30 minutes and then concentrated to dryness under reduced pressure to afford the desired product 2-(2,2-difluoroethyl)-2,7-diazaspiro[3.5]nonane (125C) as a pale yellow oil which was used in the next reaction without further purification.

The intermediates in **Table 17** were synthesized using conditions analogous to those described for intermediate **125C**:

Table 17

Structure	Compound No.	¹ H NMR	LC-MS (M+H) ⁺
	Intermediate	¹ H NMR (400 MHz, CDCl ₃) δ 4.67 - 4.24 (m, 4H), 3.74 (s, 2H), 3.35 - 3.08 (m, 6H), 1.76 - 1.66 (m, 4H). NH not observed.	N/A
	Intermediate	¹ H NMR (400 MHz, CDCl ₃) δ 5.87 - 5.57 (m, 1H), 3.41 - 3.30 (m, 4H), 3.14 (s, 4H), 2.89 - 2.77 (m, 2H), 1.76 - 1.67 (m, 4H), 1.46 (s, 9H).	N/A

Scheme 31



a) ROSO₂CF₃, Cs₂CO₃, MeCN, b) TFA, DCM

***tert*-Butyl 2-(2,2,2-trifluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (126B).**

2,2,2-Trifluoroethyl trifluoromethanesulfonate (153 mL, 1.06 mmol, 1.2 eq) was added to a suspension of *tert*-butyl 2,7-diazaspiro[3.5]nonane-7-carboxylate (126A) (200 mg, 0.88 mmol, 1.0 eq), cesium carbonate (862 mg, 2.65 mmol, 3.0 eq) in acetonitrile (2.0 mL)

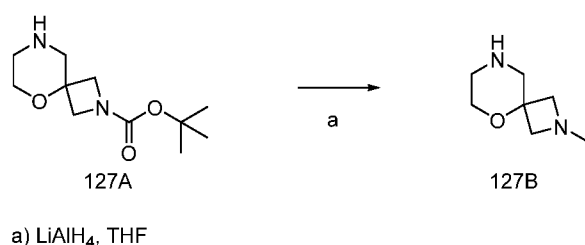
and the mixture was stirred at 80°C for 16 h. The reaction mixture was cooled to room temperature, diluted with water and extracted with ethyl acetate. The combined organic phase was washed with brine, dried passing through a phase separator and then concentrated under reduced pressure to afford *tert*-butyl 2-(2,2,2-trifluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (126B) as a sticky white solid. The sample was used in the next step without further purification.

Yield: 341 mg (Quant.). ¹H NMR (400 MHz, CDCl₃) δ 3.38 - 3.30 (m, 4H), 3.19 (s, 4H), 3.01 (q, *J* = 9.4 Hz, 2H), 1.73 - 1.69 (m, 4H), 1.45 (s, 9H).

2-(2,2,2-Trifluoroethyl)-2,7-diazaspiro[3.5]nonane (126C)

Trifluoroacetic acid (1.3 mL) was added dropwise to a solution of *tert*-butyl 2-(2,2,2-trifluoroethyl)-2,7-diazaspiro[3.5]nonane-7-carboxylate (126B) (110 mg, 0.357 mmol, 1.0 eq) in dichloromethane (1.0 mL). The mixture was stirred for 30 minutes and then concentrated to dryness under reduced pressure to afford 2-(2,2,2-trifluoroethyl)-2,7-diazaspiro[3.5]nonane (126C) as a pale brown oil, which was used directly in the next step without further purification, assumed 100% yield.

Scheme 32



2-Methyl-5-oxa-2,8-diazaspiro[3.5]nonane (127B)

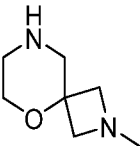
Lithium aluminium hydride (1M solution in tetrahydrofuran, 1.97 mL, 1.97 mmol, 3.0 eq) was added dropwise under nitrogen to a 0°C cooled solution of *tert*-butyl 5-oxa-2,8-diazaspiro[3.5]nonane-2-carboxylate (127A) (150 mg, 0.657 mmol, 1.0 eq) in tetrahydrofuran (4.0 mL). The reaction was stirred at 0°C for 5 minutes, the cooling bath was removed and the reaction was then heated to 70°C for 16 h (effervescence was

observed at 0°C and 35°C). The reaction mixture was cooled to 0°C and quenched by the slow addition of water (0.075 mL), aqueous sodium hydroxide solution (15%, 0.075 mL) and then water (0.22 mL). The cooling bath was removed and the reaction mixture was stirred for 15 minutes, magnesium sulfate was added and stirred for a further 40 minutes. The mixture was dried passing through a phase separator, washed with tetrahydrofuran and diethyl ether and then concentrated to dryness under reduced pressure to afford 2-methyl-5-oxa-2,8-diazaspiro[3.5]nonane (127B) as a pale brown oil. The sample was taken on into the next reaction without further purification.

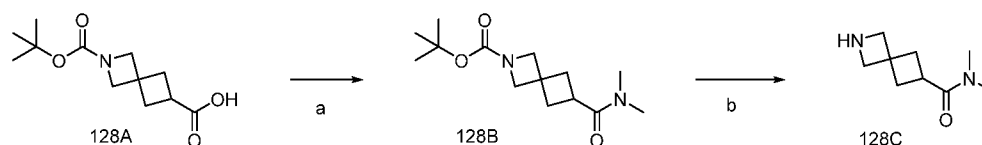
Yield: assumed 100%. ¹H NMR (400 MHz, CDCl₃) δ 3.63 - 3.56 (m, 2H), 3.47 - 3.43 (m, 2H), 3.00 (s, 2H), 2.94 - 2.86 (m, 2H), 2.83 - 2.79 (m, 2H), 2.40 (s, 3H), NH not observed.

The intermediate in **Table 18** were synthesized using conditions analogous to those described for intermediate **127B**:

Table 18

Structure	Compound No.	¹ H NMR	LC-MS (M+H) ⁺
	Intermediate	¹ H NMR (400 MHz, CDCl ₃) δ 3.63 - 3.56 (m, 2H), 3.47 - 3.43 (m, 2H), 3.00 (s, 2H), 2.94 - 2.86 (m, 2H), 2.83 - 2.79 (m, 2H), 2.40 (s, 3H), NH not observed.	-

Scheme 33



a) HATU, Et₃N, Me₂NH, DMF b) TFA, DCM

tert-Butyl 6-(dimethylcarbamoyl)-2-azaspiro[3.3]heptane-2-carboxylate (128B)

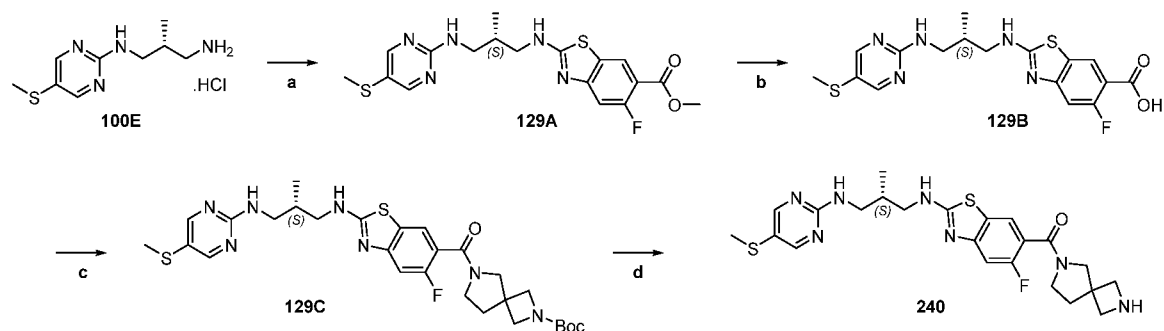
Method used was analogous to those described in **General Method 5** using 2-(*tert*-butoxycarbonyl)-2-azaspiro[3.3]heptane-6-carboxylic acid to afford the desired product *tert*-butyl 6-(dimethylcarbamoyl)-2-azaspiro[3.3]heptane-2-carboxylate (128B).

Yield: 111 mg (Quant.). ¹H NMR (400 MHz, DMSO) δ 3.87 (s, 2H), 3.70 (s, 2H), 3.23 - 3.14 (m, 1H), 2.86 (s, 3H), 2.79 (s, 3H), 2.32 - 2.24 (m, 4H), 1.37 - 1.36 (m, 9H).

N,N-Dimethyl-2-azaspiro[3.3]heptane-6-carboxamide (128C)

Trifluoroacetic acid (2.1 mL) was added dropwise to a solution of *tert*-butyl 6-(dimethylcarbamoyl)-2-azaspiro[3.3]heptane-2-carboxylate (128B) (110 mg, 0.357 mmol, 1.0 eq) in dichloromethane (2.1 mL). The mixture was stirred for 30 minutes and then concentrated to dryness under reduced pressure to afford the desired product *N,N*-dimethyl-2-azaspiro[3.3]heptane-6-carboxamide (128C) as a pale brown oil. The sample was taken on into the next reaction without further purification, assumed 100% yield.

Scheme 34



a) methyl 2-chloro-5-fluorobenzo[d]thiazole-6-carboxylate, Et₃N, DMF; b) LiOH, MeOH, THF, H₂O; c) Amine, HATU, Et₃N, DMF; d) TFA, DCM

Methyl (S)-5-fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino) benzo[d]thiazole-6-carboxylate (129A)

Methodology applied was analogous to those described in **General Method 3**.

Yield: 134 mg (20%). ¹H NMR (400 MHz, CDCl₃) δ 8.38 (s, 2H), 8.13 (d, *J* = 6.9 Hz, 1H), 7.21 (d, *J* = 12.2 Hz, 1H), 7.12 (s, 1H), 5.62 (t, *J* = 6.7 Hz, 1H), 3.93 (s, 3H), 3.64 - 3.46 (m, 2H), 3.42 - 3.22 (m, 2H), 2.38 - 2.38 (m, 3H), 2.18 - 2.09 (m, 1H), 1.07 (d, *J* = 6.9 Hz, 3H); MS (ESI+) *m/z* 422 (M+H)⁺.

(S)-5-Fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazole-6-carboxylic acid (129B)

Methodology applied was analogous to those described in **General Method 4**.

Yield: 98 mg (quant.). ¹H NMR (400 MHz, DMSO) δ 12.82 (s, 1H), 8.57 - 8.54 (m, 1H), 8.33 - 8.32 (m, 2H), 8.18 (d, *J* = 7.4 Hz, 1H), 7.50 (t, *J* = 6.1 Hz, 1H), 7.16 (d, *J* = 12.5 Hz, 1H), 2.34 (s, 3H), 2.16 - 2.06 (m, 1H), 0.97 - 0.94 (m, 3H). *NH* exchangeable protons not observed; MS (ESI+) *m/z* 408 (M+H)⁺.

***tert*-Butyl (S)-6-(5-fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazole-6-carbonyl)-2,6-diazaspiro[3.4]octane-2-carboxylate (129C)**

Methodology applied was analogous to those described in **General Method 5**.

Yield: 20 mg (54%). ¹H NMR (400 MHz, CDCl₃) δ 8.27 (d, *J* = 1.8 Hz, 1H), 8.14 (s, 1H), 7.99 (dd, *J* = 1.7, 8.5 Hz, 1H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.00 - 6.97 (m, 1H), 5.47 (dd, *J* = 6.7, 6.7 Hz, 1H), 4.37 (q, *J* = 7.2 Hz, 2H), 3.63 - 3.49 (m, 2H), 3.40 - 3.23 (m, 2H), 2.47 (s, 3H), 2.17 - 2.09 (m, 1H), 1.40 (dd, *J* = 7.2, 7.2 Hz, 3H), 1.06 (d, *J* = 6.9 Hz, 3H); MS (ESI+) *m/z* 489 (M+H)⁺.

(S)-(5-Fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazol-6-yl)(2,6-diazaspiro[3.4]octan-6-yl)methanone formate salt (Example 240)

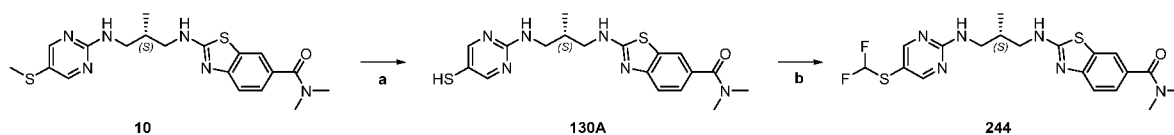
Trifluoroacetic acid (1 mL) was added dropwise to a 0°C cooled solution of *tert*-butyl (S)-6-(5-fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazole-6-carbonyl)-2,6-diazaspiro[3.4]octane-2-carboxylate (149) (17 mg, 0.0166 mmol, 1.0 eq) in anhydrous dichloromethane (1 mL). The mixture was stirred for 30 minutes and then concentrated under reduced pressure. The crude residue obtained was purified preparative HPLC (formic additive) to give the desired product (S)-(5-fluoro-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[d]thiazol-6-yl)(2,6-diazaspiro[3.4]octan-6-yl)methanone formate salt (Example 189) as an off white solid.

Yield: 9 mg (100%). ^1H NMR (400 MHz, CDCl_3) δ 8.38 - 8.36 (m, 3H), 7.60 - 7.52 (m, 1H), 5.84 - 5.72 (m, 1H), 3.98 (d, $J=9.0$ Hz, 1H), 3.84 - 3.57 (m, 6H), 3.50 - 3.24 (m, 4H), 2.86 (s, 12H), 2.38 - 2.37 (m, 3H), 2.29 - 2.13 (m, 3H), 1.09 - 1.04 (m, 3H). NH exchangeable protons not observed; MS (ESI+) m/z 502 ($\text{M}+\text{H}$) $^+$.

Using the procedures described in **Scheme 34**, the following examples were prepared:

Table 19

Structure	Ex. #	^1H NMR	LC-MS ($\text{M}+\text{H}$) $^+$
	241	^1H NMR (400 MHz, CDCl_3) δ 8.38 - 8.37 (m, 2H), 8.24 (d, $J=7.4$ Hz, 1H), 8.10 (s, 1H), 7.52 - 7.44 (m, 1H), 5.72 - 5.69 (m, 1H), 4.91 - 4.87 (m, 2H), 3.80 - 3.78 (m, 3H), 3.64 - 3.56 (m, 1H), 3.54 - 3.48 (m, 1H), 3.42 - 3.24 (m, 2H), 2.38 (s, 3H), 2.20 - 2.10 (m, 1H), 1.09 - 1.05 (m, 3H).	502
	242	^1H NMR (400 MHz, CDCl_3) δ 8.37 (s, 2H), 8.28 - 8.26 (m, 1H), 5.71 (t, $J=6.5$ Hz, 1H), 3.86 (t, $J=5.0$ Hz, 2H), 3.70 - 3.57 (m, 3H), 3.53 - 3.48 (m, 1H), 3.41 - 3.22 (m, 2H), 2.78 (s, 1H), 2.38 (s, 3H), 2.20 - 2.11 (m, 1H), 1.08 - 1.06 (m, 3H).	451
	243	^1H NMR (400 MHz, CDCl_3) δ 8.38 (s, 2H), 7.56 (d, $J=6.3$ Hz, 1H), 6.85 (t, $J=6.0$ Hz, 1H), 5.63 (t, $J=6.7$ Hz, 1H), 3.78 (s, 2H), 3.63 - 3.45 (m, 2H), 3.42 - 3.22 (m, 4H), 2.95 - 2.80 (m, 4H), 2.38 (s, 3H), 2.20 - 2.08 (m, 1H), 1.06 (d, $J=6.9$ Hz, 3H).	478

Scheme 35

a) NaSMe, NMP, 160°C, 1Hr; b) Bromodifluoromethyldiethylphosphonate, KOH, NMP, water

2-((3-((5-Mercaptopyrimidin-2-yl)amino)-2-methylpropyl)amino)-*N,N*-dimethylbenzo [*d*]thiazole-6-carboxamide (130A)

N,N-dimethyl-2-((2-methyl-3-((5-(methylthio)pyrimidin-2-yl)amino)propyl)amino)benzo[*d*]thiazole-6-carboxamide (Compound 10, 75 mg, 0.18 mmol), sodium methanethiolate (126 mg, 1.80 mmol, 10.0 eq and *N*-methylpyrrolidine (1.5 mL) were added to a microwave vessel under nitrogen, sealed and then heated to 160°C for 1 hour. LCMS analysis indicated complete conversion to the desired thiol 2-((3-((5-((difluoromethyl)thio)pyrimidin-2-yl)amino)-2-methylpropyl) amino)-*N,N*-dimethylbenzo[*d*]thiazole-6-carboxamide (130A), which was used directly in the next step without purification.

2-((3-((5-((Difluoromethyl)thio)pyrimidin-2-yl)amino)-2-methylpropyl)amino)-*N,N*-dimethylbenzo[*d*]thiazole-6-carboxamide (244)

Potassium hydroxide (201 mg, 3.58 mmol, 20.0 eq) and water (0.5 mL) were added to the crude thiol solution of 2-((3-((5-((difluoromethyl)thio)pyrimidin-2-yl)amino)-2-methylpropyl)amino)-*N,N*-dimethylbenzo[*d*]thiazole-6-carboxamide in *N*-methylpyrrolidine (1.5 mL) and the mixture was cooled to -70°C, freezing to a solid. Bromodifluoromethyldiethylphosphonate (40 uL, 0.215 mmol, 1.2 eq) was added in one portion and the reaction was allowed to warm to ambient temperature over 1 hour then re-cooled to -70°C. A further aliquot of bromodifluoromethyldiethylphosphonate (40 uL, 0.215 mmol, 1.2 eq) was added, and the mixture was allowed to warm to ambient temperature over 1 hour. Water (10 mL) was added and the mixture was extracted with ethyl acetate (3 x 20 mL). The combined organic phases were washed with water (20 mL) and brine (25 mL) then dried over magnesium sulfate. The solvents were removed under

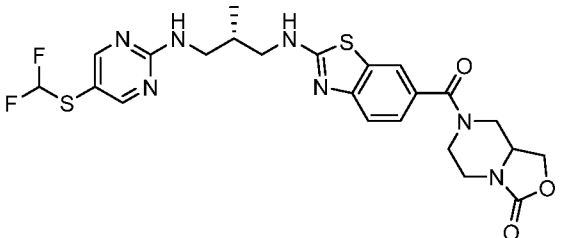
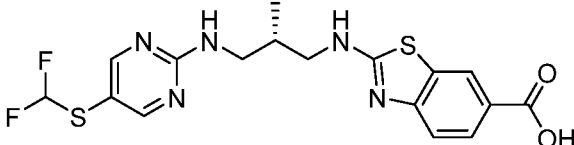
vacuum to give a crude brown oil which was purified by flash chromatography (eluting dichloromethane to methanol, 0-10%) and then by preparative HPLC to give the desired 2-((3-((5-((difluoromethyl)thio)pyrimidin-2-yl)amino)-2-methylpropyl)amino)-*N,N*-dimethylbenzo[*d*]thiazole-6-carboxamide (244) as an off white solid.

Yield: 15 mg (19%). ¹H NMR (400 MHz, CDCl₃) δ 8.42 - 8.39 (m, 2H), 7.69 (d, *J* = 1.4 Hz, 1H), 7.55 - 7.52 (m, 1H), 7.36 (dd, *J* = 1.8, 8.3 Hz, 1H), 6.33 (s, 1H), 6.15 (t, *J* = 6.7 Hz, 1H), 3.65 - 3.51 (m, 2H), 3.43 - 3.29 (m, 2H), 3.08 (s, 6H), 2.20 - 2.10 (m, 1H), 1.09 - 1.06 (m, 3H); MS (ESI+) *m/z* 453 (M+H)⁺.

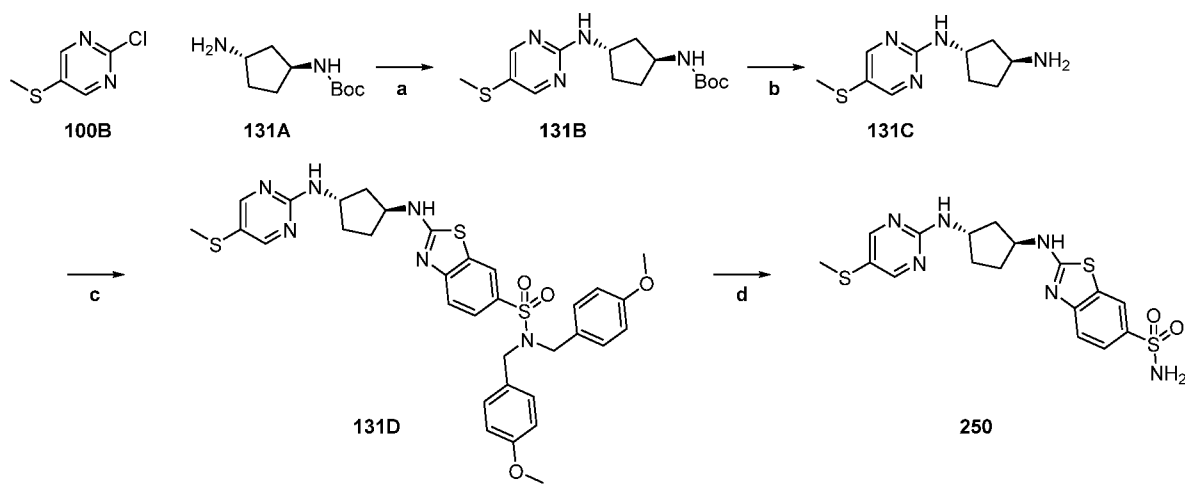
Following methodology described in **Scheme 35**, the following examples were prepared:

Table 20

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	245	¹ H NMR (400 MHz, CDCl ₃) δ 8.43 (s, 2H), 7.65 (d, <i>J</i> = 1.4 Hz, 1H), 7.53 (d, <i>J</i> = 7.9 Hz, 1H), 7.31 (dd, <i>J</i> = 1.8, 8.3 Hz, 1H), 6.68 (t, <i>J</i> = 56.8 Hz, 1H), 6.38 (s, 1H), 6.16 (dd, <i>J</i> = 6.5, 6.5 Hz, 1H), 4.48 (s, 4H), 3.64 - 3.53 (m, 6H), 3.44 - 3.31 (m, 2H), 2.20 - 2.12 (m, 1H), 1.91 (s, 4H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	535
	246	¹ H NMR (400 MHz, CDCl ₃) δ 8.42 - 8.38 (m, 2H), 7.66 - 7.65 (m, 1H), 7.54 - 7.52 (m, 1H), 7.33 - 7.30 (m, 1H), 6.32 (s, 1H), 6.14 (t, <i>J</i> = 6.6 Hz, 1H), 3.64 - 3.52 (m, 6H), 3.46 - 3.32 (m, 6H), 2.20 - 2.12 (m, 1H), 1.83 - 1.82 (m, 4H), 1.09 - 1.06 (m, 3H).	534
	247	¹ H NMR (400 MHz, CDCl ₃) δ 8.44 - 8.39 (m, 2H), 7.66 (d, <i>J</i> = 1.3 Hz, 1H), 7.54 - 7.51 (m, 1H), 6.12 (t, <i>J</i> = 6.5 Hz, 1H), 3.64 - 3.51 (m, 6H), 3.44 - 3.30 (m, 3H), 3.25 - 3.23 (m, 4H), 3.02 (q, <i>J</i> = 9.4 Hz, 2H), 2.20 - 2.10 (m, 1H), 1.80 - 1.77 (m, 4H), 1.07 (d, <i>J</i> = 6.9 Hz, 3H).	616

	248 ¹H NMR (400 MHz, CDCl₃) δ 8.44 - 8.38 (m, 4H), 7.70 (d, <i>J</i> = 1.5 Hz, 2H), 7.57 - 7.54 (m, 2H), 7.36 - 7.32 (m, 2H), 6.69 (s, 1H), 6.54 (s, 1H), 6.09 (t, <i>J</i> = 6.6 Hz, 2H), 4.45 (t, <i>J</i> = 8.4 Hz, 3H), 4.00 - 3.82 (m, 6H), 3.65 - 3.52 (m, 4H), 3.45 - 3.30 (m, 4H), 3.07 (s, 6H), 2.89 - 2.83 (m, 2H), 2.62 (s, 1H), 2.20 - 2.12 (m, 2H), 1.08 (d, <i>J</i> = 6.9 Hz, 6H).	550
	249 ¹H NMR (400 MHz, DMSO) δ 8.41 - 8.35 (m, 3H), 8.25 (d, <i>J</i> = 1.5 Hz, 1H), 7.97 - 7.92 (m, 1H), 7.81 (dd, <i>J</i> = 1.8, 8.4 Hz, 1H), 7.44 - 7.35 (m, 1H), 3.51 - 3.42 (m, 2H), 2.17 - 2.09 (m, 1H), 0.99 - 0.96 (m, 3H).	426

Scheme 36



***rac-tert*-Butyl ((1*R*,3*R*)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)carbamate (131B)**

Methodology applied was analogous to those described in **General Method 1**.

Yield: 220 mg (44%). ¹H NMR (400 MHz, CDCl₃) δ δ 8.35 - 8.34 (m, 4H), 5.35 (s, 1H), 5.18 - 5.15 (m, 1H), 4.84 - 4.82 (m, 1H), 4.56 - 4.53 (m, 1H), 4.36 (dd, *J* = 6.9, 13.8 Hz, 1H), 4.26 - 4.18 (m, 1H), 4.02 - 3.94 (m, 2H), 2.55 - 2.47 (m, 1H), 2.36 (d, *J* = 1.0 Hz,

6H), 2.30 - 2.16 (m, 2H), 2.10 - 1.89 (m, 4H), 1.46 - 1.43 (m, 24H).; MS (ESI+) m/z 325 (M+H)⁺.

***rac*-(1*R*,3*R*)-*N*¹-(5-(Methylthio)pyrimidin-2-yl)cyclopentane-1,3-diamine hydrochloride (131C)**

Methodology applied was analogous to those described in **General Method 2**.

Yield: 250 mg (quant.%). MS (ESI+) m/z 225 (M+H)⁺.

Used in next step without further purification.

***rac*-*N,N*-Bis(4-methoxybenzyl)-2-(((*trans*)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino)benzo[d]thiazole-6-sulfonamide (131D)**

Methodology applied was analogous to those described in **General Method 3**.

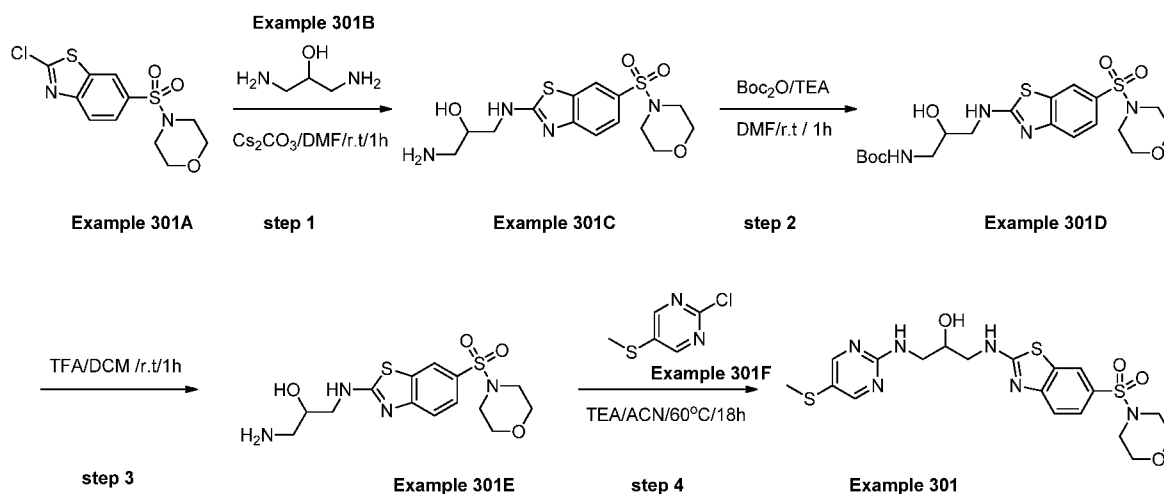
Yield: 52 mg (23%). ¹H NMR (400 MHz, CDCl₃) δ 8.36 (s, 2H), 8.00 (d, J = 1.6 Hz, 1H), 7.74 (dd, J = 1.9, 8.5 Hz, 1H), 7.58 - 7.55 (m, 1H), 7.01 - 6.96 (m, 4H), 6.76 - 6.73 (m, 4H), 5.59 - 5.54 (m, 1H), 5.22 (d, J = 6.9 Hz, 1H), 4.50 - 4.44 (m, 1H), 4.35 - 4.30 (m, 1H), 4.25 (s, 4H), 3.77 - 3.76 (m, 6H), 2.37 - 2.37 (m, 6H), 2.23 - 2.07 (m, 2H); MS (ESI+) m/z 677 (M+H)⁺.

***rac*-2-(((*trans*)-3-((5-(Methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino)benzo[d]thiazole-6-sulfonamide (250)**

Trifluoroacetic acid (1 mL) was added dropwise to an ice cooled solution of *rac*-*N,N*-bis(4-methoxybenzyl)-2-(((*trans*)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino)benzo[d]thiazole-6-sulfonamide (131D) (45 mg, 66.48 μmol, 1.0 eq) in anhydrous dichloromethane (1 mL). The mixture was allowed to warm to ambient temperature over 18 h and was then concentrated to dryness under reduced pressure. The crude residue obtained was purified by preparative HPLC and the clean fractions obtained were freeze dried to give the desired 2-(((*trans*)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino) benzo[d] thiazole-6-sulfonamide (Example 250) as a white powder.

Yield: 23 mg (79%). ¹H NMR (CDCl₃) δ 8.36 (s, 2H), 8.17 (d, *J* = 1.8 Hz, 1H), 7.84 (dd, *J* = 2.0, 8.5 Hz, 1H), 7.59 - 7.52 (m, 1H), 5.34 (d, *J* = 6.5 Hz, 1H), 4.79 (s, 2H), 4.50 - 4.43 (m, 1H), 4.34 - 4.27 (m, 1H), 2.37 - 2.37 (m, 6H), 2.22 - 2.07 (m, 2H).; MS (ESI+) *m/z* 437 (M+H)⁺.

Scheme 41



Step 1: Example 301C

To a solution of **Example 301A** (1 g, 3.14 mmol) in DMF (30 mL) was added Cs₂CO₃ (2.05 g, 6.28 mmol) and **Example 301B** (5.6 g, 62.8 mmol). The mixture was heated to 25 °C for 1 h. TLC detected the starting material was consumed. The reaction was filtered and the filtrate (crude **Example 301C**) was used to next step without any purification.

Step 2: Example 301D

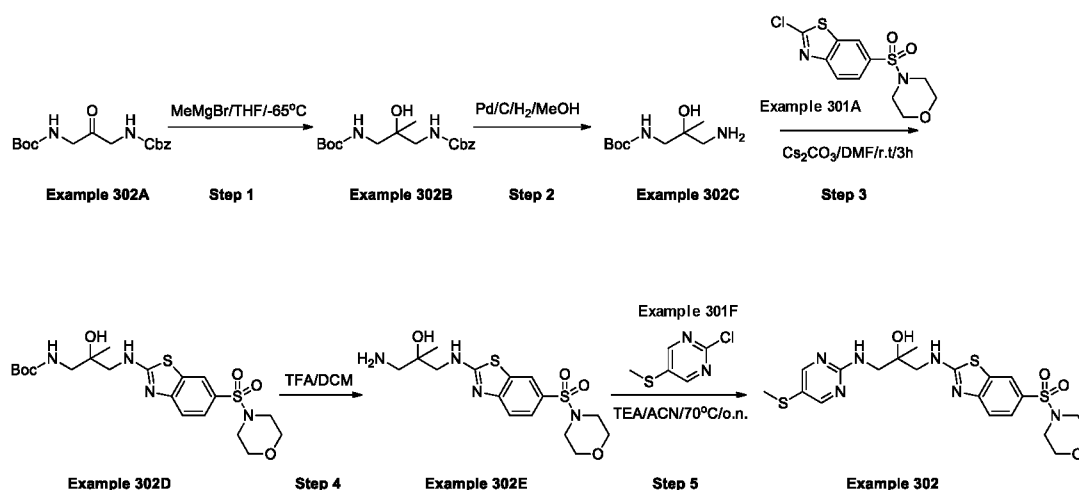
A solution of **Example 301C** was treated with Boc₂O (1.03 g, 4.72 mmol) and stirred at r.t for 2 h. Water (100 mL) was added, then extracted with EA (50 mL x 2), washed with water and brine, dried over Na₂SO₄, filtered, and the filtrate was concentrated under reduced pressure, then purified by silica gel chromatography (eluted with petroleum ether/EtOAc=1/5~1/1) to give the desired product (**Example 301D**, 1.2 g, yield 81%) as a yellow solid. LCMS [M+H]⁺= 573

Step 3: Example 301E

To a solution of **Example 301D** (1.2 g, 2.54 mmol) in DCM (3 mL) was added TFA (1 mL) at r.t. After addition, the reaction mixture was stirred at r.t. for 1 h. TLC detected the starting material was consumed, the mixture was concentrated to give the desired product (**Example 301E** 945 mg, yield: 100%) as a yellow oil, which used to next step without further purification.

Step 4: Example 301

To a solution of **Example 301E** (945mg, 2.54 mmol) in ACN(10 mL) was added TEA (514 mg, 5.08 mmol) and **Example 301F** (408 mg, 2.54 mmol) at r.t. then to 70 °C for 18 h. TLC detected the starting material was consumed. The reaction was concentrated and purified by silica gel chromatography (eluted with petroleum ether/ EtOAc=3/1~5/3) to give the desired product **Example 301** (780 mg, yield: 61%) as a white solid. LCMS $[M+H]^+ = 497$. ^1H NMR (400 MHz, DMSO- d_6) δ 8.78 (s, 1H), 8.34 (s, 2H), 8.12 (d, $J = 1.6$ Hz, 1H), 7.54 (dd, $J = 8.5, 1.8$ Hz, 1H), 7.48 (d, $J = 8.5$ Hz, 1H), 3.94-3.86 (m, 1H), 3.59 (dd, $J = 16.6, 11.9$ Hz, 6H), 3.39 (dd, $J = 19.4, 5.9$ Hz, 4H), 2.85-2.81 (m, 4H), 2.33 (s, 3H).

Scheme 42**Step 1: Example 302B**

A solution of **Example 302A** (6.77g, 21 mmol) in THF (200 mL) under N₂ atmosphere was cooled to -65 °C. MeMgBr (21 mL, 63.1 mmol, 3M in THF) was added dropwise, then stirred at -65 °C for 0.5 h. The reaction was warmed to r.t. for 2 h, quenched by addition of water (200 mL). After extraction with EtOAc (200 mL x 2), the combined organic layer was dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The residue was purified by silica gel chromatography (eluted with petroleum ether/EtOAc=3/1) to give the desired product **Example 302B** (4 g, yield 56%) as a yellow oil. LCMS [M+H]⁺ = 339

Step 2: Example 302C

To a solution of **Example 302B** (4g, 0.012 mmol) in MeOH (40 mL) a suspension of Pd/C (400 mg) catalyst was introduced into the reactor. The vessel was purged with nitrogen and then with hydrogen, and the reaction mixture was stirred at r.t. for 18 h. TLC and LCMS detected the starting material was consumed. **Example 302C** (4 g, yield: 100%) was obtained by filtration and concentrated and used in the next step without any purification. LCMS [M+H]⁺ = 205

Step 3: Example 302D

To a solution of **Example 301A** (154 mg, 0.48 mmol) in DMF (30 mL) was added Cs₂CO₃ (313 mg, 0.96 mmol) and **Example 302C** (982 mg, 4.8 mmol), the mixture was heated to 25 °C for 2h. TLC detected the starting material was consumed. The reaction was filtered and the filtrate was concentrated under reduced pressure and purified by silica gel chromatography (eluted with petroleum ether/ EtOAc=1/1~1/4) to give the desired product **Example 302D** (500mg, yield: 100%) as a white solid. LCMS [M+H]⁺ = 487

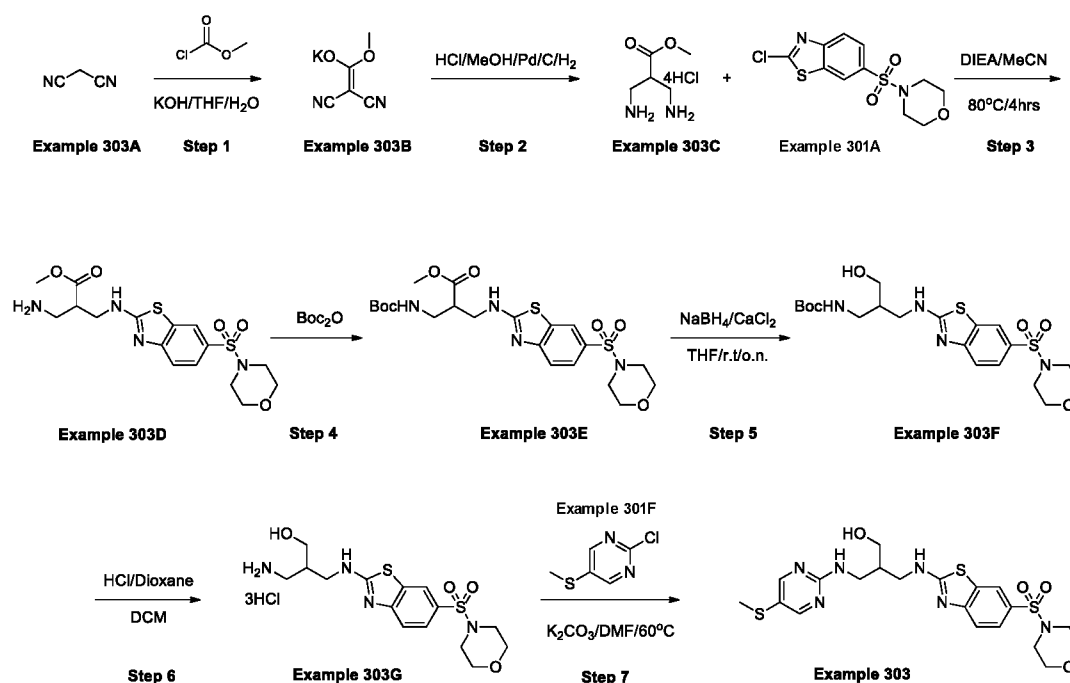
Step 4: Example 302E

To a solution of **Example 302D** (486 mg, 2 mmol) in DCM (2 mL) was added TFA (1 mL) at r.t. After addition, the reaction mixture was stirred at r.t. for 1 h. TLC detected the starting material was consumed, the mixture was concentrated to give the desired product **Example 302E** (532 mg, yield: 100%) as a yellow oil which used to next step without further purification.

Step 5: Example 302

Example 302E (193 mg, 0.5mmol), TEA (101 mg, 1 mmol) and **Example 301F** (81 mg, 0.5 mmol) were dissolved in ACN (5 mL), the mixture was heated to 60 °C for 18 h. LCMS detected TM was formed. Purified by Pre-HPLC to give the desired product **Example 302** (15 mg, yield: 6%) as a white solid. LCMS $[M+H]^+ = 511$
 ^1H NMR (400MHz, CDCl_3) δ 8.41 (s, 2H), 7.98 (s, 1H), 7.65 (s, 2H), 6.10 (s, 1H), 3.77-3.72 (m, 4H), 3.67-3.52 (m, 4H), 3.04-2.98 (m, 4H), 2.38 (s, 3H), 1.33 (s, 3H).

Scheme 43



Step 1: Example 303B

To a solution of **Example 303A** (33 g, 500 mmol) and methyl carbonochloridate (49.5 g, 520 mmol) in THF (75 mL) was added KOH (56.1 g, 1000 mmol) in H₂O (50 mL) over a period of 30 min (maintaining internal temperature below 40 °C). After addition, the suspension was stirred at room temperature for 16 h. The suspension was filtered and the filter cake was washed with EtOH (50 mL x 3) and dried in vacuum to afford the desired product **Example 303B** (67 g, yield 82.7%) as a white solid. LCMS $[M+H]^+ = 163$

Step 2: Example 303C

To a solution of **Example 303B** (4 g, 24.52 mmol) in MeOH (300 mL) and HCl (5 mL, 4.0 M in MeOH) was added Pd/C (8 g) at room temperature. The suspension was stirred under 15 psi of H₂ at room temperature for 44 h. LCMS showed the starting material was consumed completely and the desired product was detected. The mixture was filtered and the filter cake was washed with MeOH (30 mL x 3). The filtrates were concentrated under reduced pressure to afford the product **Example 303C** (3.7 g, yield: 54.4%) as a yellow solid. LCMS [M+H]⁺ = 133.2

Step 3: Example 303D

A solution of **Example 303C** (2.18 g, 7.84 mmol), **Example 301A** (0.5 g, 1.57 mmol) and DIEA (13.35 g, 103.5 mmol) in MeCN (100 mL) was heated to 80 °C and stirred for 4 h. LCMS showed the starting material was consumed completely and the desired product was detected. The reaction mixture **Example 303D** was used for the next step without further purification. LCMS [M+H]⁺ = 415.5

Step 4: Example 303E

Boc₂O (5 g, 22.9 mmol) was added to a solution of **Example 303D** at room temperature and stirred for 1 h. LCMS showed the starting material was consumed. The reaction was diluted with DCM (200 mL) and washed with water (150 mL x 2), brine (200 mL x 3), dried over Na₂SO₄, filtered and concentrated under reduced pressure, which was purified by silica gel chromatography (eluted with petroleum ether/ EtOAc=2/1~1/9) to afford the product **Example 303E** (680 mg, yield: 76.7% over two steps) as a white solid. LCMS [M+H]⁺ = 515.5

Step 5: Example 303F

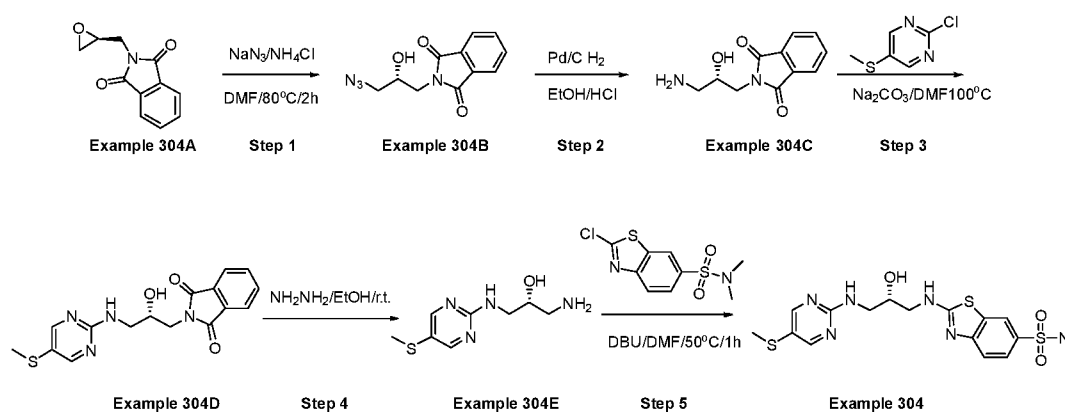
To a solution of **Example 303E** (840 mg, 1.63 mmol) in THF (20 mL) was added CaCl₂ (363 mg, 3.27 mmol) and NaBH₄ (124 mg, 3.27 mmol) at room temperature and the reaction was stirred for 16 h. The reaction was poured into sat. aq. NH₄Cl (100 mL) and diluted with EtOAc (30 mL) and separated. The aqueous layer was extracted with EtOAc (30 mL x 2) and the combined organic layers were concentrated and purified by silica gel chromatography (eluted with petroleum ether/EtOAc=3/1~1/9) to afford the product **Example 303F** (383 mg, yield: 48.3%) as a white solid. LCMS [M+H]⁺ = 487.6

Step 6: Example 303G

To a solution of **Example 303F** (553 mg, 1.14 mmol) dissolved in DCM (10 mL) was added HCl/Dioxane (4.0 M, 10 mL) at room temperature and the reaction was stirred for 0.5 h. TLC showed the starting material was consumed. The reaction mixture was concentrated under reduced pressure to afford the product **Example 303G** (563 mg, yield: 100%) as a white solid. LCMS $[M+H]^+ = 387.5$

Step 7: Example 303

To a solution of **Example 303G** (563 mg, 1.14 mmol) and K_2CO_3 (940 mg, 6.82 mmol) in DMF (10 mL) was added **Example 301A** (183 mg, 1.14 mmol) at room temperature. The reaction was then heated to 60 °C and stirred for 16 h. TLC showed the starting material was consumed. The mixture was cooled to room temperature and diluted with EtOAc (30 mL) and washed with water (20 mL). The aqueous layer was extracted with EtOAc (20 mL x 4) and the combined organic layers were washed with brine (20 mL x 2), dried over Na_2SO_4 , filtered and concentrated. The residue was purified by silica gel chromatography (eluted with petroleum ether/ EtOAc=3/1~1/9) to afford the crude product, which was purified by prep-HPLC to afford the product **Example 303** (75.2 mg, yield: 12.93%), as a light yellow solid. LCMS $[M+H]^+ = 511$
 ^1H NMR (400 MHz, $CDCl_3$) δ 8.37 (s, 2H), 7.96 (s, 1H), 7.66-7.58 (m, 2H), 6.82 (s, 1H), 5.87 (s, 1H), 3.83-3.73 (m, 5H), 3.59-3.44 (m, 5H), 3.01 (s, 4H), 2.38 (s, 3H), 2.14-2.08 (m, 1H).



Step 1: Example 304B

Example 304A (23.6 g, 0.12 mol), NaN₃ (15.1 g, 0.23 mol) and NH₄Cl (7.5 g, 0.14 mol) were suspended in DMF (250 mL), and the resulting mixture was heated to 80 °C for 1 h. After TLC detected the reaction was complete, EtOAc (1 L) was added, and the organic extract was washed with water (200 mL x 5), dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The residue was purified by silica gel chromatography (eluted with petroleum ether/EtOAc=5/1) to give the desired product

Example 304B (29 g, yield 100%) as a white solid. LCMS [M+H]⁺ = 247

Step 2: Example 304C

To a solution of **Example 304B** (29 g, 0.12 mol) in EtOH (400 mL) was added HCl (22 mL) and Pd/C (1 g), and the heterogeneous mixture was stirred at r.t. for 18 h under H₂. TLC detected the starting material was mostly consumed. The mixture was filtered and the filtrate was concentrated to give the desired product **Example 304C** (21 g, yield: 100 %) as a white solid. LCMS [M+H]⁺ = 221

Step 3: Example 304D

To a solution of **Example 304C** (6.6g, 3 mol) in DMF (50 mL) was added 2-chloro-5-(methylthio)pyrimidine (2.4 g, 15 mmol) and TEA (7.6 g, 75 mmol). The resulting mixture was stirred at 100 °C for 1 h. TLC detected the starting material was consumed. The reaction mixture was concentrated and purified by silica gel chromatography (eluted with petroleum ether/EtOAc=1/1~1/4) to give the desired product **Example 304D** (450 mg, yield: 8 %) as a white solid. LCMS [M+H]⁺ = 345

Step 4: Example 304E

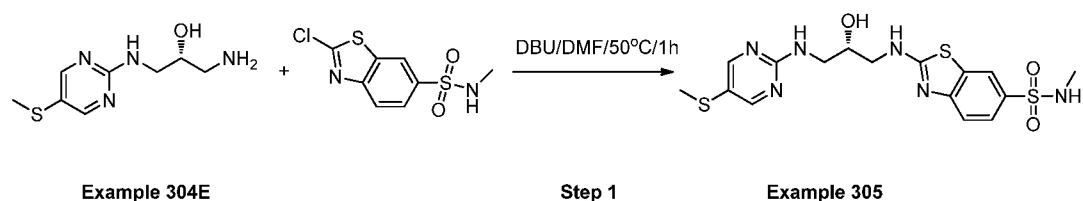
To a solution of **Example 304D** (450 mg, 1.3 mmol) in EtOH (5 mL) was added hydrazine hydrate (131 mg, 2.6 mmol) at r.t. TLC after 3 h detected the starting material was consumed, at which point the reaction was concentrated and purified by silica gel chromatography (eluted with DCM/MeOH =10/1) to give the desired product **Example 304E** (120 mg, yield: 43 %) as a white solid.

Step 5: Example 304

To solution of **Example 304E** (43 mg, 0.20 mmol) and 2-chloro-N,N-dimethylbenzo[d]thiazole-6-sulfonamide (37 mg, 0.13 mmol) in DMF (1 mL) was added DBU (40 mg, 0.26 mmol). The resulting mixture was stirred at 50 °C for 1 h. TLC

detected the starting material was consumed, and the reaction mixture was concentrated and purified by Pre-TLC to give the desired product **Example 304** (30 mg, yield: 51 %) as a white solid. LCMS $[M+H]^+ = 454.9$. ^1H NMR (400 MHz, CDCl_3) δ 8.35 (s, 2H), 7.99 (d, $J = 1.5$ Hz, 1H), 7.67 (dd, $J = 8.5, 1.7$ Hz, 1H), 7.59 (d, $J = 8.5$ Hz, 1H), 5.97 (s, 1H), 4.11 (dd, $J = 9.3, 4.8$ Hz, 1H), 3.74 (dd, $J = 13.7, 4.3$ Hz, 1H), 3.66 (s, 1H), 3.58 (dd, $J = 13.6, 6.3$ Hz, 2H), 2.70 (s, 6H), 2.37 (s, 3H).

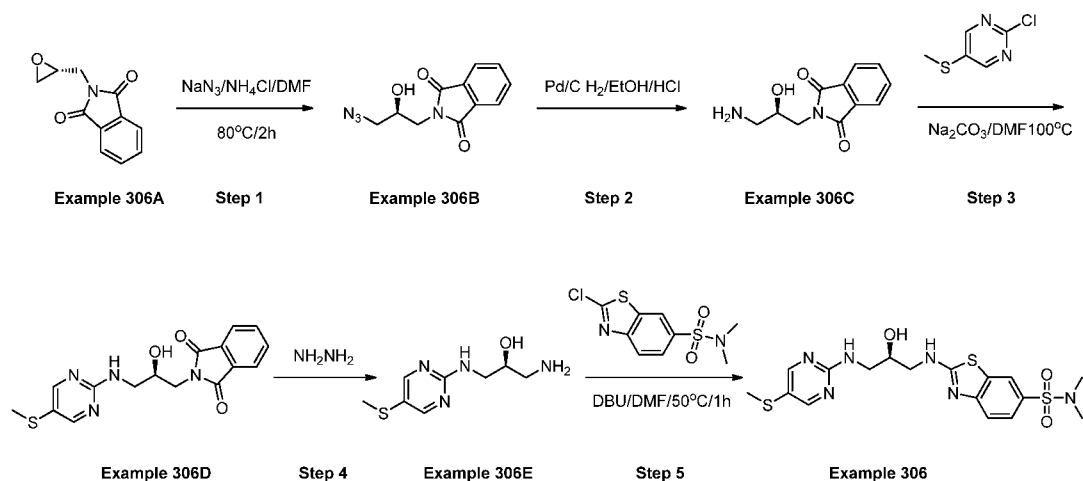
Scheme 45



Step 1: Example 305

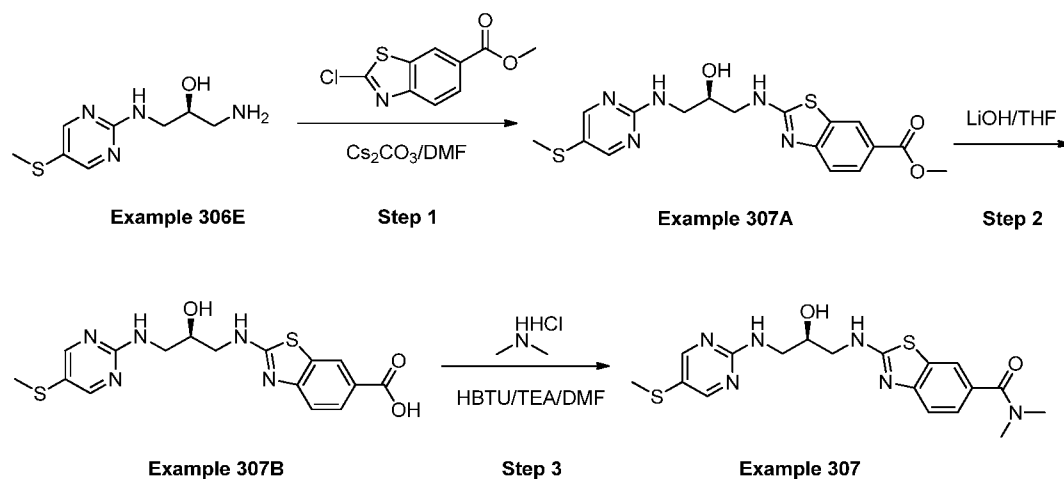
To solution of **Example 304E** (30 mg, 0.14 mmol) and 2-chloro-N-methylbenzo[d]thiazole-6-sulfonamide (24.5 mg, 0.09 mmol) in DMF (2 mL) was added DBU (47 mg, 0.18 mmol). After addition, the mixture was stirred at 50 °C for 1 h. LCMS determined that starting material was consumed. The mixture was cooled to room temperature, diluted with EtOAc (5 mL) and washed with brine (5 mL). The organic layer was concentrated and purified by Pre-TLC to give the desired product **Example 305** (23.8 mg, yield: 60 %) as a white solid. LCMS $[M+H]^+ = 440.9$. ^1H NMR (400 MHz, $\text{MeOD}-d_4$) δ 8.35 (s, 2H), 8.07 (s, 1H), 7.69 (dd, $J = 8.0$, 1H), 7.50 (d, $J = 8.0$ Hz, 1H), 4.06 (m, 0.46H), 3.57 (m, 4H), 2.51 (s, 3H), 2.32 (s, 3H).

Scheme 46



Example 306 (30 mg, yield: 50%) was prepared in analogous fashion as a white solid starting from **Example 306A**: LCMS $[M+H]^+ = 454.9$. ^1H NMR (400 MHz, CDCl_3) δ 8.35 (s, 2H), 7.98 (d, $J = 1.5$ Hz, 1H), 7.66 (dd, $J = 8.5, 1.7$ Hz, 1H), 7.58 (d, $J = 8.5$ Hz, 1H), 6.04 (t, $J = 5.6$ Hz, 1H), 4.11 (dd, $J = 9.3, 5.1$ Hz, 1H), 3.74-3.64 (m, 2H), 3.61-3.54 (m, 2H), 2.70 (s, 6H), 2.36 (s, 3H).

Scheme 47



Step 1: Example 307A

To a solution of **Example 306E** (100 mg, 0.47 mmol) in DMF (0.5 mL) was added DBU (89 mg, 0.58 mmol) and methyl 2-chlorobenzo[d]thiazole-6-carboxylate (89 mg, 0.39 mmol). The mixture was heated to 50 °C for 1 h. After TLC determined the starting material was consumed, the mixture was concentrated and purified by silica gel chromatography (eluted with petroleum ether/ EtOAc=1/1~1/4) to give the desired product **Example 307A** (50 mg, yield: 26 %) as a white solid. LCMS $[M+H]^+ = 406$

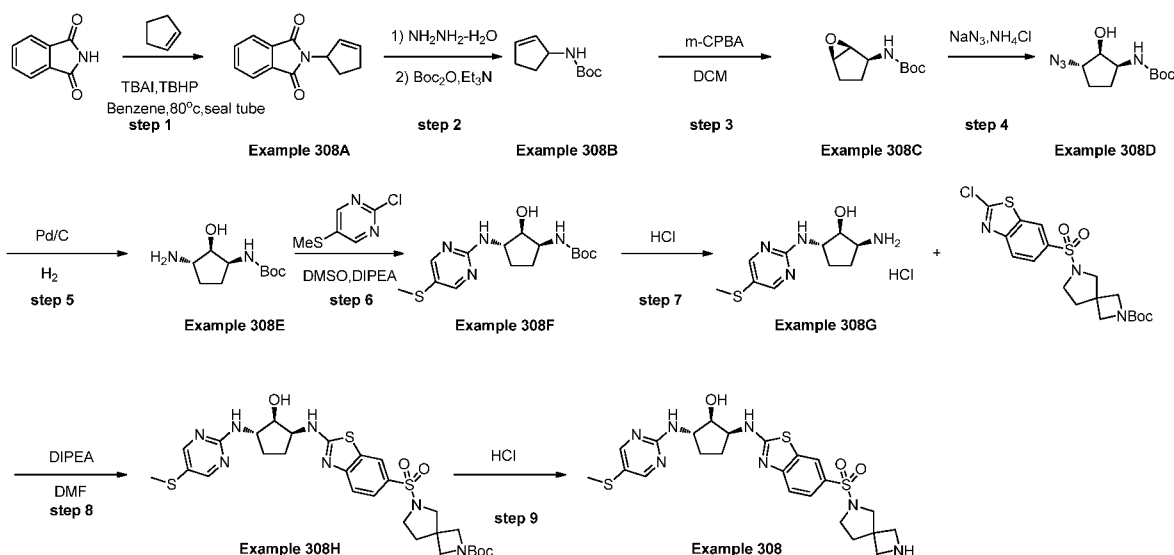
Step 2: Example 307B

To a solution of **Example 307A** (50 mg, 0.12 mmol) in THF (1 mL) was added LiOH (0.4 mL, 1M in water) and the resulting mixture was stirred at r.t. for 18 h. After TLC determined the starting material was consumed, the mixture was concentrated and purified by silica gel chromatography (eluted with DCM/MeOH=10/1) to give the desired product **Example 307B** (5 mg, yield: 11 %) as a white solid. LCMS $[M+H]^+ = 392$

Step 3: Example 307

A solution of **Example 307B** (10 mg, 0.025 mmol) was charged with dimethylamine hydrochloride (2.5 mg, 0.031 mmol), TEA (8 mg, 0.075 mmol) and HBTU (14 mg, 0.038 mmol). The resulting mixture was stirred at r.t. for 1 h. After TLC detected the starting material was consumed, the mixture was concentrated and purified by Pre-TLC (eluted with EtOAc) to give the desired product **Example 307** (2 mg, yield: 19 %) as a white solid. LCMS $[M+H]^+ = 419$. ^1H NMR (400 MHz, CDCl_3) δ 8.36 (s, 2H), 7.67 (s, 1H), 7.53 (d, $J = 8.2$ Hz, 1H), 7.35 (dd, $J = 8.3, 1.5$ Hz, 1H), 5.91 (s, 1H), 4.14-4.00 (m, 1H), 3.72-3.64 (m, 2H), 3.53 (dd, $J = 13.8, 6.3$ Hz, 2H), 3.07 (s, 6H), 2.37 (s, 3H).

Scheme 48



Step 2: Example 308A

A Schlenk tube equipped with magnetic stir bar was charged with TBAI (5 g, 13.6 mmol), cyclopentene (9.25 g, 136 mmol), and O-Phthalimide (10 g, 68 mmol) in 250 mL of benzene. A solution of 65% TBHP (18.8 g, 136 mmol) was added before the vial was sealed and the reaction mixture was stirred at 80 °C for 12 h. After cooling to room temperature, the reaction mixture was diluted in ethyl acetate and washed with brine. The aqueous phase was extracted with ethyl acetate. The combined organic layers were concentrated under reduced pressure. The residue was purified by silica gel column chromatography (eluting with PE/ethyl acetate=5/1) to afford the desired compound **Example 308A** (6.5 g) as a white solid. LCMS $[M+H]^+ = 214$.

^1H NMR (400 MHz, CDCl_3) δ 2.08-2.17 (m, 1H), 2.32-2.47 (m, 1H), 2.41-2.53 (m, 1H), 2.80-2.88 (m, 1H), 5.33-5.46 (m, 1H), 5.61- 5.70 (m, 1H), 6.07-6.16 (m, 1H), 7.67-7.75 (m, 2H), 7.80-7.87 (m, 2H).

Step 2: Example 308B

To a solution of **Example 308A** (5 g, 23.5 mmol) in THF (25 mL) was added 50% hydrazine hydrate in H_2O (3.52 g, 35.2 mmol). The mixture was stirred at 70 °C for 2 h. The mixture was then filtered and concentrated under reduced pressure. Di-tert-butyl dicarbonate (10.2 g, 47 mmol) was added and the mixture was stirred at room temperature overnight. The reaction mixture was concentrated under reduced pressure,

and the residue was purified by silica gel column chromatography (eluting with PE/ethyl acetate=5/1) to afford the desired compound **Example 308B** (550 mg) as a white solid. LCMS $[M+H]^+ = 184$.

Step 3: Example 308C

To a solution of **Example 308B** (700 mg, 3.825 mmol) in DCM (5 mL) was added m-CPBA (790 mg, 4.59 mmol) portion-wise at 0 °C. Following addition, the mixture was stirred at room temperature overnight. The resulting mixture was cooled to 0 °C and the m-chlorobenzoic acid filtered off and washed with additional cold DCM. The combined filtrate and wash were stirred with 20% NaHSO₃ for 30 min. The DCM layers were separated and extracted with 3 N NaOH (3 x 30 mL), saturated NaCl (30 mL), and then dried over Na₂SO₄. Evaporation left a white solid, which was purified by silica gel column chromatography (eluting with PE/ethyl acetate=5/1) to afford the desired compound **Example 308C** (455 mg) as a white solid. LCMS $[M+H]^+ = 144$. ¹H NMR (400 MHz, CDCl₃) δ 1.07-1.17 (m, 1H), 1.48 (s, 9H), 1.66-1.76 (m, 1H), 1.89-1.96 (m, 1H), 2.05-2.16 (m, 1H), 3.41-3.50 (m, 1H), 3.53 (br s, 1H), 4.07-4.26 (m, 1H), 4.63-4.77 (m, 1H).

Step 4: Example 308D

A mixture of **Example 308C** (445 mg, 2.28 mmol), NaN₃ (297 mg, 4.57 mmol), NH₄Cl (61 mg, 1.14 mmol), 2-methoxyethanol (5 mL) and H₂O (1 mL) was stirred in a bath maintained at 80 °C for 16 hr. The resulting solution was evaporated to dryness, and the residue was dissolved in H₂O (5 mL). This solution was saturated with NaCl and then extracted with DCM (4 x 5 mL). The DCM solution was evaporated, the residue was purified by silica gel column chromatography (eluting with MeOH/DCM=3%-5%) to afford the desired compound **Example 308D** (420 mg) as a colorless oil. LCMS $[M+H]^+ = 188$.

Step 5: Example 308E

A suspension of **Example 308D** (420 mg, 1.74 mmol), Pd/C (cat.) in EtOH (5 mL) was stirred at r.t. for 16h under H₂ atmosphere. The mixture was filtered and concentrated *in vacuo*. The residue was dried and used directly in the next step without further purification **Example 308E** (320 mg). LCMS $[M+H]^+ = 217$.

Step 6: Example 308F

A mixture of **Example 308E** (150 mg, 0.694 mmol), 2-chloro-5-(methylthio)pyrimidine (111 mg, 0.694 mmol), DIPEA (180 mg, 1.4 mmol) in DMSO (5 mL) was stirred at 130 °C for 3 hr. The resulting solution was cooled to room temperature, poured into water, and extracted with EtOAc (3 x 10 mL). The combined organic layers were concentrated under reduced pressure. The residue was purified by silica gel column chromatography (eluting with PE/EA=2/1) to afford the desired compound **Example 308F** (100 mg) as a colorless oil. LCMS $[M+H]^+ = 341$.

^1H NMR (400 MHz, CDCl_3) δ 1.45 (s, 9H), 1.75-1.85 (m, 1H), 2.13-2.21 (m, 1H), 2.23-2.30 (m, 1H), 2.38 (s, 3H), 3.83-4.05 (m, 3H), 5.33 (br s, 1H), 5.57 (br s, 1H), 8.35 (s, 2H).

Step 7: Example 308G

To a solution of **Example 308F** (100 mg, 0.294 mmol) in DCM (3 mL) was added 4 M HCl in dioxane (3 mL). The mixture was stirred at room temperature for 2 h. The mixture was concentrated under reduced pressure, dried and used directly in the next step without further purification **Example 308G** (70.6 mg). LCMS $[M+H]^+ = 241$.

Step 8: Example 308H

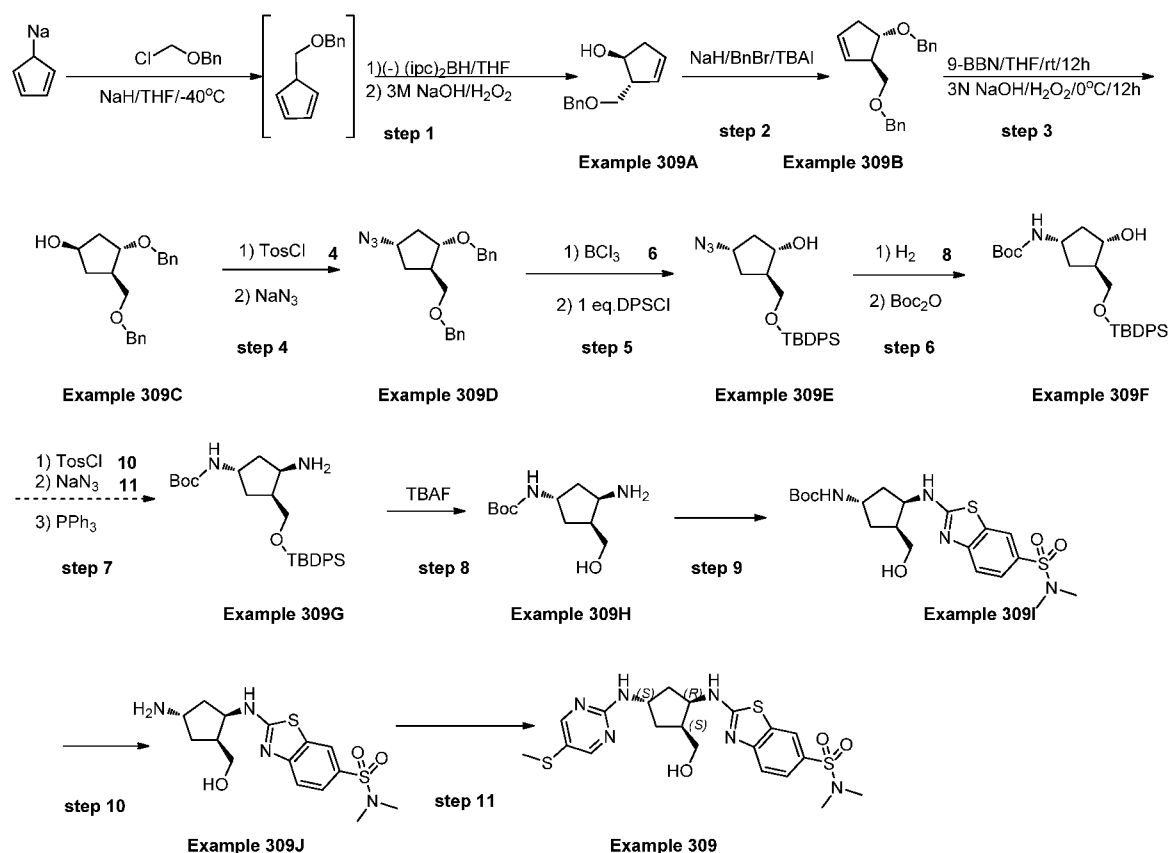
A mixture of **Example 308G** (70.6 mg, 0.256 mmol), tert-butyl 6-((2-chlorobenzo[d]thiazol-6-yl)sulfonyl)-2,6-diazaspiro[3.4]octane-2-carboxylate (130 mg, 0.294 mmol), DIPEA (99 mg, 0.768 mmol) in DMF (4 mL) was stirred at 40 °C for 2 days. The resulting solution was cooled to room temperature, poured into water, and extracted with EtOAc (3 x 10 mL). The combined organic layers were concentrated under reduced pressure. The residue was purified by silica gel column chromatography (eluting with MeOH/DCM=5%) to afford the desired compound **Example 308H** (70 mg) as a white solid. LCMS $[M+H]^+ = 648$.

Step 9: Example 308

To a solution of **Example 308H** (70 mg, 0.108 mmol) in DCM (3 mL) was added 4 M HCl in dioxane (3 mL). The mixture was stirred at room temperature for 2 h. The reaction mixture was concentrated and purified by prep-HPLC to afford the title compound **Example 308** (20 mg) as a white solid. LCMS $[M+H]^+ = 548$.

^1H NMR (400 MHz, DMSO- d_6) δ 1.47 - 1.56 (m, 1 H), 1.63 - 1.73 (m, 1 H), 1.97 (t, $J=6.98$ Hz, 2 H), 2.06 - 2.23 (m, 2 H), 2.31 - 2.41 (m, 3 H), 3.19 (t, $J=6.98$ Hz, 2 H), 3.35 (s, 2 H), 3.68 (t, $J=6.04$ Hz, 4 H), 3.95 - 4.02 (m, 1 H), 4.15 (br. s., 1 H), 4.38 (br. s., 1 H), 7.48 (d, $J=8.33$ Hz, 1 H), 7.59 (dd, $J=8.33$, 1.88 Hz, 2 H), 8.16 (d, $J=1.88$ Hz, 1 H), 8.37 (s, 2 H), 8.49 (d, $J=7.79$ Hz, 2 H), 8.66 (br. s., 1 H).

Scheme 49



Step 1: Example 309A

Sodium cyclopentadienylide (2 M solution in THF, 50 mL, 100 mmol, 1 equiv) was added dropwise to a solution of benzylchloromethyl ether (90%, 23 g, 130 mmol, 1.3 equiv) in DMF (200 mL) at -40 °C. After 20 min of vigorous stirring at -40 °C, the reaction mixture was poured into a 2:1 mixture of pentane/ice-cold water (900 mL). After shaking and allowing the phases to separate, the organic layer was washed twice with 150 mL of cold water and dried over Na₂SO₄ with stirring, maintaining the temperature below 0 °C to avoid isomerization of the double bonds. After removal of the drying agent by

filtration, the pentane was removed *in vacuo* at 0 °C to afford (benzyloxymethyl)cyclopent-2,4-ene **1** as a pale orange oil. The resulting crude material was kept at 0 °C under argon and diluted with THF (160 mL), cooled to -78 °C, and added dropwise *via* a cannula to a suspension of (–)-Ipc2BH (1 M solution in THF, 100 mL, 100 mmol, 1 equiv) in THF (400 mL) at -78 °C. The mixture was allowed to warm slowly to -10 °C and stirred for 3 days at that temperature. The reaction was then quenched by addition of MeOH (40 mL), followed by a 3 M aqueous solution of NaOH (40 mL) and 30% H₂O₂ (40 mL). After 24 h of vigorous stirring at room temperature, the THF was removed under reduced pressure and the remaining aqueous suspension was partitioned between EtOAc (400 mL) and brine (200 mL). After extraction, the organic layer was dried over Na₂SO₄ and concentrated *in vacuo*. The crude orange oil was purified by column chromatography (eluent: 9:1 ~ 8:2 heptane:EtOAc) to give **Example 309A** (4.8 g, 23.53 mmol, 23%) as a pale yellow oil. *R*_f = 0.29 (eluent: 7:3 heptane:EtOAc); ¹H NMR (400 MHz, CDCl₃) δ 2.23-2.32 (m, 1H), 2.35 (s, 1H), 2.63-2.73 (m, 1H), 2.81-2.88 (m, 1H), 3.28 (t, *J* = 8.9 Hz, 1H), 3.53 (dd, *J* = 5.4, 9.1 Hz, 1H), 4.29 (td, *J* = 4.1, 7.0 Hz, 1H), 4.52 (s, 2H), 5.53-5.58 (m, 1H), 5.70-5.74 (m, 1H), 7.24-7.37 (m, 5H).

Step 2: Example 309B

To a solution of **Example 309A** (4.8 g, 23.53 mmol, 1 equiv) in anhydrous THF (100 mL) was added NaH (50% in mineral oil, 1.13 g, 28.2 mmol, 1.2 equiv) at 0 °C and the mixture was stirred for 20 min at temperature. Benzyl bromide (BnBr, 3.6 mL, 30.5 mmol, 1.3 equiv) and tetrabutylammonium iodide (TBAI, 100 mg, 0.3 mmol, 0.01 equiv) were then added at 0 °C and the reaction mixture was stirred at room temperature. After 15 h, crushed ice was added carefully and the mixture was stirred for 30 min. After extraction with EtOAc (150 mL), the organic layer was washed with H₂O (150 mL), brine (150 mL), dried over Na₂SO₄ and concentrated *in vacuo*. Purification by column chromatography (eluent: 98:2 ~ 95:5 heptane:EtOAc) gave **Example 309B** (6.3 g, 21.4 mmol, 80%) as a colorless syrup. *R*_f = 0.41 (eluent: 9:1 heptane:EtOAc). LCMS [M+H]⁺ = 295.1 ¹H NMR (500 MHz, CDCl₃) δ 2.42 (d, *J* = 17.4 Hz, 1H), 2.65-2.70 (m, 1H), 3.07 (brs, 1H), 3.33 and 3.44 (ABX, *J*_{AB} = 9.2 Hz, *J*_{AX} = 5.7 Hz, *J*_{BX} = 7.3 Hz,

2H), 4.08 (ddd, $J = 3.0, 3.3, 7.0$ Hz, 1H), 4.51 (d, $J = 3.4$ Hz, 2H), 4.54 (s, 2H), 5.64-5.66 (m, 1H), 5.74-5.75 (m, 1H), 7.22-7.34 (m, 10H).

Step 3: Example 309C

A 0.5 M solution of 9-BBN in THF (88 mL, 44 mmol) was added dropwise to a solution of **Example 309B** (6.50 g, 22.0 mmol) in anhydrous THF (10 mL) at 0 °C under nitrogen. The reaction was slowly warmed to r.t. overnight. The reaction was cooled to 0 °C and treated sequentially with EtOH (7 mL), 3 N NaOH solution (20 mL), and H₂O₂ (33%, 20 mL). The resulting mixture was stirred at r.t. overnight. The resulting residue was filtered and washed with EtOAc (200 mL). To this suspension, water was added (150 mL) and after separation of the phases, the aqueous layer was extracted with EtOAc (3 × 50 mL). The combined organic layers were dried (Na₂SO₄) and concentrated to dryness. The crude product was purified on silica gel (eluent: 1:1 heptane:EtOAc) gave **Example 309C** (6.0 g, 19.3 mmol, 87%) as a yellow oil. LCMS $[M+H]^+ = 313$. ¹H NMR (400 MHz, CDCl₃) δ 7.35-7.25 (m, 10H, CH-arom.), 4.52 (s, 2 H, CH₂-benzyl), 4.49 (d, 1H, $J = 11.8$ Hz, CHH-benzyl), 4.44 (d, 1H, $J = 11.8$ Hz, CHH-benzyl), 4.33-4.28 (m, 1H, H-1), 4.07 (ddd, 1H, $J = 6.6$ Hz, 6.6 Hz, 4.1 Hz, H-3), 3.53 (dd, 1H, $J = 9.0$ Hz, 4.2 Hz, OCHH), 3.49 (d, 1H, $J = 9.0$ Hz, 4.3 Hz, OCHH), 2.35-2.25 (m, 2H, H-4, H-5a), 2.05 (dddd, 1H, $J = 13.5$ Hz, 6.7 Hz, 3.5 Hz, 1.7 Hz, H-2a), 1.89-1.82 (m, 1H, H-2b), 1.52-1.46 (m, 1H, H-5b).

Step 4: Example 309D

Compound **Example 309C** (6.0 g, 19.3 mmol) was dissolved in dry pyridine (30 mL) and cooled to 0 °C. TosCl (5.5 g, 28.9 mmol) was added in portions over a period of 30 min. After the addition, the reaction was stirred at room temperature for 18 h. The suspension was diluted with ethyl acetate (300 mL) and H₂O (200 mL). The organic phase was separated, washed with sat. NH₄Cl solution (3 × 200 mL), brine (100 mL) and dried over MgSO₄. The solvent was evaporated and the residue was purified by flash chromatography silica gel (hexane/ethyl acetate 5:1) to give (1R,3S,4R)-3-(benzyloxy)-4-((benzyloxy)methyl)cyclopentyl 4-methylbenzenesulfonate (1.4 g, 3.0 mmol, 15%) as a colourless oil. $R_f = 0.26$ (20% ethyl acetate in hexane). LCMS $[M+H]^+ = 467$. ¹H NMR (400 MHz, CDCl₃) δ 7.79 (m, 2H), 7.38-7.27 (m, 12H), 5.05-4.99 (m, 1H), 4.50 (s, 2H),

4.45 (s, 2H), 3.96-3.92 (m, 1H), 3.48-3.40 (td, 2H, $J = 6.3$ Hz), 2.45 (s, 3H), 2.33-2.20 (m, 2H), 2.14-2.01 (m, 2H), 1.69-1.62 (m, 1H).

Compound (1R,3S,4R)-3-(benzyloxy)-4-((benzyloxy)methyl)cyclopentyl 4-methylbenzenesulfonate (1.4 g, 3.0 mmol) was dissolved in dry DMF (20 mL) and NaN_3 (2.1 g, 15.4 mmol) was added. The mixture was stirred at 60 °C for 14 h. After the addition of ethyl acetate (300 mL), the organic layer was washed with sat. NaHCO_3 solution (2×100 mL) and brine (100 mL) and dried over MgSO_4 . The solvent was removed under reduced pressure. The residue was purified by flash chromatography silica gel (hexane/ethyl acetate 10:1) to give **Example 309D** (1.0 g, 2.95 mmol, 95%) as a colourless oil. $R_f = 0.54$ (20% ethyl acetate in hexane). LCMS $[\text{M}+\text{H}]^+ = 338$. ^1H NMR (400 MHz, CDCl_3) δ 7.39-7.25 (m, 10H), 4.52 (dd, $J = 26.0, 18.6$ Hz, 2H), 4.49 (s, 2H), 3.97-3.89 (m, 1H), 3.86 (td, $J = 7.0, 5.1$ Hz, 1H), 3.44 (d, $J = 5.5$ Hz, 2H), 2.54-2.43 (m, 1H), 2.24 (td, $J = 13.8, 6.8$ Hz, 1H), 1.99 (dddd, $J = 13.4, 8.7, 4.7, 1.3$ Hz, 1H), 1.84 (dddd, $J = 28.2, 20.8, 9.5, 4.2$ Hz, 2H).

Step 5: Example 309E

Compound **Example 309D** (1.0 g, 2.95 mmol) was dissolved in dry CH_2Cl_2 (20 mL) and cooled to -78 °C. A solution of 1M BCl_3 (40 mL) in CH_2Cl_2 was added by means of a dropping funnel over a period of 45 min and the mixture was stirred at -78 °C for 3 h, then warmed up to room temperature. The reaction was quenched with dry MeOH (20 mL) at -78 °C and was allowed to warm up to room temperature overnight. The solvents were evaporated and the residue was purified on silica gel (hexane/ethyl acetate 1:1) to give (1S,2R,4S)-4-azido-2-(hydroxymethyl)cyclopentanol (420 mg, 2.67 mmol, 90%) obtained as a yellow oil. LCMS $[\text{M}+\text{H}]^+ = 158$. ^1H NMR (400 MHz, CDCl_3) δ 4.07 (dd, $J = 13.3, 6.0$ Hz, 1H), 4.02-3.95 (m, 1H), 3.79 (ddd, $J = 10.4, 5.2, 3.0$ Hz, 1H), 3.56 (dd, $J = 10.4, 8.0$ Hz, 1H), 2.36-2.20 (m, 4H), 1.99-1.92 (m, 1H), 1.77 (dddd, $J = 14.0, 6.0, 4.5, 1.6$ Hz, 1H), 1.58 (ddd, $J = 13.9, 9.8, 6.8$ Hz, 1H).

Compound (1S,2R,4S)-4-azido-2-(hydroxymethyl)cyclopentanol (0.42 g, 2.67 mmol) was dissolved in dry DMF (10 mL), and imidazole (198 mg, 2.94 mmol) was added at room temperature. After the portion-wise addition of TBDPSCl (808 mg, 2.94 mmol) at 0 °C, the mixture was stirred at room temperature for 16 h. The reaction was diluted with

CH₂Cl₂ (200 mL), washed once with sat. NH₄Cl (70 mL) and with brine (50 mL) and dried over MgSO₄. The solvent was removed in vacuo and the crude product was purified by silica gel (hexane/ethyl acetate 10:1) to give **Example 309E** (630 mg, 1.6 mmol, 60%) obtained as a yellow oil. LCMS [M+H]⁺ = 360. ¹H NMR (400 MHz, CDCl₃) δ 7.69-7.66 (m, 4H), 7.49-7.40 (m, 6H), 4.15 (dd, *J* = 7.0, 7.0 Hz, 1H), 4.02-3.99 (m, 1H), 3.81 (dd, *J* = 4.8, 4.8 Hz, 1H), 3.59 (dd, *J* = 7.2, 7.2 Hz, 1H), 2.35-2.28 (m, 2H), 1.91-1.88 (m, 1H), 1.83-1.78 (m, 1H), 1.70-1.62 (m, 1H), 1.08 (s, 9H).

Step 6: Example 309F

10% Pd/C (63 mg) was added to a suspension of compound **Example 309E** (630 g, 1.6 mmol) in dry EtOH (100 mL). The reaction was evacuated twice to exchange the inert gas atmosphere, and then connected to two balloons that were filled with H₂. The suspension was vigorously stirred at room temperature for 15 h. The palladium catalyst was removed by using a PTFE-Filter (Whatman Puradisc) and the solvent was removed under reduced pressure. The amine (588 g, 100%) was obtained as a colorless liquid, and was used without further purification. LCMS [M+H]⁺ = 370.

To a solution of amine (588 mg, 1.6 mmol) in DCM (50 mL) at 0 °C was added Boc₂O (700 mg, 3.2 mmol) in DCM (10 mL) and stirred at 0 °C, then stirred at RT for 2 h. The reaction mixture was concentrated and the crude product was purified by silica gel (hexane/ethyl acetate 5:1) to give **Example 309F** (650 mg, 1.38 mmol, 87%) obtained as a colourless oil. LCMS [M+H]⁺ = 470. ¹H NMR (400 MHz, CDCl₃) δ 7.68-7.65 (m, 4H), 7.48-7.40 (m, 6H), 4.97 (br s, 1H), 4.20 (m, 1H), 4.02 (br s, 1H), 3.74 (dd, *J* = 4.2, 4.2 Hz, 1H), 3.51 (dd, *J* = 8.4, 8.4 Hz, 1H), 2.29-2.22 (m, 2H), 1.78-1.57 (m, 3H), 1.45 (s, 9H), 1.07 (s, 9H).

Step 7: Example 309G

Compound **Example 309F** (630 mg, 1.34 mmol), DIEA (300 mg, 2.28 mmol) and DMAP (278 mg, 2.28 mmol) in DCM (50 mL) was added TosCl (384 mg, 2.0 mmol) at 0°C. The mixture was stirred at RT for 14 h and then concentrated to dryness. The crude product was purified by silica gel (hexane/ethyl acetate 10:1) to give (1S,2R,4S)-4-(((tert-butoxycarbonyl)amino)-2-(((tert-butyl) diphenylsilyl)oxy)methyl)cyclopentyl 4-

methylbenzenesulfonate (590 mg, 0.94 mmol, 70%) obtained as a colourless oil. LCMS $[M+H]^+ = 625$.

(1S,2R,4S)-4-((tert-butoxycarbonyl)amino)-2-(((tert-butyldiphenylsilyl)oxy)methyl)cyclopentyl 4-methylbenzenesulfonate (590 g, 0.94 mmol) was dissolved in dry DMF (10 mL) and NaN_3 (92 mg, 1.4 mmol) was added. The mixture was stirred at 60 °C for 14 h. After the addition of ethyl acetate (100 mL), the organic layer was washed with sat. NaHCO_3 solution (2×50 mL) and brine (50 mL) and dried over MgSO_4 . The solvent was removed under reduced pressure. The residue was purified by flash chromatography silica gel (hexane/ethyl acetate 5:1) to give tert-butyl ((1S,3R,4S)-3-azido-4-(((tert-butyldiphenylsilyl)oxy)methyl)cyclopentyl)carbamate (460 mg, 0.93 mmol, 99%) as a colourless oil. $R_f = 0.54$ (20% ethyl acetate in hexane). LCMS $[M+H]^+ = 496$. ^1H NMR (400 MHz, CDCl_3) δ 7.72-7.67 (m, 4H), 7.46-7.40 (m, 6H), 4.45 (br s, 1H), 4.20 (m, 1H), 4.08 (br s, 1H), 3.79-3.72 (m, 1H), 3.68-3.62 (m, 1H), 2.41-2.35 (m, 2H), 1.80-1.47 (m, 5H), 1.46 (s, 9H), 1.08 (s, 9H).

10% Pd/C (46 mg) was added to a suspension of tert-butyl ((1S,3R,4S)-3-azido-4-(((tert-butyldiphenylsilyl)oxy)methyl)cyclopentyl)carbamate (460 g, 0.93 mmol) in dry EtOH (50 mL). The reaction was evacuated twice to exchange the inert gas atmosphere, and then connected to two balloons that were filled with H_2 . The suspension was vigorously stirred at room temperature for 15 h. The palladium catalyst was removed by using a PTFE-Filter (Whatman Puradisc) and the solvent was removed under reduced pressure. The amine **Example 309G** (460 mg, 0.93 mmol, quant.) was obtained as a colourless liquid, and was used without further purification. LCMS $[M+H]^+ = 470$

Step 8: Example 309H

To a solution of compound **Example 309G** (70 mg, 0.17 mmol) in THF (5 mL) was added 1M TBAF (1.7 mL, 0.17 mmol) at 0 °C under N_2 , then stirred at RT for 2 h. The reaction mixture was concentrated to give crude product **13**, the crude product was next step. LCMS $[M+H]^+ = 231$.

Step 9: Example 309I

A mixture of compound **Example 309H** (crude, 0.17 mmol), 2-chloro-N,N-dimethylbenzo[d]thiazole-6-sulfonamide (46 mg, 0.17 mmol) and DIEA (65 mg, 0.51

mmol) in DMSO was stirred at 60 °C for overnight. The mixture was purified by Prep-HPLC to give compound **Example 309I** (38 mg, 47%) as white solid. LCMS $[M+H]^+ = 472$.

Step 10: Example 309J

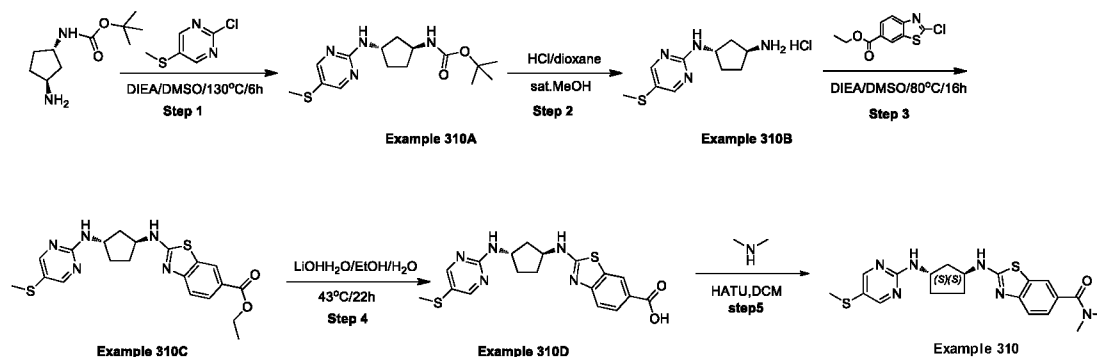
A solution of 4M HCl/dioxane (5 L) was added to compound **Example 309I** (38 mg, 0.08 mmol) in DCM (1 mL) and the mixture was stirred at RT for 1h. The mixture was concentrated to give compound **Example 309J** (30 mg, 100%) as white solid. LCMS $[M+H]^+ = 372$.

Step 16: Example 309

A mixture of compound **Example 309J** (30 mg, 0.08 mmol), 2-chloro-5-(methylthio)pyrimidine (15 mg, 0.09 mmol) and DIEA (34 mg, 0.25 mmol) in DMSO (2.5 mL) was stirred at 120 °C for 4h. The mixture was purified by Prep-HPLC to give compound **Example 309** (5 mg, 12%) as white solid. LCMS $[M+H]^+ = 496$.

^1H NMR (400 MHz, CD₃OD) δ 8.36 (s, 2H), 8.09 (d, $J = 1.6$ Hz, 1H), 7.68 (dd, $J = 2.0, 1.6$ Hz, 1H), 7.56 (d, $J = 8.4$ Hz, 1H), 4.62 (br s, 5H), 4.54 (br m, 1H), 3.63-3.58 (m, 2H), 2.70 (s, 3H), 2.69-2.65 (m, 1H), 2.37 (s, 3H), 2.36-2.28 (m, 1H), 2.16-2.10 (m, 1H), 2.05-1.99 (m, 1H), 1.86-1.82 (m, 1H).

Scheme 50



Step 1: Example 310A

To a mixture of tert-butyl ((1S,3S)-3-aminocyclopentyl)carbamate (1.5 g, 7.5 mmol), 2-chloro-5-(methylthio)pyrimidine (1.3 g, 8.3 mmol) in dimethyl sulfoxide (28 mL) was added N,N-Diisopropylethylamine (3.7 mL, 22.5 mmol) at room temperature. The

resulting mixture was stirred at 130 °C for 6.5 h under N₂ atmosphere. To the mixture was then added water (90 mL) and ethyl acetate (160 mL). The combined organic layers were washed with brine (100 mL), dried over anhydrous sodium sulfate, filtered and evaporated. The residue was purified by silica gel column chromatography (PE:EA=20:1~PE:EA=6:1) to give **Example 310A** (1.8 g, yield 76%) as a yellow oli. LCMS [M+H]⁺= 325.

Step 2: Example 310B

To a mixture of **Example 310A** (1.8 g, 5.7 mmol) in methanol (2 mL) was added HCl/dioxane (8.0 mL, 4 mol/L) at room temperature. The resulting mixture was stirred at room temperature for 2.5 h under N₂ atmosphere. The mixture was then evaporated to give **Example 310B** (1.5 g, yield 100%) as a brown solid. LCMS [M+H]⁺= 225.

Step 3: Example 310C

To a mixture of **Example 310B** (1.5 g, 5.7 mmol), ethyl 2-chlorobenzo[d]thiazole-6-carboxylate (1.4 g, 5.7 mmol) in DMSO (28 mL) was added DIEA (2.9 mL, 17.3 mmol) at room temperature. The resulting mixture was stirred at 80 °C for 18 h under N₂ atmosphere. To the mixture was then added water (80 mL) and ethyl acetate (150 mL). The combined organic layers were washed with brine (90 mL), dried over anhydrous sodium sulfate, filtered and evaporated. The residue was purified by silica gel column chromatography (PE:EA=30:1~5:1) to give **Example 310C** (1.9 g, yield 77%) as a yellow solid. LCMS [M+H]⁺= 430.

Step 4: Example 310D

To a mixture of **Example 310C** (1.9 g, 4.4 mmol) in ethanol (20 mL) and water (10 mL) was added lithium hydroxide monohydrate (372 mg, 8.9 mmol) at room temperature. The resulting mixture was stirred at room temperature for 18 h under nitrogen atmosphere. The mixture was then concentrated. To the residue was added water (60 mL) and HCl (3 mol/L) until pH=5. The precipitate was filtered and the filter cake was dried to give **Example 310D** (1.5 g, yield 84%) as a brown solid. LCMS [M+H]⁺= 402. ¹H NMR (400MHz, DMSO-*d*₆) δ 8.49-8.47 (d, *J* = 6.8 Hz, 1H), 8.34 (s, 2H), 8.26-8.25 (d, *J* = 1.6 Hz, 1H), 7.81-7.79 (m, 1H), 7.55-7.53 (d, *J* = 7.2 Hz, 1H), 7.40-7.38 (d, *J* =

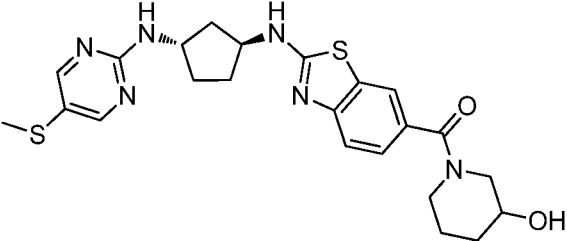
8.4 Hz, 1H), 4.39-4.33 (m, 2H), 2.35 (s, 3H), 2.21-2.19 (m, 2H), 2.12-2.10 (m, 2H), 1.98-1.94 (t, $J = 13.6$ Hz, 1H).

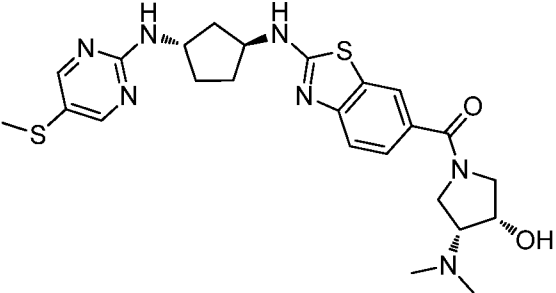
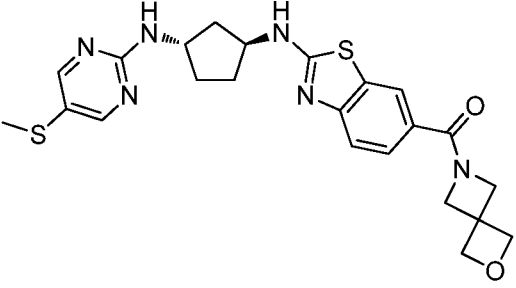
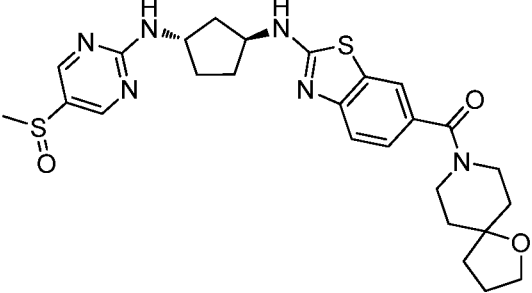
Step E: Example 310

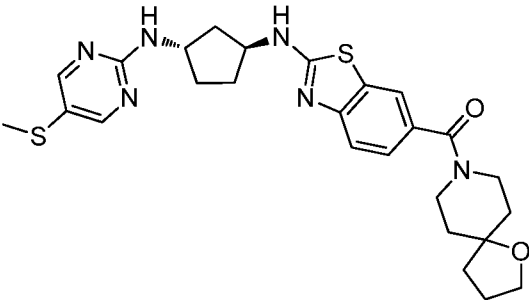
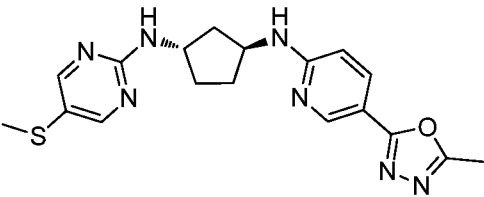
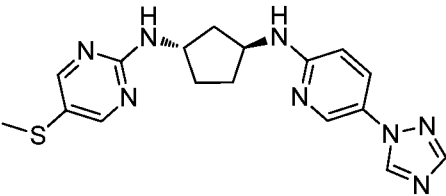
A mixture of **Example 310D** (30 mg, 0.075 mmol), dimethylamine (6.75 mg, 0.15 mmol), HATU (28.5 mg, 0.075 mmol) in DCM was stirred at room temperature for 2 h. The resulting solution was concentrated under reduced pressure. The residue was purified by Prep-HPLC to afford the title compound **Example 310** (20 mg) as a yellow solid. LCMS $[M+H]^+ = 429$. ^1H NMR (600 MHz, DMSO- d_6) δ 1.54-1.64 (m, 2H), 1.98 (t, $J = 6.75$ Hz, 2H), 2.09-2.16 (m, 1H), 2.18-2.27 (m, 1H), 2.36 (s, 3H), 2.97 (s, 6H), 4.35 (br s, 2H), 7.30 (dd, $J = 8.35, 1.49$ Hz, 1H), 7.40 (d, $J = 8.24$ Hz, 1H), 7.57 (br s, 1H), 7.74-7.81 (m, 1H), 8.35 (s, 2H), 8.58 (br s, 1H).

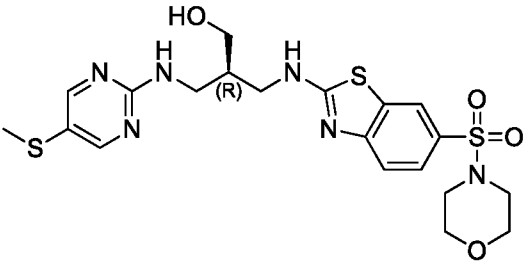
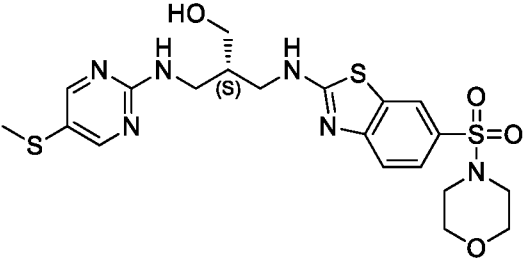
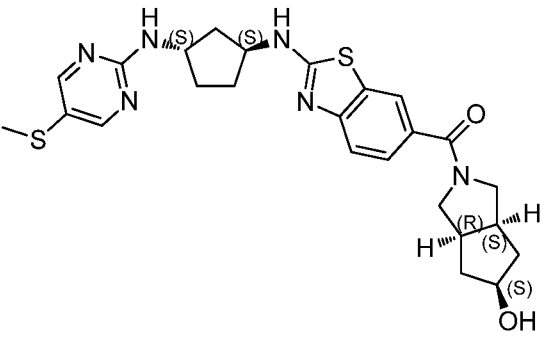
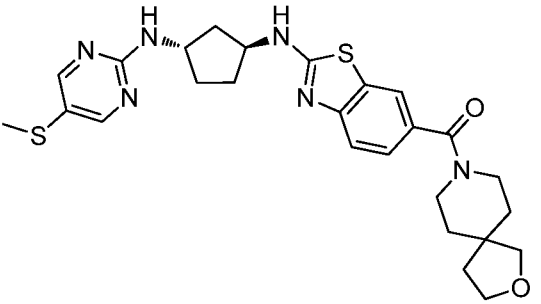
Using the above procedures, the following examples were synthesized:

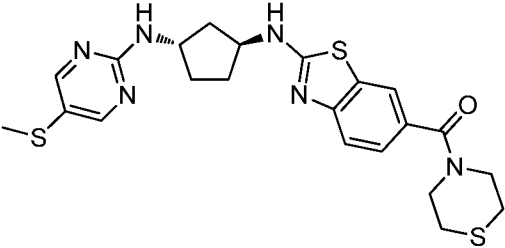
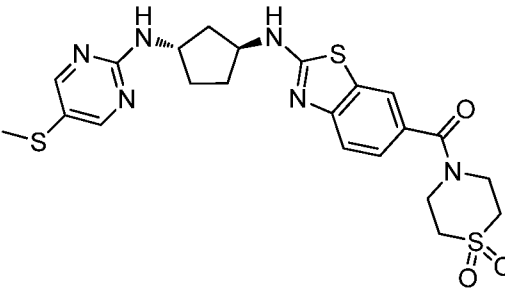
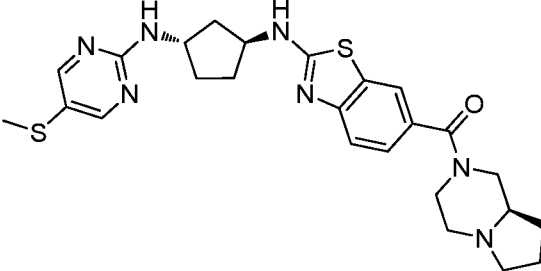
Table 31

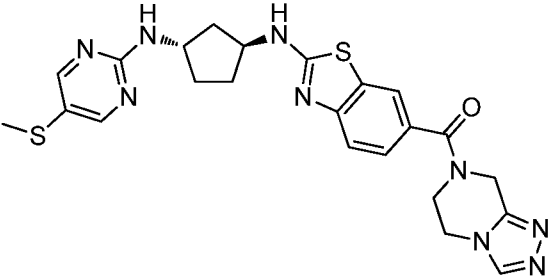
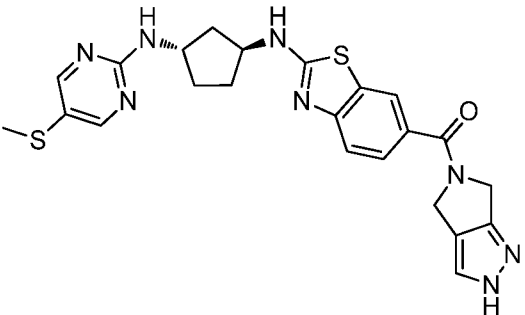
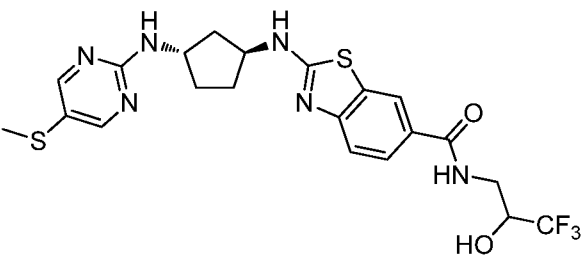
Structure	Ex. #	^1H NMR	LC-MS ($M+H$) $^+$
	311	^1H NMR (400 MHz, DMSO- d_6) δ 8.34 (s, 2H), 8.29 (d, $J = 6.7$ Hz, 1H), 7.72 (d, $J = 1.3$ Hz, 1H), 7.53 (d, $J = 7.3$ Hz, 1H), 7.37 (d, $J = 8.3$ Hz, 1H), 7.23 (d, $J = 8.3$ Hz, 1H), 4.96-4.79 (m, 1H), 4.34 (td, $J = 6.9, 13.7$ Hz, 2H), 3.53-3.44 (m, 2H), 3.14-3.03 (m, 2H), 2.97-2.84 (m, 1H), 2.34 (s, 3H), 2.24-2.05 (m, 2H), 1.95 (t, $J = 6.7$ Hz, 2H), 1.89-1.80 (m, 1H), 1.75-1.62 (m, 1H), 1.61-1.50 (m, 2H), 1.45-1.32 (m, 2H).	485

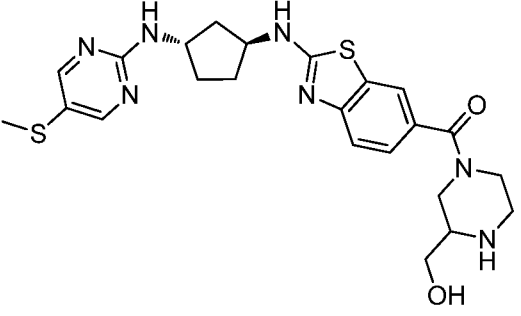
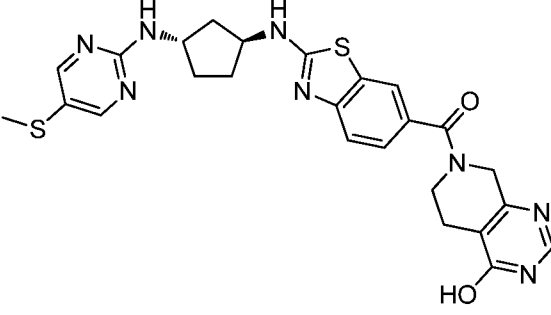
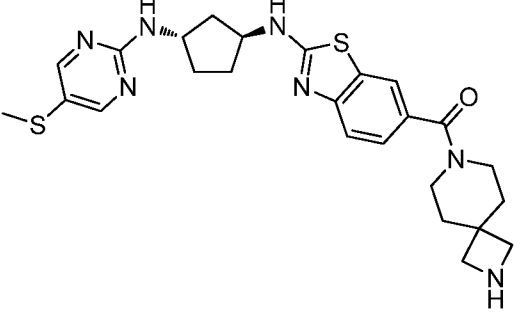
	312	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.32 (d, <i>J</i> = 7.3 Hz, 1H), 7.87 (s, 1H), 7.53 (d, <i>J</i> = 7.3 Hz, 1H), 7.42-7.34 (m, 2 H), 4.48-4.39 (m, 1H), 4.35 (td, <i>J</i> = 6.5, 13.5 Hz, 2H), 4.20-4.05 (m, 1H), 3.79-3.34 (m, 4H), 2.34 (s, 3H), 2.24-2.17 (m, 4H), 2.15-2.06 (m, 4H), 1.95 (t, <i>J</i> = 6.7 Hz, 2H), 1.61 - 1.52 (m, 2H).	514
	313	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.39 (d, <i>J</i> = 6.7 Hz, 1H), 8.34 (s, 2H), 7.97 (d, <i>J</i> = 1.6 Hz, 1H), 7.53 (d, <i>J</i> = 7.3 Hz, 1H), 7.48 (dd, <i>J</i> = 1.7, 8.5 Hz, 1H), 7.37 (d, <i>J</i> = 8.3 Hz, 1H), 4.68 (s, 4H), 4.51 (br s, 2H), 4.34 (td, <i>J</i> = 6.9, 13.7 Hz, 2H), 4.19 (br s, 2H), 2.34 (s, 3H), 2.24-2.05 (m, 2H), 1.95 (t, <i>J</i> = 6.6 Hz, 2H), 1.62-1.51 (m, 2H).	483
	314	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.58 (s, 2H), 8.31 (d, <i>J</i> = 6.7 Hz, 1H), 8.05 (d, <i>J</i> = 7.3 Hz, 1H), 7.74 (d, <i>J</i> = 1.6 Hz, 1H), 7.37 (d, <i>J</i> = 8.1 Hz, 1H), 7.24 (dd, <i>J</i> = 1.7, 8.2 Hz, 1H), 4.49-4.30 (m, 2H), 3.74 (t, <i>J</i> = 6.6 Hz, 2H), 3.40-3.29 (m, 4H), 2.83 (s, 3H), 2.25 - 2.08 (m, 2H), 1.98 (t, <i>J</i> = 6.7 Hz, 2H), 1.87 (quin, <i>J</i> = 7.1 Hz, 2H), 1.69 (t, <i>J</i> = 7.4 Hz, 2H), 1.64 - 1.49 (m, 6H).	541

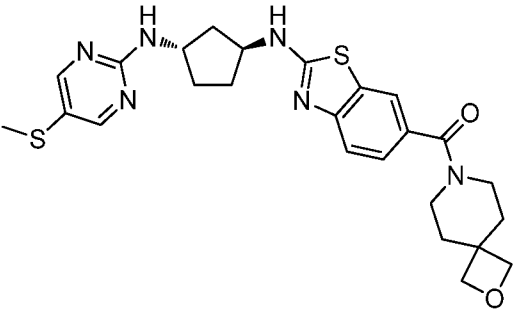
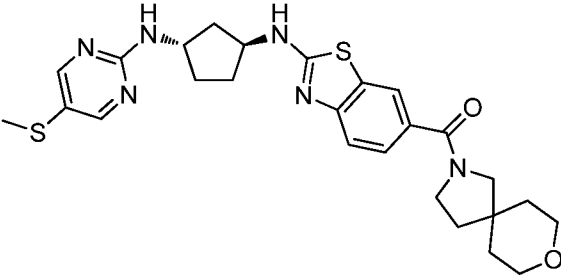
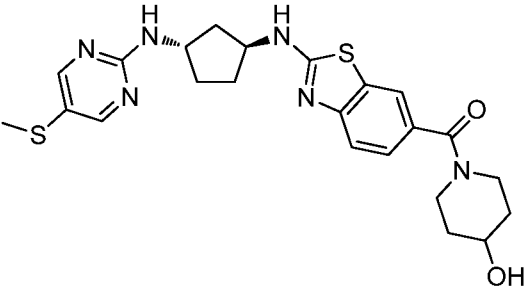
	315	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.29 (d, <i>J</i> = 7.0 Hz, 1H), 7.73 (d, <i>J</i> = 1.6 Hz, 1H), 7.53 (d, <i>J</i> = 7.3 Hz, 1H), 7.37 (d, <i>J</i> = 8.3 Hz, 1H), 7.23 (dd, <i>J</i> = 1.7, 8.2 Hz, 1H), 4.38-4.29 (m, 2H), 3.73 (t, <i>J</i> = 6.7 Hz, 2H), 3.40-3.26 (m, 4H), 2.34 (s, 3H), 2.24-2.05 (m, 2H), 1.95 (t, <i>J</i> = 6.9 Hz, 2H), 1.87 (quin, <i>J</i> = 7.1 Hz, 2H), 1.68 (t, <i>J</i> = 7.4 Hz, 2H), 1.62-1.47 (m, 6H).	525
	316	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.53 (d, <i>J</i> = 2.1 Hz, 1H), 8.33 (s, 2H), 7.84 (dd, <i>J</i> = 2.4, 8.9 Hz, 1H), 7.51 (d, <i>J</i> = 7.3 Hz, 1H), 7.42 (d, <i>J</i> = 7.0 Hz, 1H), 6.59 (d, <i>J</i> = 8.9 Hz, 1H), 4.42-4.28 (m, 2H), 2.52 (s, 3H), 2.34 (s, 3H), 2.19-2.06 (m, 2H), 1.97-1.81 (m, 2H), 1.58-1.44 (m, 2H).	384
	317	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 9.34 (s, 1H), 8.33 (s, 2H), 8.26 (s, 1H), 8.08 (d, <i>J</i> = 5.6 Hz, 1H), 7.49 (d, <i>J</i> = 7.3 Hz, 1H), 6.99 (dd, <i>J</i> = 1.7, 5.5 Hz, 2H), 6.90 (d, <i>J</i> = 1.6 Hz, 1H), 4.39-4.27 (m, 2H), 2.34 (s, 3H), 2.18-2.06 (m, 2H), 1.95-1.81 (m, 2H), 1.57-1.44 (m, 2H).	369

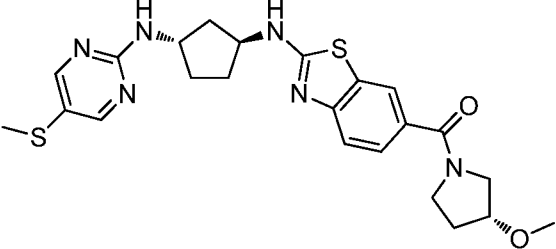
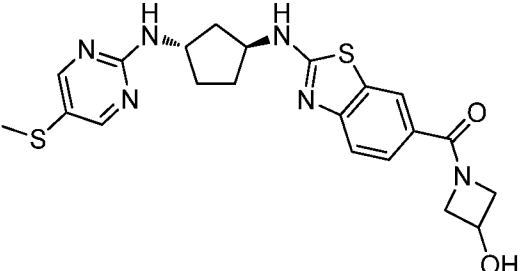
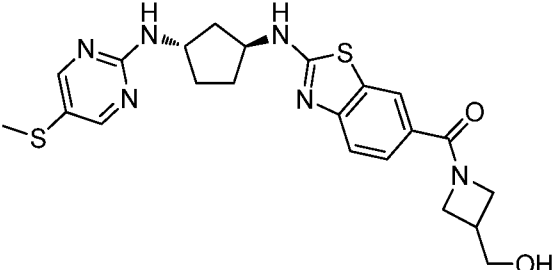
	318	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.97 (d, <i>J</i> = 1.6 Hz, 1H), 7.70 - 7.59 (m, 2H), 6.95 (br s, 1H), 6.00 (br s, 1H), 3.84 (dd, <i>J</i> = 4.7, 13.8 Hz, 1H), 3.78-3.71 (m, 4H), 3.66-3.50 (m, 5H), 3.07-2.95 (m, 4H), 2.39 (s, 3H), 2.17-2.08 (m, 1H).	511
	319	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.97 (d, <i>J</i> = 1.6 Hz, 1H), 7.70-7.59 (m, 2H), 6.95 (br s, 1H), 6.00 (br s, 1H), 3.84 (dd, <i>J</i> = 4.7, 13.8 Hz, 1H), 3.78-3.71 (m, 4H), 3.66-3.50 (m, 5H), 3.07-2.95 (m, 4H), 2.39 (s, 3H), 2.17-2.08 (m, 1H).	511
	320	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.30 (d, <i>J</i> = 6.9 Hz, 1H), 7.82 (s, 1H), 7.53 (d, <i>J</i> = 7.3 Hz, 1H), 7.38-7.31 (m, 2H), 4.65 (br s, 1H), 4.35 (td, <i>J</i> = 6.8, 13.7 Hz, 2H), 4.06 (quin, <i>J</i> = 6.3 Hz, 1H), 3.68-3.58 (m, 2H), 3.57-3.38 (m, 2H), 2.59-2.52 (m, 2H), 2.34 (s, 3H), 2.24-2.05 (m, 2H), 2.03-1.89 (m, 4H), 1.63-1.50 (m, 2H), 1.36-1.25 (m, 2H).	525
	321	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.29 (d, <i>J</i> = 6.7 Hz, 1H), 7.73 (s, 1H), 7.53 (d, <i>J</i> = 7.4 Hz, 1H), 7.37 (d, <i>J</i> = 8.2 Hz, 1H), 7.23 (d, <i>J</i> = 8.2 Hz, 1H), 4.40 - 4.27 (m, 2H), 3.74 (t, <i>J</i> = 7.2 Hz, 2H), 3.63-3.37 (m, 4H), 3.47 (s, 2H), 2.34 (s,	487

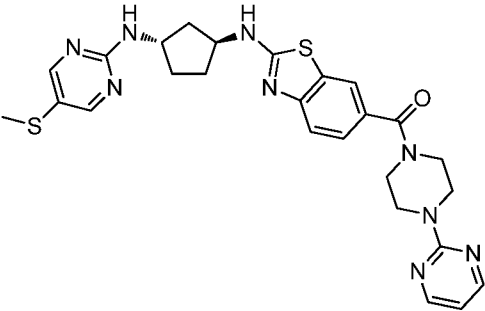
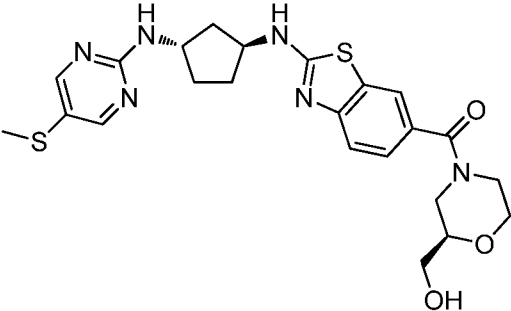
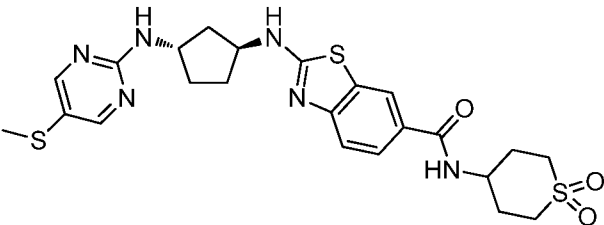
		3H), 2.24-2.04 (m, 2H), 1.95 (t, $J = 6.6$ Hz, 2H), 1.74 (t, $J = 7.1$ Hz, 2H), 1.62 - 1.43 (m, 6H).	
	322	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.31 (d, $J = 6.9$ Hz, 1H), 7.75 (s, 1H), 7.53 (d, $J = 7.3$ Hz, 1H), 7.38 (d, $J = 8.2$ Hz, 1H), 7.24 (d, $J = 8.1$ Hz, 1H), 4.34 (td, $J = 6.9, 13.7$ Hz, 2H), 3.72 (br. s., 4H), 2.63 (br. s., 4H), 2.34 (s, 3H), 2.24-2.05 (m, 2H), 1.95 (t, $J = 6.6$ Hz, 2H), 1.62-1.49 (m, 2H).	519
	323	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (d, $J = 6.7$ Hz, 1H), 8.34 (s, 2H), 7.84 (s, 1H), 7.53 (d, $J = 7.4$ Hz, 1H), 7.43-7.32 (m, 2H), 4.39-4.30 (m, 2H), 3.88 (br s, 4H), 3.24 (br s, 4H), 2.34 (s, 3H), 2.25-2.05 (m, 2H), 1.95 (t, $J = 6.6$ Hz, 2H), 1.63-1.48 (m, 2H).	511
	324	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.30 (d, $J = 6.7$ Hz, 1H), 7.74 (d, $J = 1.6$ Hz, 1H), 7.53 (d, $J = 7.3$ Hz, 1H), 7.38 (d, $J = 8.1$ Hz, 1H), 7.23 (dd, $J = 1.6, 8.3$ Hz, 1H), 4.59-4.18 (m, 2H), 4.34 (td, $J = 6.9, 13.7$ Hz, 2H), 3.92-3.48 (m, 2H), 3.11-2.86 (m, 4H), 2.34 (s, 3H), 2.24-2.00 (m, 4H), 1.95 (t, $J = 6.7$ Hz, 2H), 1.89-1.80 (m, 1H), 1.76 - 1.50 (m, 4H).	510

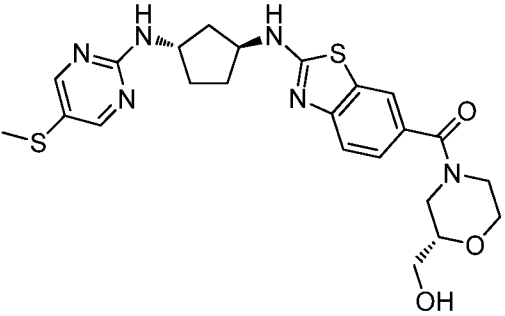
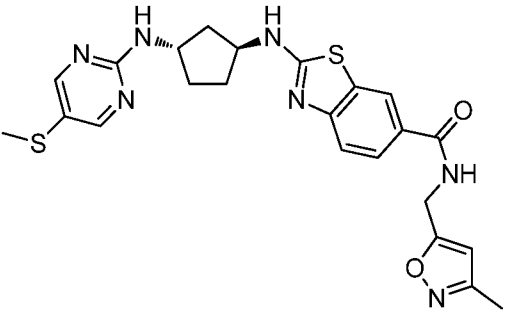
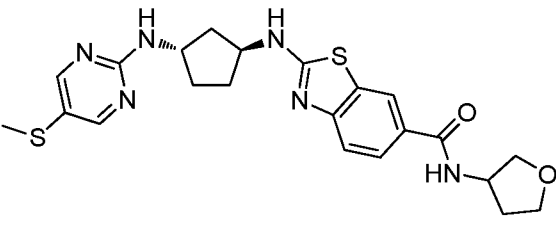
	325	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.52 (s, 1H), 8.37 (d, <i>J</i> = 7.0 Hz, 1H), 8.34 (s, 2H), 7.87 (d, <i>J</i> = 1.3 Hz, 1H), 7.54 (d, <i>J</i> = 7.3 Hz, 1H), 7.42 (d, <i>J</i> = 8.3 Hz, 1H), 7.36 (dd, <i>J</i> = 1.7, 8.2 Hz, 1H), 4.87 (s, 2H), 4.41-4.30 (m, 2H), 4.15 (t, <i>J</i> = 5.4 Hz, 2H), 3.89 (br s, 2H), 2.34 (s, 3H), 2.25-2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.7 Hz, 2H), 1.63-1.50 (m, 2H).	508
	326	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 12.71 (br s, 1H), 8.38-8.30 (m, 3H), 7.97 (d, <i>J</i> = 5.1 Hz, 1H), 7.60-7.44 (m, 3H), 7.42-7.37 (m, 1H), 4.61 (br s, 2H), 4.57 (brs, 2H), 4.40-4.31 (m, 2H), 2.35 (s, 3H), 2.25-2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.7 Hz, 2H), 1.63-1.51 (m, 2H).	493
	327	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.57 (t, <i>J</i> = 5.6 Hz, 1H), 8.41 (d, <i>J</i> = 7.0 Hz, 1H), 8.34 (s, 2H), 8.18 (d, <i>J</i> = 1.6 Hz, 1H), 7.75 (dd, <i>J</i> = 1.7, 8.5 Hz, 1H), 7.54 (d, <i>J</i> = 7.3 Hz, 1H), 7.40 (d, <i>J</i> = 8.3 Hz, 1H), 6.48 (d, <i>J</i> = 6.4 Hz, 1H), 4.40-4.30 (m, 2H), 4.24-4.12 (m, 1H), 3.61 (td, <i>J</i> = 5.0, 13.3 Hz, 1H), 3.29-3.24 (m, 1H), 2.34 (s, 3H), 2.24-2.06 (m, 2H), 1.95 (t, <i>J</i> = 6.7 Hz, 2H), 1.63-1.51 (m, 2H).	513

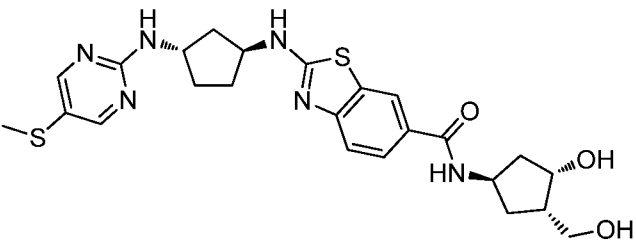
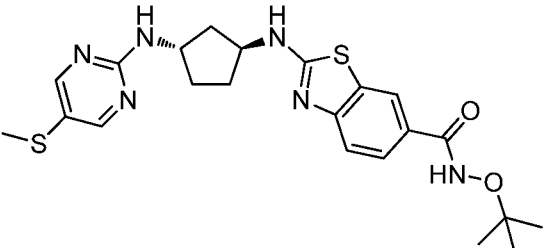
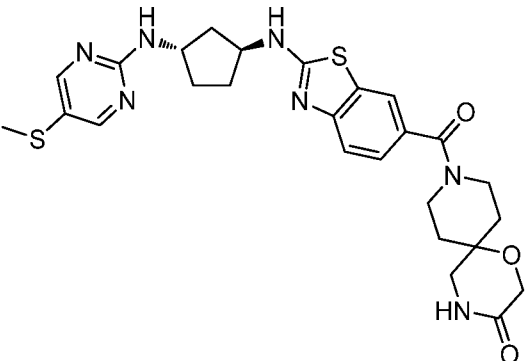
	328	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.30 (d, <i>J</i> = 7.0 Hz, 1H), 7.74-7.70 (m, 1H), 7.54 (d, <i>J</i> = 7.3 Hz, 1H), 7.37 (d, <i>J</i> = 8.3 Hz, 1H), 7.22 (dd, <i>J</i> = 1.6, 8.3 Hz, 1H), 4.63 (br s, 1H), 4.40-4.29 (m, 2H), 3.82-3.56 (m, 1H), 3.41-3.12 (m, 4H), 2.86 (br s, 2H), 2.63-2.53 (m, 2H), 2.34 (s, 3H), 2.24-2.04 (m, 2H), 1.95 (t, <i>J</i> = 6.6 Hz, 2H), 1.62-1.49 (m, 2H).	500
	329	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 12.45 (br s, 1H), 8.34 (s, 2H), 8.34 (d, <i>J</i> = 7.0 Hz, 1H), 8.06 (br s, 1H), 7.82 (d, <i>J</i> = 1.5 Hz, 1H), 7.54 (d, <i>J</i> = 7.4 Hz, 1H), 7.40 (d, <i>J</i> = 8.2 Hz, 1H), 7.31 (dd, <i>J</i> = 1.7, 8.3 Hz, 1H), 4.43 (br s, 2H), 4.39-4.31 (m, 2H), 3.65 (br s, 2H), 3.30 (br s, 2H), 2.34 (s, 3H), 2.25-2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.7 Hz, 2H), 1.63-1.50 (m, 2H).	535
	330	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.30 (d, <i>J</i> = 6.7 Hz, 1H), 7.71 (d, <i>J</i> = 1.6 Hz, 1H), 7.54 (d, <i>J</i> = 7.3 Hz, 1H), 7.37 (d, <i>J</i> = 8.3 Hz, 1H), 7.21 (dd, <i>J</i> = 1.7, 8.2 Hz, 1H), 4.34 (td, <i>J</i> = 6.8, 13.8 Hz, 2H), 3.37 (br s, 4H), 3.23 (br s, 4H), 2.34 (s, 3H), 2.23-2.05 (m, 2H), 1.95 (t, <i>J</i> = 6.7 Hz, 2H), 1.68 (br s, 4H), 1.60-1.50 (m, 2H).	510

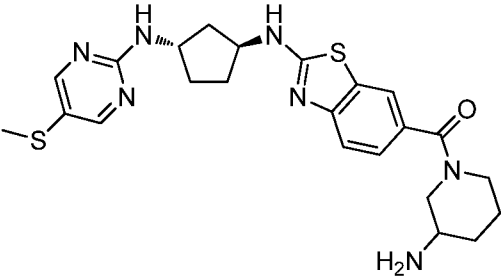
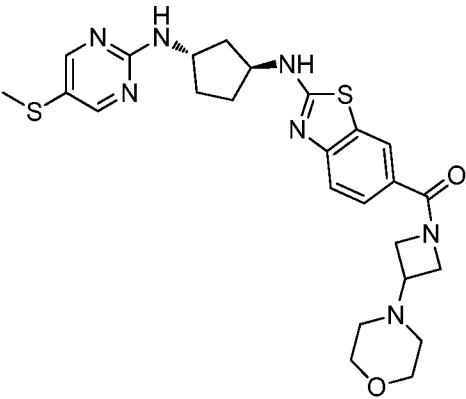
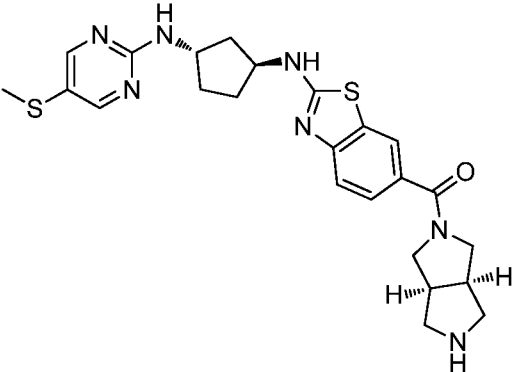
	331	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.31 (d, <i>J</i> = 6.8 Hz, 1H), 7.72 (d, <i>J</i> = 1.6 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.38 (d, <i>J</i> = 8.0 Hz, 1H), 7.22 (dd, <i>J</i> = 8.0, 1.6 Hz, 1H), 4.34 (s, 6H), 3.40 (br s, 4H), 2.35 (s, 3H), 2.24-2.08 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.80 (br s, 4H), 1.60-1.54 (m, 2H).	511
	332	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.32 (d, <i>J</i> = 6.8 Hz, 1H), 7.89 (d, <i>J</i> = 14.8 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.38 (s, 2H), 4.41-4.32 (m, 2H), 3.66-3.49 (m, 5H), 3.48-3.35 (m, 3H), 2.35 (s, 3H), 2.24-2.08 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.80 (d, <i>J</i> = 25.2 Hz, 2H), 1.62-1.52 (m, 4H), 1.43 (br s, 2H).	525
	333	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.30 (d, <i>J</i> = 6.8 Hz, 1H), 7.73 (d, <i>J</i> = 1.6 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.38 (d, <i>J</i> = 8.4 Hz, 1H), 7.23 (dd, <i>J</i> = 8.4, 1.6 Hz, 1H), 4.78 (d, <i>J</i> = 3.2 Hz, 1H), 4.40-4.32 (m, 2H), 3.73 (d, <i>J</i> = 3.2 Hz, 2H), 3.21-3.14 (m, 3H), 2.35 (s, 3H), 2.24-2.07 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.73 (br s, 2H), 1.60-1.54 (m, 2H), 1.35 (d, <i>J</i> = 8.4 Hz, 2H).	485

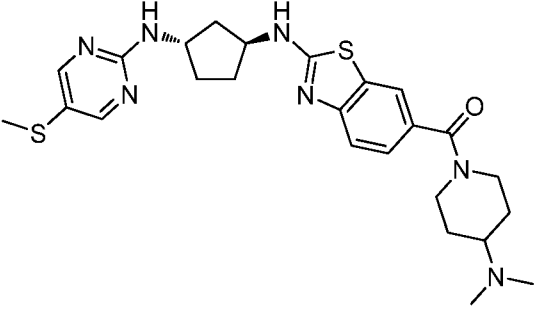
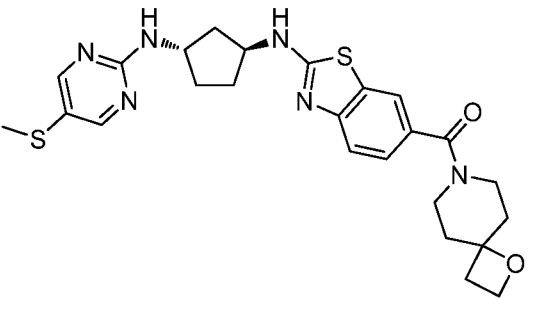
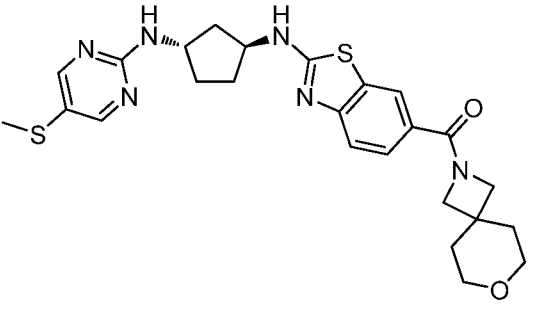
	334	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.33 (d, <i>J</i> = 6.8 Hz, 1H), 7.89 (br s, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.41-7.36 (m, 2H), 4.39-4.32 (m, 2H), 3.97 (d, <i>J</i> = 30 Hz, 1H), 3.68-3.42 (m, 3H), 3.27 (s, 2H), 3.16 (s, 2H), 2.35 (s, 3H), 2.24-2.08 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 4H), 1.62-1.52 (m, 2H).	485
	335	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.38 (d, <i>J</i> = 6.8 Hz, 1H), 8.35 (s, 2H), 7.98 (d, <i>J</i> = .6 Hz, 1H), 7.54-7.48 (m, 2H), 7.37 (d, <i>J</i> = 8.4 Hz, 1H), 5.72 (br s, 1H), 4.49 (br s, 2H), 4.39-4.34 (m, 2H), 4.28-4.19 (m, 1H), 4.06-4.01 (m, 1H), 3.84-3.74 (m, 1H), 2.35 (s, 3H), 2.25-2.07 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.60-1.52 (m, 2H).	457
	336	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.38 (d, <i>J</i> = 7.2 Hz, 1H), 8.35 (s, 2H), 7.98 (d, <i>J</i> = 1.6 Hz, 1H), 7.55-7.48 (m, 2H), 7.37 (d, <i>J</i> = 8.4 Hz, 1H), 4.80 (t, <i>J</i> = 6.8 Hz, 1H), 4.38-4.30 (m, 3H), 4.03 (d, <i>J</i> = 6.4 Hz, 2H), 3.78-3.73 (m, 1H), 3.54 (t, <i>J</i> = 5.6 Hz, 2H), 2.35 (s, 3H), 2.24-2.07 (m, 2H), 2.03-1.94 (m, 3H), 1.58-1.53 (m, 2H).	471

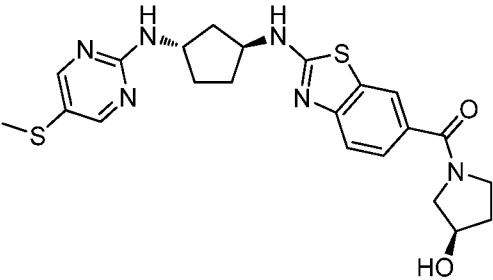
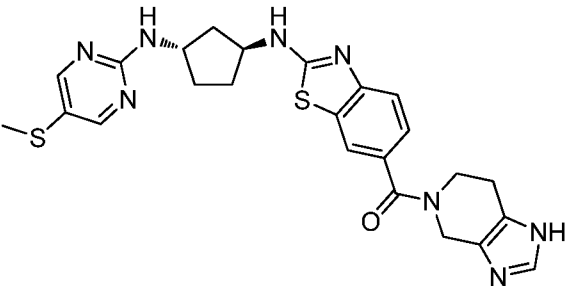
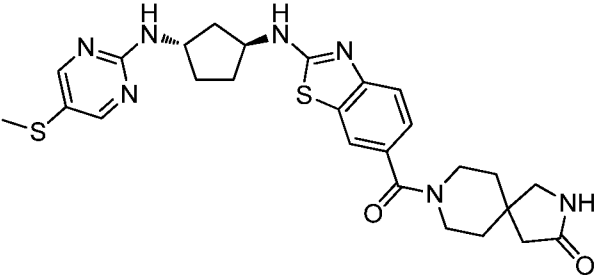
	337	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.38 (d, <i>J</i> = 8.4 Hz, 2H), 8.34 (s, 2H), 8.32 (s, 1H), 7.80 (s, 1H), 7.53 (d, <i>J</i> = 7.2 Hz, 1H), 7.40 (d, <i>J</i> = 8.0 Hz, 1H), 7.31 (d, <i>J</i> = 8.4 Hz, 1H), 6.66 (t, <i>J</i> = 4.8 Hz, 1H), 4.36 (q, <i>J</i> = 13.2, 6.4 Hz, 2H), 3.79 (s, 4H), 3.58 (br s, 4H), 2.35 (s, 3H), 2.24-2.07 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.58-1.53 (m, 2H).	548
	338	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.34 (s, 2H), 8.32 (d, <i>J</i> = 6.8 Hz, 1H), 7.76 (s, 1H), 7.53 (d, <i>J</i> = 7.2 Hz, 1H), 7.38 (d, <i>J</i> = 7.2 Hz, 1H), 7.26 (d, <i>J</i> = 8.4 Hz, 1H), 4.76 (br s, 1H), 4.35 (q, <i>J</i> = 13.6, 7.2 Hz, 2H), 3.84-3.82 (m, 1H), 3.49-3.33 (m, 4H), 3.29-2.58 (m, 4H), 2.35 (s, 3H), 2.23-2.07 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.53 (m, 2H).	501
	339	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.41 (d, <i>J</i> = 6.8 Hz, 1H), 8.35 (s, 2H), 8.29 (d, <i>J</i> = 7.6 Hz, 1H), 8.18 (d, <i>J</i> = 2.0 Hz, 1H), 7.75 (dd, <i>J</i> = 8.4, 2.0 Hz, 1H), 7.55 (d, <i>J</i> = 7.2 Hz, 1H), 7.39 (d, <i>J</i> = 8.4 Hz, 1H), 4.36 (q, <i>J</i> = 13.6, 6.8 Hz, 2H), 4.21-4.17 (m, 1H), 3.30-3.24 (m, 2H), 3.14 (d, <i>J</i> = 12.8 Hz, 2H), 2.35 (s, 3H), 2.23-2.06 (m, 6H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.60-1.54 (m, 2H).	533

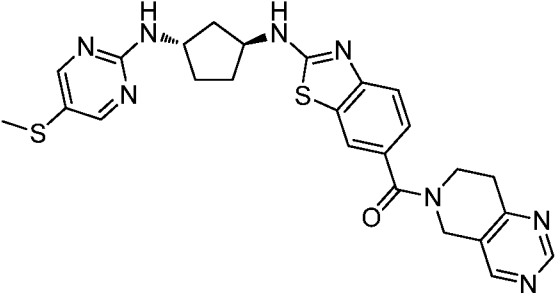
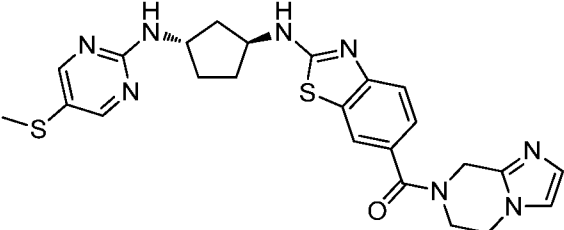
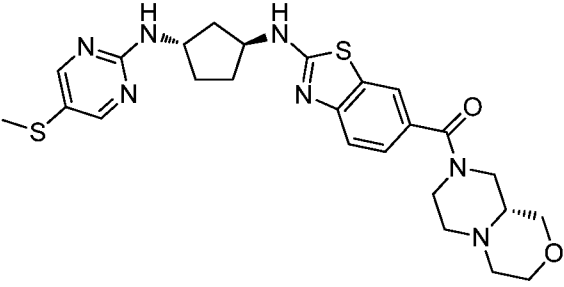
	340	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.23 (s, 2H), 7.62 (s, 1H), 7.37 (d, <i>J</i> = 8.4 Hz, 1H), 7.25 (d, <i>J</i> = 8.4 Hz, 1H), 4.35-4.27 (m, 2H), 4.03-3.82 (m, 1H), 3.55-3.37 (m, 4H), 2.25 (s, 3H), 2.23-2.07 (m, 2H), 1.98 (t, <i>J</i> = 7.2 Hz, 2H), 1.63-1.51 (m, 2H), 1.25-1.12 (m, 4H).	501
	341	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 9.00 (t, <i>J</i> = 5.6 Hz, 1H), 8.42 (d, <i>J</i> = 6.8 Hz, 1H), 8.34 (s, 2H), 8.19 (s, 1H), 7.76 (d, <i>J</i> = 8.8 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.40 (d, <i>J</i> = 8.4 Hz, 1H), 6.20 (s, 1H), 4.53 (d, <i>J</i> = 5.6 Hz, 2H), 4.36 (t, <i>J</i> = 6.4 Hz, 2H), 2.34 (s, 3H), 2.23-2.06 (m, 2H), 2.19 (s, 3H), 1.95 (t, <i>J</i> = 6.8 Hz, 2H), 1.57-1.53 (m, 2H).	496
	342	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.39-8.71 (m, 1H), 8.34 (s, 2H), 8.18 (s, 1H), 7.75 (d, <i>J</i> = 8.4 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.43-7.37 (m, 2H), 4.45-4.33 (m, 3H), 3.87-3.82 (m, 2H), 3.71 (q, <i>J</i> = 14.0, 8.0 Hz, 1H), 3.57 (q, <i>J</i> = 8.8, 4.0 Hz, 1H), 2.34 (s, 3H), 2.22-2.07 (m, 3H), 2.01-1.89 (m, 3H), 1.59-1.53 (m, 2H).	471

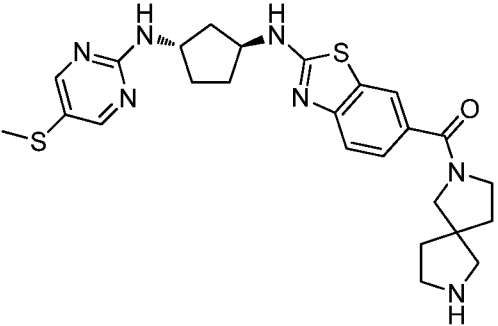
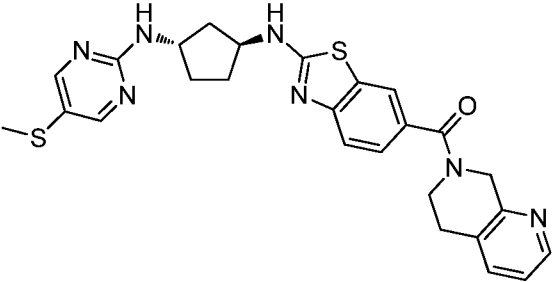
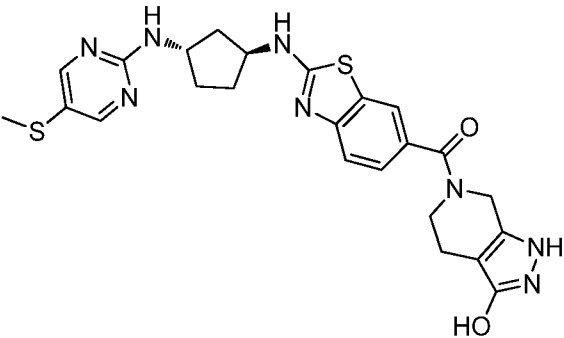
	343	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.36 (d, <i>J</i> = 7.2 Hz, 1H), 8.34 (s, 2H), 8.20-8.14 (m, 2H), 7.72 (d, <i>J</i> = 8.4 Hz, 1H), 7.54 (d, <i>J</i> = 7.2 Hz, 1H), 7.37 (d, <i>J</i> = 8.0 Hz, 1H), 4.49-4.45 (m, 1H), 4.38-4.31 (m, 3H), 4.25 (t, <i>J</i> = 5.2 Hz, 1H), 4.18 (d, <i>J</i> = 4.4 Hz, 1H), 3.58-3.53 (m, 1H), 3.39-3.35 (m, 1H), 2.34 (s, 3H), 2.22-2.07 (m, 3H), 1.95 (d, <i>J</i> = 6.8 Hz, 3H), 1.79-1.70 (m, 2H), 1.61-1.55 (m, 3H).	515
	344	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 10.81 (s, 1H), 8.41 (d, <i>J</i> = 7.2 Hz, 1H), 8.35 (s, 2H), 8.09 (d, <i>J</i> = 1.6 Hz, 1H), 7.65 (dd, <i>J</i> = 8.0, 1.6 Hz, 1H), 7.55 (d, <i>J</i> = 7.6 Hz, 1H), 7.40 (d, <i>J</i> = 8.8 Hz, 1H), 4.40-4.33 (m, 2H), 2.35 (s, 3H), 2.24-2.06 (m, 2H), 1.96 (d, <i>J</i> = 6.8 Hz, 2H), 1.76-1.52 (m, 2H), 1.24 (s, 9H).	473
	345	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.31 (d, <i>J</i> = 6.8 Hz, 1H), 7.99 (s, 1H), 7.75 (d, <i>J</i> = 1.6 Hz, 1H), 7.55 (d, <i>J</i> = 7.2 Hz, 1H), 7.38 (d, <i>J</i> = 8.0 Hz, 1H), 7.26 (dd, <i>J</i> = 8.4, 1.6 Hz, 1H), 4.38-4.32 (m, 2H), 4.01 (s, 1H), 3.31 (s, 2H), 3.13 (d, <i>J</i> = 2.4 Hz, 1H), 2.68 (t, <i>J</i> = 2.0 Hz, 1H), 2.68-2.51 (m, 3H), 2.35 (s, 3H), 2.23-2.06 (m, 2H), 1.96 (d, <i>J</i> = 6.8 Hz, 2H), 1.85-1.78 (m, 2H), 1.63-1.54 (m, 4H).	554

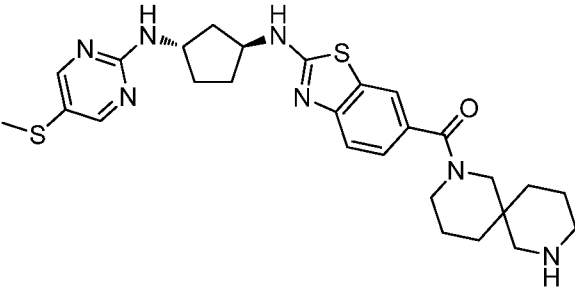
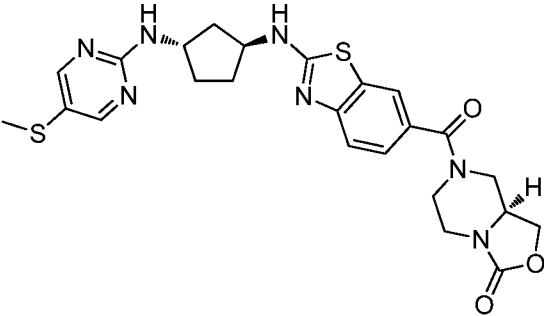
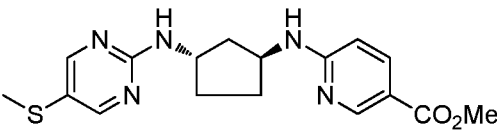
	346	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.35 (s, 2H), 8.30 (d, <i>J</i> = 6.4 Hz, 1H), 7.72 (d, <i>J</i> = 1.6 Hz, 1H), 7.55 (d, <i>J</i> = 7.2 Hz, 1H), 7.37 (d, <i>J</i> = 8.0 Hz, 1H), 7.23 (dd, <i>J</i> = 8.0, 1.6 Hz, 1H), 4.38-4.32 (m, 2H), 2.89-2.56 (m, 4H), 2.49-2.44 (m, 2H), 2.35 (s, 3H), 2.34-2.32 (m, 1H), 2.23-2.06 (m, 4H), 1.96 (d, <i>J</i> = 6.8 Hz, 2H), 1.86-1.78 (m, 2H), 1.62-1.53 (m, 2H).	484
	347	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.36 (s, 2H), 7.96 (d, <i>J</i> = 2.0 Hz, 1H), 7.60 (dd, <i>J</i> = 8.4, 1.6 Hz, 1H), 7.47 (d, <i>J</i> = 8.4 Hz, 1H), 4.46-4.42 (m, 3H), 4.30-4.22 (m, 3H), 4.07-4.04 (m, 1H), 3.74 (t, <i>J</i> = 8.8 Hz, 4H), 3.32-3.26 (m, 1H), 2.45 (s, 3H), 2.37 (s, 3H), 2.36-2.25 (m, 2H), 2.12-2.09 (m, 2H), 1.74-1.71 (m, 2H).	526
	348	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.44 (s, 2H), 7.96 (d, <i>J</i> = 2.0 Hz, 1H), 7.60 (dd, <i>J</i> = 8.4, 1.6 Hz, 1H), 7.54 (d, <i>J</i> = 8.4 Hz, 1H), 4.46-4.42 (m, 3H), 4.30-4.22 (m, 3H), 4.07-4.04 (m, 1H), 3.64 (t, <i>J</i> = 8.4 Hz, 4H), 3.25 (s, 3H), 2.40 (s, 3H), 2.37 (m, 1H), 2.35-2.27 (m, 2H), 2.25-2.22 (m, 2H), 1.87-1.73 (m, 2H).	496

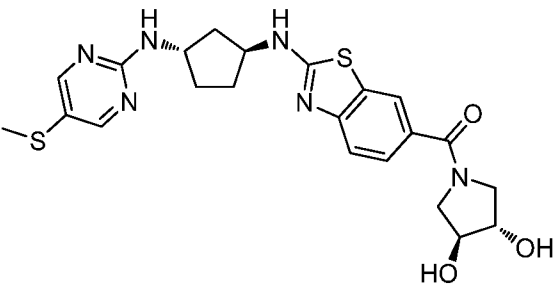
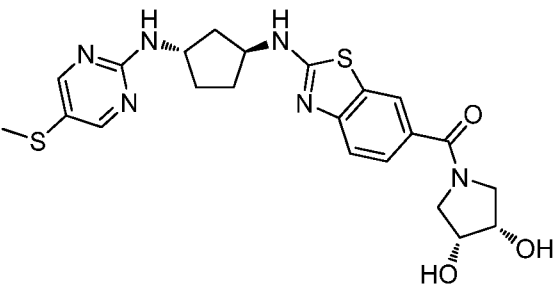
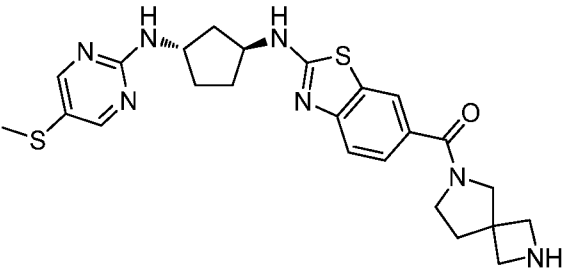
	349	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.38-8.25 (m, 3H), 7.75 (d, <i>J</i> = 1.34 Hz, 1H), 7.53 (d, <i>J</i> = 7.25 Hz, 1H), 7.38 (d, <i>J</i> = 8.19 Hz, 1H), 7.25 (dd, <i>J</i> = 8.19, 1.48 Hz, 1H), 4.35 (dt, <i>J</i> = 13.57, 6.65 Hz, 2H), 2.92 (d, <i>J</i> = 15.58 Hz, 3H), 2.43 (br s, 5H), 2.35 (s, 3H), 2.24 - 2.15 (m, 1H), 2.15-2.05 (m, 1H), 1.96 (t, <i>J</i> = 6.72 Hz, 2H), 1.87 (br s, 2H), 1.62 - 1.40 (m, 4H).	512
	350	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.45-8.18 (m, 3H), 7.75 (d, <i>J</i> = 1.61 Hz, 1H), 7.54 (d, <i>J</i> = 7.25 Hz, 1H), 7.38 (d, <i>J</i> = 8.33 Hz, 1H), 7.24 (dd, <i>J</i> = 8.19, 1.75 Hz, 1H), 4.48-4.30 (m, 4H), 4.35 (dt, <i>J</i> = 13.57, 6.65 Hz, 2H), 2.92 (d, <i>J</i> = 15.58 Hz, 3H), 2.43 (br s, 5H), 2.42-2.29 (m, 5H), 2.24 - 2.15 (m, 1H), 2.15-2.05 (m, 1H), 2.02-1.96 (m, 3H), 1.80 (br s, 4H), 1.61 - 1.40 (m, 2H).	511
	351	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.45-8.26 (m, 3H), 8.02 (d, <i>J</i> = 1.61 Hz, 1H), 7.60-7.48 (m, 2H), 7.38 (d, <i>J</i> = 8.33 Hz, 1H), 4.42-4.30 (m, 2H), 4.11 (br s, 2H), 3.78 (br s, 2H), 3.52 (d, <i>J</i> = 16.39 Hz, 4H), 2.36 (s, 3H), 2.20 (d, <i>J</i> = 5.10 Hz, 1H), 2.12 (d, <i>J</i> = 6.98 Hz, 1H), 1.96 (t, <i>J</i> = 6.72 Hz, 2H), 1.71 (t, <i>J</i> =	511

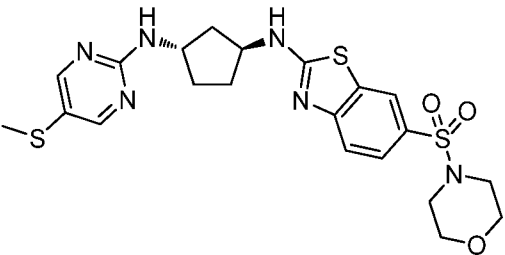
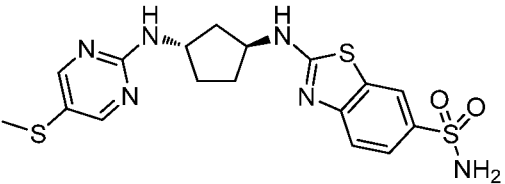
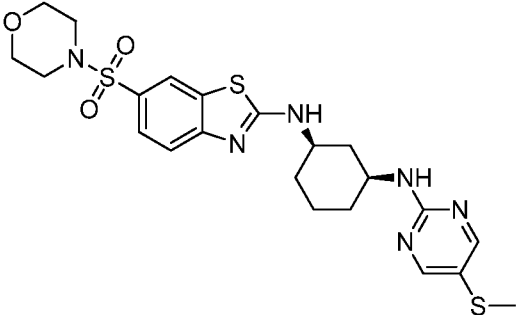
		5.10 Hz, 4H), 1.62-1.52 (m, 2H).	
	352	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.45-8.22 (m, 3 H), 7.87 (br s, 1H), 7.53 (d, <i>J</i> = 7.25 Hz, 1H), 7.43-7.32 (m, 2H), 4.91 (br s, 1H), 4.46-4.27 (m, 2H), 4.23 (br s, 1H), 3.68-3.14 (m, 3H), 3.33-3.24 (m, 1H), 2.35 (s, 3H), 2.05-2.24 (m, 2H), 1.96 (t, <i>J</i> = 6.72 Hz, 3H), 1.79 (br s, 1H), 1.62-1.47 (m, 2H).	471
	353	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 11.91 (br s, 1H), 8.41-8.26 (m, 3H), 7.81 (s, 1H), 7.55 (d, <i>J</i> = 7.25 Hz, 1H), 7.50 (br s, 1H), 7.41 (d, <i>J</i> = 8.33 Hz, 1H), 7.34-7.26 (m, 1H), 4.52 (d, <i>J</i> = 40 Hz, 2H), 4.41-4.29 (m, 2H), 3.70 (br s, 2H), 2.70 (br s, 2H), 2.62 (br s, 1H), 2.36 (s, 3H), 2.26-2.16 (m, 1H), 2.15-2.07 (m, 1H), 1.97 (t, <i>J</i> = 6.72 Hz, 2H), 1.64-1.51 (m, 2H).	507
	354	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.38-8.25 (m, 3H), 7.75 (d, <i>J</i> = 1.34 Hz, 1H), 7.53 (d, <i>J</i> = 7.25 Hz, 1H), 7.38 (d, <i>J</i> = 8.19 Hz, 1H), 7.25 (dd, <i>J</i> = 8.19, 1.48 Hz, 1H), 4.35 (dt, <i>J</i> = 13.57, 6.65 Hz, 2H), 2.92 (d, <i>J</i> = 15.58 Hz, 3H), 2.43 (br s, 5H), 2.35 (s, 3H), 2.15-2.24 (m, 1H), 2.05-2.15 (m, 1H), 1.96 (t, <i>J</i> =	538

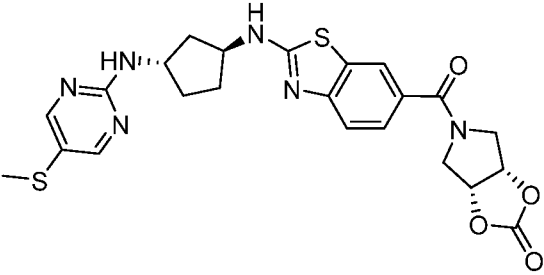
		6.72 Hz, 2H), 1.87 (br s, 2H), 1.40-1.62 (m, 4H).	
	355	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.97 (s, 1H), 8.65 (br s, 1H), 8.47-8.47 (m, 3H), 7.86 (d, <i>J</i> = 1.34 Hz, 1H), 7.55 (d, <i>J</i> = 7.25 Hz, 1H), 7.42 (d, <i>J</i> = 8.06 Hz, 1H), 7.38-7.32 (m, 1H), 4.78 (s, 2H), 4.41-4.30 (m, 2H), 3.82 (br s, 2H), 3.04-2.93 (m, 2H), 2.36 (s, 3H), 2.26-2.16 (m, 1H), 2.15 - 2.07 (m, 1H), 1.97 (t, <i>J</i> = 6.72 Hz, 2H), 1.64-1.51 (m, 2H).	519
	356	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.42-8.31 (m, 3H), 7.87 (d, <i>J</i> = 1.34 Hz, 1H), 7.55 (d, <i>J</i> = 7.52 Hz, 1H), 7.43 (d, <i>J</i> = 8.33 Hz, 1H), 7.36 (dd, <i>J</i> = 8.33, 1.88 Hz, 1H), 7.14 (s, 1H), 6.90 (s, 1H), 4.73 (s, 2H), 4.43-4.29 (m, 2H), 4.12-4.03 (m, 2H), 3.92 (br s, 2H), 2.36 (s, 3H), 2.26-2.16 (m, 1H), 2.15 - 2.07 (m, 1H), 1.97 (t, <i>J</i> = 6.72 Hz, 2H), 1.64-1.48 (m, 2H).	507
	357	¹ H NMR (400 MHz, CDCl ₃) δ 8.38 (s, 2H), 7.69-7.74 (m, 1H), 7.53 (d, <i>J</i> = 8.33 Hz, 1H), 7.35 (dd, <i>J</i> = 1.61, 8.33 Hz, 1H), 5.35 (d, <i>J</i> = 6.72 Hz, 1H), 4.42-4.53 (m, 1H), 4.32 (t, <i>J</i> = 6.18 Hz, 1H), 3.88 (d, <i>J</i> = 11.28 Hz, 1H), 3.74 (t, <i>J</i> = 10.61 Hz, 2H), 3.28 (br. s., 2H), 2.73 (d, <i>J</i> = 11.55 Hz, 3H), 2.32-2.49 (m,	526

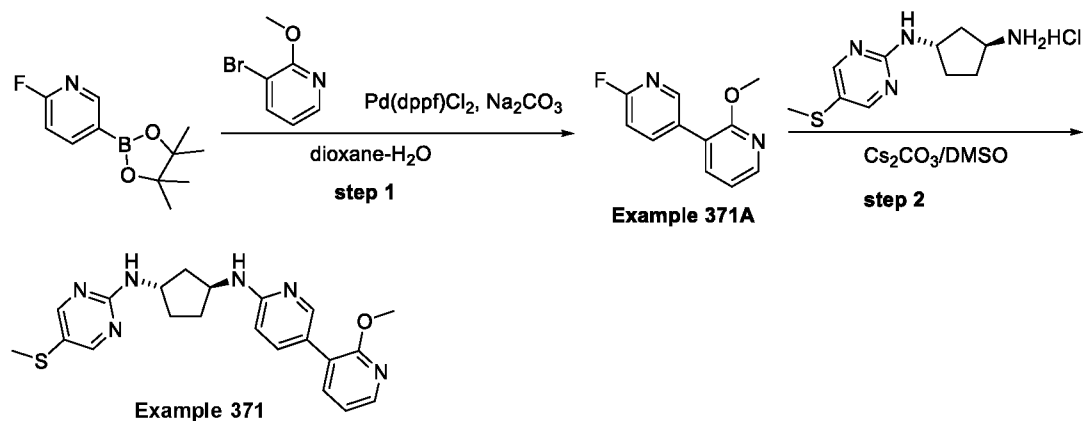
		8H), 2.07-2.22 (m, 3H), 1.59-1.72 (m, 3H).	
	358	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.85 (br s, 1H), 8.42 (br s, 1H), 8.35 (s, 2H), 7.91 (d, <i>J</i> = 16.39 Hz, 1H), 7.55 (d, <i>J</i> = 6.18 Hz, 1H), 7.35-7.47 (m, 2H), 4.34 (d, <i>J</i> = 6.45 Hz, 2H), 3.38-3.55 (m, 4H), 3.31 (br s, 1H), 3.24 (br s, 1H), 3.17 (br s, 1H), 3.08 (br s, 1H), 2.35 (s, 3H), 2.06-2.25 (m, 2H), 1.96 (t, <i>J</i> = 6.45 Hz, 5H), 1.86 (br s, 1H), 1.50 - 1.63 (m, 2H).	510
	359	¹ H NMR (CDCl ₃ , 400 MHz) δ 8.49 (d, <i>J</i> = 4.03 Hz, 1H), 8.38 (s, 2H), 7.79 (d, <i>J</i> = 1.61 Hz, 1H), 7.59 (d, <i>J</i> = 8.33 Hz, 1H), 7.43-7.47 (m, 1H), 7.29 (s, 2H), 5.35 (d, <i>J</i> = 6.72 Hz, 1H), 4.87 (br s, 2H), 4.49 (d, <i>J</i> = 6.98 Hz, 1H), 4.32 (s, 1H), 3.94 (br s, 2H), 3.17 (t, <i>J</i> = 5.78 Hz, 2H), 2.37-2.47 (m, 5H), 2.18-2.26 (m, 2H), 1.67 (s, 1H).	518
	360	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.31-8.38 (m, 3H), 7.80 (d, <i>J</i> = 1.53 Hz, 1H), 7.54 (d, <i>J</i> = 7.32 Hz, 1H), 7.40 (d, <i>J</i> = 8.24 Hz, 1H), 7.29 (dd, <i>J</i> = 1.53, 8.24 Hz, 1H), 4.52 (br s, 2H), 4.30-4.42 (m, 2H), 2.41 (t, <i>J</i> = 5.49 Hz, 2H), 2.35 (s, 3H), 2.20 (d, <i>J</i> = 7.32 Hz, 1H), 2.11 (d, <i>J</i> = 7.02 Hz, 1H), 1.96 (t, <i>J</i> =	523

		6.71 Hz, 2H), 1.57 (dd, J = 3.97, 7.02 Hz, 2H).	
	361	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.80 (br s, 1H), 8.54 (br s, 1H), 8.36 (s, 2H), 7.81 (br s, 1H), 7.62 (br s, 1H), 7.46 (d, J = 8.19 Hz, 1H), 7.31 (d, J = 7.66 Hz, 1H), 4.37 (d, J = 6.72 Hz, 2H), 3.69 (dd, J = 4.84, 13.03 Hz, 2H), 3.27 (br s, 2H), 2.92 (br s, 4H), 2.31-2.40 (m, 3H), 2.08-2.28 (m, 2H), 1.98-2.02 (m, 2H), 1.50-1.69 (m, 8H)	510
	362	¹ H NMR (400 MHz, CDCl ₃) δ 8.36 (s, 2H), 7.72 (s, 1H), 7.53 (d, J = 8.33 Hz, 1H), 7.34 (d, J = 8.19 Hz, 1H), 5.73 (br s., 1H), 5.31 (d, J = 6.85 Hz, 1H), 4.40-4.50 (m, 2H), 4.24-4.33 (m, 1H), 3.98 (br s, 1H), 3.85 (d, J = 9.67 Hz, 2H), 2.99-3.15 (m, 2H), 2.86 (br s, 1H), 2.26-2.51 (m, 5H), 2.04-2.21 (m, 2H), 1.53-1.63 (m, 2H).	526
	363	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.50 (d, J = 1.88 Hz, 1H), 8.36 (s, 2 H), 8.22 (br s, 1H), 7.94 (d, J = 8.06 Hz, 1H), 7.56 (br s, 1H), 6.71 (d, J = 9.13 Hz, 1H), 4.35 (br s, 2H), 3.80 (s, 3 H) 2.36 (s, 3H), 2.24-2.04 (m, 2H), 1.02-1.86 (m, 2H), 1.66-1.45 (m, 2H).	360

	364	¹ H NMR (DMSO- <i>d</i> ₆ , 400MHz) δ 8.35 (s, 2H), 8.33 (d, <i>J</i> = 7.2 Hz, 1H), 7.89 (s, 1H), 7.55 (d, <i>J</i> = 7.2 Hz, 1H), 7.37 (d, <i>J</i> = 1.2 Hz, 2H), 5.19 (br m, 1H), 5.08 (br m, 1H), 4.39-4.33 (m, 2H), 3.97 (br m, 1H), 3.90 (br m, 1H), 3.78-3.76 (m, 1H), 3.70-3.65 (br m, 1H), 3.30-3.23 (m, 2H), 2.35 (s, 3H), 2.22 - 2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.54 (m, 2H).	487
	365	¹ H NMR (DMSO- <i>d</i> ₆ , 400MHz) δ 8.35 (s, 2H), 8.33 (d, <i>J</i> = 7.2 Hz, 1H), 7.89 (s, 1H), 7.55 (d, <i>J</i> = 7.2 Hz, 1H), 7.37 (d, <i>J</i> = 1.2 Hz, 2H), 4.94 (br m, 2H), 4.39-4.33 (m, 2H), 4.09 (br m, 1H), 3.99 (br m, 1H), 3.60-3.56 (m, 2H), 2.35 (s, 3H), 2.22 - 2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.54 (m, 2H).	487
	366	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆ + D ₂ O) δ 8.35 (s, 2H), 7.91 (s, 1H), 7.44 (s, 2H), 4.40-4.33 (m, 2H), 4.5-4.02 (m, 2H), 3.90-3.85 (m, 3H), 3.74-3.72 (m, 2H), 3.52 (t, <i>J</i> = 6.8 Hz, 2H), 2.35 (s, 3H), 2.22 - 2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.54 (m, 2H).	496

	367	¹ H NMR (DMSO- <i>d</i> ₆ , 400MHz) δ 8.65 (d, <i>J</i> = 6.4 Hz, 2H), 8.35 (s, 2H), 8.13 (s, 1H), 7.756-7.53 (m, 3H), 4.40-4.33 (m, 2H), 3.63 (t, <i>J</i> = 4.4 Hz, 4H), 2.84 (t, <i>J</i> = 4.4 Hz, 4H), 2.35 (s, 3H), 2.22-2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.54 (m, 2H).	507
	368	¹ H NMR (DMSO- <i>d</i> ₆ , 400MHz) δ 8.52 (d, <i>J</i> = 7.2 Hz, 1H), 8.35 (s, 2H), 8.13 (d, <i>J</i> = 1.6 Hz, 1H), 7.66 (dd, <i>J</i> = 2.0, 2.0 Hz, 1H), 7.56 (d, <i>J</i> = 7.2 Hz, 1H), 7.47 (d, <i>J</i> = 8.8 Hz, 1H), 7.22 (br s, 2H), 4.40-4.33 (m, 2H), 2.35 (s, 3H), 2.22-2.06 (m, 2H), 1.96 (t, <i>J</i> = 6.8 Hz, 2H), 1.61-1.54 (m, 2H).	437
	369	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ 8.63 (d, <i>J</i> = 7.32 Hz, 1H), 8.33 (s, 2H), 8.11 (s, 1H), 7.58-7.49 (m, 2H), 7.44 (d, <i>J</i> = 7.93 Hz, 1H), 4.29 (br s, 1H), 4.19-4.09 (m, 1H), 3.69-3.54 (m, 4H), 2.83 (br s, 4H), 2.34 (s, 3H), 1.90 (br s, 1H), 1.81 (d, <i>J</i> = 8.24 Hz, 2H), 1.67 (br s, 4H), 1.36 (br s, 1H), 1.23 (s, 1H).	521

	370	¹ H NMR (400MHz, CD ₃ OD) δ 8.54 (s, 2H), 8.01 (s, 1H), 7.69-7.62 (m, 2H), 5.52 (s, 2H), 4.64-4.59 (m, 2H), 3.88- 3.84 (m, 2H), 2.57-2.44 (m, 5H), 2.31-2.24 (m, 2H), 1.92- 1.83 (m, 2H), 1.56-1.49 (m, 4H).	513

Scheme 51**Step 1: Example 371A**

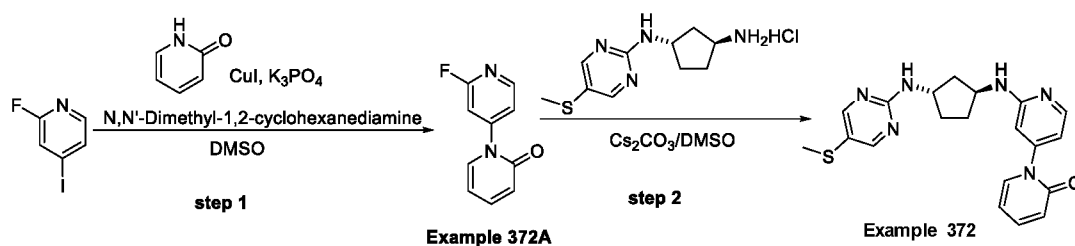
The mixture of 2-fluoro-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridine (1.0 g, 4.5 mmol), 3-bromo-2-methoxypyridine (930 mg, 4.9 mmol), Pd(dppf)Cl₂ (320 mg, 0.45 mmol) and Na₂CO₃ (950 mg, 9.0 mmol) in dioxane:H₂O= 4:1 (50 mL) was stirred at 110 °C under N₂ atmosphere overnight. The mixture was cooled to room temperature and water (50 mL) was added. The mixture was extracted with EtOAc (20 mL x3), and the combined organic layers were washed with brine (50 mL), dried over Na₂SO₄, filtered, concentrated; the residue was purified by chromatography on silica gel eluting with petroleum ether: EtOAc= 5:1 to afford **Example 371A** (660 mg, 72%) as a white solid.

Step 2: Example 371

The mixture of (1*S*, 3*S*)-N1-(5-(methylthio)pyrimidin-2-yl)cyclopentane-1,3-diamine hydrochloride (100 mg, 0.38 mmol), **Example 371A** (86 mg, 0.42 mmol) and Cs₂CO₃ (376 mg, 1.15 mmol) in DMSO (5 mL) was stirred at 130 °C for 2 days. The mixture was cooled to room temperature and water (10 mL) was added. The mixture was extracted with EtOAc (10 mL x5), the combined organic layers were washed with brine (20 mL), dried over Na₂SO₄, filtered, concentrated. The residue was purified by prep-HPLC to afford **Example 371** (10 mg, 6.4%). LCMS [M+H]⁺ = 409.

¹H NMR (400 MHz, CD₃OD) δ 8.41 (s, 2H), 8.20-8.17 (m, 2H), 8.09 (s, 1H), 7.82 (d, *J* = 7.2 Hz, 1H), 7.13-7.07 (m, 2H), 4.51-4.49 (m, 1H), 4.29-4.27 (m, 1H), 3.99 (s, 1H), 2.41-2.33 (m, 2H), 2.38 (s, 3H), 2.19-2.15 (m, 2H), 1.78-1.75 (m, 1H).

Scheme 52



Step 1: Example 372A

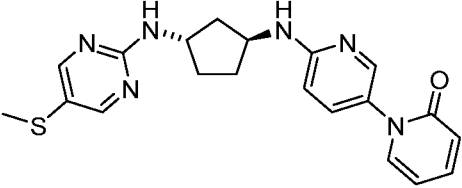
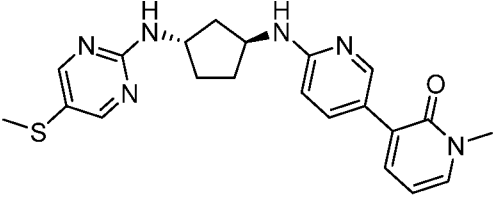
The mixture of 2-fluoro-4-iodopyridine (200 mg, 0.9 mmol), pyridin-2(1H)-one (102 mg, 1.1 mmol), CuI (17 mg, 0.09 mmol), N,N'-Dimethyl-1,2-cyclohexanediamine (19 mg, 0.17 mmol) and K₃PO₄ (381 mg, 1.8 mmol) in DMSO (5 mL) was stirred at 100 °C under N₂ atmosphere for 3 h. The mixture was cooled and water (20 mL) was added. The mixture was extracted with EtOAc (20 mL x3), and the combined organic layers were washed with brine (50 mL), dried over Na₂SO₄, filtered, concentrated gave crude product, which was purified by chromatography on silica gel eluting with petroleum ether: EtOAc= 5:1-1:1 to afford **Example 372A** (97 mg, 57%) as an off-white solid.

Step 2: Example 372

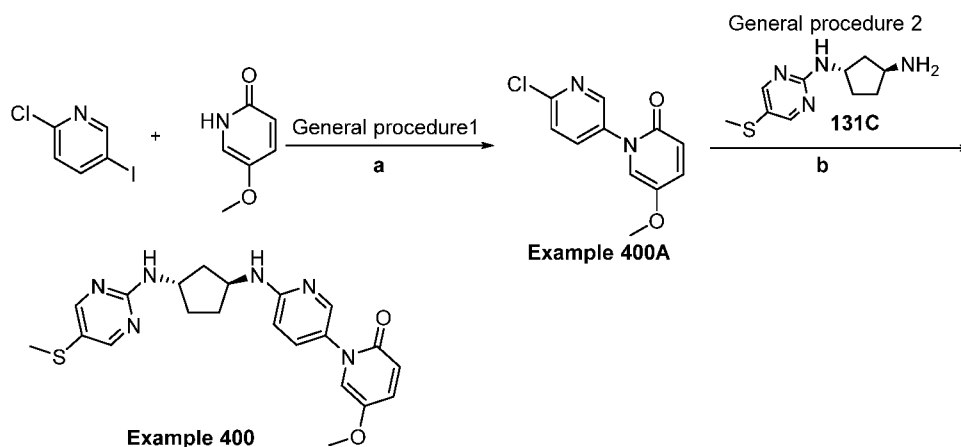
The mixture of **Example 372A** (50 mg, 0.19 mmol), (1*S*,3*S*)-N1-(5-(methylthio)pyrimidin-2-yl) cyclopentane-1,3-diamine hydrochloride (40 mg, 0.21 mmol) and

Cs_2CO_3 (185 mg, 0.57 mmol) in DMSO (3 mL) was stirred at 130 °C for 2 days. The mixture was cooled and water (10 mL) was added. The mixture was extracted with EtOAc (10 mL x5), the combined organic layers were washed with brine (20 mL), dried over Na_2SO_4 , filtered, concentrated. The residue was purified by prep-HPLC to afford **Example 372** (10 mg, 13%). LCMS $[\text{M}+\text{H}]^+ = 395$. ^1H NMR (400 MHz, CD_3OD) δ 8.39 (s, 2H), 7.99 (d, $J = 7.2$ Hz, 1H), 7.70-7.64 (m, 2H), 7.20 (s, 1H), 7.05-7.03 (m, 1H), 7.67 (d, $J = 9.2$ Hz, 1H), 6.58-6.54 (m, 1H), 4.51-4.47 (m, 1H), 4.29-4.27 (m, 1H), 2.42-2.33 (m, 2H), 2.38 (s, 3H), 2.20-2.14 (m, 2H), 1.78-1.74 (m, 1H).

Using the above procedures, the following example was synthesized:

Structure	Ex. #	^1H NMR	LC-MS ($\text{M}+\text{H}$) $^+$
	373	^1H NMR (CD_3OD , 400MHz) δ 8.42 (s, 2H), 8.11-8.10 (d, $J = 2.0$ Hz, 1H), 7.99-7.96 (dd, $J = 2.0$ Hz, $J = 2.4$ Hz 1H), 7.97-7.96 (d, $J = 2.4$ Hz, 1H), 7.69-7.64 (m, 2H), 7.16-7.13 (d, $J = 9.2$ Hz, 1H), 6.68-6.66 (d, $J = 9.2$ Hz, 1H), 6.55-6.51 (m, 1H), 4.52-4.49 (t, $J = 6.8$ Hz 1H), 4.31-4.28 (m, 1H), 2.43-2.33 (m, 2H), 2.33(s, 3H), 2.21-2.15 (m, 2H), 1.82-1.74 (m, 2H).	395
	375	^1H NMR (CD_3OD , 400 MHz) δ 8.49 (d, $J = 1.8$ Hz, 1H), 8.36 (s, 2H), 8.23 (dd, $J = 9.5$, 2.1 Hz, 1H), 7.83 (dd, $J = 7.2$, 1.9 Hz, 1H), 7.73 (d, $J = 1.9$ Hz, 1H), 7.09 (d, $J = 9.5$ Hz, 1H), 6.49 (t, $J = 6.9$ Hz, 1H), 4.51 – 4.39 (m, 1H), 4.24 (t, $J = 5.2$ Hz, 1H), 3.64 (s, 3H),	409

		2.46 – 2.25 (m, 5H), 2.21 – 2.03 (m, 2H), 1.80 – 1.65 (m, 2H).	

Scheme 54

a) CuI, K₃PO₄, N,N'-Dimethyl-1,2-cyclohexanediamine DMSO 120°C; b) tBuXphos Pd G₃, tBuOK, dioxane 110°C.

General method 1**6'-chloro-5-methoxy-2H-[1,3'-bipyridin]-2-one (Example 400A)**

A mixture of compound **2-chloro-5-iodopyridine** (191 mg, 0.8 mmol, 1.0 eq), **5-methoxypyridin-2(1H)-one** (100 mg, 0.8 mmol, 1.0eq), CuI (15 mg, 0.08 mmol, 0.1 eq), N,N'-Dimethyl-1, 2-cyclohexanediamine (23 mg, 0.16 mmol, 0.2 eq) and K₃PO₄ (339 mg, 1.6 mmol, 0.2 eq) in DMSO (5 mL) was stirred at 120 °C under N₂ atmosphere overnight. The mixture was cooled to room temperature and water (20 mL) was added. The mixture was extracted with EtOAc (20 mL x2), The combined organic layers were washed with brine (30 mL), dried over Na₂SO₄, filtered, concentrated and purified by chromatography on silica gel eluting with PE: EA = 1:1 to afford **400A** (60 mg, 0.23 mmol, 32%) as an off-white solid.

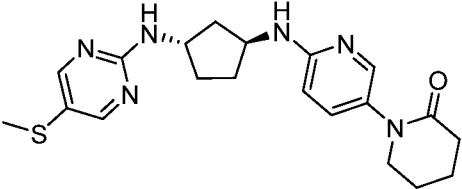
General procedure 2

5-methoxy-6'-(((1S,3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino)-2H-[1,3'-bipyridin]-2-one (Example 400)

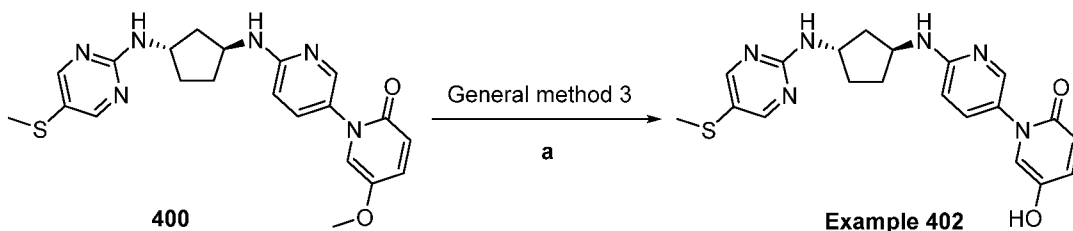
The mixture of **400A** (53 mg, 0.22 mmol, 1.0 eq), **131C** (50 mg, 0.22 mmol, 1.0 eq), tBuXphos Pd G3 (18 mg, 0.022 mmol, 0.1 eq) and tBuOK (49 mg, 0.44 mmol, 0.2 eq) in dioxane (5 mL) was stirred at 110 °C under N₂ atmosphere overnight. The mixture was cooled to room temperature and filtered. The filtrate was concentrated and purified by Prep-TLC and then Prep-HPLC to afford compound **400** (50 mg, 53%, TFA salt) as an off-white solid. LCMS [M+H]⁺ = 425.

¹H NMR (400 MHz, CD₃OD) δ 8.36 (s, 2H), 8.09 (s, 1H), 7.95 (d, *J* = 9.6 Hz, 1H), 7.50 (d, *J* = 9.6 Hz, 1H), 7.23 (s, 1H), 7.10 (d, *J* = 9.6 Hz, 1H), 6.61 (d, *J* = 9.6 Hz, 1H), 4.48-4.46 (m, 1H), 4.25-4.23 (m, 1H), 3.73 (s, 3H), 2.40-2.35 (m, 5H), 2.16-2.13 (m, 2H), 1.76-1.74 (m, 2H).

Using the above procedures, the following example was synthesized:

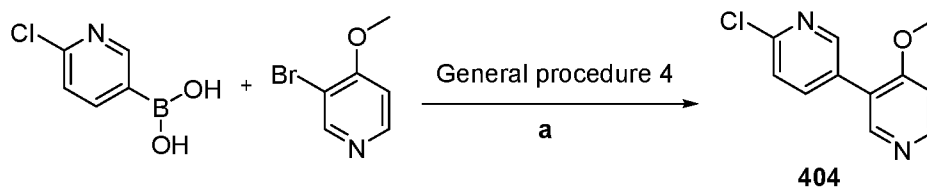
Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	401	¹ H NMR (400 MHz, CD ₃ OD) δ: 8.35 (s, 2H), 7.88-7.85 (m, 2H), 7.06-7.04 (m, 1H) 4.47-4.43 (t, <i>J</i> = 14 Hz, 1H), 4.23-4.19 (m, 1H), 3.67-3.64 (t, <i>J</i> = 11.2 Hz, 2H), 2.53-2.50 (t, <i>J</i> = 12.4 Hz, 2H), 2.40-2.228 (m, 5H), 2.14-2.09 (m, 2H), 2.00-1.93 (m, 4H), 1.75-1.69 (m, 2H).	399.4

Scheme 55



Methods analogous to those described in **General Method 1**, **General Method 2** and **General Method 3** from starting material 4-(benzyloxy) pyridin-2(1H)-one afforded the title compound: ^1H NMR (400 MHz, CD_3OD) δ 8.32 (s, 2H), 7.89 (d, $J = 2.2$ Hz, 1H), 7.45 (d, $J = 7.5$ Hz, 2H), 7.39 (dd, $J = 9.0, 2.7$ Hz, 1H), 6.60 (d, $J = 8.6$ Hz, 1H), 6.13 (dd, $J = 7.5, 2.6$ Hz, 1H), 5.88 (d, $J = 8.6, 2.5$ Hz, 1H), 4.48 – 4.25 (m, 2H), 2.35 (s, 3H), 2.32 – 2.19 (m, 2H), 2.06 – 1.92 (m, 2H), 1.70 – 1.52 (m, 2H). $[\text{M}+\text{H}]^+ = 411.49$.

Scheme 57



a) $\text{Pd}(\text{dppf})\text{Cl}_2$, Na_2CO_3 , dioxane/ H_2O , 105°C .

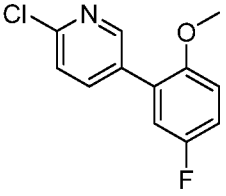
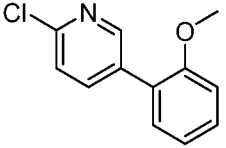
General procedure 4

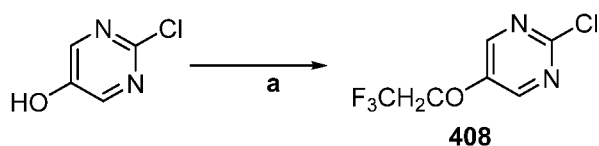
6'-chloro-4-methoxy-3,3'-bipyridine (404)

A mixture of (6-chloropyridin-3-yl) boronic acid (1.0 g, 6.4 mmol, 1 eq), 3-bromo-4-methoxypyridine (1.2 g, 6.4 mmol, 1 eq), $\text{Pd}(\text{dppf})\text{Cl}_2$ (468 mg, 0.64 mmol, 0.1 eq) and Na_2CO_3 (1.3 g, 12.8 mmol, 2 eq) in dioxane (8 mL) and water (2 mL) was stirred at 105°C under N_2 atmosphere overnight. The mixture was cooled down to room temperature and quenched with water (10 mL). The mixture was extracted with EtOAc (20 mL x3). The combined organic layers were washed with brine (50 mL), dried over Na_2SO_4 , filtered, concentrated. The residue was purified by chromatography on silica gel eluting with petroleum ether: EtOAc= 5:1 to afford compound **404** (200 mg, 14%) as a brown solid.

Using the above procedures, the following examples were synthesized:

Structure	Ex. #
	405

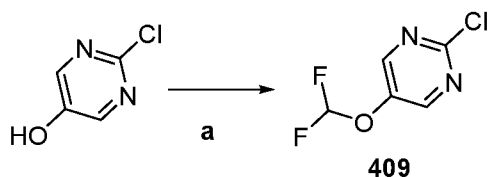
	406
	407

Scheme 58

a) 2,2,2-trifluoroethyl trifluoromethanesulfonate, Cs_2CO_3 , DMF, rt

2-chloro-5-(2,2,2-trifluoroethoxy) pyrimidine (408)

To a solution of 2-chloropyrimidin-5-ol (0.5 g, 3.8 mmol, 1.0 eq) and CS_2CO_3 (1.49 g, 4.6 mmol, 1.2 eq) in DMF (20 mL) was added 2,2,2-trifluoroethyl trifluoromethanesulfonate (0.97 g, 4.2 mmol, 1.1 eq). The resulting suspension was stirred at room temperature for 16 h and then partitioned between EtOAc (30 mL) and water (80 mL). The separated aqueous layer was extracted with EtOAc (20 mLx3). The combined organic layers were washed with brine (20 mL), dried over Na_2SO_4 , filtered and concentrated to afford to afford **408** (0.74g), which was used to next step directly. LCMS $[\text{M}+\text{H}]^+ = 213$.

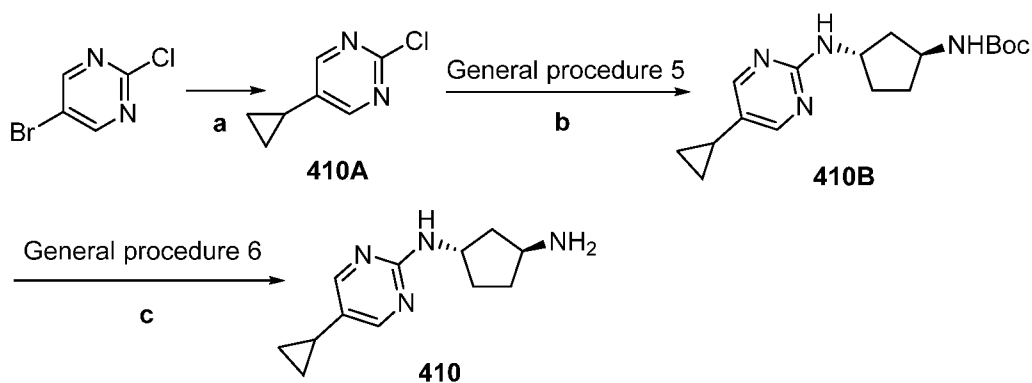
Scheme 59

a) sodium 2-chloro-2,2-difluoroacetate, Cs_2CO_3 , DMF, 100°C

2-chloro-5-(difluoromethoxy) pyrimidine (409)

A solution of 2-chloropyrimidin-5-ol (101.6 g, 0.76 mol, 1.0 eq) in DMF (2000 mL) was charged with Cs_2CO_3 (300 g, 0.92 mol, 1.2 eq) and then stirred at room temperature for 1.5 h. Sodium 2-chloro-2,2-difluoroacetate (340 g, 2.3 mol, 3.0 eq) was added, and the reaction mixture was stirred at 100 °C for 3.5 h. The reaction mixture was poured in water (5L) and extracted with EA (3 x 1L). The combined organic phases were dried over anhydrous Na_2SO_4 and concentrated. The residue was purified by flash chromatograph on silica gel (PE: EA=10:1) to afford **409** (70 g).

Scheme 60



a) cyclopropylboronic acid, Cs_2CO_3 , $\text{Pd}(\text{dppf})\text{Cl}_2$, dioxane, 110°C; b) *tert*-butyl ((1*S*,3*S*)-3-aminocyclopentyl)carbamate, DIPEA, DMSO, 110°C; c) HCl in dioxane, MeOH

2-chloro-5-cyclopropylpyrimidine (410A)

To the solution of 5-bromo-2-chloropyrimidine (100 g, 518 mmol, 1.0 eq), cyclopropylboronic acid (53 g, 616 mmol, 1.2 eq) and $\text{Pd}(\text{dppf})\text{Cl}_2$ (10 g, 13.7 mmol, 0.03 eq) in dioxane (1.5 L) was added Cs_2CO_3 (250 g, 769 mmol, 1.5 eq) and stirred at 110 °C for 12 h under N_2 . The reaction mixture was cooled to room temperature and filtered. The filtrate was concentrated under reduced pressure and the residue was purified by silica gel column chromatography (elute with hexane: ethyl acetate=15:1) to afford **410A** (55 g) as a yellow solid. LCMS $[\text{M}+\text{H}]^+=155$.

General procedure 5

Tert-butyl ((1*S*, 3*S*)-3-((5-cyclopropylpyrimidin-2-yl) amino) cyclopentyl) carbamate (410B)

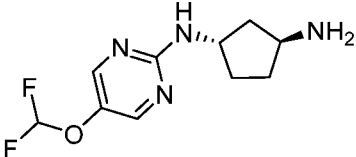
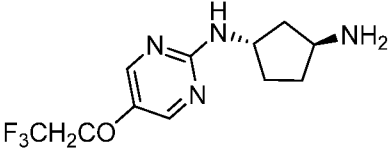
A mixture of **410A** (40 g, 260 mmol, 1 eq) tert-butyl ((1*S*,3*S*)-3-aminocyclopentyl) carbamate (55 g, 275 mmol, 1.05 eq) and DIPEA (105g, 814 mmol, 3.13 eq) in DMSO (400 mL) was stirred at 110 °C for 12 h under N₂. The mixture was then cooled down to room temperature and diluted with water (1000 mL). The resulting mixture was extracted with EtOAc (100 mL x 3), and the combined organic layers were washed with brine, dried over Na₂SO₄, filtered and concentrated. The residue was purified by chromatography on silica gel (eluting with hexane: ethyl acetate=5:1 to 4:1) to afford compound **410B** (55 g) as a pale solid. LCMS [M+H]⁺=319.

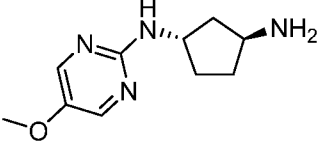
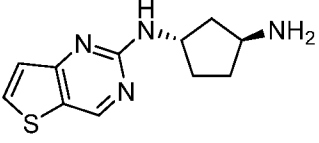
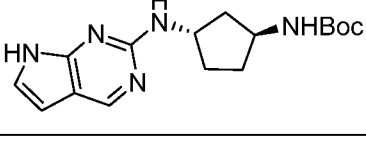
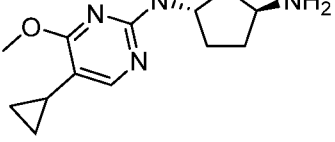
General procedure 6

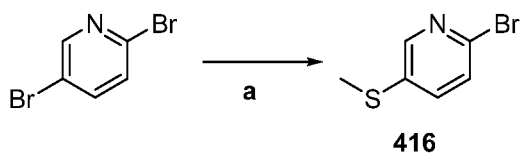
(1*S*, 3*S*)-N¹-(5-cyclopropylpyrimidin-2-yl) cyclopentane-1, 3-diamine (**410C**)

To a solution of **410B** (44 g, 13.8 mmol, 1.0 eq) in MeOH (250 mL) was added HCl (4M in dioxane, 250 mL) drop-wise and resulting solution was stirred at room temperature for 2.5 h. After the reaction was completed, the mixture was concentrated to dryness under vacuum. The residue was re-dissolved in MeOH (500 mL) and ion exchange resin (Ambersep® 900 OH⁻ form) was added to adjust the pH to about 8. The mixture was filtered off and the filtrate was concentrated to afford **410C** (44.5) as yellow oil. LCMS [M+H]⁺=219.

Using the above procedures, the following examples were synthesized:

Structure	Ex. #
	411
	412

	413
	414
	415
	415A

Scheme 61

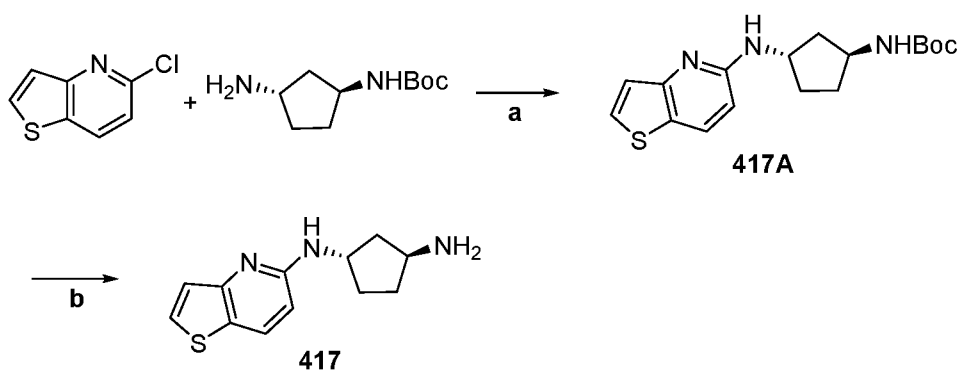
a) 1,2-dimethyldisulfane, n-BuLi, THF, -78°

2-bromo-5-(methylthio) pyridine (416)

A solution of 2,5-dibromopyridine (1 g, 4.22 mmol, 1 eq) in THF (20 mL) was cooled to -78 °C under N₂. Then, n-BuLi (2.5 M, 1.77 mL, 4.43 mmol, 1.05 eq) was added dropwise at -78 °C. The reaction mixture was stirred for 20 minutes, followed by the slow addition of 1,2-dimethyldisulfane (0.411 mL, 4.64 mmol, 1.1 eq). The reaction mixture was stirred for another 1 hour before quenched by saturated NH₄Cl. The reaction mixture was extracted with EA (100 mL) and water (100 mL), and then washed with brine. The organic phase was dried over anhydrous Na₂SO₄. The mixture was filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 10:1) to give **416** (86.8 mg): ESI [M+H]⁺ =

204.1 ^1H NMR (400 MHz, CDCl_3) δ 8.25 (t, $J = 6.2$ Hz, 1H), 7.41 (ddd, $J = 8.9, 8.3, 1.6$ Hz, 2H), 2.58 – 2.40 (m, 3H).

Scheme 62



a) General procedure 2; b) General procedure 6

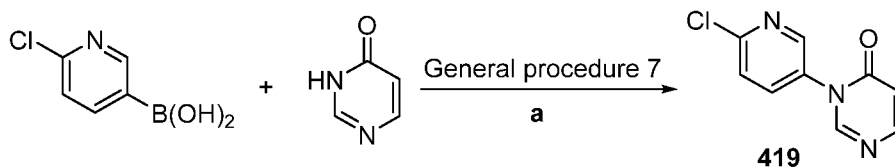
(1S,3S)-N1-(thieno[3,2-b]pyridin-5-yl)cyclopentane-1,3-diamine (417)

Methods analogous to those described in **General Method 2** and **General Method 6** from starting material 5-chlorothieno[3,2-b]pyridine allowed the synthesis of the title compound.

Using the above procedures, the following example was synthesized:

Structure	Ex. #	^1H NMR	LC-MS (M+H) $^+$
	418		224.3

Scheme 63



a) $\text{Cu}(\text{OAc})_2$, pyridine, 4Å MS, DCM, rt

General procedure 7

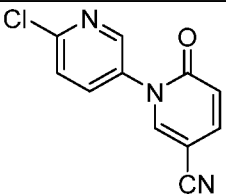
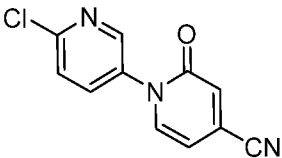
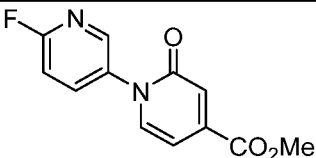
3-(6-chloropyridin-3-yl)pyrimidin-4(3H)-one (419)

A solution of pyrimidin-4(3H)-one (1.5 g, 15.61 mmol, 1.0 eq), (6-chloropyridin-3-yl) boronic acid (2.9 g, 18.73 mmol, 1.2 eq), Cu (OAc)₂ (7.9 g, 43.71 mmol, 2.8 eq), pyridine (2.5 mL, 31.22 mmol, 2.0 eq) and 4Å molecular sieves (8 g) in DCM (60 mL) was stirred at room temperature for 48 h. The mixture was filtered through celite, and the filtrate was concentrated and purified by flash column (petroleum ether: EtOAc: 1:1) to obtain

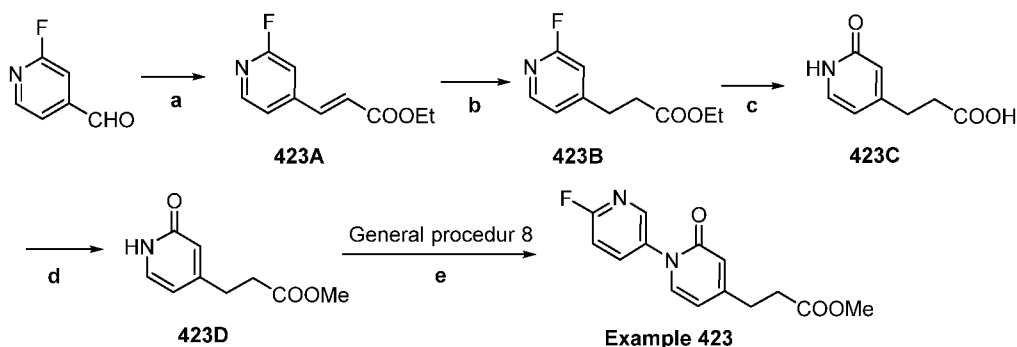
Example 419 as a yellow solid (170 mg, 5.3% yield).

¹H NMR (400MHz, CDCl₃) δ 8.43 (d, *J* = 2.6 Hz, 1H), 8.15 (s, 1H), 7.97 (d, *J* = 6.8 Hz, 1H), 7.80 (dd, *J* = 8.4, 2.8 Hz, 1H), 7.53 (d, *J* = 8.5 Hz, 1H), 6.59 (dd, *J* = 6.8, 0.8 Hz, 1H); MS (ESI+) *m/z* 208.0 (M+H)⁺

Using the procedures described in **Scheme 63**, the following examples were prepared:

Structure	Ex. #
	420
	421
	422

Scheme 64



a) Ethyl 2-(ethoxy(propoxy)phosphoryl)acetate, NaH, THF, 0°C-rt; b) H₂, 10% Pd/C, EtOH; c) HCl, 100°C; d) MeOH, H₂SO₄, reflux; e) 2-fluoro-5-iodopyridine, CuI, N,N'-Dimethyl-1,2-cyclohexanediamine, K₂CO₃, dioxane, 110°C

Ethyl (E)-3-(2-fluoropyridin-4-yl) acrylate (423A)

To a suspension of 60% NaH (1.54 g, 38.4 mmol, 1.2 eq) in THF (15 mL) was added dropwise a solution of ethyl 2-(ethoxy(propoxy)phosphoryl) acetate (8.6 g, 38.4 mmol, 1.2 eq) in THF at 0°C under N₂ atmosphere. The mixture was stirred at 0 °C for 25 min followed by addition of a solution of 2-fluoroisonicotinaldehyde (4.0 g, 32.0 mmol, 1.0 eq) in DMF (15 mL). The resulting mixture was stirred at room temperature for 16 h, and then quenched by sat. aq. NH₄Cl at 0 °C. The aqueous phase was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over Na₂SO₄ and concentrated under vacuum. The residue was purified by column chromatography (PE to PE: EA = 1: 15) to give **423A** (3.0 g, 50% yield) as a white solid. LCMS: m/z 196 [M+H]⁺, rt 2.890 min. ¹H-NMR (400 MHz, CDCl₃) δ 8.26 (d, *J* = 5.2 Hz, 1H), 7.59 (d, *J* = 16.1 Hz, 1H), 7.29 – 7.26 (m, 1H), 7.00 (d, *J* = 1.7 Hz, 1H), 6.60 (d, *J* = 16.0 Hz, 1H), 4.30 (q, *J* = 7.1 Hz, 2H), 1.35 (t, *J* = 7.1 Hz, 3H).

Ethyl 3-(2-fluoropyridin-4-yl) propanoate (423B)

To a solution of **423A** (3.0 g, 20.5 mmol) in EtOH (20 mL) was added 10%Pd/C (400 mg). The reaction system was purged with H₂ and the mixture was stirred under H₂ atmosphere overnight. Pd/C was filtered off and the filtrate was concentrated under vacuum to give **423B** (2.3 g, yield 76.7%), which was used directly: LCMS: m/z 198.1 [M+H]⁺, rt 2.801 min. ¹H-NMR (400 MHz, CDCl₃) δ 8.12 (d, *J* = 5.5 Hz, 1H), 7.04 (d, *J* = 4.8 Hz, 1H), 6.78 (d, *J* = 4.0 Hz, 1H), 4.13 (p, *J* = 6.8 Hz, 2H), 3.03 – 2.97 (m, 2H), 2.66 (t, *J* = 7.6 Hz, 2H),

1.24 (t, $J = 6.7$ Hz, 3H).

3-(2-oxo-1,2-dihydropyridin-4-yl) propanoic acid (423C)

To a 100 mL flask with **423B** (1.53 g, 7.77 mmol) was added concentrated HCl (5 mL). The mixture was heated to 100 °C for 16 h. The mixture was then cooled to room temperature and 2 mL of water was added. Solid NaHCO₃ was added portion- wise to adjust pH to 6. The mixture was extracted with 30% *i*-PrOH in CHCl₃, the combined organic layers were dried over Na₂SO₄ and concentrated. The residue was purified by column chromatography (MeOH/DCM) to give **423C** (1.6 g, yield 91%), which was used to next step directly. LCMS: m/z 167.8 [M+H]⁺; ¹H NMR (400 MHz, CDCl₃) δ 8.14 (d, $J = 5.1$ Hz, 1H), 7.05 (dt, $J = 5.3, 1.7$ Hz, 1H), 6.82 – 6.76 (m, 1H), 3.01 (t, $J = 7.5$ Hz, 2H), 2.73 (t, $J = 7.5$ Hz, 2H).

Methyl 3-(2-oxo-1,2-dihydropyridin-4-yl) propanoate (423D)

To a 100 mL flask with a solution of crude **423C** (1.6 g) in MeOH (28 mL) was added 98% H₂SO₄ (0.15 mL). The reaction was heated to 90 °C for 16 h and then cooled to room temperature. Sat. aq. NaCl was added to above mixture, which was extracted with 30% *i*-PrOH in CHCl₃. The combined organic layers were dried over Na₂SO₄ and concentrated. The residue was purified by column chromatography (MeOH: DCM = 1:15) to give product **423D** (702 mg, yield 55%). LCMS: m/z 182.1 [M+H]⁺.

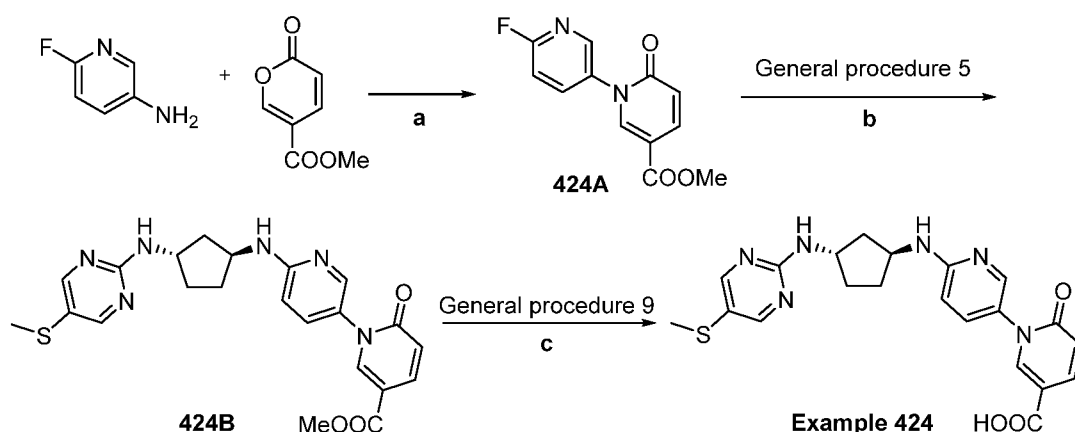
General procedure 8

Methyl 3-(6'-fluoro-2-oxo-2H-[1,3'-bipyridin]-4-yl) propanoate (423)

To a sealed tube was added **423D** (100.0 mg, 0.55 mmol, 1.0 eq), 2-fluoro-5-iodopyridine (147 mg, 0.66 mmol, 1.2 eq), CuI (21.0 mg, 0.10 mmol, 0.2 eq), N, N'-Dimethyl-1,2-cyclohexanediamine (15.5 mg, 0.10 mmol, 0.2 eq), and K₂CO₃ (151.0 mg, 1.10 mmol, 2.0 eq). Dioxane (3 mL) was added and the resulting mixture was purged with N₂ and stirred at 110 °C for 16 h. The mixture was then diluted with dichloromethane and filtered. The filtrate was washed with water and separated. Aqueous phase was extracted with dichloromethane three times. The combined organic layers were dried over Na₂SO₄,

concentrated and purified by silica gel chromatography to give **423** (42 mg, yield 27.6%).
LCMS: m/z 278.08 $[M+H]^+$

Scheme 65



a) EtOH, reflux; b) **131C**, General procedure 5; c) NaOH, MeOH/H₂O, 50°C.

Methyl 6'-fluoro-2-oxo-2H-[1,3'-bipyridine]-5-carboxylate (**424A**)

A mixture of 6-fluoropyridin-3-amine (1.1 g, 10 mmol, 1.0 eq) and methyl 2-oxo-2H-pyran-5-carboxylate (1.5 g, 10 mmol, 1.0 eq) in EtOH (10 mL) was stirred at reflux overnight, and then cooled down to room temperature. The resulting precipitate was collected by filtration and purified by chromatography on silica gel eluting with petroleum ether: EtOAc = 2:1 to afford compound **424A** (440 mg, 18%) as an off-white solid.

Methyl 6'-(((1S,3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino)-2-oxo-2H-[1,3'-bipyridine]-5-carboxylate (**424B**)

Methods analogous to those described above from starting material **131C** and **424A** afforded **424B**.

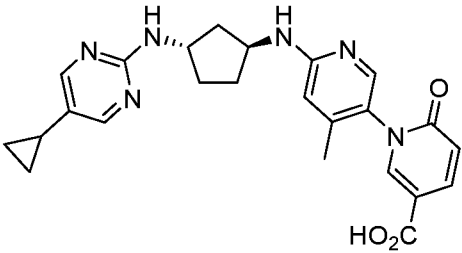
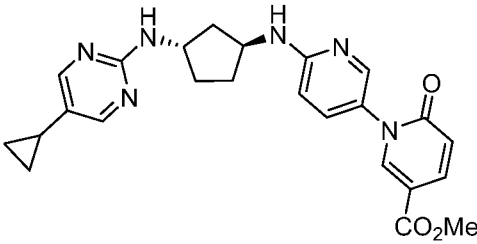
General procedure 9

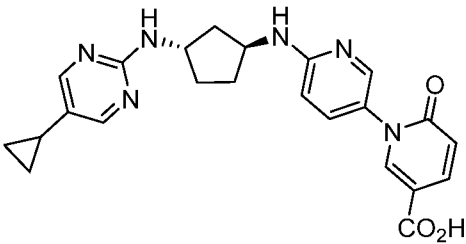
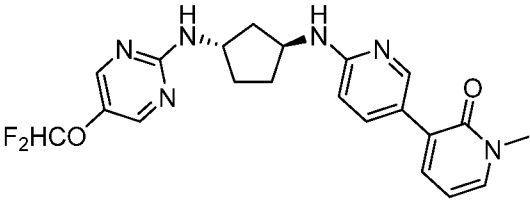
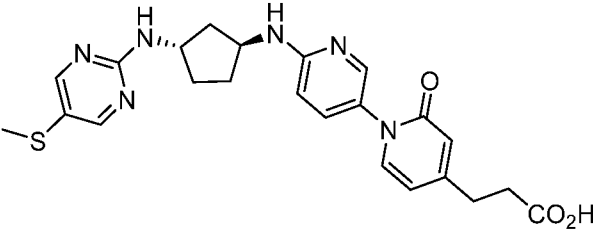
6'-(((1S, 3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino)-2-oxo-2H-[1, 3'-bipyridine]-5-carboxylic acid (Example 424)

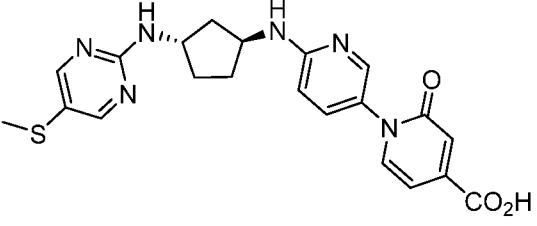
To a solution of compound **424B** (100 mg, 0.22 mmol, 1.0 eq) in MeOH: H₂O = 5:1 (10 mL) was added NaOH (35 mg, 0.88 mmol, 4.0 eq). The mixture was stirred at 50 °C for 3

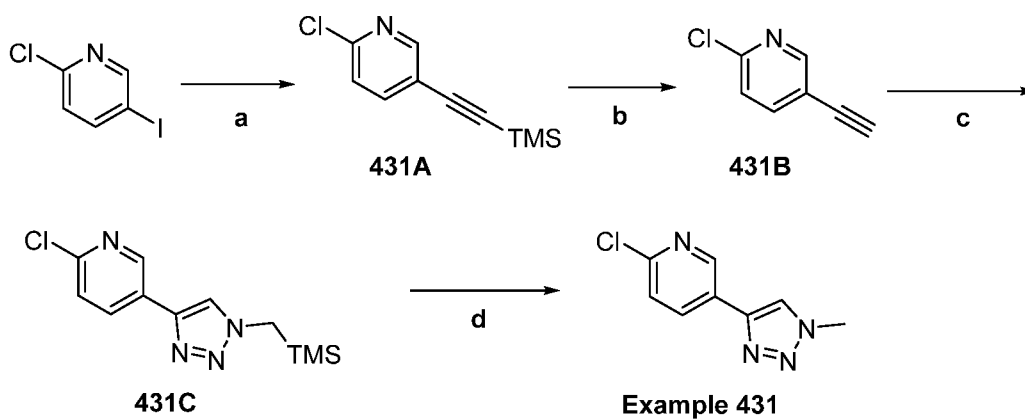
h and then acidified to pH= 5-6 after cooling down to room temperature. The resulting mixture was concentrated and re-dissolved in THF (50 mL). The solid was filtered off and the filtrate was concentrated and triturated with EA: MeOH= 5:1 to afford **Example 424** (90 mg, 93%) as a light yellow solid: ^1H NMR (400 MHz, DMSO- d_6) δ : 8.35(s, 2H), 8.25s, 1H), 8.10 1H), 7.87 (d, J = 9.2 Hz, 1H), 7.56 (s, 1H), 6.87 (s, 1H), 6.51 (d, J = 9.2 Hz, 1H), 4.36-4.33 (m, 2H), 2.35 (s, 3H), 2.22-2.10 (m, 2H), 2.01-1.93 (m, 2H), 1.57-1.55 (m, 2H).

Using the above procedures, the following examples were synthesized:

Structure	Ex. #	^1H NMR	LC-MS (M+H) $^+$
	425	^1H NMR (400 MHz, CD $_3$ OD) δ 8.35 (d, J = 2.3 Hz, 1H), 8.31 (s, 2H), 8.11 (dd, J = 9.6, 2.5 Hz, 1H), 8.06 (s, 1H), 7.00 (s, 1H), 6.67 (d, J = 9.6 Hz, 1H), 4.58-4.51 (m, 1H), 4.33-4.27 (m, 1H), 2.50 – 2.28 (m, 2H), 2.24 – 2.10 (m, 5H), 1.93 – 1.82 (m, 1H), 1.82 – 1.73 (m, 2H), 1.06 – 0.96 (m, 2H), 0.78 – 0.65 (m, 2H).	447.5
	426	^1H NMR (400 MHz, CD $_3$ OD) δ 8.40 (d, J = 1.6 Hz, 1H), 8.25 (d, J = 21.6 Hz, 2H), 8.11 (s, 1H), 8.06-8.03 (m, 1H), 7.87 (t, J = 9.2 Hz, 1H), 7.03 (d, J = 9.2 Hz, 1H), 6.63 (d, J = 9.6 Hz, 1H), 4.50 (d, J = 6.0 Hz, 1H), 4.31 (d, J = 4.8 Hz, 1H), 3.86 (s, 3H), 2.40-2.32 (m, 2H), 2.18 (t, J = 12.8 Hz, 2H), 1.86-1.75 (m, 3H), 0.99-0.97 (m, 2H), 0.69 (d, J = 4.8 Hz, 2H).	

	427	¹ H NMR (400MHz, CD ₃ OD) δ 8.37-8.36 (d, <i>J</i> = 2.4 Hz, 1H), 8.19 (s, 2H), 8.10-8.06(m, 2H), 8.04-8.03 (d, <i>J</i> = 2.4 Hz, 1H), 7.85-7.83 (d, <i>J</i> = 8.0 Hz, 1H), 7.00-6.97 (d, <i>J</i> = 9.6 Hz, 1H), 6.64-6.62 (d, <i>J</i> = 9.6 Hz, 1H), 4.46-4.42 (t, <i>J</i> = 13.6 Hz, 1H), 4.31-4.29 (t, <i>J</i> = 11.2 Hz, 1H), 2.39-2.31 (m, 2H), 2.15-2.11 (t, <i>J</i> = 16.4 Hz, 1H), 1.83-1.72 (m, 3H), 0.98-0.94 (m, 2H), 0.68-0.64 (m, 2H).	433.4
	428	¹ H NMR (400MHz, CD ₃ OD) δ: 8.49-8.48 (d, <i>J</i> = 2.0 Hz, 1H), 8.24-8.19 (m, 3H), 7.83- 7.81 (m, 1H), 7.74-7.72 (m, 1H), 7.09-7.07 (d, <i>J</i> = 9.2 Hz, 1H), 6.88-6.47 (m, 2H), 4.47- 4.40 (m, 1H), 4.27-4.21 (m, 1H), 3.66-3.64 (d, <i>J</i> = 9.6 Hz 3H), 2.44-2.26 (m, 2H), 2.19- 2.07 (m, 2H), 1.77-1.65 (m, 2H).	429
	429	¹ H-NMR (400 MHz, CDCl ₃) δ 10.40 (s, 1H), 10.14 (s, 1H), 7.92 (s, 2H), 7.36 (d, <i>J</i> = 9.5 Hz, 1H), 7.21 (d, <i>J</i> = 7.3 Hz, 1H), 6.57 (s, 1H), 6.28 (d, <i>J</i> = 6.9 Hz, 1H), 4.62 (s, 1H), 4.31 (s, 1H), 2.87 (q, <i>J</i> = 7.1 Hz, 3H), 2.72 (d, <i>J</i> = 7.5 Hz, 3H), 2.44 (s, 3H), 2.43 – 2.25 (m, 3H), 2.08 (dt, <i>J</i> = 14.2, 7.7 Hz, 1H), 1.97 – 1.71 (m, 2H).	467

	430	¹ H NMR (400 MHz, CD ₃ OD) : δ 8.378 (s, 2H), 8.12(s, 1H), 7.93 (s, 1H), 7.73-7.72 (d, <i>J</i> = 7.2 Hz, 1H), 7.21 (s, 1H), 7.10- 7.08 (d, <i>J</i> = 9.6 Hz, 1H), 6.92- 6.90 (m, 1H), 4.48 (s, 1H), 4.29 (s, 1H), 2.38-2.33 (m, 5H), 2.16-2.14 (d, <i>J</i> = 7.2 Hz, 2H), 1.76-1.75 (d, <i>J</i> = 3.6 Hz, 2H).	439

Scheme 66

a) Ethynyltrimethylsilane, CuI, Pd(PPh₃)Cl₂, Et₃N, 120°C; b) K₂CO₃, MeOH, rt;
c) (azidomethyl)trimethylsilane, CuI, Et₃N, THF, rt; d) TBAF, THF, rt;

2-chloro-5-((trimethylsilyl)ethynyl) pyridine (431A)

To a degassed solution of 2-chloro-5-iodopyridine (5 g, 20.88 mmol, 1.0 eq) in triethylamine (35 mL) were added ethynyltrimethylsilane (3.2 mL, 22.97 mmol, 1.1 eq), CuI (397.7 mg, 2.09 mmol, 0.1 eq) and Pd(PPh₃)₂Cl₂ (1.5 g, 2.09 mmol, 0.1 eq). The reaction mixture was stirred at room temperature for 16 h under Nitrogen. Water (150 mL) was added and the system was extracted with Et₂O (100 mLx2). The combined organic layers were dried over Na₂SO₄, filtered and then concentrated under reduced

pressure. The resulting crude **431A** (6.2 g, black solid) was used for the next step without further purification. MS (ESI+) m/z 209.9 (M+H)⁺

2-chloro-5-ethynylpyridine (431B)

A solution of **431A** (crude, 20.88 mmol, 1.0 eq) and K₂CO₃ (2.9 g, 20.88 mmol, 1.0 eq) in methanol (50 mL) was stirred at room temperature for 2 h. Following solvent removal under reduced pressure, DCM was added (150 mL) and the mixture was filtered. The filtration was concentrated and purified by flash column (petroleum ether: EtOAc= 10:1) to afford compound **432B** as a yellow solid (1.0 g, 34.8% yield in two steps). MS (ESI+) m/z 138.1 (M+H)⁺; ¹H NMR (400MHz, DMSO-*d*₆) δ : 8.55 (d, J = 2.1 Hz, 1H), 7.98 (dd, J = 8.4, 2.4 Hz, 1H), 7.57 (d, J = 8.3 Hz, 1H), 4.56 (s, 1H).

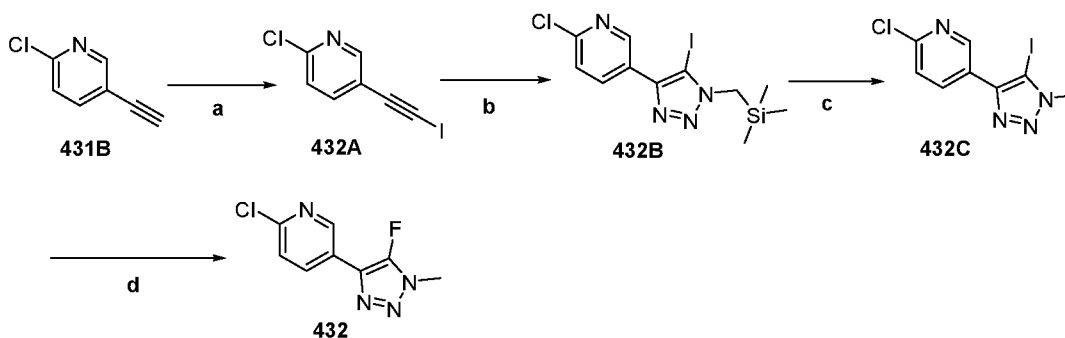
2-chloro-5-(1-((trimethylsilyl)methyl)-1H-1,2,3-triazol-4-yl) pyridine (431C)

A solution of **431B** (345 mg, 2.54 mmol, 1.0 eq), (azidomethyl)trimethylsilane (327 mg, 2.54 mmol, 1.0 eq), CuI (48 mg, 0.25 mmol, 0.1 eq), NEt₃ (513 mg, 5.08 mmol, 2.0 eq) in THF (10 mL) was stirred at room temperature for 16 h. The reaction mixture was then concentrated to afford **431C** (673 mg) which was used without further purification.

2-chloro-5-(1-methyl-1H-1,2,3-triazol-4-yl) pyridine (431)

To a solution of **431C** in THF (10 mL) was added TBAF (0.80 g, 3.0 mmol, 1.2 eq) and the resulting solution was stirred at room temperature for 2h. The reaction mixture was concentrated under reduced pressure and crude product was purified by column chromatography on silica gel (PE: EA=1:1) to afford **431** (150 mg).

Scheme 67



a) LDA, I₂, THF, -78°C; b) (azidomethyl)trimethylsilane, Et₃N, CuI, THF, rt; c) TBAF, THF/H₂O, rt
d) KF, CH₃CN/H₂O, MW, 160°C

2-chloro-5-(iodoethynyl) pyridine (432A)

LDA (4.4 mL, 8.73 mmol, 1.2 eq) was added dropwise to a solution of **431B** (1.0 g, 7.27 mmol, 1.0 eq) in THF (15 mL) at -78 °C under nitrogen. The mixture was stirred at -78 °C for 0.5 hour, then a solution of iodine (2.0 g, 8.00 mmol, 1.1 eq) in THF (10 mL) was added dropwise. The resulting solution was slowly warmed to room temperature and stirred for another 5 h, and then quenched by addition of sat. ammonium chloride solution (25 mL). The organic layer was separated and the aqueous layer extracted with EtOAc (50 mL). The combined organic layers were washed with Na₂S₂O₃ (25 mLx2) and brine (30 mL), dried over Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by flash column (petroleum ether: EtOAc: 20:1) to afford **432A** as yellow solid (1.56 g, 82.1% yield). MS (ESI+) *m/z* 263.9 (M+H)⁺; ¹H NMR (400MHz, DMSO-*d*₆) δ: 8.51 (d, *J* = 2.0 Hz, 1H), 7.94 (dd, *J* = 8.3, 2.4 Hz, 1H), 7.55 (d, *J* = 8.3 Hz, 1H).

2-chloro-5-(5-iodo-1-((trimethylsilyl)methyl)-1H-1,2,3-triazol-4-yl) pyridine (432B)

CuI (108.4 mg, 5.69 mmol, 1.0 eq) and Et₃N (1.6 mL, 11.39 mmol, 2.0 eq) were stirred in THF (60 mL) at room temperature under nitrogen for 1 hour. A solution of **432A** (1.5 g, 5.69 mmol, 1.0 eq) and (azidomethyl)trimethylsilane (735.8 mg, 5.69 mmol, 1.0 eq) in THF (20 mL) was added in a single portion to above catalyst solution. Then, the mixture was stirred at room temperature for 16 h. The reaction was quenched by addition of 10% ammonium chloride solution (15 mL) and concentrated. The residue was washed with

water (30 mL) and EtOAc (8 mL) to afford **432B** as yellow solid (1.6 g, 72.7% yield), which was used to next step directly. ^1H NMR (400MHz, DMSO- d_6) δ 8.74 (d, J = 2.3 Hz, 1H), 8.14 (dd, J = 8.3, 2.5 Hz, 1H), 7.51 (d, J = 8.4 Hz, 1H), 3.80 (s, 2H), 0.00 (s, 9H). MS (ESI+) m/z 393.0 (M+H) $^+$

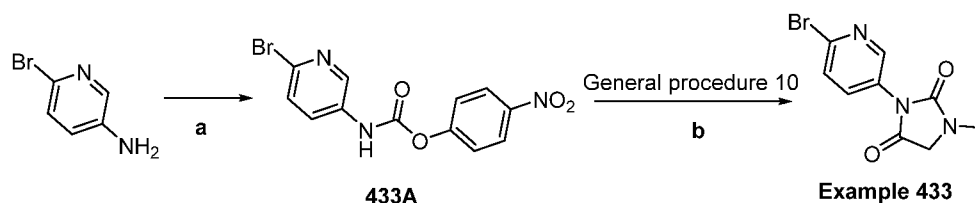
2-chloro-5-(5-iodo-1-methyl-1H-1,2,3-triazol-4-yl) pyridine (432C)

To a solution of **432B** (1.6 g, 4.07 mmol, 1.0 eq) in THF (70 mL) was added water (0.15 mL, 8.15 mmol, 2.0 eq), followed by addition of TBAF (4.9 mL, 4.89 mmol, 1.2 eq) dropwise at 0 °C. The resulting reaction mixture was stirred at 0 °C for 15 min and poured into water (100 mL), which was extracted with DCM (300 mL). The separated organic layer was washed with brine (80 mL), dried over Na₂SO₄ and concentrated. The residue was purified by flashed column (petroleum ether: EtOAc: DCM: 2:1:1) to obtain **432B** as yellow solid (810 mg, 62.3% yield). MS (ESI+) m/z 320.9 (M+H) $^+$; ^1H NMR (400MHz, DMSO- d_6) δ : 8.91 (d, J = 2.1 Hz, 1H), 8.32 (dd, J = 8.4, 2.5 Hz, 1H), 7.70 (d, J = 8.4 Hz, 1H), 4.13 (s, 3H).

2-chloro-5-(5-fluoro-1-methyl-1H-1,2,3-triazol-4-yl) pyridine (432)

A suspension of **406B** (800 mg, 2.50 mmol, 1.0 eq) and KF (1.5 g, 25.00 mmol, 10.0 eq) in acetonitrile/water (14 mL, 1:1) was reacted in microwave reactor at 160 °C for 20 min. After evaporation under reduced pressure, the residue was dissolved with DCM (300 mL) and filtered. The filtrate was concentrated and purified by flash column (petroleum ether: EtOAc: DCM: 2:1:1) to afford **Example 432** as yellow solid (220mg, 41.4% yield). MS (ESI+) m/z 213.0 (M+H) $^+$; ^1H NMR (400 MHz, DMSO- d_6) δ 8.77 (d, J = 2.4 Hz, 1H), 8.17 (dd, J = 8.3, 2.4 Hz, 1H), 7.67 (d, J = 8.3 Hz, 1H), 4.01 (s, 3H).

Scheme 68



a) 4-nitrophenyl carbonochloridate, CH₃CN; b) methyl 2-(methylamino)acetate hydrochloride, DIPEA, CH₃CN

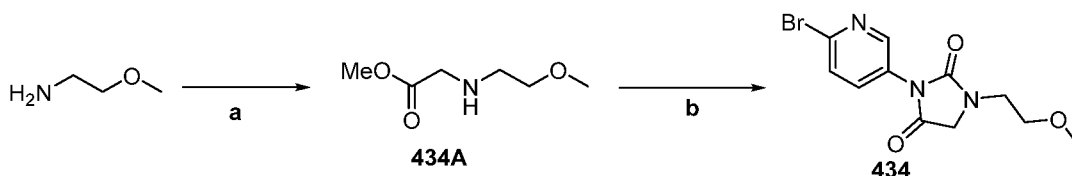
4-nitrophenyl (6-bromopyridin-3-yl) carbamate (433A)

To a solution of 6-bromopyridin-3-amine (600 mg, 3.47 mmol, 1.0 eq) in acetonitrile (20 mL) was added 4-nitrophenyl carbonochloridate (768.9 mg, 3.81 mmol, in 4 mL acetonitrile, 1.1 eq) dropwise, and the system temperature was maintained below 40 °C. After the addition, the mixture was continued to stir at room temperature for 30 min and a yellow precipitate was observed. The precipitate was filtered and washed with acetonitrile (2 mL) to afford **433A** as a yellow solid (1.1 g, ~50% purity), which was used in the next step without further purification.

General procedure 10**3-(6-bromopyridin-3-yl)-1-methylimidazolidine-2,4-dione (Example 433)**

A solution of methyl 2-(methylamino) acetate hydrochloride (454.1 mg, 3.25 mmol, 1.0 eq) and DIPEA (1.7 mL, 9.76 mmol, 3.0 eq) in acetonitrile (15 mL) was stirred at room temperature for 15 min. **433A** (1.1 g, 3.25 mmol, 1.0 eq) was added, and the resulting system was continued to stir at room temperature for 10 min. The mixture was concentrated and the residue was purified by flash column (petroleum ether: EtOAc: 1:1) to afford compound **Example 433** as a yellow oil (510 mg, 54.6% yield by two steps). MS (ESI+) *m/z* 270.1 (M+H)⁺; ¹H NMR (400MHz, DMSO-*d*₆) δ 8.48 - 8.52 (m, 1H), 7.82 – 7.89 (m, 2H), 4.19 (s, 2H), 3.00 (s, 3H).

Scheme 69



a) methyl 2-bromoacetate, TEA, THF rt; b) **433A**, General procedure 10

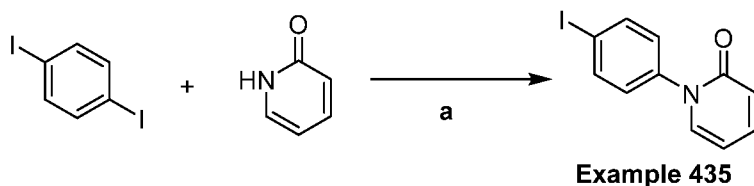
Methyl (2-methoxyethyl) glycidate (434A)

To a solution of 2-methoxyethan-1-amine (2.9 mL, 33.36 mmol, 1.0 eq) in THF (40 mL) was added dropwise Et₃N (9.3 mL, 66.90 mmol, 2.0 eq), followed by the addition of methyl 2-bromoacetate (2.8 mL, 29.58 mmol, 0.9 eq). The reaction mixture was stirred at room temperature for 19 h. The reaction mixture was diluted with EA then washed with water and brine. The organic phase was dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 20:1) to afford **434A** (830 mg) as a colorless liquid. ¹H NMR (400 MHz, DMSO-*d*₆) δ 3.62 (s, 3H), 3.38-3.34 (m, 4H), 3.23 (s, 3H), 2.65 (t, *J* = 5.6 Hz, 2H).

3-(6-bromopyridin-3-yl)-1-(2-methoxyethyl) imidazolidine-2, 4-dione (Example 434)

Methods analogous to those described above from starting material **434A** and **433A** afforded Example **434** as a yellow solid: ¹H NMR (400 MHz, CDCl₃) δ 8.59 (d, *J* = 2.6 Hz, 1H), 7.74 (dd, *J* = 8.5, 2.7 Hz, 1H), 7.58 (d, *J* = 8.5 Hz, 1H), 4.22 (s, 2H), 3.70 – 3.64 (m, 2H), 3.64 – 3.60 (m, 2H), 3.39 (s, 3H). ESI (M+H)⁺ = 314.3.

Scheme 70

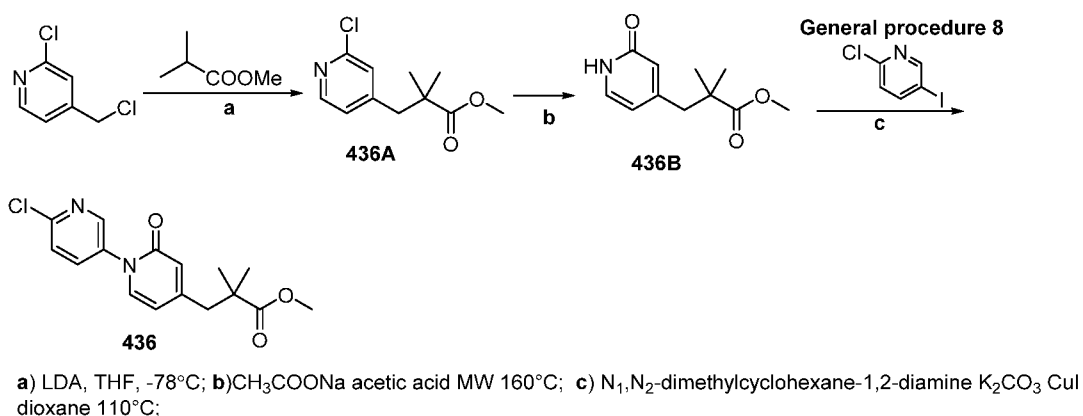


a) CuI, K₂CO₃, DMSO, 130°C

1-(4-iodophenyl) pyridin-2(1H)-one (435)

A solution of 1,4-diiodobenzene (1.0 g, 3.0 mmol, 1.0 eq), pyridin-2(1H)-one (288 mg, 3 mmol, 1.0 eq), CuI (58 mg, 0.3 mmol, 0.1eq) and K₂CO₃ (828 mg, 6 mmol, 2.0 eq) in DMSO (10 mL) was stirred at 130 °C under N₂ for 2 h. The reaction mixture was cooled down to room temperature and diluted with ethyl acetate (30 mL). The organic mixture was washed with water and brine in turn, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 10: 1 to EA) to afford 200 mg of **Example 435** as a white solid. ESI (M+H)⁺ = 298.09

Scheme 71



Methyl 3-(2-chloropyridin-4-yl)-2,2-dimethylpropanoate (436A)

A solution of methyl isobutyrate (3.3 g, 32.0 mmol, 2.08 eq) in THF (25 mL) was added dropwise to a solution of LDA (17 mL, 34.0 mmol, 2.2 eq) in THF (50 mL) at -78 °C under N₂ atmosphere over 15 min. The resulting mixture was stirred at -78 °C for 45 minutes, and then treated with a solution of 2-chloro-4-(chloromethyl) pyridine (2.5 g, 15.4 mmol, 1.0 eq) in THF (6 mL) over 5 minutes. The cooling bath was removed, and the reaction mixture was stirred for 18 h at rt. 1.0 N aq. hydrochloric acid was added dropwise to above solution (50 mL) to quench the reaction. The organic phase was separated, the aqueous phase was extracted with ethyl acetate. The combined organic layers were washed with water, dried over sodium sulfate, and concentrated under vacuum. The crude product was purified by column chromatograph to provide compound **436A** (3.2 g) as a yellow oil: LCMS: m/z 228.0. ¹H NMR (400 MHz, CDCl₃) δ 8.33 – 8.21 (m, 1H), 7.16 – 7.07 (m,

1H), 6.98 (dd, $J = 5.1, 1.5$ Hz, 1H), 3.68 (s, 3H), 2.84 (s, 2H), 1.21 (s, 6H).

Methyl 2,2-dimethyl-3-(2-oxo-1,2-dihydropyridin-4-yl) propanoate (436B)

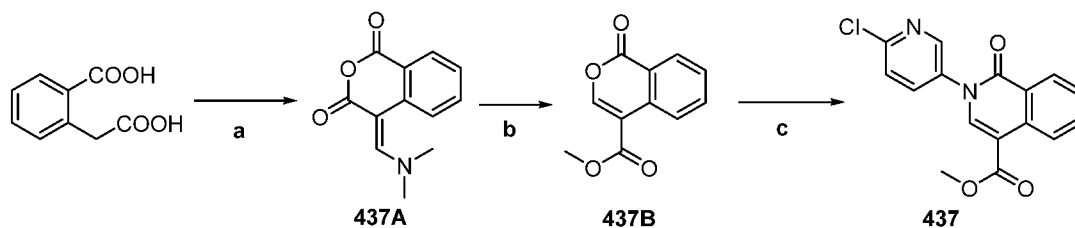
A solution of **436A** (1.2 g, 5.3 mmol, 1.0 eq) sodium acetate (868 mg, 10.6 mmol, 2.0 eq) in acetic acid (5.3 mL) was heated in a microwave reactor at 160 °C for 1 h. The mixture was concentrated under vacuum and the residue was poured into water. The aqueous phase was extracted twice with 15% isopropanol in DCM. The combined organic layers were washed with sat. aq. NaHCO_3 and dried over Na_2SO_4 , and concentrated under vacuum. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 20: 1) to afford **436B** (330mg) as a white solid: ESI $[\text{M}+\text{H}]^+ = 210.24$.

General procedure 11

Methyl 3-(6'-chloro-2-oxo-2H-[1,3'-bipyridin]-4-yl)-2,2-dimethylpropanoate (436C)

A suspension of **436B** (330 mg, 1.58 mmol, 1.0 eq), 2-chloro-5-iodopyridine (567 mg, 2.37 mmol, 1.5 eq), N_1, N_2 -dimethylcyclohexane-1,2-diamine (44.8 mg, 0.316 mmol, 0.2 eq), CuI (60 mg, 0.316 mmol, 0.2 eq) and K_3CO_3 (436 mg, 3.16 mmol, 2.0 eq) in dioxane (8 mL) was stirred at 110 °C for overnight under N_2 . The reaction mixture was cooled to room temperature and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EtOAc = 3: 1 to PE: EtOAc = 1: 1) to afford **436C** (350 mg) as a yellow oil: ESI $[\text{M}+\text{H}]^+ = 321.77$.

Scheme 72



a) POCl_3 , DMF, 0°C; b) HCl, MeOH, rf; c) 6-chloropyridin-3-amine, HOAc, 120°C.

(E)-4-((dimethylamino) methylene) isochromane-1, 3-Dione (437A)

Phosphoryl chloride (10 mL, 107mmol, 2.1 eq) was added, with stirring, to a solution of 2- (carboxymethyl) benzoic acid (10 g, 50 mmol, 1.0 eq) in DMF (100 mL) at 0 °C. The resulting mixture was stirred for a further 1 h, and then poured into ice water. The precipitate formed was collected by filtration and washed with water to give the **437A** as a yellow solid (10 g).

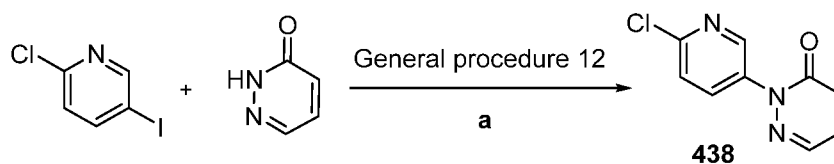
Methyl 1-oxo-1H-isochromene-4-carboxylate (**437B**)

Dry hydrogen chloride gas was passed through a stirring solution of **437A** (6.2 g, 0.03 mmol, 1.0 eq) in methanol (180 mL) at room temperature for 2 h. The solution was heated under reflux for 2 h and then concentrated under reduced pressure. The residue was diluted with water and then extracted with DCM (20 mLx3). The combined organic layers were washed with brine (20 mL), dried over Na₂SO₄, filtered and concentrated. The crude residue was purified by column chromatography on silica gel (PE: EA=3:1) to afford **437B** (1.9 g).

Methyl 2-(6-chloropyridin-3-yl)-1-oxo-1,2-dihydroisoquinoline-4-carboxylate (Example **437**)

A solution of **437B** (0.83 g, 0.41 mmol, 1.0 eq) and 6-chloropyridin-3-amine (0.53 g, 0.41 mmol, 1.0 eq) in AcOH (15 mL) was heated to 120 °C and stirred for 2 h. The system was cooled down to room temperature and concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel (PE: EA=10:1) to afford Example **437** (400 mg).

Scheme 73



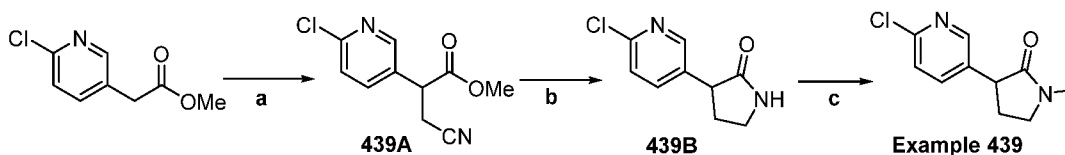
a) CuI, K₂CO₃, N₁,N₂-dimethylcyclohexane-1,2-diamine, DMSO, 120°C

General procedure 12

2-(6-chloropyridin-3-yl) pyridazin-3(2H)-one (**438**)

A mixture of 2-chloro-5-iodopyridine (5.95 g, 25 mmol, 1.0 eq), pyridazin-3(2H)-one (2.52 g, 26.3 mmol, 1.05 eq), CuI (475 mg, 2.5 mmol, 0.1 eq), trans-N,N'-Dimethyl-1,2-cyclohexanediamine (534 mg, 3.76 mmol, 0.15 eq) and K₂CO₃ (6.9 g, 50 mmol, 2.0 eq) in DMSO (25 mL) was stirred at 120 °C under N₂ atmosphere overnight. The mixture was cooled down to room temperature and filtered. The filtrate was diluted with water and then extracted with EA (200 mL x 2). The combined organic layers were washed with brine, dried over Na₂SO₄, filtered, concentrated. The resulting residue was purified by chromatography on silica gel eluting with PE: EA= 5:1-1:1 to afford **438** (3.6 g, 69%) as a white solid.

Scheme 74



a) LiHMDS, BrCH₂CN, -78°C; b) NaBH₄, CoCl₂, THF/H₂O, 0°C-rt; c) NaH, MeI, THF, 0°C-rt

Methyl 2-(6-chloropyridin-3-yl)-3-cyanopropanoate (**439A**)

To a cold (-78 °C) solution of methyl 2-(6-chloropyridin-3-yl) acetate (3.0 g, 16.2 mmol, 1.0 eq) in THF (30 mL) was added dropwise LiHMDS (24.24 mL, 24.24 mmol, 1.5 eq). The reaction mixture was stirred at -78 °C for 2 h. 2-bromoacetonitrile (1.7 mL, 24.24 mmol, 1.5 eq) was added dropwise at -78 °C. The reaction mixture was stirred at -78 °C for another 2 h before it was quenched by water. The reaction mixture was extracted with EA three times. The combined organic phases were washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 2:1) to afford **439A** (1.46 g) as a yellow oil. ESI (M+H)⁺ = 225.3

3-(6-chloropyridin-3-yl) pyrrolidin-2-one (**439B**)

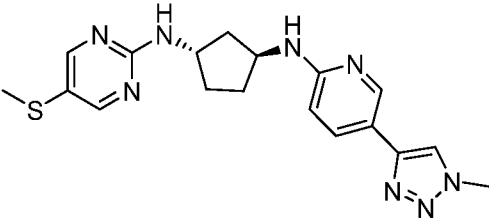
To a cold (0 °C) solution of **439A** (700 mg, 3.1 mmol, 1.0 eq) and CoCl₂ (370 mg, 1.56 mmol, 0.5 eq) in THF/water (6mL/3mL) was added NaBH₄ (590 mg, 15.6 mmol, 5.0 eq)

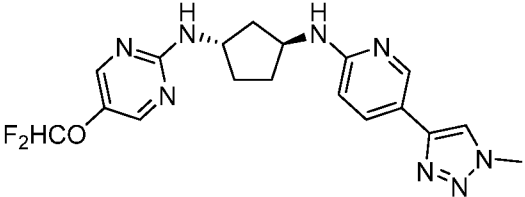
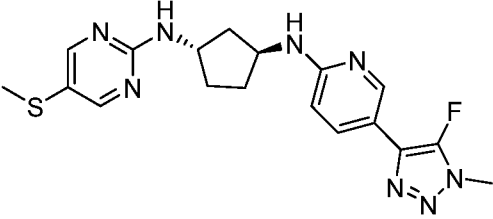
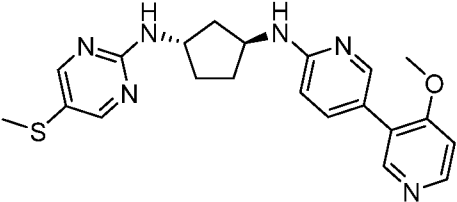
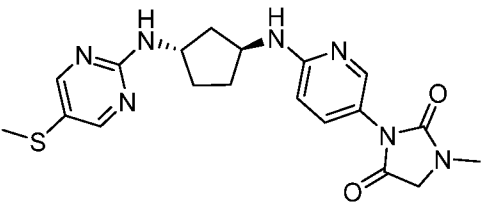
under N₂ at 0 °C. The reaction mixture was stirred for 2 h while the temperature was allowed to warm up to room temperature. The reaction was then quenched with saturated NH₄Cl and filtered through celite. The filtrate was extracted with DCM three times. The combined organic layers were washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:1) to afford **439B** (360 mg) as a white solid: ¹H NMR (400 MHz, CDCl₃) δ 8.32 (d, *J* = 2.5 Hz, 1H), 7.64 (dd, *J* = 8.3, 2.5 Hz, 1H), 7.33 (d, *J* = 8.3 Hz, 1H), 3.65 (t, *J* = 9.4 Hz, 1H), 3.54 – 3.50 (m, 2H), 2.66 (ddd, *J* = 13.5, 9.4, 4.9 Hz, 1H), 2.32 – 2.15 (m, 1H). ESI (M+H)⁺ = 197.2.

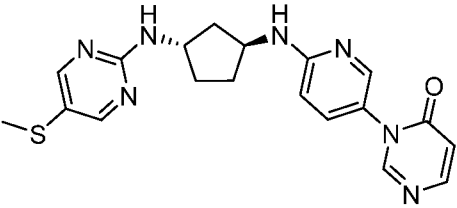
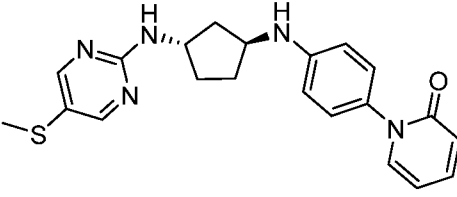
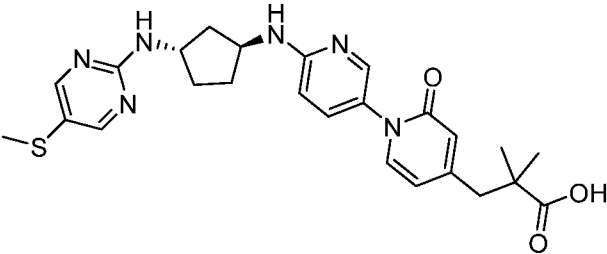
3-(6-chloropyridin-3-yl)-1-methylpyrrolidin-2-one (Example 439)

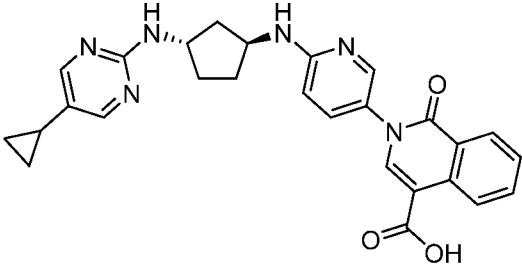
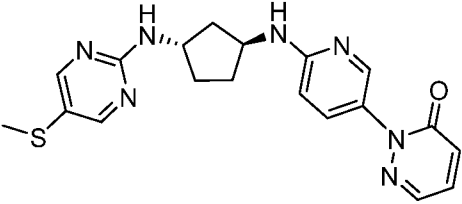
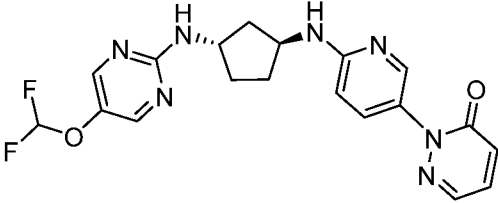
To a cold (0 °C) solution of **439B** (210 mg, 1.1 mmol, 1.0 eq) in THF (10 mL) was added 60% NaH (64 mg, 1.6 mmol, 1.5 eq). The reaction mixture was stirred at 0 °C for 15 minutes before the addition of iodomethane (0.053 mL, 0.8 mmol, 0.8 eq) in THF (0.5 mL) dropwise. The resulting solution was continued to stir for another 2 h at 0 °C and quenched with saturated NH₄Cl. The system was partitioned and separated, and the aqueous phase was then extracted with EA three times. The combined organic phases were dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:4) to afford **Example 439** (80 mg) as a brown oil. ESI (M+H)⁺ = 211.2

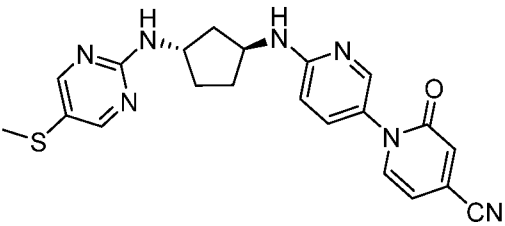
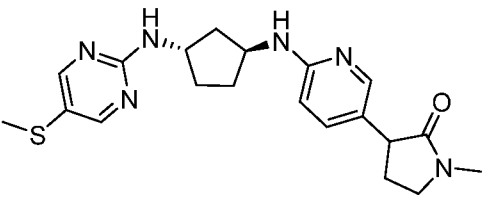
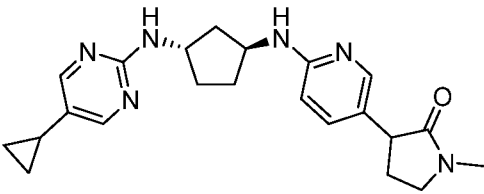
Using the above procedures, the following examples were synthesized:

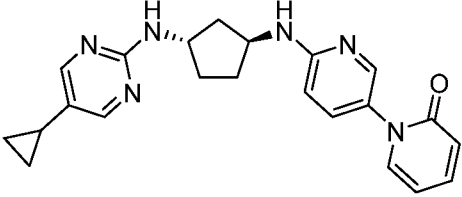
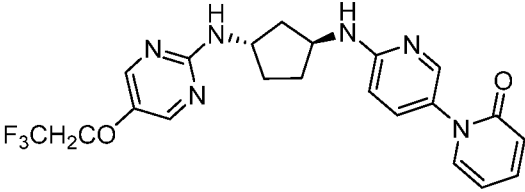
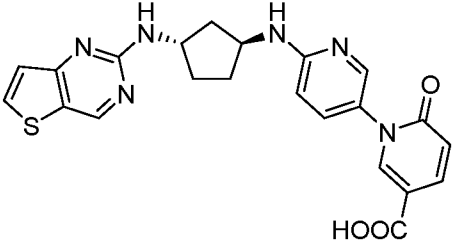
Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	440	¹ H NMR (400 MHz, CD ₃ OD) δ: 8.37 (s, 1H), 8.33 (s, 2H), 8.13 (s, 1H), 7.81 (d, <i>J</i> = 7.2 Hz, 1H), 6.60 (d, <i>J</i> = 7.2 Hz, 1H), 4.40-4.32 (m, 2H), 4.13 (s, 3H), 2.28-2.24 (m, 2H), 2.35 (s, 3H),	383

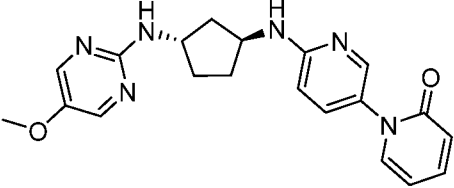
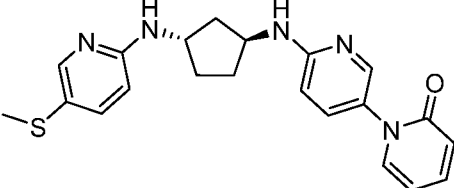
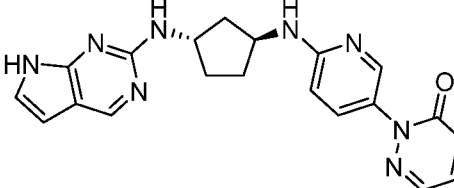
		2.28-2.24 (m, 2H), 2.03-1.97 (m, 2H), 1.63-1.60 (m, 2H).	
	441	¹ H NMR (400 MHz, CD ₃ OD) δ: 8.37 (d, <i>J</i> = 2 Hz, 1H), 8.16 (s, 2H), 8.13 (s, 1H), 7.82 (dd, <i>J</i> = 9.2 Hz, 2.4 Hz, 1H), 6.69 (t, <i>J</i> = 73.6 Hz, 1H), 6.60 (d, <i>J</i> = 8.4 Hz, 1H), 4.39-4.31 (m, 2H), 4.15 (s, 3H), 2.29-2.22 (m, 2H), 2.04-1.96 (m, 2H), 1.63-1.58 (m, 2H).	403.1
	442	¹ H NMR (400 MHz, CD ₃ OD) δ: 8.37 (s, 2H), 8.25 (dd, <i>J</i> = 9.4, 2.0 Hz, 1H), 8.13 (d, <i>J</i> = 1.6 Hz, 1H), 7.18 (d, <i>J</i> = 9.4 Hz, 1H), 4.44 - 4.51 (m, 1H), 4.19 - 4.32 (m, 1H), 4.03 (d, <i>J</i> = 1.1 Hz, 3H), 2.25 - 2.47 (m, 5H), 2.10 - 2.22 (m, 2H), 1.68 - 1.83 (m, 2H)	401
	443	¹ H NMR (400 MHz, CD ₃ OD) δ: 8.36-8.28 (m, 4H), 8.08 (s, 1H), 7.61 (d, <i>J</i> = 8.8 Hz, 1H), 7.13 (d, <i>J</i> = 5.6 Hz, 1H), 6.59 (d, <i>J</i> = 8.8 Hz, 1H), 4.42-4.30 (m, 2H), 3.93 (s, 3H), 2.35 (s, 3H), 2.29-2.25 (m, 2H), 2.04-1.98 (m, 2H), 1.63-1.60 (m, 2H).	409
	444	¹ H NMR (METHANOL- <i>d</i> ₄) δ: 8.32 (s, 2H), 7.91 (d, <i>J</i> = 2.3 Hz, 1H), 7.36 (dd, <i>J</i> = 8.9, 2.4 Hz, 1H), 6.57 (d, <i>J</i> = 9.0 Hz, 1H), 4.37 - 4.45 (m, 1H), 4.23 - 4.35 (m, 1H), 4.08 (s, 2H),	414

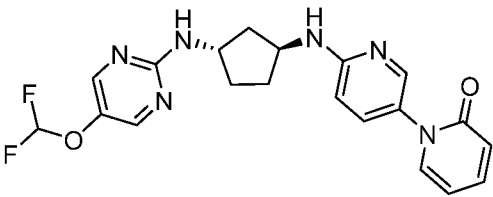
		3.02 (s, 3H), 2.34 (s, 3H), 2.20 - 2.31 (m, 2H), 1.93 - 2.07 (m, 2H), 1.52 - 1.67 (m, 2H)	
	445	¹ H NMR (400MHz, CD ₃ OD) δ 8.33 - 8.47 (m, 3H), 8.15 (d, <i>J</i> = 2.3 Hz, 1H), 8.03 (d, <i>J</i> = 6.8 Hz, 1H), 7.93 (dd, <i>J</i> = 9.6, 2.4 Hz, 1H), 7.09 (d, <i>J</i> = 9.6 Hz, 1H), 6.59 (dd, <i>J</i> = 6.8, 0.8 Hz, 1H), 4.39 - 4.51 (m, 1H), 4.22 - 4.33 (m, 1H), 2.27 - 2.47 (m, 5H), 2.06 - 2.22 (m, 2H), 1.68 - 1.85 (m, 2H)	396
	446	¹ H NMR (400 MHz, CD ₃ OD) δ 8.32 (s, 2H), 7.64 - 7.47 (m, 2H), 7.15 - 7.03 (m, 2H), 6.75 - 6.68 (m, 2H), 6.60 (d, <i>J</i> = 8.9 Hz, 1H), 6.44 (t, <i>J</i> = 6.7, 1.3 Hz, 1H), 4.41 (m, 2H), 3.99 (m, 2H), 2.35 (s, 3H), 2.30 - 2.17 (m, 2H), 2.03 - 1.93 (m, 2H), 1.69 - 1.50 (m, 2H).	394.5
	447	¹ H NMR (400 MHz, CD ₃ OD) δ 8.23 (s, 2H), 7.83 (d, <i>J</i> = 2.4 Hz, 1H), 7.41 - 7.29 (m, 2H), 6.82 (s, 1H), 6.51 (d, <i>J</i> = 8.9 Hz, 1H), 6.35 (s, 1H), 6.26 (dd, <i>J</i> = 7.0, 1.8 Hz, 1H), 4.33 - 4.18 (m, 2H), 2.70 (s, 2H), 2.25 (s, 3H), 2.21 - 2.10 (m, 2H), 1.96 - 1.80 (m, 2H), 1.56 - 1.41 (m, 2H), 1.30 (s, 6H).	495

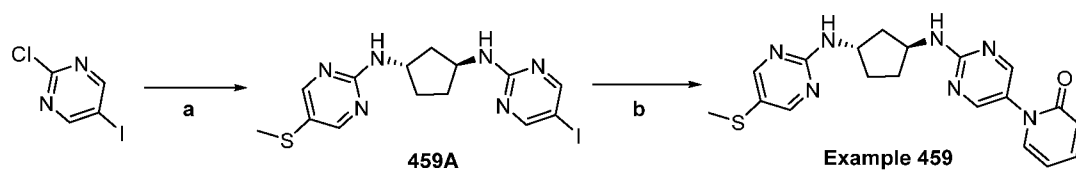
	448	¹ H NMR (400 MHz, DMSO- <i>d</i> ₆) δ: 12.87 (s, 1H), 8.87-8.85 (d, <i>J</i> = 8.4 Hz, 1H), 8.31-8.29 (m, 1H), 8.15 (s, 1H), 8.07 (s, 2H), 8.06 (d, <i>J</i> = 5.6 Hz, 1H), 7.87-7.83 (m, 1H), 7.63-7.59 (m, 1H), 7.52-7.50 (m, 1H), 7.02-6.97 (m, 2H), 6.58-6.55 (d, <i>J</i> = 8.8 Hz, 1H), 4.35-4.30 (m, 2H), 2.18-2.07 (m, 2H), 1.93-1.66 (m, 2H), 1.75-1.69 (m, 1H), 1.55-1.47 (m, 2H), 0.86-0.81 (m, 2H), 0.62-0.58 (m, 2H).	483.3
	449	¹ H NMR (400 MHz, CD ₃ OD) δ 8.42 – 8.31 (m, 3H), 8.21 (dd, <i>J</i> = 9.7, 2.4 Hz, 1H), 8.07 (dd, <i>J</i> = 3.9, 1.6 Hz, 1H), 7.49 (dd, <i>J</i> = 9.5, 3.9 Hz, 1H), 7.16 – 7.05 (m, 1H), 4.47 (p, <i>J</i> = 6.8 Hz, 1H), 4.31 – 4.18 (m, 1H), 2.50 – 2.24 (m, 2H), 2.22 – 2.04 (m, 1H), 1.86 – 1.64 (m, 1H).	395.5
	450	¹ H NMR (400 MHz, CD ₃ OD) δ 8.16-8.14 (t, <i>J</i> = 7.6 Hz, 3H), 8.03-8.01 (m, 1H), 7.62-7.59 (m, 1H), 7.47-7.44 (m, 1H), 7.07-7.04 (m, 1H), 6.87-6.50 (m, 2H), 4.40 – 4.32 (m, 2H), 2.28-2.24 (m, 2H), 2.03-2.00 (m, 2H), 1.62-1.57 (m, 2H).	416.5

	451	¹ H NMR (400 MHz, CD ₃ OD) δ 8.32 (s, 2H), 7.96 (d, J = 2.8 Hz, 1H), 7.76 (d, J = 7.2 Hz, 1H), 7.45 (dd, J = 2.8, 9.2 Hz, 1H), 7.01 (d, J = 1.2 Hz, 1H), 6.60 (d, J = 9.2 Hz, 1H), 6.57 (dd, J = 2.0, 7.2 Hz, 1H), 4.41-4.34 (m, 2H), 2.41 (s, 3H), 2.34-2.23 (m, 2H), 2.02-1.97 (m, 2H), 1.62-1.59 (m, 2H).	
	452	¹ H NMR (400 MHz, CD ₃ OD) δ 8.39 (s, 2H), 7.82 (dd, J = 9.4, 2.1 Hz, 1H), 7.75 (d, J = 2.0 Hz, 1H), 7.06 (d, J = 9.3 Hz, 1H), 4.47 (p, J = 7.0 Hz, 1H), 4.27-4.14 (m, 1H), 3.75 (t, J = 9.6 Hz, 1H), 3.57-3.44 (m, 2H), 2.93 (d, J = 10.0 Hz, 3H), 2.60-2.47 (m, 1H), 2.45-2.25 (m, 5H), 2.18-2.02 (m, 3H), 1.80-1.65 (m, 2H).	399.3
	453	¹ H NMR (400 MHz, MeOD) δ 8.06 (s, 2H), 7.80 (d, J = 2.3 Hz, 1H), 7.31 (dd, J = 8.7, 2.4 Hz, 1H), 6.55 (d, J = 8.7 Hz, 1H), 4.40-4.30 (m, 1H), 4.29-4.19 (m, 1H), 3.58 (t, J = 9.2 Hz, 1H), 3.53-3.45 (m, 2H), 2.9 (s, 3H), 2.54-2.43 (m, 1H), 2.30-2.16 (m, 2H), 2.09-1.99 (m, 1H), 1.99-1.89 (m, 2H), 1.79-1.70 (m, 1H), 1.63	

		- 1.50 (m, 2H), 0.95 – 0.84 (m, 2H), 0.65 – 0.55 (m, 2H).	
	454	¹ H NMR (400 MHz, CD ₃ OD) δ : 8.07 (s, 2H), 7.93 (s, 1H), 7.59-7.56 (m, 2H), 7.45-7.42 (m, 1H), 6.62-6.59 (m, 2H), 6.46-6.45 (m, 1H), 4.28-4.25 (m, 2H), 2.15-2.10 (m, 2H), 2.00-1.97 (m, 2H), 1.80-1.75 (m, 1H), 1.60-1.50 (m, 2H), 0.92-0.89 (m, 2H), 0.61-0.59 (m, 2H).	389.2
	455	¹ H NMR (400MHz, CD ₃ OD) δ : 8.14 (s, 2H), 7.93 (t, J = 2.8 Hz, 1H), 7.62-7.56 (m, 2H), 7.44 (dd, J = 8.8 Hz, 2.4 Hz, 1H), 6.61 (d, J = 8.8 Hz, 2H), 6.46 (dt, J = 1.6 Hz, 6.8 Hz, 1H), 4.531 (q, J = 8.8 Hz, 2H), 4.36-4.31 (m, 2H), 2.27-2.23 (m, 2H), 2.01-1.97 (m, 2H), 1.62-1.56 (m, 2H).	447.1
	456	¹ H NMR (400 MHz, CD ₃ OD) δ : 8.84 (s, 1H), 8.25 (d, J = 0.8 Hz, 1H), 8.09-7.98 (m, 3H), 7.47 (dd, J = 8.4 Hz, 2.8 Hz, 1H), 7.19-7.17 (m, 1H), 6.63 (d, J = 9.2 Hz, 1H), 6.59 (d, J = 9.6 Hz, 1H), 4.51-4.48 (m, 1H), 4.39-4.366 (m, 1H), 2.34-2.27 (m, 2H), 2.08-2.04 (m, 2H), 1.69-1.61 (m, 2H).	449.4

	457	¹ H NMR (400 MHz, CD ₃ OD) δ 8.24 (s, 2H), 8.09 (d, J = 2.2 Hz, 1H), 7.96 (dd, J = 9.6, 2.4 Hz, 1H), 7.70 – 7.59 (m, 2H), 7.14 (d, J = 9.6 Hz, 1H), 6.65 (dd, J = 10.0, 1.2 Hz, 1H), 6.51 (td, J = 6.8, 1.2 Hz, 1H), 4.47 (m, 1H), 4.37 – 4.26 (m, 1H), 3.85 (s, 3H), 2.39 (m, 1H), 2.26 – 2.13 (m, 2H), 1.88 – 1.71 (m, 2H).	379.4
	458	¹ H NMR (400 MHz, MeOD) δ 7.97 (d, J = 2.2 Hz, 1H), 7.94 (d, J = 2.5 Hz, 1H), 7.64 – 7.56 (m, 2H), 7.50 (dd, J = 8.8, 2.4 Hz, 1H), 7.44 (dd, J = 9.0, 2.7 Hz, 1H), 6.64 – 6.58 (m, 2H), 6.47 (ddd, J = 11.0, 8.0, 5.0 Hz, 2H), 4.30 (dp, J = 25.7, 6.4 Hz, 2H), 2.32 (d, J = 15.9 Hz, 3H), 2.29 – 2.18 (m, 2H), 1.99 (q, J = 6.9 Hz, 2H), 1.66 – 1.51 (m, 2H)	394.4
	458A	¹ H NMR (400 MHz, CD ₃ OD) δ 8.36 (s, 1H), 8.05 (s, 1H), 7.92 (s, 1H), 7.50 (d, J = 8.8 Hz, 1H), 7.35 (d, J = 9.2 Hz, 1H), 6.96 (d, J = 9.2 Hz, 1H), 6.90 (s, 1H), 6.50 (d, J = 8.8 Hz, 1H), 6.25 (s, 1H), 4.30-4.28 (m, 1H), 4.26-4.25 (m, 1H), 2.21-2.18 (m, 2H), 1.97-	389

		1.93 (m, 2H), 1.54-1.52 (m, 2H).	
	458B	¹ H NMR (400 MHz, CD ₃ OD) δ 8.15 (d, <i>J</i> = 9.1 Hz, 2H), 7.94 (d, <i>J</i> = 2.3 Hz, 1H), 7.66 – 7.53 (m, 2H), 7.44 (dd, <i>J</i> = 9.0, 2.7 Hz, 1H), 6.69(t, <i>J</i> = 73.6 Hz, 1H), 6.55(d, <i>J</i> = 9.2Hz, 2H), 6.48 – 6.44 (m, 2H), 4.45 – 4.28 (m, 2H), 2.33 – 2.16 (m, 2H), 2.11 – 1.91 (m, 2H), 1.70 – 1.51 (m, 2H).	415.2

Scheme 75

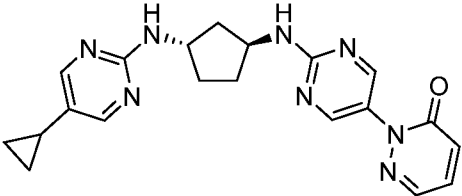
a) **131C**, General procedure 5; b) pyridin-2(1H)-one, General procedure 1.

1-(2-(((1S,3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino) pyrimidin-5-yl) pyridin-2(1H)-one (Example 459)

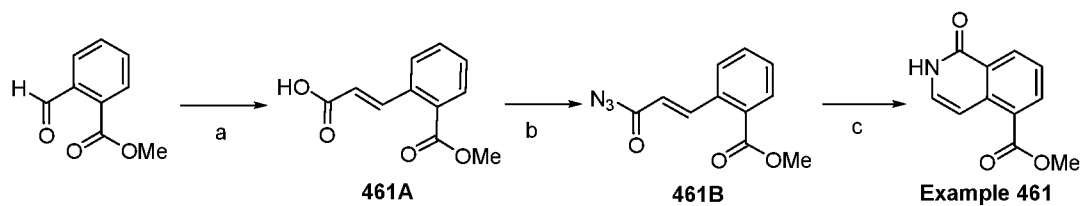
Methods analogous to those described in **General Method 5** and **General Method 1** from starting material 2-chloro-5-iodopyrimidine afforded the title compound: ¹H NMR (400 MHz, CD₃OD) δ 8.41-8.40 (d, *J* = 2.4 Hz, 2H), 8.34 (s, 2H), 7.63-7.59(m, 2H), 6.63-6.61 (d, *J* = 8.8 Hz, 1H), 6.49-6.46 (m, 1H), 4.49-4.41 (m, 2H), 2.40-2.39 (d, *J* = 1.2 Hz, 3H), 2.31-2.25 (m, 2H), 2.08-2.05 (t, *J* = 13.6 Hz, 2H), 1.69-1.64 (m, 2H).

Using the above procedures, the following example was synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺

	460	¹H NMR (400 MHz, CD₃OD) δ 8.51 (s, 2H), 8.07 (s, 2H), 8.04 (dd, J = 3.9, 1.5 Hz, 1H), 7.47 (dd, J = 9.5, 3.9 Hz, 1H), 7.07 (dd, J = 9.5, 1.5 Hz, 1H), 4.51 – 4.43 (m, 1H), 4.42 – 4.34 (m, 1H), 2.26 (td, J = 10.3, 4.6 Hz, 2H), 2.01 (dt, J = 11.3, 5.5 Hz, 2H), 1.75 (td, J = 8.6, 4.5 Hz, 1H), 1.68 – 1.54 (m, 2H), 0.94 – 0.85 (m, 2H), 0.66 – 0.55 (m, 2H).

Scheme 76



a) malonic acid, morpholine, pyridine, 100°C; b) DPPA, Et₃N, toluene, rt; c) diphenylmethane, 80-240°C.

(E)-3-(2-(methoxycarbonyl) phenyl) acrylic acid (461A)

A mixture of methyl 2-formylbenzoate (2.5 g, 15.23 mmol, 1.0 eq), malonic acid (1.8 g, 17.67 mmol, and 1.16 eq), morpholine (0.15 mL) and pyridine (4 mL) was stirred at 100 °C for 4 h. After cooling to room temperature, the resulting solution was poured into a mixture of crushed ice (50 g) and 35% aq. HCl (25 mL). The precipitate was filtered, washed with water (25 mLx2). Then, the white solid was recrystallized from methanol to afford **461A** (2.0 g, 63.7% yield): ¹H NMR (400MHz, CDCl₃) δ 8.58 (d, J = 15.9 Hz, 1H), 7.99 (dd, J = 7.8, 1.1 Hz, 1H), 7.61 - 7.68 (m, 1H), 7.53 - 7.60 (m, 1H), 7.41 - 7.51 (m, 1H), 6.33 (d, J = 15.9 Hz, 1H), 3.95 (s, 3H).

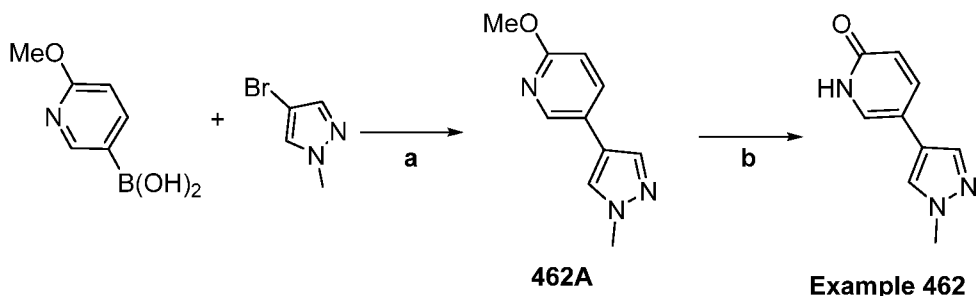
(E)-Methyl 2-(3-azido-3-oxoprop-1-en-1-yl) benzoate (461B)

To a solution of **461A** (1.2 g, 5.82 mmol, 1.0 eq) and Et₃N (1.6 mL 11.64 mmol, 2.0 eq) in toluene (15 mL) was added DPPA (1.2 mL, 5.53 mmol, 0.95 eq) dropwise. The mixture was continued to stir at room temperature for 16 h. The solution was concentrated and purified by flash column (petroleum ether: EtOAc = 10:1) to afford **461B** as white solid (1.0 g, 74.6% yield): ¹H NMR (400 MHz, CDCl₃) δ 8.56 (d, *J* = 15.8 Hz, 1H), 8.00 (dd, *J* = 7.8, 0.9 Hz, 1H), 7.53 - 7.67 (m, 2H), 7.42 - 7.53 (m, 1H), 6.31 (d, *J* = 15.8 Hz, 1H), 3.95 (s, 3H).

Methyl 1-oxo-1, 2-dihydroisoquinoline-5-carboxylate (**461**)

A solution of **461B** (500 mg, 2.16 mmol, 1.0 eq) in diphenylmethane (3 mL) was stirred at 80 °C for 1 hour under nitrogen. Then, the mixture was continued to stir at 240 °C for 3 h. After cooling to room temperature, the mixture was purified by flash column (petroleum ether: EtOAc: 2:1) to afford crude product and further purified by Prep-HPLC to afford **Example 461** as a white solid (30 mg, 6.8% yield): MS (ESI+) *m/z* 204.0 (M+H)⁺; ¹H NMR (400MHz, DMSO-*d*₆) δ 11.51 (br. s., 1H), 8.46 (d, *J* = 7.9 Hz, 1H), 8.27 (d, *J* = 6.9 Hz, 1H), 7.57 (t, *J* = 7.8 Hz, 1H), 7.24 - 7.46 (m, 2H), 3.90 (s, 3H).

Scheme 77



a) Pd(dppf)Cl₂, Cs₂CO₃, dioxane/H₂O, 110°C; b) HBr, EtOH, 80°C.

2-methoxy-5-(1-methyl-1H-pyrazol-4-yl) pyridine (**462A**)

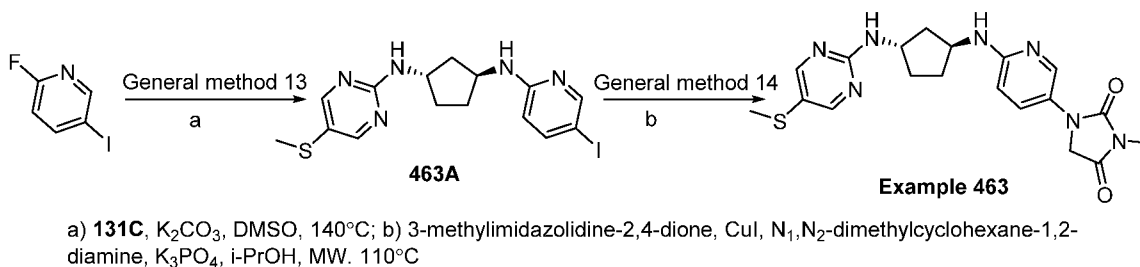
A suspension of (6-methoxypyridin-3-yl) boronic acid (820 mg, 5.4 mmol, 1.0 eq), 4-bromo-1-methyl-1H-pyrazole (1.04 g, 6.4 mmol, 1.2 eq), Pd(dppf)Cl₂ (392.3 mg, 0.54 mmol, 0.1 eq) and Cs₂CO₃ (3.5 g, 10.8 mmol, 2.0 eq) in dioxane/water (40 mL / 10 mL) was stirred at 110 °C under N₂ for 16 h. The reaction mixture was partitioned between ethyl acetate and water. The organic phase was separated and washed with brine, dried

over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 20:1) to afford **462A** (662.4 mg) as a yellow solid: ESI (M+H)⁺ = 190.1.

5-(1-methyl-1H-pyrazol-4-yl) pyridin-2(1H)-one (Example 462)

To a solution of **462A** (200 mg, 1.1 mmol) in EtOH (0.5 mL) was added HBr solution (40% in H₂O, 2.5 mL). The reaction mixture was stirred at 80 °C for 20 h. The reaction mixture was cooled to room temperature and basified by adding aqueous NH₃ dropwise. The solvent was evaporated under reduced pressure and the crude residue was purified by flash chromatography (DCM: MeOH: NH₄OH) = 10:1:0.1) to afford **Example 462** (120 mg) as a grey solid. ¹H NMR (400 MHz, CD₃OD) δ 7.94 (dd, *J* = 9.4, 2.6 Hz, 1H), 7.77 (d, *J* = 2.3 Hz, 1H), 7.65 (s, 1H), 7.38 (d, *J* = 1.1 Hz, 1H), 6.57 (dd, *J* = 21.7, 9.3 Hz, 1H), 3.76 (s, 3H). ESI (M+H)⁺ = 176.1.

Scheme 78.



General method 13

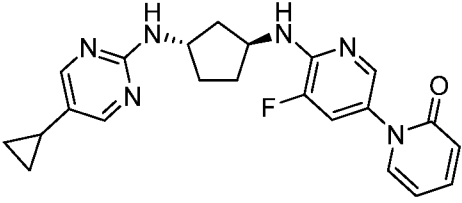
(1*S*, 3*S*)-N¹-(5-iodopyridin-2-yl)-N³-(5-(methylthio) pyrimidin-2-yl) cyclopentane-1,3-diamine (**463A**)

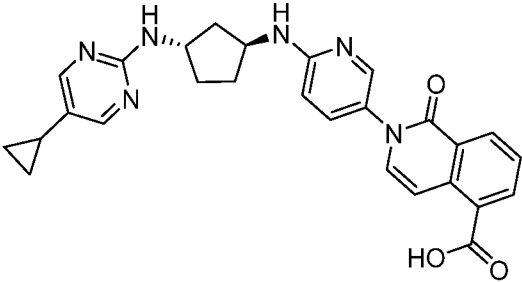
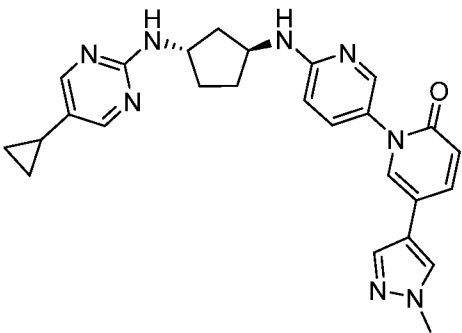
A suspension of **131C** (150 mg, 0.669 mmol, 1.0 eq), 2-fluoro-5-iodopyridine (178.9mg, 0.802 mmol, 1.2 eq) and K₂CO₃ (277.2 mg, 2.006 mmol, 3.0 eq) in DMSO (5 mL) was stirred at 140 °C under N₂ for 16.5 h. The reaction mixture was cooled down to room temperature and filtered. The filtrate was diluted with ethyl acetate and washed with water and brine, dried over Na₂SO₄, filtered and concentrated under reduced vacuum. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:1) to give **463A** (125.5 mg). ESI (M+H)⁺ = 428.1.

General method 14**3-Methyl-1-(6-(((1*S*, 3*S*)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino) pyridin-3-yl) imidazolidine-2, 4-dione (463)**

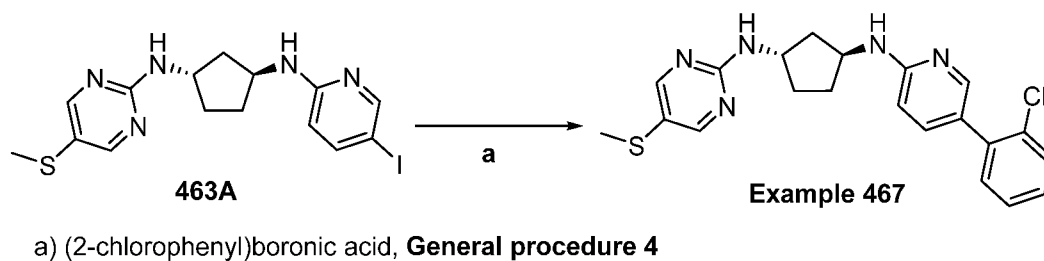
A suspension of **463A** (65.5 mg, 0.153 mmol, 1.0 eq), 3-methylimidazolidine-2, 4-dione (35.0 mg, 0.307 mmol, 2.0 eq), N₁, N₂-dimethylcyclohexane-1, 2-diamine (10.9 mg, 0.077 mmol, 0.5 eq), CuI (14.6 mg, 0.077 mmol, 0.5 eq) and K₃PO₄ (97.6 mg, 0.460 mmol, 3.0 eq) in i-PrOH (3 mL) was purged with N₂. The reaction mixture was stirred at 110 °C under microwave irradiation for 4 h. The reaction mixture was concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 20:1) to give **Example 463** (20 mg) as a white powder: ¹H NMR (400 MHz, TFA-*d*₄) δ 8.8 (brs, 2H), 8.40 (d, *J* = 2.4 Hz, 1H), 8.25 (dd, *J* = 9.8, 2.3 Hz, 1H), 7.23 (d, *J* = 9.8 Hz, 1H), 4.83-4.78 (m, 1H), 4.68 (s, 2H), 4.56-4.39 (m, 1H), 3.28 (s, 3H), 2.62 – 2.49 (m, 2H), 2.54(s, 3H), 2.45 – 2.30 (m, 2H), 1.96-1.88 (m, 2H). ESI (M+H)⁺ = 414.3.

Using the above procedures, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	464	¹ H NMR (400 MHz, CD ₃ OD) δ 8.31 (s, 2H), 7.85 (d, <i>J</i> = 2.1 Hz, 1H), 7.67 – 7.53 (m, 2H), 7.44 (dd, <i>J</i> = 11.4, 2.2 Hz, 1H), 6.62 (d, <i>J</i> = 8.9 Hz, 1H), 6.47 (td, <i>J</i> = 6.8, 1.3 Hz, 1H), 4.58 (p, <i>J</i> = 6.8 Hz, 1H), 4.43 (dd, <i>J</i> = 13.0, 6.7 Hz, 1H), 2.43 – 2.25 (m, 2H), 2.15 – 2.04 (m, 2H), 1.94 – 1.81 (m, 1H), 1.78 – 1.58 (m, 2H), 1.07 – 0.97 (m, 2H), 0.78 – 0.67 (m, 2H).	407.5

	465	¹ H NMR (400MHz, DMSO- <i>d</i> ₆) δ : 13.34 (br. s., 1H), 8.49 (d, <i>J</i> = 7.4 Hz, 1H), 8.33 (dd, <i>J</i> = 7.6, 1.3 Hz, 1H), 7.99 - 8.11 (m, 3H), 7.46 - 7.70 (m, 4H), 7.08 (d, <i>J</i> = 6.1 Hz, 1H), 6.66 (d, <i>J</i> = 8.9 Hz, 1H), 4.25 - 4.48 (m, 2H), 2.06 - 2.25 (m, 2H), 1.84 - 2.02 (m, 2H), 1.65 - 1.78 (m, 1H), 1.42 - 1.60 (m, 2H), 0.78 - 0.92 (m, 2H), 0.54 - 0.68 (m, 2H)	483.3
	466	¹ H NMR (400 MHz, CD ₃ OD) δ 8.30 (s, 2H), 8.14 (d, <i>J</i> = 2.2 Hz, 1H), 7.96 (dd, <i>J</i> = 9.5, 2.4 Hz, 1H), 7.89 (dd, <i>J</i> = 8.7, 2.1 Hz, 3H), 7.75 (d, <i>J</i> = 0.5 Hz, 1H), 7.10 (d, <i>J</i> = 9.5 Hz, 1H), 6.70 (dd, <i>J</i> = 8.4, 1.9 Hz, 1H), 4.59 - 4.48 (m, 1H), 4.38 - 4.26 (m, 1H), 3.91 (s, 3H), 2.49 - 2.28 (m, 2H), 2.21 (dt, <i>J</i> = 13.2, 6.7 Hz, 2H), 1.86 (tt, <i>J</i> = 7.9, 4.9 Hz, 1H), 1.82 - 1.68 (m, 2H), 1.06 - 0.97 (m, 2H), 0.76 - 0.62 (m, 2H).	469.3

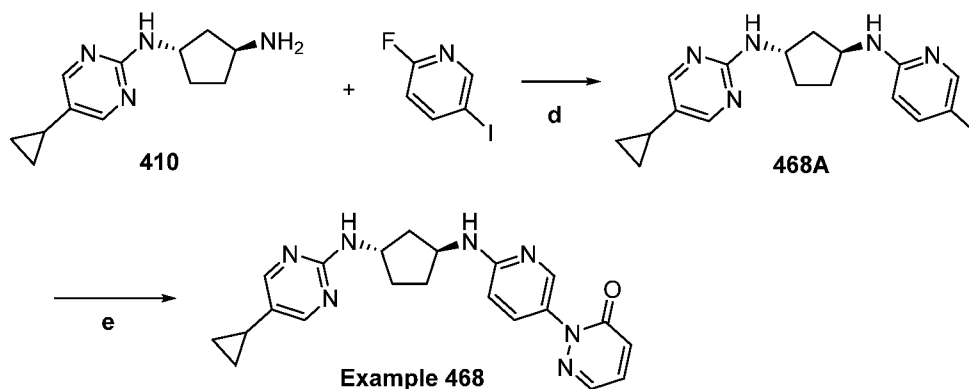
Scheme 79



(1*S*, 3*S*)-*N*¹-(5-(2-chlorophenyl) pyridin-2-yl)-*N*³-(5-(methylthio) pyrimidin-2-yl) cyclopentane-1, 3-diamine (Example 467)

Methods analogous to those described in **General Method 4** from starting material **463A** and (2-chlorophenyl) boronic acid afforded the title compound: ¹H NMR (400 MHz, CDCl₃) δ 10.20 (s, 1H), 8.53(bris, 1H), 8.45 (s, 2H), 7.95 (dd, *J* = 9.2, 1.4 Hz, 1H), 7.83 (s, 1H), 7.56 – 7.47 (m, 1H), 7.36 (dd, *J* = 5.9, 3.4 Hz, 2H), 7.25-7.27(m, 1H), 7.13 (d, *J* = 9.3 Hz, 1H), 4.59 (bris, 1H), 4.24 (bris, 1H), 2.52 – 2.29 (m, 5H), 2.20 (ddt, *J* = 20.7, 13.8, 7.0 Hz, 2H), 1.99 – 1.86 (m, 1H), 1.74 (dt, *J* = 13.0, 6.6 Hz, 1H). ESI (M+H)⁺ = 412.3.

Scheme 80



d) **General method 6**;

e) pyridazin-3(2H)-one, CuI, (1*S*,2*S*)-*N*¹,*N*²-dimethylcyclohexane-1,2-diamine, K₂CO₃, DMSO, 135°C

(1*S*, 3*S*)-*N*¹-(5-cyclopropylpyrimidin-2-yl)-*N*³-(5-iodopyridin-2-yl) cyclopentane-1, 3-diamine (468A)

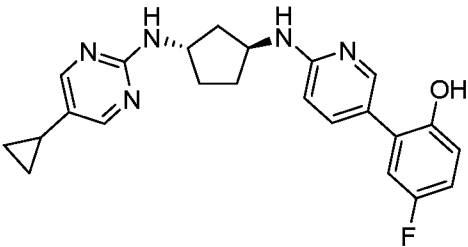
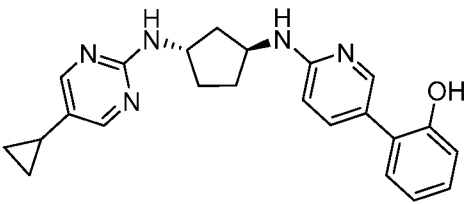
Methods analogous to those described above from starting material **425C** (44.5 g, 208.7 mmol, 1.0 eq) afforded **425D** (24.7 g) as a pale solid. LCMS [M+H]⁺ = 422.

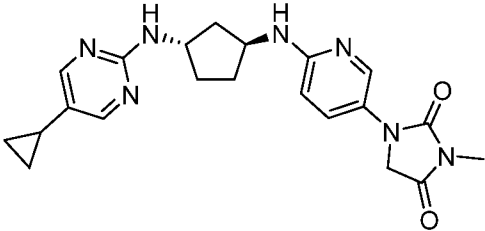
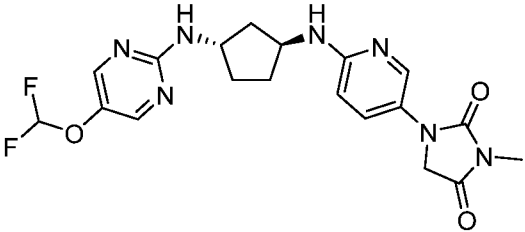
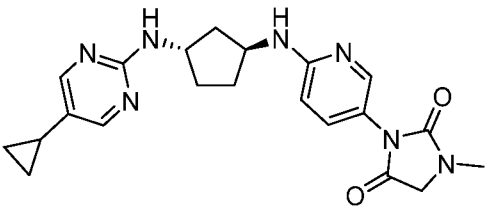
2-(6-(((1*S*, 3*S*)-3-((5-cyclopropylpyrimidin-2-yl) amino) cyclopentyl) amino) pyridin-3-yl) pyridazin-3(2H)-one (Example 468)

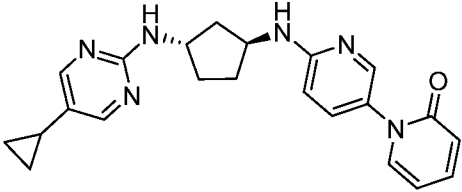
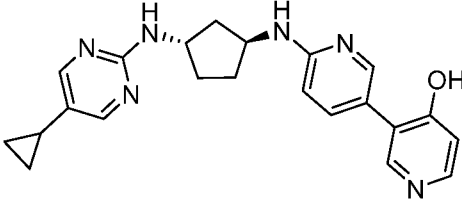
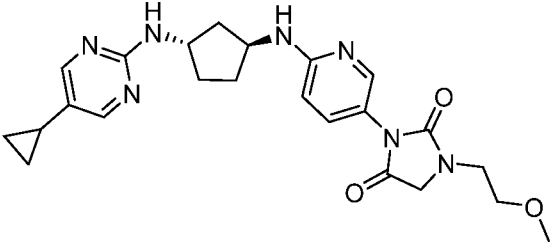
To a solution of **468A** (18.7 g, 44.4 mmol, 1.0 eq), pyridazin-3(2H)-one (8.53 g, 88.8 mmol, 2.0 eq), (1*S*, 2*S*)-*N*¹,*N*²-dimethylcyclohexane-1,2-diamine (1.26 g, 8.88 mmol, 0.2 eq) and CuI (0.85 g, 4.44 mmol, 0.1 eq) in DMSO (150 mL) was added K₂CO₃ (18.5 g,

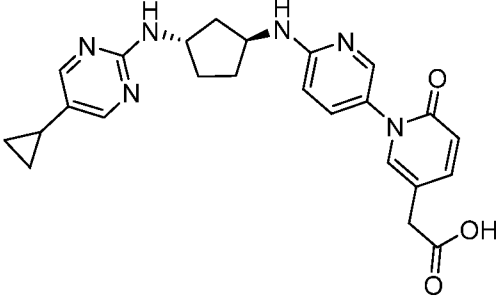
133.2 mmol, 3.0 eq) and the resulting system was stirred at 135 °C for 12 h under N₂. The reaction mixture was cooled to room temperature and poured into water (1 L) and extracted with ethyl acetate (150 mL x3). The combined organic layers were washed with brine and dried over anhydrous Na₂SO₄. The ethyl acetate phase was filtered and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (elute with DCM: MeOH=100:1 to 50:1) to afford **Example 468** (25.3g) as a light yellow solid: ¹H NMR (400 MHz, CD₃OD) δ 8.15 (d, *J* = 2.5 Hz, 1H), 8.07 (s, 2H), 8.02 (dd, *J* = 3.9, 1.6 Hz, 2H), 7.60 (dd, *J* = 9.0, 2.6 Hz, 1H), 7.46 (dd, *J* = 9.4, 3.9 Hz, 1H), 7.06 (dd, *J* = 9.5, 1.6 Hz, 1H), 6.59 (d, *J* = 9.0 Hz, 1H), 4.42 – 4.27 (m, 2H), 2.34 – 2.18 (m, 2H), 1.99 (t, *J* = 6.8 Hz, 2H), 1.81 – 1.70 (m, 1H), 1.65 – 1.53 (m, 2H), 0.95 – 0.85 (m, 2H), 0.66 – 0.54 (m, 2H). LCMS [M+H]⁺ = 390.

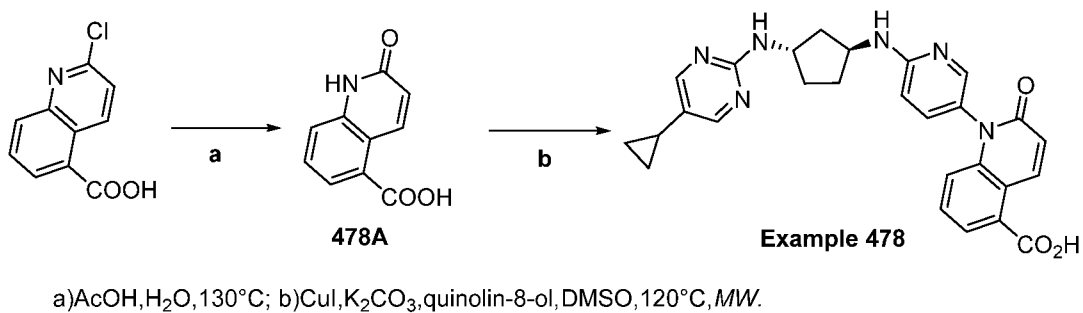
Using the above procedures, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	469	¹ H NMR (400 MHz, CD ₃ OD) δ 8.17 (d, <i>J</i> = 1.8 Hz, 1H), 8.07 (s, 2H), 7.70 (dd, <i>J</i> = 8.8, 2.4 Hz, 1H), 7.04 – 6.93 (m, 1H), 6.83 (dd, <i>J</i> = 7.0, 2.8 Hz, 2H), 6.59 (d, <i>J</i> = 8.9 Hz, 1H), 4.42 – 4.24 (m, 2H), 2.37 – 2.15 (m, 3H), 2.10 – 1.91 (m, 3H), 1.75 (ddd, <i>J</i> = 13.5, 8.4, 5.1 Hz, 1H), 1.60 (dd, <i>J</i> = 12.7, 8.8 Hz, 2H), 0.96 – 0.85 (m, 2H), 0.60 (dt, <i>J</i> = 6.2, 4.7 Hz, 2H).	406.3
	470	¹ H NMR (400 MHz, CDCl ₃) δ 8.16 (s, 1H), 8.09 (s, 2H), 7.76 (d, <i>J</i> = 8.5 Hz, 1H), 7.23 – 7.13 (m, 2H), 7.01 (d, <i>J</i> = 8.1 Hz, 1H), 6.95 (t, <i>J</i> = 7.3 Hz, 1H), 6.60 (d, <i>J</i> = 8.5 Hz, 1H),	388.3

		5.14 (s, 1H), 4.43 (d, $J = 5.3$ Hz, 1H), 4.17 (s, 1H), 2.36 – 2.26 (m, 2H), 2.14 – 1.95 (m, 3H), 1.75 – 1.64 (m, 2H), 1.58 (s, 1H), 0.90 (d, $J = 7.6$ Hz, 2H), 0.58 (d, $J = 5.0$ Hz, 2H).	
	471	¹ H NMR (400 MHz, CDCl ₃) δ 8.09 (s, 2H), 8.05 (s, 1H), 7.87 (d, $J = 8.8$ Hz, 1H), 6.52 (d, $J = 9.0$ Hz, 1H), 5.49 (s, 1H), 5.35 (s, 1H), 4.50 – 4.35 (m, 1H), 4.25 (s, 2H), 4.21 (s, 1H), 3.11 (s, 3H), 2.32 (dd, $J = 10.2, 5.3$ Hz, 2H), 1.72 (td, $J = 8.5, 4.3$ Hz, 1H), 1.67 – 1.53 (m, 2H), 0.92 (dd, $J = 13.2, 6.0$ Hz, 2H), 0.59 (q, $J = 5.0$ Hz, 2H).	408.4
	472	¹ H NMR (400 MHz, TFA-d) δ 8.47 (t, $J = 103.6$ Hz, 4H), 7.24 (s, 1H), 6.61 (t, $J = 70.1$ Hz, 1H), 4.84 (s, 1H), 4.68 (s, 2H), 4.44 (s, 1H), 3.28 (s, 3H), 2.57 (s, 2H), 2.39 (d, $J = 18.4$ Hz, 2H), 1.93 (s, 2H).	434.3
	473	¹ H NMR (400 MHz, CD ₃ OD) δ 8.07 (s, 2H), 7.91 (d, $J = 2.1$ Hz, 1H), 7.36 (dd, $J = 9.0, 2.6$ Hz, 1H), 6.58 (d, $J = 9.0$ Hz, 1H), 4.42 – 4.25 (m, 2H), 4.08 (s, 2H), 3.02 (s, 3H), 2.30 – 2.16 (m, 2H), 2.03 – 1.93 (m, 2H), 1.75 (ddd, $J = 17.0, 8.5, 5.2$ Hz, 1H), 1.63 – 1.52 (m, 2H),	408.4

		0.90 (ddd, $J = 12.8, 7.4, 4.1$ Hz, 2H), 0.65 – 0.58 (m, 2H).	
	474	¹ H NMR (400 MHz, CD ₃ OD) δ 7.93 (s, 2H), 7.93 (d, $J = 0.4$ Hz, 1H), 7.62-7.56 (m, 2H), 7.45-7.42 (m, 1H), 6.62-6.59 (m, 2H), 6.47-6.43 (m, 1H), 4.38 – 4.31 (m, 2H), 2.27-2.23 (m, 2H), 2.00-1.97 (t, $J = 13.6$ Hz, 2H), 1.77-1.73 (m, 1H), 1.62-1.56 (m, 2H), 0.93-0.89 (m, 2H) 0.68-0.64 (m, 2H).	389
	475	¹ H NMR (400 MHz, CD ₃ OD) δ 8.39-8.39 (d, $J = 1.6$ Hz, 1H), 8.15-8.12 (m, 4H), 7.84-7.82 (m, 1H), 7.09-7.06 (d, $J = 9.2$ Hz, 1H), 6.61-6.59 (d, $J = 7.2$ Hz, 1H), 4.47-4.40 (m, 1H), 4.27-4.21 (m, 1H), 2.43-2.26 (m, 2H), 2.18-2.03 (m, 2H), 2.43-2.26 (m, 2H), 2.18-2.03 (m, 2H), 1.81-1.66 (m, 3H), 0.95-0.89 (m, 2H), 0.64-0.60 (m, 2H).	391
	476	¹ H NMR (400 MHz, CD ₃ OD) δ 8.26 (s, 2H), 8.03 (d, $J = 2.0$ Hz, 1H), 7.98 (dd, $J = 9.6, 2.4$ Hz, 1H), 7.09 (d, $J = 9.6$ Hz, 1H), 4.50 (p, $J = 6.8$ Hz, 1H), 4.27 (dd, $J = 12.4, 6.2$ Hz, 1H), 4.20 (s, 2H), 3.69 – 3.58 (m, 4H), 3.38 (s, 3H), 2.50 – 2.24 (m, 2H), 2.24 – 2.08 (m, 2H), 1.84 (tt, $J = 8.5, 5.2$ Hz,	452.5

		1H), 1.81 – 1.70 (m, 2H), 1.05 – 0.93 (m, 2H), 0.77 – 0.60 (m, 2H).	
	477	1H NMR (400 MHz, CD ₃ OD) δ: 8.15 (s, 2H), 8.08-8.01 (m, 1H), 7.79-7.77 (d, <i>J</i> = 9.6 Hz, 1H), 7.62-7.54 (m, 1H), 7.54-7.53 (d, <i>J</i> = 2 Hz, 1H), 6.96-6.93 (d, <i>J</i> = 9.2 Hz, 1H), 6.63-6.60 (t, <i>J</i> = 9.2 Hz, 1H), 4.46-4.39 (m, 1H), 4.32-4.27 (m, 1H), 3.49-3.47 (m, 2H), 2.40-2.26 (m, 2H), 2.12-2.00 (m, 2H), 1.83-1.76 (m, 1H), 1.74-1.65 (m, 2H), 0.97-0.88 (m, 2H), 0.66-0.61 (m, 2H).	447.4

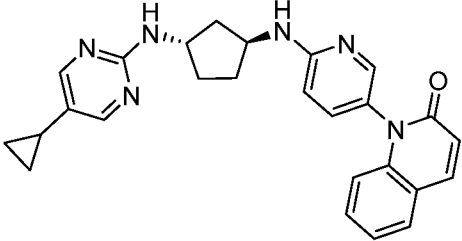
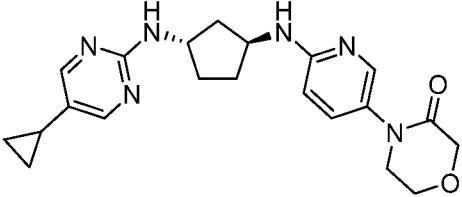
Scheme 74**2-oxo-1,2-dihydroquinoline-5-carboxylic acid (478A)**

A suspension of 2-chloroquinoline-5-carboxylic acid (300 mg, 1.45 mmol, 1.0 eq) in AcOH (5 mL) and H₂O (2 mL) was stirred at 130 °C overnight. The reaction was cooled to 0 °C and stirred for 0.5 h. The precipitate was collected by filtration, and the solid was dried in vacuum to give **478A** (250mg).

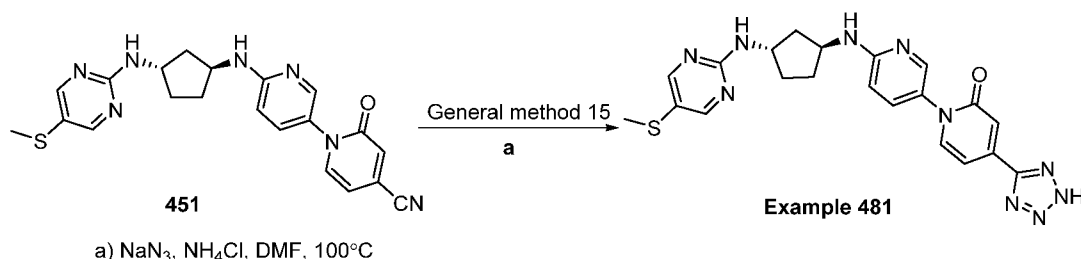
1-(6-(((1S,3S)-3-((5-cyclopropylpyrimidin-2-yl) amino) cyclopentyl) amino) pyridin-3-yl)-2-oxo-1,2-dihydroquinoline-5-carboxylic acid (Example 478)

A suspension of **478A** (18m g, 0.1 mmol, 1.0 eq), (1S,3S)-N1-(5-cyclopropylpyrimidin-2-yl)-N3-(5-iodopyridin-2-yl) cyclopentane-1,3-diamine (40mg, 0.1 mmol, 1.0 eq), quinolin-8-ol (3mg, 0.02mmol, 0.2 eq), CuI (4mg, 0.02 mmol, 0.2 eq), K₂CO₃ (20mg, 0.15mmol, 1.5 eq), in DMSO (3mL) was purged with N₂. The reaction mixture was then stirred at 120 °C under microwave irradiation for 2 h. The reaction mixture was filtered and the filtrate was partitioned between ethyl acetate (5mL) and water (10mL). After separation, the aqueous phase was concentrated under reduced pressure. The crude residue was purified by Prep-HPLC to give **Example 478** (4.7mg): ¹H NMR (400 MHz, CD₃OD) δ 9.11 (d, *J* = 10.1 Hz, 1H), 8.25 (s, 2H), 8.05 (s, 1H), 7.95 (d, *J* = 7.5 Hz, 1H), 7.79 (d, *J* = 9.4 Hz, 1H), 7.67 – 7.50 (m, 1H), 7.27-7.15 (m, 2H), 6.84 (d, *J* = 10.1 Hz, 1H), 4.58-4.45 (m, 1H), 4.38-4.28 (m, 1H), 2.53 – 2.28 (m, 2H), 2.27 – 2.06 (m, 2H), 1.91-1.68(m, 3H), 1.03-0.92(m, 2H), 0.73-0.63 (d, *J* = 4.5 Hz, 2H). ESI (M+H)⁺ = 483.

Using the above procedures, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	479	¹ H NMR (400 MHz, MeOD) δ 8.22 (s, 2H), 8.11-8.01 (m, 2H), 7.83 – 7.73 (m, 2H), 7.53 (t, <i>J</i> = 7.9 Hz, 1H), 7.34 (t, <i>J</i> = 7.4 Hz, 1H), 7.18 (d, <i>J</i> = 9.4 Hz, 1H), 7.00 (d, <i>J</i> = 8.5 Hz, 1H), 6.75 (d, <i>J</i> = 9.6 Hz, 1H), 4.56-4.44 (m, 1H), 4.38-4.28 (m, 1H), 2.51 – 2.29 (m, 2H), 2.28 – 2.12 (m, 2H), 1.90 – 1.68 (m, 3H), 1.03 – 0.91 (m, 1H), 0.76-0.60(m, 1H)	439
	480	¹ H NMR (400 MHz, CD ₃ OD) δ 8.07 (s, 2H), 7.91 (d, <i>J</i> = 2.3 Hz, 1H), 7.38 (dd, <i>J</i> = 9.0, 2.6 Hz, 1H), 6.56 (d, <i>J</i> = 8.9 Hz, 1H), 4.40 – 4.30 (m, 1H), 4.31 – 4.22 (m, 3H), 4.04 – 3.97 (m,	395

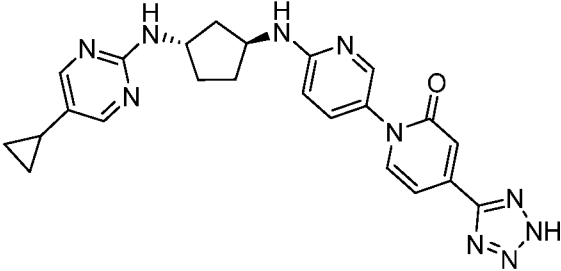
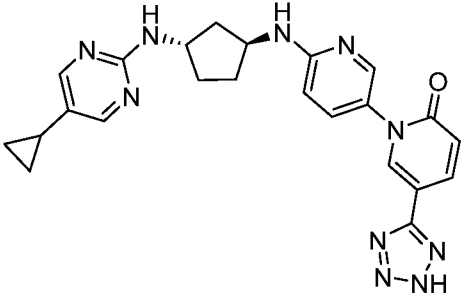
		2H), 3.73 – 3.64 (m, 2H), 2.31 – 2.15 (m, 2H), 1.99 – 1.91 (m, 2H), 1.80 – 1.70 (m, 1H), 1.64 – 1.50 (m, 2H), 0.94 – 0.86 (m, 2H), 0.63 – 0.56 (m, 2H).	

Scheme 75**General method 15****6'-(((1S, 3S)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino)-4-(2H-tetrazol-5-yl)-2H-[1, 3'-bipyridin]-2-one (Example 481)**

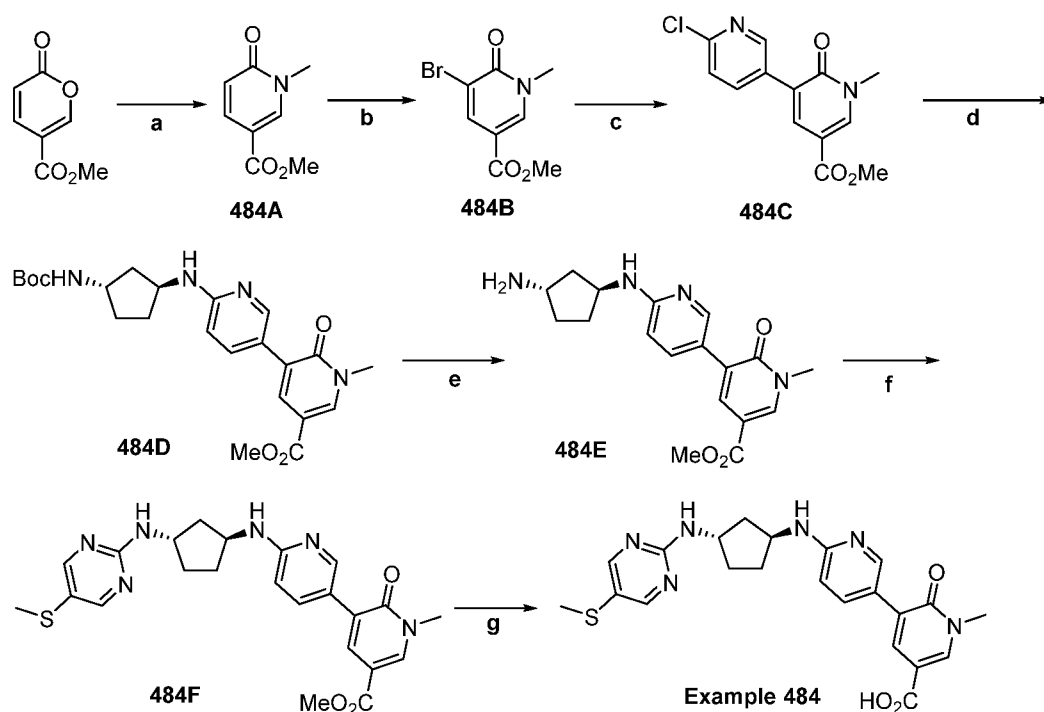
A mixture of **451** (35 mg, 0.083 mmol, 1.0 eq), NH₄Cl (44 mg, 0.83 mmol, 10.0 eq) and NaN₃ (54 mg, 0.83 mmol, 10.0 eq) in DMF (2 mL) was stirred at 100 °C for 5 h. The mixture was cooled down to room temperature and filtered. The filtrate was purified by Prep-HPLC to give **Example 481** (13 mg, 33.7%) as a yellow solid. ¹H NMR (400 MHz, CD₃OD) δ ppm: 8.37 (s, 2H), 8.15 (d, *J* = 2.0 Hz, 1H), 7.98 (dd, *J* = 2.1 Hz, 9.6 Hz, 1H), 7.83 (dd, *J* = 0.4 Hz, 7.2 Hz, 1H), 7.34 (d, *J* = 1.2 Hz, 1H), 7.10-7.15 (m, 2H), 4.46-4.50 (m, 1H), 4.27-4.31 (m, 1H), 2.43-2.43 (m, 5H), 2.11-2.18 (m, 2H), 1.71-1.80 (m, 2H). LCMS [M+H]⁺ = 463.4.

Using the above procedures, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺

	482	¹ H NMR (400 MHz, CD ₃ OD) δ ppm 8.28(s, 2H), 8.14 (d, J = 2.4 Hz, 1H), 7.94 (d, J = 9.6 Hz, 1H), 7.82 (d, J = 6.4 Hz, 1H), 7.33 (d, J = 1.2 Hz, 1H), 7.14 (dd, J = 2.0, 7.2 Hz, 1H), 7.07(d, J = 9.2Hz, 1H), 4.52-4.51 (m, 1H), 4.34-4.31 (m, 1H), 2.43-2.30(m, 2H), 2.19-2.14(m, 2H), 1.78-1.72(m, 3H), 0.99-0.97(m, 2H), 0.72-0.689(m, 2H).	457.5
	483	¹ H NMR (400 MHz, CD ₃ OD) δ 8.42 (d, J = 2.8 Hz, 1H), 8.23(s, 2H), 8.17-8.14 (m, 2H), 7.92-7.89 (m, 1H), 7.02 (dd, J = 2.8, 8.8 Hz, 1H), 6.80 (dd, J = 0.8, 9.6 Hz, 1H), 4.50-4.47 (m, 1H), 4.34-4.31 (m, 1H), 2.43-2.30 (m, 2H), 2.17-2.14(m, 2H), 1.85-1.70 (m, 3H), 1.01-0.96 (m, 2H), 0.71-0.67 (m, 2H).	457.4

Scheme 76



a) MeNH_2 , EtOH, 60 °C; b) NBS, HOAc, 80 °C; c) (6-chloropyridin-3-yl)boronic acid, **General procedure 4**; d) tert-butyl ((1S,3S)-3-aminocyclopentyl)carbamate, **General procedure 2**; e) TFA, DCM; f) 2-chloro-5-(methylthio)pyrimidine, **General procedure 6**; g) **General procedure 7**.

Methyl 1-methyl-6-oxo-1, 6-dihydropyridine-3-carboxylate (484A)

A solution of methyl 2-oxo-2H-pyran-5-carboxylate (3 g, 19.465 mmol, 1.0 eq) and methylamine (33% in EtOH, 1.904 g, 20.439 mmol, 1.05 eq) in EtOH (10 mL) was stirred at 60 °C for 18 h in sealed tube. The reaction mixture was cooled down to room temperature and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:2) to afford **484A** (393.6 mg) as a yellow solid. ESI $(\text{M}+\text{H})^+ = 168.1$

Methyl 5-bromo-1-methyl-6-oxo-1, 6-dihydropyridine-3-carboxylate (484B)

A solution of **484A** (393.6 mg, 2.355 mmol, 1 eq) and NBS (628.6 mg, 3.532 mmol, 1.5 eq) in AcOH (16 mL) was stirred at 80 °C for 2 h. The reaction mixture was cooled down to room temperature and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:1) to afford **484B** (377.3 mg)

as a white solid: ^1H NMR (400 MHz, CDCl_3) δ 8.26 (d, $J = 2.3$ Hz, 1H), 8.18 (d, $J = 2.3$ Hz, 1H), 3.90 (s, 3H), 3.68 (s, 3H). ESI (M+H) $^+ = 246.0$.

Methyl 6'-chloro-1-methyl-2-oxo-1, 2-dihydro-[3, 3'-bipyridine]-5-carboxylate (484C)

Methods analogous to those described above from starting material **484B** and (6-chloropyridin-3-yl) boronic acid afforded **484C**: ^1H NMR (400 MHz, CDCl_3) δ 8.68 (d, $J = 2.2$ Hz, 1H), 8.27 (d, $J = 2.3$ Hz, 1H), 8.21 – 8.13 (m, 1H), 8.08 (d, $J = 2.4$ Hz, 1H), 7.39 (t, $J = 11.7$ Hz, 1H), 3.91 (s, 3H), 3.69 (s, 3H). ESI (M+H) $^+ = 279.2$

Methyl 6'-(((1S, 3S)-3-((tert-butoxycarbonyl) amino) cyclopentyl) amino)-1-methyl-2-oxo-1, 2-dihydro-[3, 3'-bipyridine]-5-carboxylate (484D)

Methods analogous to those described above from starting material **484C** and tert-butyl ((1S,3S)-3-aminocyclopentyl) carbamate afforded **484D**: ESI (M+H) $^+ = 443.3$

Methyl 6'-(((1S, 3S)-3-aminocyclopentyl) amino)-1-methyl-2-oxo-1, 2-dihydro-[3, 3'-bipyridine]-5-carboxylate (484E)

To a solution of **484D** (35 mg) in DCM (1 mL) was added dropwise TFA (1 mL). The reaction mixture was stirred at room temperature for 30 minutes and then concentrated under reduced pressure. The residue was dissolved in MeOH, followed by the addition of ion-exchange resins (Ambersep® 900 OH $^-$ form) to adjust the pH level to 8. The mixture was filtered and the filtrate was concentrated under reduced pressure to give **484E** (27 mg) **8** as yellow oil.

Methyl 1-methyl-6'-(((1S, 3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino)-2-oxo-1, 2-dihydro-[3, 3'-bipyridine]-5-carboxylate (484F)

Methods analogous to those described above from starting material **484E** and 2-chloro-5-(methylthio) pyrimidine afforded **484F**: ESI (M+H) $^+ = 467.2$.

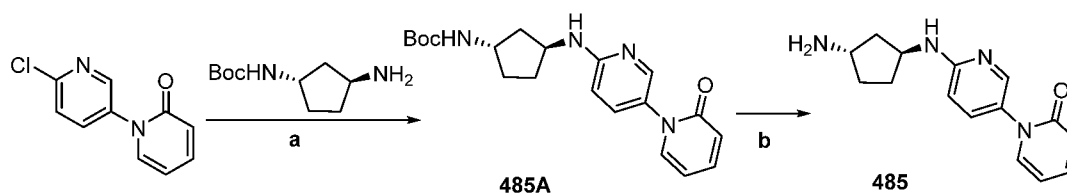
1-methyl-6'-(((1S, 3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) amino)-2-oxo-1, 2-dihydro-[3,3'-bipyridine]-5-carboxylic acid (Example 484)

Methods analogous to those described above from starting material **484F** afforded

Example 484: ^1H NMR (400 MHz, CD_3OD) δ 8.51 (dd, $J = 14.0, 2.1$ Hz, 2H), 8.35 (s, 2H), 8.25 (dd, $J = 10.7, 2.2$ Hz, 2H), 7.10 (d, $J = 9.5$ Hz, 1H), 4.51 – 4.41 (m, 1H), 4.31

– 4.20 (m, 1H), 3.69 (s, 3H), 2.49 – 2.39 (m, 1H), 2.35 (d, $J = 7.6$ Hz, 3H), 2.33 – 2.27 (m, 1H), 2.22 – 2.07 (m, 2H), 1.84 – 1.65 (m, 2H). ESI (M+H)⁺ = 453.3.

Scheme 77



a) General procedure 2; b) General procedure 6

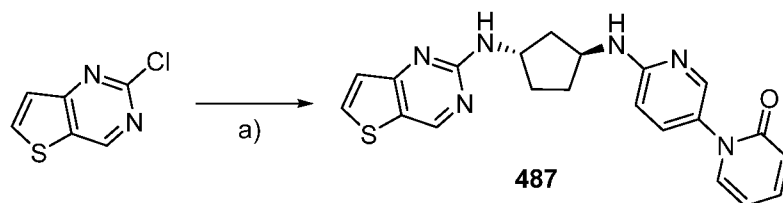
6'-(((1S,3S)-3-aminocyclopentyl) amino)-2H-[1,3'-bipyridin]-2-one (485)

Methods analogous to those described in **General Method 2** and **General procedure 6** from starting material 6'-chloro-2H-[1,3'-bipyridin]-2-one afforded **485**: m/z 271.0 [M+H]⁺.

Using the above procedures, the following example was synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	486		271.1

Scheme 78

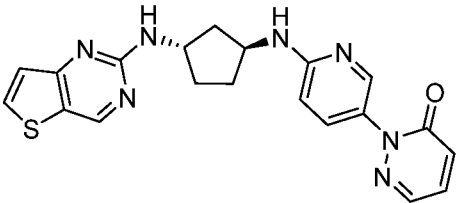


a) DIPEA, DMA, 150°C

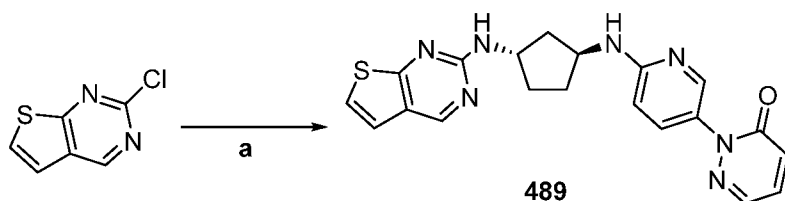
6'-(((1S,3S)-3-(thieno [3, 2-d] pyrimidin-2-ylamino) cyclopentyl) amino)-2H-[1, 3'-bipyridin]-2-one (487)

A solution of **485** (150 mg, 0.405 mmol, 1.0 eq.), DIPEA (260 mg, 2.0 mmol, 5.0 eq) and 2-chlorothieno[3,2-d]pyrimidine (69 mg, 0.405 mmol, 1.0 eq) in DMA (2 mL) was stirred at 150 °C for 30 min. The resulting mixture was diluted with ethyl acetate (10 mL), washed with water (2x10 mL), and the aqueous phase was extracted with ethyl acetate (4x20 mL). The combined organic layers were concentrated under vacuum and purified with Prep-HPLC to give **487** (12 mg) as white solid: LCMS m/z 405 $[M+H]^+$. ^1H NMR (400 MHz, $CDCl_3$) δ 10.73 (brs, 1H), 10.21 (brs, 1H), 9.03 (brs, 1H), 8.19 (d, J = 5.3 Hz, 1H), 7.92 (dd, J = 9.4, 2.3 Hz, 1H), 7.83 (d, J = 2.3 Hz, 1H), 7.54 – 7.43 (m, 2H), 7.41 (d, J = 5.5 Hz, 1H), 7.26 – 7.21 (m, 1H), 6.69 (dd, J = 9.3, 1.2 Hz, 1H), 6.38 – 6.29 (m, 1H), 4.81 – 4.59 (m, 1H), 4.53 – 4.25 (m, 1H), 2.52 – 2.31 (m, 3H), 2.08 (dt, J = 14.3, 7.8 Hz, 1H), 1.98 – 1.77 (m, 2H).

Using the above procedures, the following example was synthesized:

Structure	Ex. #	^1H NMR	LC-MS ($M+H$) $^+$
	488	^1H NMR (400 MHz, CD_3OD) δ 8.83 (s, 1H), 8.16 (dd, J = 2.7, 0.7 Hz, 1H), 8.05 (dd, J = 5.3, 1.4 Hz, 1H), 8.01 (dt, J = 3.0, 1.5 Hz, 1H), 7.61 (dd, J = 9.0, 2.7 Hz, 1H), 7.45 (ddd, J = 9.5, 4.2, 1.5 Hz, 1H), 7.18 (d, J = 5.4 Hz, 1H), 7.05 (dd, J = 9.4, 1.6 Hz, 1H), 6.60 (d, J = 9.1 Hz, 1H), 5.49 (s, 1H), 4.49 (p, J = 6.2 Hz, 1H), 4.36 (p, J = 6.3 Hz, 1H), 2.40 – 2.22 (m, 2H), 2.12 – 1.98 (m, 2H), 1.63 (ddt, J = 15.5, 9.8, 5.0 Hz, 2H).	406.1

Scheme 79



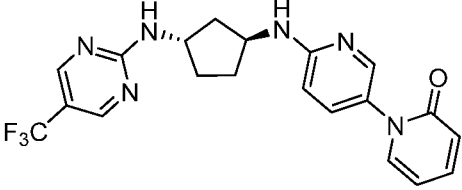
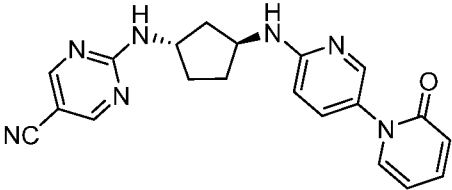
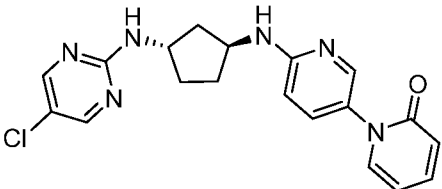
a) **486** DIPEA, DMSO 100°C

2-(6-(((1S, 3S)-3-(thieno [2, 3-d] pyrimidin-2-ylamino) cyclopentyl) amino) pyridin-3-yl) pyridazin-3(2H)-one (489)

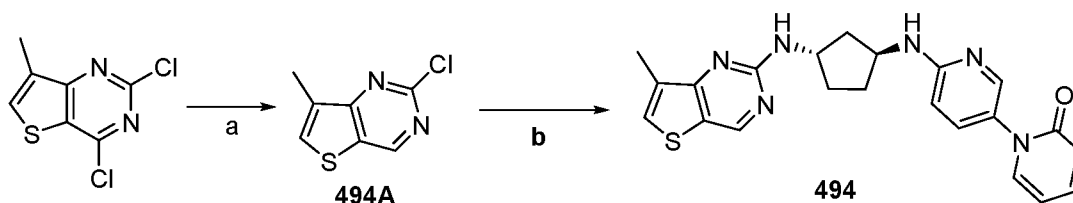
A solution of **486** (50 mg, 0.18 mmol), 5-chlorothiazolo[4,5-d] pyrimidine (30.5 mg, 0.18 mmol), DIPEA (70 mg, 0.54 mmol) in DMSO (5 mL) was stirred at 100 °C under N₂ for overnight. The reaction mixture was extracted with EA and water. The organic phase was washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by prep-TLC and prep-HPLC to afford 2.6 mg of **489** (2.3 mg): ESI (M+H)⁺ = 406.48; ¹H NMR (400 MHz, CD₃OD) δ 8.76 (s, 1H), 8.39 (d, *J* = 2.2 Hz, 1H), 8.22 (d, *J* = 9.7 Hz, 1H), 8.10 (d, *J* = 3.8, 1.6 Hz, 1H), 7.52 (dd, *J* = 9.5, 3.9 Hz, 1H), 7.22 (d, *J* = 6.0 Hz, 2H), 7.16 – 7.06 (m, 2H), 4.67 – 4.48 (m, 1H), 4.36 – 4.23 (m, 1H), 2.52 – 2.31 (m, 2H), 2.30 – 2.12 (m, 2H), 1.86 – 1.69 (m, 2H).

Using the above procedures, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	490	¹ H NMR (400 MHz, CD ₃ OD) δ 8.80 (m, 1H), 8.38 (s, 1H), 8.18 (m, 1H), 8.09 (dd, <i>J</i> = 3.9, 1.6 Hz, 1H), 7.52 (dd, <i>J</i> = 9.5, 3.9 Hz, 1H), 7.17 – 7.05 (m, 2H), 7.00 (m, 1H), 4.58 (m, 1H), 4.32 (m, 1H), 2.69 (s, 3H), 2.52 – 2.30 (m, 2H), 2.21 (m, 2H), 1.80 (m, 2H).	420.5

	491	¹ H NMR (400 MHz, CD ₃ OD) δ 8.49(s, 2H), 7.95-7.74(m, 1H), 7.63-7.57(m, 2H), 7.44 (dd, J = 2.4, 8.8 Hz, 1H), 6.60-6.63 (m, 2H), 6.44-6.48 (m, 1H), 4.52-4.48(m, 1H), 4.37-4.34(m, 1H), 2.31-2.24(m, 2H), 2.07-2.00(m, 2H), 1.66-1.61(m, 2H).	417.3
	492	¹ H NMR (400 MHz, CD ₃ OD) δ 8.57 (s, 1H), 8.50 (s, 1H), 7.94 (dd, J = 0.4, 2.8 Hz, 1H), 7.63-7.57 (m, 2H), 7.46-7.43 (m, 1H), 6.62-6.60 (m, 2H), 6.48-6.44 (m, 1H), 4.52-4.50 (m, 1H), 4.36-4.34 (m, 1H), 2.28-2.25 (m, 2H), 2.05-1.77 (m, 2H), 1.62-1.66 (m, 2H).	374.2
	493	¹ H NMR (400 MHz, CD ₃ OD) δ 8.22 (s, 2H), 7.93 (dd, J = 0.4, 2.8 Hz, 1H), 7.63-7.57 (m, 2H), 7.44 (dd, J = 2.8, 9.2 Hz, 1H), 6.63-6.60 (m, 2H), 6.48-6.44 (m, 1H), 4.39-4.32 (m, 2H), 2.28-2.23 (m, 2H), 2.02-1.97 (m, 2H), 1.64-1.58 (m, 2H).	383.3

Scheme 80



a) H_2 , $\text{Pd}(\text{OH})_2$, NaOAc , $\text{EA}/i\text{-PrOH}$, rt; b) K_2CO_3 , DMSO , 140°C

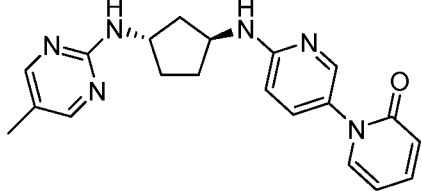
2-chloro-7-methylthieno [3, 2-d] pyrimidine (494A)

A suspension of 2,4-dichloro-7-methylthieno[3,2-d] pyrimidine (500 mg, 2.3 mmol, 1 eq), $\text{Pd}(\text{OH})_2$ (20% on carbon, 200 mg, 0.14 mmol, 0.55 eq) and NaOAc (400 mg, 4.8 mmol, 2.0 eq) in EA (8 mL) and $i\text{-PrOH}$ (1 mL) was stirred in a Parr apparatus under H_2 atmosphere (50 psi) for 18 h at room temperature. The reaction mixture was filtered on celite and the filtrate was concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE : EA = 4:1) to give **494A** (320 mg) as a white powder. $\text{ESI } (\text{M}+\text{H})^+ = 185.0$; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 9.09 (s, 1H), 7.73 (q, $J = 1.1$ Hz, 1H), 2.51 (d, $J = 1.2$ Hz, 3H).

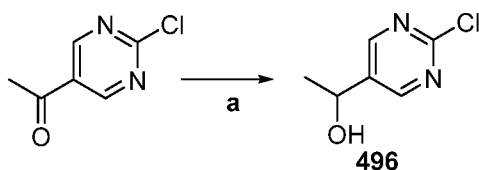
6'-(((1S, 3S)-3-((7-methylthieno [3, 2-d] pyrimidin-2-yl) amino) cyclopentyl) amino)-2H-[1, 3'-bipyridin]-2-one (494)

A suspension of **494A** (28.45 mg, 0.1541 mmol, 1.0 eq), **485** (50 mg, 0.185 mmol, 1.2 eq) and K_2CO_3 (63.9 mg, 0.462 mmol, 3.0 eq) in DMSO (5mL) was stirred at 140°C for 16 h under N_2 . The reaction mixture was extracted with DCM and water. The organic phase was washed with brine, dried over Na_2SO_4 , filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 20:1) to give **494** (10.4 mg) as a white powder. $^1\text{H NMR}$ (400 MHz, $\text{DMSO}-d_6$) δ 7.92 (d, $J = 2.6$ Hz, 1H), 7.60 (dd, $J = 6.8, 1.8$ Hz, 1H), 7.47 (ddd, $J = 9.0, 6.6, 2.1$ Hz, 1H), 7.39 (dd, $J = 8.9, 2.7$ Hz, 1H), 7.21 (d, $J = 7.2$ Hz, 1H), 6.92 (d, $J = 7.0$ Hz, 1H), 6.53 (d, $J = 9.1$ Hz, 1H), 6.44 (d, $J = 8.9$ Hz, 1H), 6.27 (td, $J = 6.7, 1.3$ Hz, 1H), 4.52 – 4.39 (m, 1H), 4.38 – 4.26 (m, 1H), 2.27 (d, $J = 0.9$ Hz, 3H), 2.16 (dd, $J = 9.8, 5.4$ Hz, 2H), 2.03 – 1.86 (m, 3H), 1.63 – 1.47 (m, 1H). $\text{ESI } (\text{M}+\text{H})^+ = 419.3$

Using the above procedures, the following example was synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	495	¹ H NMR (400 MHz, CDCl ₃) δ 10.53 (s, 1H), 10.27 (s, 1H), 8.56(brs, 2H) 7.91 (d, <i>J</i> = 9.3 Hz, 1H), 7.83 (s, 1H), 7.49 – 7.37 (m, 2H), 7.24 (d, <i>J</i> = 5.8 Hz, 1H), 6.67 (d, <i>J</i> = 9.3 Hz, 1H), 6.32 (t, <i>J</i> = 6.6 Hz, 1H), 4.60 (s, 1H), 4.42 – 4.25 (m, 1H), 2.48 – 2.28 (m, 3H), 2.25 (s, 3H), 2.11 – 1.99 (m, 1H), 1.98 – 1.84 (m, 1H), 1.79 (ddd, <i>J</i> = 12.5, 11.1, 7.0 Hz, 1H).	363.4

Scheme 81

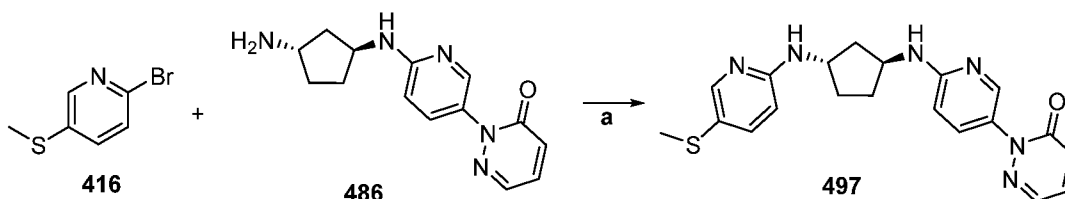


a) NaBH₄, MeOH, 0 °C,

1-(2-chloropyrimidin-5-yl) ethan-1-ol (496)

To the solution of 1-(2-chloropyrimidin-5-yl) ethan-1-one (500 mg, 3.2 mmol, 1.0 eq) in MeOH (15 mL) was added NaBH₄ (240 mg, 6.4 mmol, 2.0 eq) at 0 °C. After stirring at room temperature for 2 h, water (5 mL) was added to above mixture to quench the reaction. The resulting mixture was concentrated under reduced pressure, and the crude residue was purified by silica gel column chromatography (hexane: ethyl acetate = 5:1 to ethyl acetate) to give **496** as a pale solid (100 mg). ESI [M+H]⁺ = 159.1.

Scheme 82



a) General procedure 2

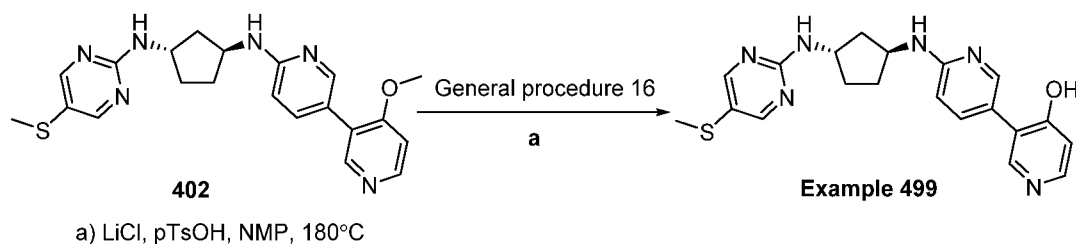
2-(6-(((1S,3S)-3-((5-(methylthio)pyridin-2-yl)amino)cyclopentyl)amino)pyridin-3-yl)pyridazin-3(2H)-one (497)

Methods analogous to those described in **General Method 2** from starting material **416** and **486** afforded **497**: ^1H NMR (400 MHz, CD_3OD) δ 8.28 (d, $J = 2.3$ Hz, 1H), 8.04 (dd, $J = 9.6, 2.3$ Hz, 1H), 7.97 (dd, $J = 3.8, 1.5$ Hz, 1H), 7.82 (dd, $J = 9.4, 2.2$ Hz, 1H), 7.63 (d, $J = 2.0$ Hz, 1H), 7.40 (dd, $J = 9.5, 3.9$ Hz, 1H), 7.00 (ddd, $J = 9.6, 6.5, 5.0$ Hz, 3H), 4.37 – 4.20 (m, 2H), 2.39 (s, 3H), 2.37 – 2.29 (m, 2H), 2.17 (t, $J = 6.4$ Hz, 2H), 1.80 – 1.67 (m, 2H). ESI $(\text{M}+\text{H})^+ = 395.3$

Using the above procedures, the following example was synthesized:

Structure	Ex. #	^1H NMR	LC-MS ($\text{M}+\text{H})^+$
	498	^1H NMR (400 MHz, CD_3OD) δ 8.27 (s, 2H), 7.59 (t, $J = 8.3$ Hz, 1H), 7.64-7.53 (m, 2H), 7.44 (m, 1H), 6.61 (d, $J = 9$ Hz, 2H), 6.64 (m, 1H), 4.72 (q, $J = 6.5$ Hz, 1H), 4.37 (m, 2H), 2.25 (m, 2H), 1.99 (m, 2H), 1.60 (m, 2H), 1.43 (d, $J = 10$ Hz, 3H).	393.2

Scheme 83



General procedure 16

6'-((((1S, 3S)-3-((5-(methylthio)pyrimidin-2-yl)amino)cyclopentyl)amino)-[3,3'-bipyridin]-4-ol (Example 499)

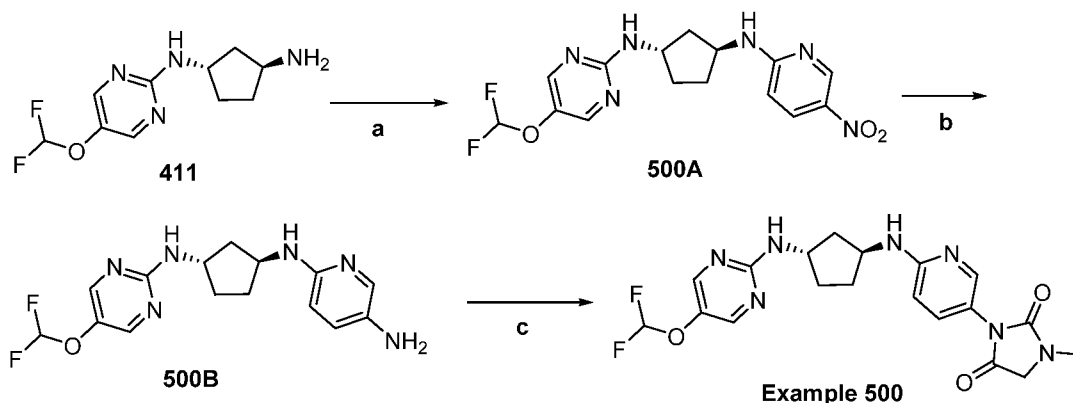
To a solution of compound **402** (40 mg, 0.1 mmol, 1eq) in NMP (3 mL) was added LiCl (42 mg, 1 mmol, 10 eq) and *p*-Toluenesulfonic acid (172 mg, 1 mmol, 10 eq). The mixture was stirred at 180 °C for 4 h and cooled down to room temperature. The mixture was diluted with water (10 mL) and then basified with sat. NaHCO₃ to pH= 10. The resulting mixture was extracted with ethyl acetate (10 mL x 6), the combined organic layers were washed with brine (20 mL), dried over Na₂SO₄, filtered and concentrated. The resulting residue was purified by Prep-HPLC to afford **Example 499** (10 mg, 26%) as a yellow solid: LCMS [M+H]⁺= 395; ¹H NMR (400 MHz, CD₃OD) δ: 8.33 (s, 2H), 8.18 (s, 1H), 7.88 (s, 1H), 7.77-7.72 (m, 1H), 6.63 (d, *J* = 9.2 Hz, 1H), 6.52 (d, *J* = 9.2 Hz, 1H), 4.45-4.35 (m, 2H), 2.35 (s, 3H), 2.30-2.24 (m, 2H), 2.04-1.98 (m, 2H), 1.63-1.60 (m, 2H).

Using the above procedures, the following example was synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	499A	¹ H NMR (400 MHz, CD ₃ OD) δ 7.94 (d, <i>J</i> = 2.3 Hz, 1H), 7.67 – 7.53 (m, 2H), 7.43 (dd, <i>J</i> = 9.0, 2.7 Hz, 1H), 6.65 – 6.55 (m, 2H), 6.46 (td, <i>J</i> = 6.8, 1.3 Hz, 1H), 4.40 – 4.25 (m, 2H), 2.31 – 2.19 (m, 2H), 1.98 (t, <i>J</i> = 6.7 Hz, 2H), 1.68 – 1.49	405

		(m, 3H), 0.84 – 0.73 (m, 2H), 0.49 (s, 2H).	

Scheme 84



a) 2-chloro-5-nitropyridine, K_2CO_3 , DMF, 80°C; b) H_2 , 10%Pd/C, rt;
c) 1) 4-nitrophenyl carbonochloridate, DIPEA, CH_3CN ; 2) methylglycinate hydrochloride, DIPEA, rt.

(1S, 3S)-N¹-(5-(difluoromethoxy) pyrimidin-2-yl)-N3-(5-nitropyridin-2-yl) cyclopentane-1,3-diamine (500A)

A suspension of **411** (43g, 176 mmol, 1.0 eq), 2-chloro-5-nitropyridine (27.9 g, 176 mmol, 1.0 eq) and K_2CO_3 (48.6 g, 382 mmol, 2.0 eq) in DMSO (500 mL) was stirred at 80 °C for 16 h. The reaction mixture was cooled down to room temperature and filtered. The filtrate was partitioned between EA (400 mL) and water (400 mL); and the aqueous phase was extracted with EA (300 mL). The combined organic phases were washed with brine (400 mL) and then concentrated under reduced pressure. The crude residue was purified by column chromatography on silica gel (PE: EA=3:1) to give **500A** (52 g).

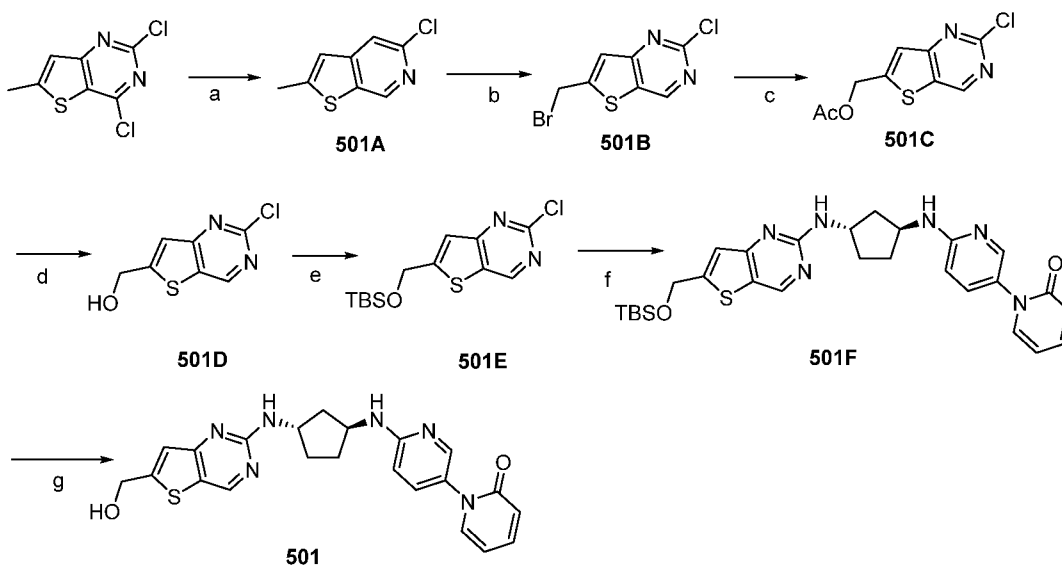
N²-((1S, 3S)-3-((5-(difluoromethoxy) pyrimidin-2-yl) amino) cyclopentyl) pyridine-2,5-diamine (500B)

To a solution of **500A** (45g, 123mmol, 1.0 eq) in MeOH(450mL) was added 10%Pd/C (4.5g). Then the reaction mixture was degassed with H_2 three times and stirred under H_2 at room temperature for 8 h. The reaction mixture was filtered through celite. The filtrate was concentrated to remove solvent, and the residue was purified by column chromatography on silica gel (EA: MeOH=30:1) to give **500B** (31g)

3-(6-(((1S,3S)-3-((5-(difluoromethoxy) pyrimidin-2-yl) amino) cyclopentyl) amino) pyridin-3-yl)-1-methylimidazolidine-2,4-dione (Example 500)

A solution of **500B** (27.2 g, 81mmol, 1.0 eq) and 4-nitrophenyl carbonochloridate (16.3g, 81mmol, 1.0 eq) in acetonitrile (280 mL) was stirred at room temperature for 1hr. Methyl methylglycinate hydrochloride (11.8g, 84 mmol, 1.1 eq) and DIPEA (31.3g, 24.2mmol, 3.0 eq) was added into the reaction and stirred for further 16 h. The reaction mixture was concentrated to remove most solvent, and the residue was partitioned between DCM (70 mL) and water (70 mL). The organic phase was separated and concentrated. The resulting residue was purified by column chromatography on silica gel (DCM: MeOH=40:1) to give crude product as slurry. The compound was further purified by trituration in PE/EA (4:1, 40mL) and de-colored with activated carbon in MeOH to give **Example 500** (25g): ¹H NMR (400 MHz, CD₃OD) δ 8.16 (s, 2H), 7.91 (d, *J* = 2.1 Hz, 1H), 7.36 (dd, *J* = 9.0, 2.6 Hz, 1H), 6.93 – 6.43 (m, 2H), 4.47 – 4.25 (m, 2H), 4.08 (s, 2H), 3.02 (s, 3H), 2.35 – 2.19 (m, 2H), 2.12 – 1.87 (m, 2H), 1.69 – 1.46 (m, 2H).

Scheme 85



a) Zn, AcOH, MeOH, b) NBS, AIBN, CCl₄, c) AcOCs, DMF, d) K₂CO₃, DMF, e) TBSCl, Et₃N, DMF
f) **485**, General procedure **5**; g) TBAF

2-chloro-6-methylthieno [3, 2-d] pyrimidine (501A)

A solution of 2,4-dichloro-6-methylthieno[3,2-d] pyrimidine (1.5 g, 6.85 mmol, 1.0 eq), zinc (1.8 g, 27.39 mmol, 4.0 eq) and acetic acid (2.4 mL, 41.08 mmol, 6.0 eq) in methanol (30 mL) was stirred at 70 °C for 16 h. After cooling to room temperature, the mixture was filtered, and the filter cake was washed with methanol (30 mL x 2). The filtrate was concentrated and purified by flash column (petroleum ether: EtOAc = 4:1) to obtain **501A** (620 mg, 47.6% yield) as a white solid. MS (ESI+) m/z 185.0 (M+H)⁺

6-(bromomethyl)-2-chlorothieno[3,2-d] pyrimidine (501B)

A solution of **501A** (600 mg, 3.25 mmol, 1.0 eq), N-Bromosuccinimide (694.0 mg, 3.90 mmol, 1.2 eq) and AIBN (26.7 mg, 0.16 mmol, 0.05 eq) in carbon tetrachloride (20 mL) was refluxed in a sealed tube for 16 h. After cooling to room temperature, the mixture was concentrated and purified by flash column (petroleum ether: EtOAc: 4:1) to obtain **501B** (614 mg, 71.2% yield) as a yellow solid. MS (ESI+) m/z 262.9 (M+H)⁺

(2-chlorothieno [3,2-d]pyrimidin-6-yl)methyl acetate (501C)

A solution of **501B** (600 mg, 2.3 mmol, 1.0 eq) and cesium acetate (2.2 g, 11.4 mmol, 5.0 eq) in DMF (15 mL) was stirred at room temperature for 30 min. The mixture was diluted with EtOAc (100 mL), washed with water (80 mL) and brine (60 mL), dried over Na₂SO₄. After the filtration, the filtrate was concentrated and purified by flash column (petroleum ether:EtOAc: 4:1) to obtain **501C** (373 mg, 67.5% yield) as a white solid. MS (ESI+) m/z 243.0 (M+H)⁺; ¹H NMR (400MHz, CDCl₃) δ 9.07 (s, 1H), 7.39 - 7.52 (m, 1H), 5.43 (d, *J* = 0.9 Hz, 2H), 2.17 (s, 3H).

(2-chlorothieno [3, 2-d] pyrimidin-6-yl) methanol (501D)

A solution of **501C** (160 mg, 0.66 mmol, 1.0 eq) and potassium carbonate (136.7 mg, 0.99 mmol, 1.5 eq) in methanol (15 mL) was stirred at room temperature for 1 h. Then, the mixture was concentrated and purified by flash column (petroleum ether: EtOAc: 1:1) to obtain **501D** (100 mg, 75.8% yield) as white solid: MS (ESI+) m/z 201.0 (M+H)⁺

6-(((tert-butyldimethylsilyl)oxy)methyl)-2-chlorothieno[3,2-d]pyrimidine (501E)

A solution of **501D** (100 mg, 0.50 mmol, 1.0 eq) in DMF (5 mL) was cooled to 0 °C. TBSCl (97.6 mg, 0.65 mmol, 1.3 eq) was added followed by triethylamine (0.14 mL, 1.00 mmol, 2.0 eq). The mixture was stirred at room temperature for 16 h. The mixture was diluted with ethyl acetate (60 mL), washed with water (60 mL) and brine (30 mL), dried over Na₂SO₄. The filtrate was concentrated and purified by flash column (petroleum ether: EtOAc: 4:1) to obtain **501D** (126 mg, 80.5% yield) as white solid: MS (ESI+) m/z 315.2 (M+H)⁺

6'-(((1S,3S)-3-((6-(((tert-butyldimethylsilyl)oxy)methyl)thieno[3,2-d]pyrimidin-2-yl)amino)cyclopentyl)amino)-2H-[1,3'-bipyridin]-2-one (501F)

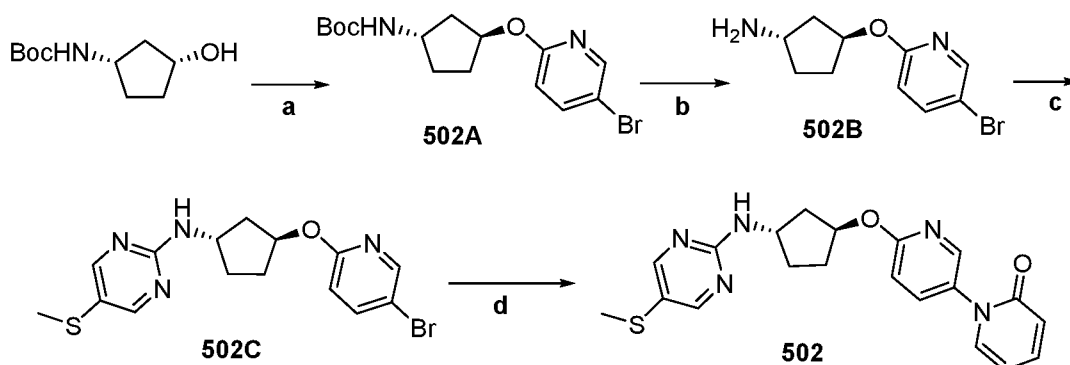
Methods analogous to those described in **General Method 5** from starting material **501E** and **485** afforded **501F**.

6'-(((1S, 3S)-3-((6-(hydroxymethyl) thieno[3,2-d]pyrimidin-2-yl)amino)cyclopentyl)amino)-2H-[1,3'-bipyridin]-2-one (501)

TBAF (3 mL) was added to the solution of **501F** (crude, 0.16 mmol, 1.0 eq) in DMSO (10 mL) and stirred for 30 min. Then, the mixture was diluted with water (50 mL) and extracted with EtOAc (50 mLx2), dried over Na₂SO₄. The filtrate was concentrated and purified by flash column on silica gel (DCM: MeOH: 15:1) to afford crude compound, which was further purified by Prep-HPLC to obtain pure **501** (2.3 mg, 3.3% yield by two steps) as white solid: MS (ESI+) m/z 435.1 (M+H)⁺

¹H NMR (400MHz, CD₃OD) δ 8.84 (s, 1H), 7.98 (d, *J* = 2.0 Hz, 1H), 7.82 (dd, *J* = 9.6, 2.4 Hz, 1H), 7.47 - 7.61 (m, 2H), 7.06 (d, *J* = 0.8 Hz, 1H), 6.99 (d, *J* = 9.5 Hz, 1H), 6.55 (dt, *J* = 9.1, 1.0 Hz, 1H), 6.41 (td, *J* = 6.8, 1.3 Hz, 1H), 4.83 (d, *J* = 1.1 Hz, 2H), 4.50 (t, *J* = 6.8 Hz, 1H), 4.17 - 4.28 (m, 1H), 2.22 - 2.39 (m, 2H), 2.07 - 2.17 (m, 2H), 1.63 - 1.77 (m, 2H).

Scheme 86



a) 5-bromopyridin-2-ol, PPh_3 , DEAD, THF, 0°C ; b) **General procedure 6** c) **General procedure 5**;
d) pyridin-2(1*H*)-one, **General procedure 14**.

Tert-butyl ((1*S*, 3*S*)-3-((5-bromopyridin-2-yl) oxy) cyclopentyl) carbamate (502A)

To a cold (0°C) solution of tert-butyl ((1*S*, 3*R*)-3-hydroxycyclopentyl) carbamate (865 mg, 4.3 mmol, 1.5 eq) and 5-bromopyridin-2-ol (500 mg, 2.9 mmol, 1.0 eq) in THF (20 mL) was added PPh_3 (1.884 g, 7.2 mmol, 2.5 eq), followed by addition of DEAD (1.04 mL, 7.2 mmol, 2.5 eq) dropwise under N_2 . The reaction mixture was stirred at 0°C for 1.5 h. The reaction mixture was then partitioned between EA and water. The separated organic phase was washed with brine and dried over Na_2SO_4 , filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 5:1) to afford **502A** (1.02 g) as a white solid: ESI $(\text{M}+\text{H})^+ = 357.2$. ^1H NMR (400 MHz, CDCl_3) δ 8.15 (d, $J = 2.4$ Hz, 1H), 7.60 (ddd, $J = 13.9, 7.8, 6.1$ Hz, 1H), 6.58 (d, $J = 8.8$ Hz, 1H), 4.50 (s, 1H), 4.20 (s, 1H), 2.20 (tt, $J = 12.3, 6.3$ Hz, 3H), 1.87 – 1.72 (m, 2H), 1.58 (d, $J = 13.9$ Hz, 1H), 1.44 (s, 9H).

(1*S*, 3*S*)-3-((5-bromopyridin-2-yl) oxy) cyclopentylamine (502B)

Methods analogous to those described in **General Method 6** from starting material **502A** afforded **502B** as yellow oil.

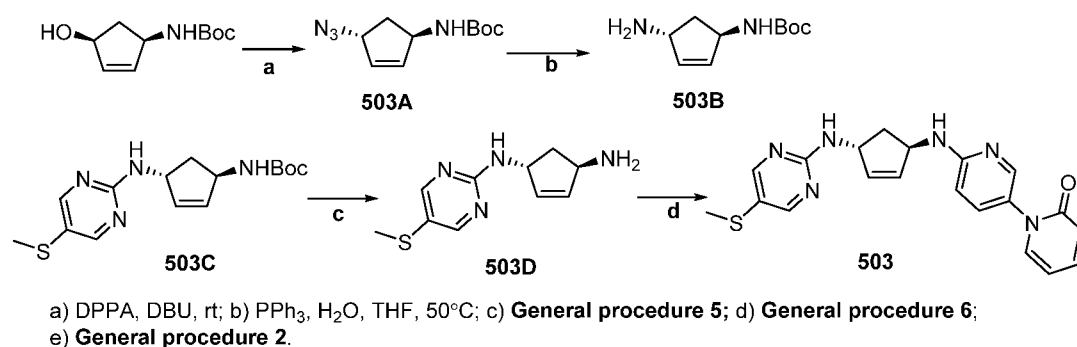
N-((1*S*, 3*S*)-3-((5-bromopyridin-2-yl) oxy) cyclopentyl)-5-(methylthio)pyrimidin-2-amine (502C)

Methods analogous to those described in **General Method 5** from starting material **502B** and 2-chloro-5-(methylthio)pyrimidine afforded **502C** a yellow solid: ESI (M+H)⁺ = 381.1

6'-(((1S, 3S)-3-((5-(methylthio) pyrimidin-2-yl) amino) cyclopentyl) oxy)-2H-[1, 3'-bipyridin]-2-one (502)

Methods analogous to those described in **General Method 14** from starting material **502** and **pyridin-2(1H)-one** afforded **502** a white solid: ESI (M+H)⁺ = 396.3. ¹H NMR (400 MHz, CD₃OD) δ 8.40 (s, 2H), 8.21 – 8.14 (m, 1H), 7.74 (dd, *J* = 8.8, 2.8 Hz, 1H), 7.66 – 7.57 (m, 2H), 6.90 (dd, *J* = 8.8, 0.5 Hz, 1H), 6.63 (dt, *J* = 8.9, 1.1 Hz, 1H), 6.49 (td, *J* = 6.8, 1.3 Hz, 1H), 5.61 – 5.53 (m, 1H), 4.51 (p, *J* = 7.1 Hz, 1H), 2.39 (s, 3H), 2.37 – 2.26 (m, 3H), 2.08 – 1.99 (m, 1H), 1.91 (tdd, *J* = 10.0, 7.7, 2.7 Hz, 1H), 1.74 – 1.60 (m, 1H).

Scheme 87



tert-butyl ((1R,4R)-4-azidocyclopent-2-en-1-yl)carbamate (503A)

To a solution of tert-butyl ((1R,4S)-4-hydroxycyclopent-2-en-1-yl)carbamate (200 mg, 1.0 mmol, 1.0 eq) in THF (10 mL) was added DPPA (414 mg, 1.5 mmol, 1.5 eq) and DBU (230 mg, 1.5 mmol, 1.5 eq) at room temperature and then stirred for 2 days. Water (10 mL) was added to above solution, which was then extracted with EtOAc (10 mL x3). The combined organic layers were washed with brine (30 mL), dried over Na₂SO₄, filtered, concentrated and purified by chromatography on silica gel eluting with PE: EA= 5:1 to afford **503A** (200 mg, 89%) as a white solid.

Tert-butyl ((1R, 4R)-4-aminocyclopent-2-en-1-yl) carbamate (503B)

To a solution of **503A** (200 mg, 0.9 mmol, 1.0 eq) in THF: H₂O=4: 1 (10 mL) was added PPh₃ (234 mg, 0.9 mmol, 1.0 eq) at room temperature under N₂ atmosphere. The mixture was then stirred at 50 °C overnight and then cooled down to room temperature. The filtrate was concentrated and purified by chromatography on silica gel eluting with DCM: MeOH=20:1-3:1 to afford **503B** (100 mg, 57%) as a semi solid.

tert-butyl ((1R,4R)-4-((5-(methylthio)pyrimidin-2-yl)amino)cyclopent-2-en-1-yl)carbamate (503C)

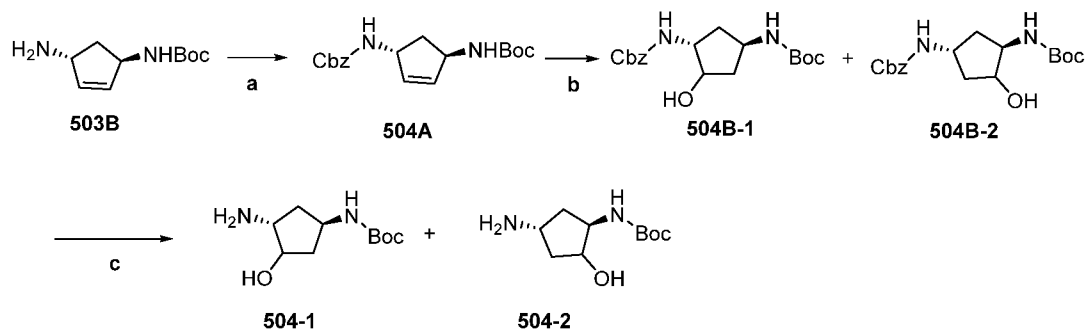
Methods analogous to those described in **General Method 5** from starting material **503B** and 2-chloro-5-(methylthio)pyrimidine afforded **503C** as a brown solid.

(1R, 3R)-N1-(5-(methylthio) pyrimidin-2-yl) cyclopent-4-ene-1,3-diamine (503D)

Methods analogous to those described in **General Method 6** from starting material **503C** afforded **503D** as brown oil, which was used in the next step directly.

6'-(((1R, 4R)-4-((5-(methylthio) pyrimidin-2-yl) amino) cyclopent-2-en-1-yl) amino)-2H-[1,3'-bipyridin]-2-one (503)

Methods analogous to those described in **General Method 2** from starting material **503D** afforded **503** as a off-white solid: LCMS [M+H]⁺= 393; ¹H NMR (400 MHz, CD₃OD) δ 8.34 (s, 2H), 7.96 (s, 1H), 7.65-7.55 (m, 2H), 7.48-7.45 (m, 1H), 6.63-6.60 (m, 2H), 6.50-6.46 (m, 1H), 6.02-6.00 (m, 2H), 5.20-5.15 (m, 2H), 2.35 (s, 3H), 2.20-2.16 (m, 2H).

Scheme 88

a) Cbz-Cl, Na₂CO₃, THF, H₂O; b) BH₃, THF, H₂O₂, NaOH; c) Pd(OH)₂/C, MeOH.

Benzyl tert-butyl ((1R, 3R)-cyclopent-4-ene-1, 3-diyl)dicarbamate (504A)

To a solution of **503B** (0.5 g, 2.5 mmol, 1.0 eq) in THF (10 mL) and H₂O (2 mL) was added Na₂CO₃ (0.65 g, 5.8 mmol, 2.5 eq) and Cbz-Cl (510 mg, 3.0 mmol, 1.2 eq). The resulting solution was stirred at room temperature for 2.5 h. The reaction mixture was poured into water (50 mL) and extracted with ethyl acetate (25 mL x3). The combined organic layers were washed with brine and dried over anhydrous Na₂SO₄. The filtrate was concentrated under reduced pressure. The crude residue was purified by silica gel column chromatography (hexane: ethyl acetate = 5:1) to give **504A** (566 mg) as a pale solid. ESI [M+H]⁺ = 333.

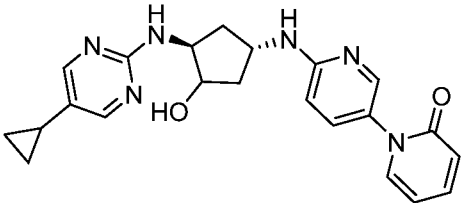
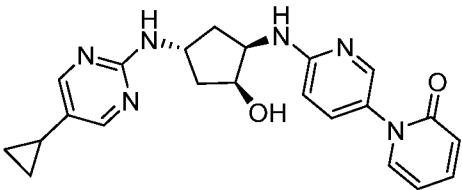
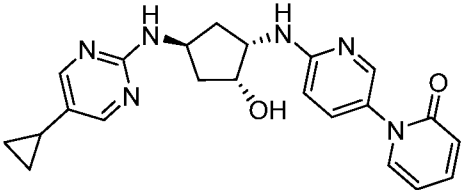
Benzyl tert-butyl ((1R,3R)-4-hydroxycyclopentane-1,3-diyl)dicarbamate (504B-1) & benzyl tert-butyl ((1R,3R)-4-hydroxycyclopentane-1,3-diyl)dicarbamate (504B-2)

To a solution of **504A** (524 mg, 1.7 mmol, 1 eq) in THF (10 mL) was added BH₃.THF (1N, 7.8 mL, 7.8 mmol, 4.5 eq) at 0 °C. The resulting solution was stirred at room temperature for 6 h. H₂O (7.5 mL) and NaOH (3M, 12 mL) was added, followed by H₂O₂ (30%, 20 mL). The mixture was stirred at room temperature for another 10 min before addition of EtOH (7.5 mL). The resulting mixture was stirred at room temperature for 20 h. After pouring into water (20 mL), the mixture was extracted with ethyl acetate (15 mL x 6). The combined organic layers were washed with brine and dried over anhydrous Na₂SO₄. The organic phase was filtered off and concentrated under reduced pressure. The crude residue was purified by silica gel chromatography (hexane: ethyl acetate = 10:1 to 1:2) to afford the title compounds (566 mg in total) as a pale solid: ESI [M+H]⁺ = 351.

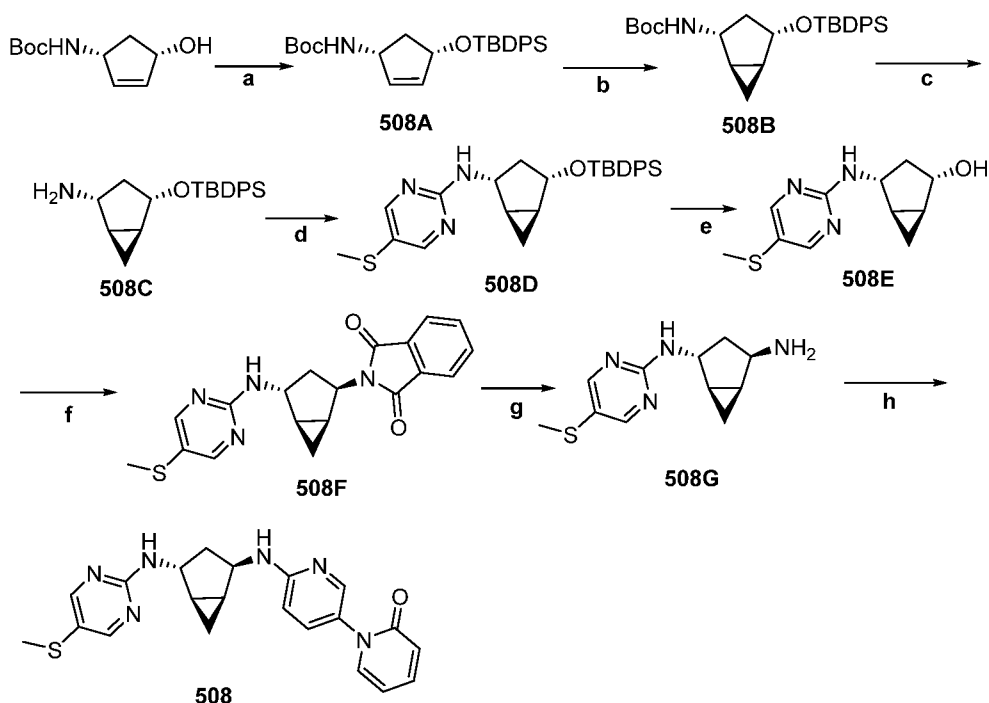
tert-butyl ((1R,3R)-3-amino-4-hydroxycyclopentyl)carbamate (504-1) & tert-butyl ((1R,4R)-4-amino-2-hydroxycyclopentyl)carbamate (504-2)

360 mg of starting material (1.1 mmol, 1 eq) in MeOH (25 mL) was stirred with Pd(OH)₂ (100 mg) under H₂ at room temperature for 19 hr. The catalyst was removed by filtration and the filtrate was concentrated to afford the title compound as a pale solid. Yield: 200 mg. ESI [M+H]⁺ = 217.

Using the procedures described above, the following examples were synthesized:

Structure	Ex. #	¹ H NMR	LC-MS (M+H) ⁺
	505	¹ H NMR (400 MHz, CD ₃ OD) δ 8.10 (s, 2H), 7.94 (s, 1H), 7.67 – 7.54 (m, 2H), 7.45 (dd, <i>J</i> = 9.0, 2.6 Hz, 1H), 6.62 (dd, <i>J</i> = 9.0, 3.0 Hz, 2H), 6.46 (t, <i>J</i> = 6.7 Hz, 1H), 4.40 – 4.28 (m, 1H), 4.10 (m, 2H), 2.65 – 2.47 (m, 1H), 2.23 – 2.11 (m, 1H), 2.06 (m, 1H), 1.76 (m, 1H), 1.63 (m, 1H), 0.98 – 0.78 (m, 2H), 0.66 – 0.51 (m, 2H).	405.2
	506	¹ H NMR (400 MHz, MeOD) δ 8.13 – 8.04 (s, 2H), 7.96 (s, 1H), 7.65 – 7.53 (m, 2H), 7.53 – 7.38 (m, 1H), 6.74 – 6.56 (m, 2H), 6.46 (m, 1H), 4.39 (m, 1H), 4.16 – 3.96 (m, 2H), 2.51 (m, 1H), 2.19 (m, 1H), 2.04 (m, 1H), 1.76 (m, 1H), 1.71 – 1.58 (m, 1H), 0.97 – 0.84 (m, 2H), 0.67 – 0.54 (m, 2H).	405.2
	507	¹ H NMR (400 MHz, MeOD) δ 8.10 – 8.04 (s, 2H), 7.95 (s, 1H), 7.59 (m, 2H), 7.50 – 7.41 (m, 1H), 6.79 – 6.56 (m, 2H), 6.46 (m, 1H), 4.55 – 4.44 (m, 1H), 4.41 – 4.27 (m, 2H), 2.27 (m, 1H), 2.22 – 2.09 (m, 1H), 2.06 – 1.93 (m, 1H), 1.93 – 1.80 (m, 1H), 1.81 – 1.66 (m, 1H), 0.97 – 0.80 (m, 2H), 0.68 – 0.49 (m, 2H).	405.2

Scheme 89



a) TBDPSCl, imidazole, DMF, rt; b) $\text{Et}_2\text{N}, \text{CH}_2\text{I}_2$, DCM, -15-0°C; c) TFA, DCM, rt; d) **General procedure 5**; e) pyridine HF, THF, rt; f) isoindoline-1,3-dione, PPh_3 , DEAD, THF, rt; g) hydrazine hydrate, EtOH, rt; h) **General procedure 2**.

tert-butyl ((1R,4S)-4-((tert-butyldiphenylsilyl)oxy)cyclopent-2-en-1-yl)carbamate (508A)

To a cold (0 °C) solution of tert-butyl ((1R, 4S)-4-hydroxycyclopent-2-en-1-yl) carbamate (500 mg, 2.5 mmol, 1.0 eq) and imidazole (342 mg, 5.0 mmol, 2.0 eq) in DMF (10 mL) was added dropwise TBDPSCl (0.85 mL, 3 mmol, 1.3 eq). The reaction mixture was then stirred for 16 h while the temperature was allowed to rise to room temperature. The reaction mixture was partitioned between EA and water. The separated organic layer was washed with brine, dried over Na_2SO_4 , filtered and concentrated under reduced pressure. The crude residue was purified by reverse-phase flash chromatography ($\text{CH}_3\text{CN}:\text{H}_2\text{O}$ = 40% - 90%) to afford **508A** (869.2 mg) as a clear oil: ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.65 (dd, J = 6.8, 1.0 Hz, 4H), 7.53 – 7.41 (m, 6H), 7.10 (d, J = 7.8 Hz, 1H), 4.67 (t, J = 6.7 Hz, 1H), 4.25 (dd, J = 14.6, 7.2 Hz, 1H), 3.20 (d, J = 4.0 Hz, 1H), 2.53 (dt, J = 3.6, 1.8 Hz, 1H), 2.52 – 2.43 (m, 1H), 1.60 – 1.49 (m, 1H), 1.39 (s, 9H), 1.03 (s, 9H).

tert-butyl ((1R,2R,4S,5S)-4-((tert-butyldiphenylsilyl)oxy)bicyclo[3.1.0]hexan-2-yl)carbamate (508B)

To a cold (-15 °C) solution of Et₂Zn (4.6 mL, 4.6 mmol, 3.0 eq) in dry DCM (5 mL) was added dropwise diiodomethane (0.74 mL, 9.2 mmol, 6 eq) in DCM (4 mL). The reaction mixture was stirred at -15 °C for 10 minutes until a white precipitate formed. Then **508A** (670mg, 1.5 mmol, 1.0 eq) in DCM (5mL) was added dropwise to the reaction mixture. The stirring was continued for 22 h while the temperature was allowed to warm to room temperature gradually. The reaction was quenched by addition of saturated NH₄Cl, and then it was partitioned between DCM and water. The separated organic phase was washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 10:1) to afford **508B** (280 mg) as a colorless oil. ¹H NMR (400 MHz, CDCl₃) δ 7.75 – 7.59 (m, 4H), 7.47 – 7.30 (m, 6H), 4.66 – 4.50 (m, 1H), 4.39 (td, *J* = 8.0, 4.8 Hz, 1H), 4.01 (s, 1H), 2.17 – 2.07 (m, 1H), 1.44 (d, *J* = 7.8 Hz, 9H), 1.34 – 1.24 (m, 2H), 1.05 (d, *J* = 5.7 Hz, 9H), 0.83 (dt, *J* = 9.0, 2.9 Hz, 1H), 0.46 – 0.33 (m, 1H).

(1R, 2R, 4S, 5S)-4-((tert-butyldiphenylsilyl) oxy) bicyclo [3.1.0] hexan-2-amine (508C)

To a solution of **508B** (230 mg) in DCM (3 mL) was added TFA (5 mL). The reaction mixture was stirred at room temperature for 1 h and then concentrated under reduced pressure. The residue was redissolved in MeOH and the pH level was increased to 8 by adding ion-exchange resins. The filtrate was concentrated under reduced pressure to afford **508C** (189.2 mg) as a yellow oil.

N-((1R,2R,4S,5S)-4-((tert-butyldiphenylsilyl)oxy)bicyclo[3.1.0]hexan-2-yl)-5-(methylthio)pyrimidin-2-amine (508D)

Methods analogous to those described in **General Method 5** from starting material **504C** and 2-chloro-5-(methylthio)pyrimidine afforded **504D** as a brown oil.

(1S,2S,4R,5R)-4-((5-(methylthio)pyrimidin-2-yl)amino)bicyclo[3.1.0]hexan-2-ol (508E)

To a solution of **508D** (50 mg) in THF (2 mL) was added dropwise pyridine HF (0.5 mL). The reaction mixture was stirred for 4 h at room temperature and then partitioned between EA and water. The separated organic phase was washed with brine. The organic phase was dried over Na₂SO₄, filtered and concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (DCM: MeOH = 10:1) to afford **508E** (54.4 mg) as a light yellow oil. ESI (M+H)⁺ = 238.3

2-((1S,2R,4R,5R)-4-((5-(methylthio)pyrimidin-2-yl)amino)bicyclo[3.1.0]hexan-2-yl)isoindoline-1,3-dione (508F)

To a solution of **508E** (50 mg, 0.2 mmol, 1.0 eq), isoindoline-1,3-dione (37 mg, 0.25 mmol, 1.2 eq) and PPh₃ (600 mg, 2.3 mmol, 10.0 eq) in THF (10 mL) was added dropwise DEAD (398 mg, 2.3 mmol, 10.0 eq) at 0 °C under N₂. The reaction mixture was stirred for 2 h while the temperature was allowed to rise to room temperature gradually. The reaction mixture was concentrated under reduced pressure. The crude residue was purified by flash chromatography on silica gel (PE: EA = 1:1) twice to afford **508F** (214 mg, contaminated with impurities) as a yellow oil. ESI (M+H)⁺ = 367.4

(1R,2R,4R,5S)-N2-(5-(methylthio)pyrimidin-2-yl)bicyclo[3.1.0]hexane-2,4-diamine (508G)

A solution of **508F** (214 mg, 0.584 mmol) and hydrazine hydrate (0.2 mL) in EtOH (5 mL) was stirred at 60 °C under N₂ for 2 h. The reaction mixture was concentrated under reduced pressure and purified by flash chromatography on silica gel (DCM:MeOH = 20:1) to afford **508G** (30 mg) as a yellow oil: ESI (M+H)⁺ = 237.4

6'-((((1S,2R,4R,5R)-4-((5-(methylthio)pyrimidin-2-yl)amino)bicyclo[3.1.0]hexan-2-yl)amino)-2H-[1,3'-bipyridin]-2-one (508)

Methods analogous to those described in **General Method 2** from starting material **508G** afforded **508** as a yellow solid: ESI (M+H)⁺ = 407.4. ¹H NMR (400 MHz, CD₃OD) δ

8.35 (s, 2H), 8.07 (d, $J = 2.2$ Hz, 1H), 7.93 (dd, $J = 9.6, 2.4$ Hz, 1H), 7.72 – 7.57 (m, 2H), 7.12 (d, $J = 9.5$ Hz, 1H), 6.65 (d, $J = 9.0$ Hz, 1H), 6.51 (td, $J = 6.8, 1.2$ Hz, 1H), 4.23 (d, $J = 5.9$ Hz, 1H), 2.36 (s, 3H), 2.22 – 2.10 (m, 1H), 1.93 (dt, $J = 9.7, 4.3$ Hz, 1H), 1.61 (dt, $J = 9.9, 6.4$ Hz, 2H), 0.76 (dt, $J = 7.8, 3.9$ Hz, 1H), 0.69 (dd, $J = 14.0, 7.9$ Hz, 1H).

C. Biological Assays

Human recombinant PCSK9 was expressed as follows:

Protein sequence:

QEDEDGDYEELVLALRSEEDGLAEAPEHGTTATFHRC AKDPWRLPGTYVVVLK
EETHLSQSERTARRLQAQAARRGYLTKILHVFHGLLPGLVKMSGDLLELALKLP
HVDYIEEDSSVFAQSIPWNLERITPPRYRADEYQPPDGGSLVEVYLLDTSIQSDHR
EIEGRVMVTD FENVPEEDGTRFHRQASKCDSHGTHLAGVVSGRDAGVAKGASM
RSLRVLNCQGKGTVSGTLIGLEFIRKSQLVQPVGPLVVLLPLAGGYSRVLNAACQ
RLARAGVVLVTAAGNFRDDACLYSPASAPEVITVGATNAQDQPVTLGTLGTNFG
RCVDLFAPGEDIIGASSDCSTCFVSQSGTSQAAAHVAGIAAMMLSAEPELTLAEL
RQRLIHFS AKDVINEAWFPEDQRVLT PNLVAALPPSTHGAGWQLFCRTVWSAHS
GPTRMATAVARCAPDEELLSCSSFSRSGKRRGERMEAQGGKLV CRAHNAFGGE
GVYAIARCCLLPQANCSVHTAPPAEASMGTRVHCHQQGHVLTGCSSHWEVEDL
GTHKPPVLRPRGQPNQCVGHREASIHASCCHAPGLECKVKEHGIPAPQEQTVA
CEEGWTLTGCSALPGTSHVLGAYAVDNTCVVRSRDVSTTGSTSEGAVTAVAICC
RSRHLAQASQELQSGSGGLNDIFEAQKIEWHENLYFQGHHHHHH

The following assay method was used to identify and evaluate compounds of Formula (I) that are effective in inhibiting PCSK9 function.

Example: PCSK9 SPR Assay

Surface plasmon resonance data was collected on a Biacore™ T200 or 3000 system (GE Healthcare) at 25°C. Streptavidin was immobilized on a CM5 (GE Healthcare) or CMD500d sensor chip (XanTec Bioanalytics) using standard amine-coupling chemistry at 25°C with HBS-N (10 mM HEPES, 0.15 M NaCl, pH 7.4) as the running buffer. Briefly, the carboxymethyl dextran surface was activated with a 12 min injection of a 1:1 ratio of 0.4 M 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC)/0.1 M *N*-hydroxy succinimide (NHS) at a flow rate of 10 µL/min.

For capture of streptavidin, protein was diluted to 0.2 mg/mL in 10 mM sodium acetate (pH 4.5) and captured by injecting 100 μ L onto the activated chip surface. Residual activated groups were blocked with a 7 min injection of 1 M ethanolamine (pH 8.5). Avi-tagged PCSK9 protein was captured on the streptavidin surface by injection of 150 μ L of protein diluted to 16 μ g/mL in HBS-N, 0.05% tween-20, 0.1 mM CaCl_2 . Typical surface densities obtained were 8000-10000 RU. SPR binding data were obtained using an appropriate dilution series of each compound at a flow rate of 30 μ L/ min, with a capture time of 100 s and dissociation times of 300 s. Running buffer for compound binding studies was HBS-N, 0.05% tween-20, 0.1 mM CaCl_2 , 4% DMSO. Data were corrected for DMSO excluded volume effects. All data were double-referenced for blank injections and reference surface using standard processing procedures and data processing and kinetic fitting were performed using Scrubber software, version 2.0c (BioLogic Software). Data were fitted using a simple 1:1 binding model to determine k_a , k_d and K_D values.

The ability of compounds Formula (I) or pharmaceutically acceptable salts thereof to bind and inhibit PCSK9 was established with the representative compounds of Formula (I) listed in the table below:

PCSK9 Affinity (nM)	Category
$K_D = 2,000 - 20,000$ nM	+
$K_D = 200 - 2,000$ nM	++
$K_D < 200$ nM	+++

Example #	K_D
1	+++
2	++
3	++
4	+++
5	+++
6	++
7	+++
8	++
9	++

Example #	K _D
10	+++
11	+++
12	+++
13	+++
14	++
15	+++
16	+++
17	+++
18	+++
19	+++
20	+++
21	+++
22	+++
23	+++
24	+++
25	++
26	+++
27	+++
28	+++
29	++
30	++
31	+++
32	+++
33	+++
34	+++
35	+++
36	+++
37	++
38	+++
39	+++
40	+++
41	+++
42	++
43	+++
44	+++
45	+++
46	+++
47	+++
48	+++
49	+++
50	+++
87	+++

Example #	K _D
88	+++
89	+++
90	+++
91	+++
92	+++
93	+++
94	+++
95	+++
96	+++
97	++
98	++
99	++
100	++
102	++
103	+
104	+
105	+++
106	++
107	++
164	+
165	++
166	++
167	+
168	++
169	+
170	++
171	+
172	+
173	+
174	+
175	+++
176	+++
177	+
178	+
179	+
180	+++
181	+++
182	+++
183	+++
184	+++
185	++
186	++

Example #	K _D
187	++
188	+++
189	++
190	+
203	+++
204	++
205	++
206	+++
207	+++
208	++
209	++
210	++
211	++
212	+++
213	+
214	+
215	++
216	++
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231	++
232	++
233	++
240	+++
241	+++
242	++
243	+++
244	++
245	+++
246	+++

Example #	K _D
247	+++
248	+++
249	++
250	+++
301	++
302	+++
303	+
304	++
305	++
306	++
307	++
308	++
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329	+++
330	+++
331	+++
332	+++
333	+++
334	+++
335	+++
336	+++
337	+++
338	+++

Example #	K _D
339	+++
340	+++
341	+++
342	+++
343	+++
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345	+++
346	+++
347	+++
348	+++
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369	+
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371	+++
372	+
373	+++
375	+++
400	+++
401	+++
402	+++
403	+++
424	+++
425	+++

Example #	K _D
426	+++
427	+++
428	+++
429	+++
430	+++
440	+++
441	+++
442	+++
443	+++
444	+++
445	+++
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451	+++
452	+++
453	+++
454	+++
455	+++
456	+++
457	+++
458	+++
458A	+++
458B	+++
459	+++
460	+++
463	+++
464	+++
465	+++
466	+++
467	+++
468	+++
469	+++
470	+++
471	+++
472	+++
473	+++
474	+++
475	+++
476	+++

Example #	K _D
477	+++
478	+++
479	+++
480	+++
481	+++
482	+++
483	+++
484	+++
487	+++
488	+++
489	+++
490	+++
491	+++
492	+++
493	+++
494	+++
495	+++
497	+++
498	+++
499	+++
499A	+++
500	+++
501	+++
502	+++
503	+++
505	+++
506	+++
507	+++
508	+++

Example: *In vitro* cellular assay to measure the effects of compounds on secreted PCSK9 levels, cellular LDLR levels and cell viability.

Compound screening was performed in 96 well tissue culture plates with 25,000 HepG2 cells plated in 200 µl of assay media (DMEM - Gibco 31966-021 with 10% lipoprotein depleted FBS -Sigma S5394). Cell plates were incubated overnight (20-24 hrs) and then assay media was removed, cells washed with 200 µl DMEM, and 200 µl compound or vehicle (0.3% DMSO) in assay media was added to each well. After 48 hours incubation with compound the following analyses were performed.

For measurement of secreted PCSK9 levels a 100 µl samples of the cell culture assay media were collected and stored at -80 °C prior to analysis using a PCSK9 (human) AlphaLISA Detection Kit (Perkin Elmer AL270F). Samples (5 µl) of cell culture assay media were transferred to 384 well white optiPlate (Perkin Elmer –6007290). Also included were 5µl samples of assay media alone to determine assay background and assay media samples spiked with a known concentration of recombinant human PCSK9 (standard curve). To each 5 µl sample 20 µl of a solution of AlphaLISA AntiPCSK9 acceptor beads (final concentration 10 µg/ml) and Biotinylated Antibody Anti-PCSK9 (final concentration 1 nM) diluted in AlphaLISA immunoassay buffer (all provided in the AlphaLISA Detection Kit) were added and plates incubated a room temperature 1 hour. Following incubation 25 µl of a solution of streptavidin donor beads (final concentration 40 µg/ml) diluted in AlphaLISA immunoassay buffer was added to each sample and samples incubated for a further 1 hour at room temperature protected from light. In the presence of the PCSK9 (analyte), the donor and acceptor beads come into close proximity. The light emission at 615 nm is then measured on an Enspire Alpha plate reader following excitation. The percentage inhibition was calculated using the following formula after the concentration of PCSK9 was determined using the standard curve values: $(1 - (\text{test well value} - \text{mean background value}) / (\text{mean vehicle value} - \text{mean background value})) * 100$

The cell viability analysis was performed on the same cell plates as the PCSK9 analysis, after the sample of cell media had been collected. The assay is based on the reduction of MTS tetrazolium compound by viable cells to generate a coloured formazan product that is soluble in cell culture media. To each cell well, containing 100 µl of remaining culture media, 20 µl MTS reagent (Promega G543) was added. Also included were wells containing 100 µl assay media plus MTS reagent without cells to determine the background measurements. Plates were incubated at 37°C for 1 hour and the optical density (OD) measured at a wavelength of 490 nm. OD values were converted to % change in viability values using the following formula: $-(1 - (\text{test well value} - \text{mean background value}) / (\text{mean vehicle value} - \text{mean background value})) * 100$

Cellular LDLR levels were determined using Human LDL R Immunoassay (R&D systems DLDLR0) and all reagents provided in the immunoassay unless stated. HepG2

cells were treated as described above and following the 48 hours compound incubation, media was removed, cells washed with phosphate buffered saline solution and cells lysed in 50 μ L of lysis buffer (25 mM Tris-HCl pH 7.4, 150 mM NaCl, 1 mM EDTA, 1% NP-40 and 5% glycerol) with protease inhibitors (Halt inhibitor cocktail - Pierce 78430). Lysates were cleared by centrifugation and samples stored at -80°C prior analysis in the immunoassay. In addition to the samples a standard curve of a known concentration of recombinant LDLR diluted in calibrator diluent was included and no LDLR to determine assay background. Samples (30 μ l) were incubated in microplate well strips (pre-coated with capture antibody) with 50 μ l assay diluent for 2 hours at room temperature. Then the microplate well strips were washed four times with wash buffer and 200 μ l of Human LDLR conjugate added. After a further 2 hour incubation at room temperature plates were washed as before and 200 μ l of substrate solution added. After 20 minutes 50 μ l of stop solution was applied and the optical density of each well measured at 450 nm and wavelength correction of 540 nm applied. The percentage increase was calculated using the following formula after the concentration of LDLR was determined using the standard curve values: (test well value - mean background value)/(mean vehicle value - mean background value)*100

As a positive control, an inhibitor of PCSK9 translation, R-4-(3*H*-[1,2,3]triazolo[4,5-*b*]pyridin-3-yl)-*N*-(3-chloropyridin-2-yl)-*N*-(piperidin-3-yl)benzamide (**SI-1**), was synthesized according to WO 2014170786.

Using the assays above, the ability of compounds Formula (I) or pharmaceutically acceptable salts thereof to inhibit PCSK9 function was established with the representative compounds of Formula (I) listed in the table below:

Example #	Inhibitor Concentration (μ M)	Inhibition of PCSK9 Secretion (%)	Increase in LDLR (%)	Change in Cell Viability (%)
10	75	56	32	1

17	75	40	58	-6
88	75	61	90	-9
89	75	57	136	-14
91	75	52	76	-2
128	75	48	125	12
159	75	49	116	11
175	75	72	109	-8
SI-1	18.8	95	47	7

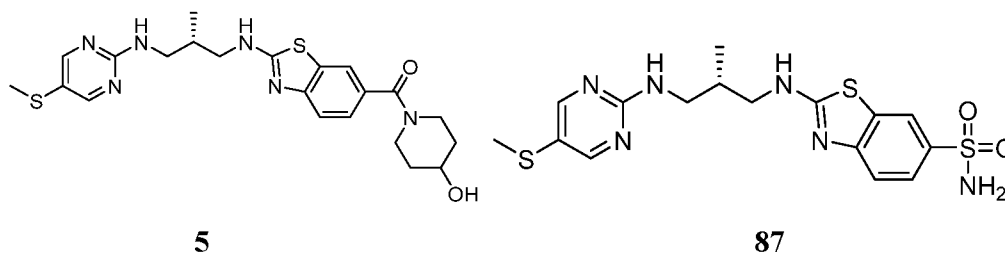
D. Pharmacophore Characterization

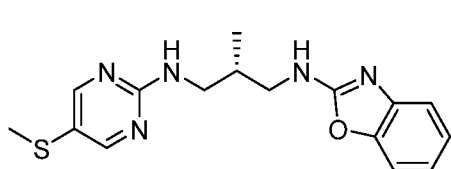
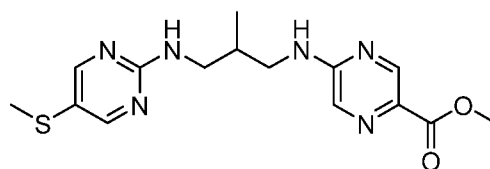
PCSK9(31-692)-AVI-TEV-His6 was expressed using HEK293 cells and purified from the growth medium by nickel-affinity chromatography followed by size exclusion chromatography. Pure protein was concentrated to ~8 mg/mL, mixed with inhibitor compound to a final concentration of 1 mM and incubated at 4°C for four hours.

Co-crystals were grown by the hanging drop method of vapour diffusion in 24-well format. Crystals were cryo-cooled for synchrotron data collection at ESRF beamline ID30A-1 on a Pilatus3 2M detector or DLS beamline i04 on a Pilatus 6M-F detector.

Crystallographic Parameters

The following crystallographic parameters are given for compounds 5, 87, 105 and 188.



**105****188**

Example #	5	87	105	188
Wavelength (Å)				
Resolution range (Å)	58.01-2.48 (2.58-2.48)	74.17-2.44 (2.48-2.44)	89.37-2.95 (3.05-2.95)	74.65-2.44 (2.48-2.44)
Space group	P 21 21 21	P 21 21 21	P 21 21 21	P 21 21 21
Unit cell	63.04 70.80 148.23	62.99 70.64 148.34	119.39 132.60 134.77	63.07 70.71 149.30
Total reflections	158294	160732	284167	163750
Unique reflections	24142	25385	45785	25629
Multiplicity	6.6 (6.6)	6.3 (5.9)	6.2 (6.3)	6.4 (5.9)
Completeness (%)	99.1 (92.6)	100.0 (96.7)	100.0 (100.0)	100.0 (100.0)
Mean I/sigma(I)	9.2 (1.7)	5.8 (1.1)	7.3 (1.6)	4.8 (1.3)
Wilson B-factor	88.5	34.335	48.1	
R-merge	0.164 (1.119)	0.200 (1.429)	0.110 (0.743)	0.286 (1.264)
R-meas	0.193 (1.317)	0.218 (1.581)	0.133 (0.890)	0.311 (1.388)

CC1/2	0.993 (0.609)	0.991 (0.618)	0.994 (0.828)	0.980 (0.539)
CC*				
R-work	0.2070	0.2333	0.2135	0.2419
R-free	0.2555	0.2951	0.2530	0.2990
Number of non-hydrogen atoms	4352	4499		4478
macromolecules	4258	4357	8635	4345
ligands	32	27	46	24
water	56	109	0	103
Protein residues	574	580		580
RMS(bonds)	0.008	0.008	0.008	0.010
RMS(angles)	1.358	1.359	1.368	1.365
Ramachandran favored (%)	95.00	96.45	93.30	95.41
Ramachandran outliers (%)	0.36	0.35	1.12	0.71
Average B-factor				
macromolecules	40.54	42.65	68.38	31.06
ligands	45.17	39.89	92.21	26.97
solvent	36.14	39.77	-	23.91

Sequence Listing of Exemplary PCSK9 Isoforms (Uniprot ID provided)

SEQID NO:1 Q8NBP7#VAR_017197

MGTVSSRRSWWPLPLLLLLLLLLLPAGARAQEDEDGDYEELVLALLSEEDGLAE
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 LTKILHVFHGLLPGLVKMSGDLLELALKLPHVDYIEEDSSVFAQSIPWNLERITP
 PRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTD FENVPEEDGTRFHR

QASKCDSHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGTVSGTLIGLEFIR
 KSQLVQPVGPLVVLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
 SPASAPEVITVGATNAQDQPVTLTGTLGTNFGRCVDLFAPGEDIIGASSDCSTCFVS
 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVINEAWFPEDQRV
 LTPNLVAALPPSTHGAGWQLFCRTVWSAHSGPTRMATAVARCAPDEELLSCSSF
 SRSGKRRGERMEAQGGKLCRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPA
 EASMGTRVHCHQQGHVLTGCSHWEVEDLGTHKPPVLRPRGQPNQCVGHREAS
 IHASCCHAPGLECKVKEHGIPAPQEQTVAEEGWTLTGCSALPGTSHVLGAYA
 VDNTCVVRSRDVSTTGSTSEGAVTAVAICCRSRHLAQASQELQ

SEQID NO:2 Q8NBP7#VAR_017198

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 LTKILHVFHGLLPGLVKMSGDLLELALKLPHVDYIEEDSSVFAQSIPWNLERITP
 PRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTD FENVPEEDGTRFHR
 QASKCDSHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGTVSGTLIGLEFIR
 KSQLVQPVGPLVVLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
 SPASAPEVITVGATNAQDQPVTLTGTLGTNFGRCVDLFAPGEDIIGASSDCSTCFVS
 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVINEAWFPEDQRV
 LTPNLVAALPPSTHGAGWQLFCRTVWSAHSGPTRMATAVARCAPDEELLSCSSF
 SRSGKRRGERMEAQGGKLCRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPA
 EASMGTRVHCHQQGHVLTGCSHWEVEDLGTHKPPVLRPRGQPNQCVGHREAS
 IHASCCHAPGLECKVKEHGIPAPQEQTVAEEGWTLTGCSALPGTSHVLGAYA
 VDNTCVVRSRDVSTTGSTSEGAVTAVAICCRSRHLAQASQELQ

SEQID NO:3 Q8NBP7#VAR_021337

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 QASKCDSHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGTVSGTLIGLEFIR
 KSQLVQPVGPLVVLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
 SPASAPEVITVGATNAQDQPVTLTGTLGTNFGRCVDLFAPGEDIIGASSDCSTCFVS
 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVISEAWFPEDQRV
 LTPNLVAALPPSTHGAGWQLFCRTVWSAHSGPTRMATAVARCAPDEELLSCSSF
 SRSGKRRGERMEAQGGKLCRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPA
 EASMGTRVHCHQQGHVLTGCSHWEVEDLGTHKPPVLRPRGQPNQCVGHREAS
 IHASCCHAPGLECKVKEHGIPAPQEQTVAEEGWTLTGCSALPGTSHVLGAYA
 VDNTCVVRSRDVSTTGSTSEGAVTAVAICCRSRHLAQASQELQ

SEQID NO:4 Q8NBP7#VAR_021338

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 LTKILHVFHGLLP GFLVKMSGDLLELALKLPHVDYIEEDSSVFAQSIPWNLERITP
 PRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTD FENVPEEDGTRFHR
 QASKCD SHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGT VSGTLIGLEFIR
 KSQLVQPVGPLV VLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
 SPASAPEVITVGATNAQDQPVT LGTLGTNFGRCVDLFAPGEDII GASSDCSTCFVS
 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVINEAWFPEDQRV
 LTPNLVATLPPSTHGAGWQLFCRTVWSAHSGPTRMATAVARCAPDEELLSCSSF
 SRSGKRRGERMEAQGGKLV CRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPA
 EASMGTRVHCHQQGHVLTG CSSHWEVEDLGTHKPPVLRPRGQPNQCVGHREAS
 IHASCCHAPGLECKVKEHGIPAPQE QVTVACEEGWTLTGCSALPGTSHVLGAYA
 VDNTCVVRSRDVSTTGSTSEGAVTAVAICCRSRHLAQASQELQ

SEQID NO:5 Q8NBP7#VAR_021339

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 PRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTD FENVPEEDGTRFHR
 QASKCD SHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGT VSGTLIGLEFIR
 KSQLVQPVGPLV VLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
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 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVINEAWFPEDQRV
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 RSGKRRGERMEAQGGKLV CRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPAE
 ASMGTRVHCHQQGHVLTG CSSHWEVEDLGTHKPPVLRPRGQPNQCVGHREASI
 HASCCHAPGLECKVKEHGIPAPQE QVTVACEEGWTLTGCSALPGTSHVLGAYAV
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SEQID NO:6 Q8NBP7#VAR_017201

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 QASKCD SHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQGKGT VSGTLIGLEFIR
 KSQLVQPVGPLV VLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLY
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 QSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFS AKDVINEAWFPEDQRV

LTPNLVAALPPSTHGAGWQLFCRTVWSAHSGPTRMATAVARCAPDEELLSCSSF
SRSGKRRGERMEAQGGKLVCRAHNAFGGEGVYAIARCCLLPQANCSVHTAPPA
EASMGTRVHCHQQGHVLTGCSSHWEVEDLGTHKPPVLRPRGQPNQCVGHREAS
IHASCCHAPGLECKVKEHGIPAPQEQVTVACEEGWTLTGCSALPGTSHVLGAYA
VDNTCVVRSRDVSTTGSTSEEAVTAVAICCRSRHLAQASQELQ

Incorporation by Reference

All publications and patents mentioned herein are hereby incorporated by reference in their entirety as if each individual publication or patent was specifically and individually indicated to be incorporated by reference. In case of conflict, the present application, including any definitions herein, will control.

Equivalents

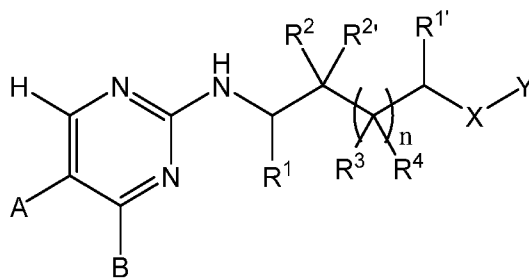
While specific embodiments of the subject invention have been discussed, the above specification is illustrative and not restrictive. Many variations of the invention will become apparent to those skilled in the art upon review of this specification and the claims below. The full scope of the invention should be determined by reference to the claims, along with their full scope of equivalents, and the specification, along with such variations.

Claims:

1. A method of inhibiting PCSK9, comprising contacting PCSK9 with an inhibitor of PCSK9 that binds to a binding pocket defined by amino acid residues Val589 and Ser636 of human PCSK9.
2. The method of claim 1, wherein the inhibitor is an allosteric inhibitor.
3. The method of claim 1 or 2, wherein the method comprises contacting the surface of a cell that secretes PCSK9 with the inhibitor.
4. The method of claim 1, wherein the method comprises contacting intracellular PCSK9 with the inhibitor .
5. The method of claim 1, wherein the method comprises contacting PCSK9 that is circulating in plasma with the inhibitor.
6. The method of claim 1, wherein the inhibitor comprises an H-bond acceptor/donor group having two H-bond acceptor moieties and one H-bond donor moiety disposed to donate an H-bond to and accept an H-bond from the backbone amide functionality of residue Val589, and accept an H-bond from the hydroxymethyl sidechain of Ser636 of human PCSK9.
7. The method of claim 1, wherein the inhibitor comprises an H-bond acceptor/donor group having two H-bond donor moieties and one H-bond acceptor moiety disposed to donate an H-bond to and accept an H-bond from the backbone amide functionality of residue Val589, and donate an H-bond to the hydroxymethyl sidechain of Ser636 of human PCSK9.

8. The method of any preceding claim, wherein the inhibitor comprises a pyrimidinyl ring and the two H-bond acceptor moieties are the two nitrogen atoms present on the pyrimidinyl ring.
9. The method of claim 8, wherein the inhibitor comprises a 2-NH-pyrimidinyl moiety and the one H-bond donor moiety is the amino hydrogen atom.
10. The method of any preceding claim, wherein the inhibitor further comprises one or more of:
- a) an H-bond acceptor moiety disposed to bind with amino acid residues Ser642, His643 or Val 644,
 - b) an H-bond donor moiety disposed to bind with amino acid residue Ala637 or Thr641, and
 - c) a cation-pi stacking interaction moiety disposed to bind with amino acid residue Arg495 or His591,
- wherein the H-bond acceptor/donor group is bound to amino acid residues Val589 and Ser636 of human PCSK9.
11. The method of any preceding claim, wherein the inhibitor further comprises an H-bond acceptor moiety disposed to bind with amino acid residue Glu612.
12. The method of any preceding claim, wherein the inhibitor interacts with at least one residue in the M2 C-terminal domain and at least one residue in the M3 C-terminal domain.
13. The method of any preceding claim, wherein the inhibitor further interacts with at least one residue in the M1 C-terminal domain.

14. The method of any one of claims 1-11, wherein the inhibitor interacts with at least one residue in the M1 C-terminal domain and at least one residue in the M3 C-terminal domain.
15. The method of any one of claims 1-11, wherein the inhibitor interacts with at least one residue in the M1 C-terminal domain and at least one residue in the M2 C-terminal domain.
16. The method of any one of claims 1-12, wherein the inhibitor interacts with a pocket in PCSK9 between amino acid residues 558-590 in the M2 C-terminal domain and amino acids residues 631-650 in the M3 C-terminal domain.
17. The method of claim 1, wherein the inhibitor interacts with at least one residue in beta strand 3 and beta strand 5 of the M2 C-terminal domain and beta strand 3 and beta strand 4 of the M3 C-terminal domain.
18. The method of claim 17, wherein the inhibitor interacts with a pocket in PCSK9 created between amino acid residues 558-566 in beta strand 3 of the M2 C-terminal domain and amino acids residues 587-590 in beta strand 5 of the M2 C-terminal domain.
19. The method of claim 18, wherein the inhibitor interacts with a pocket in PCSK9 created between amino acid residues 631-637 in beta strand 3 of the M3 C-terminal domain and amino acids residues 644-650 in beta strand 4 of the M3 C-terminal domain.
20. The method of any preceding claim, wherein the inhibitor is a compound of formula (I):



(I)

wherein:

A is selected from H, halo, hydroxy, alkyl, thioalkyl, alkenyl, alkoxy, acyloxy, cyano, cycloalkyl, $-C(O)OR^6$, and $-C(O)NR^6R^7$;

B is selected from H, alkyl, and halo, or

A and B are taken together with the carbon atoms to which they are attached to form a 5- or 6-membered heteroaryl;

X is NR^5 or O;

R^1 and $R^{1'}$ are each independently selected from H and alkyl; or

if n is 0, R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4-8 membered cycloalkyl or cycloalkenyl ring;

R^2 is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, hydroxyalkyl, alkylamino, cyano, and hydroxy; or

R^1 and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; or

$R^{1'}$ and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring;

$R^{2'}$ is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, and cyano, or

R^2 and $R^{2'}$, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring;

each R^3 and R^4 is independently H or alkyl; or

R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring; and

R^5 is H or alkyl; or

R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclyl ring; or
 R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclyl ring;
each R^6 and R^7 is independently H or alkyl;
Y is selected from aryl, heteroaryl and heterocyclyl;
and
n is 0 or 1.

21. The method of claim 20 wherein A is selected from H, hydroxy, thioalkyl, alkyl, alkoxy, acyloxy, cyano, cycloalkyl, $-C(O)OR^6$, and $-C(O)NR^6R^7$.
22. The method of claim 20, wherein A is H.
23. The method of claim 20, wherein A is alkyl.
24. The method of claim 20, wherein A is thioalkyl.
25. The method of claim 20, wherein A is alkoxy.
26. The method of claim 20, wherein A is cycloalkyl.
27. The method of claim 20, wherein A is selected from $-SCH_3$, $-SCHF_2$, and $-OCHF_2$.
28. The method of claim 20, wherein A and B are taken together with the carbon atoms to which they are attached to form a pyrrolyl or thienyl ring, which is unsubstituted or substituted with one or more alkyl.
29. The method of any one of claims 20-28, wherein B is H.
30. The method of any one of claims 20-29, wherein X is NR^5 .

31. The method of any one of claims 20-30, wherein Y is heteroaryl or heterocyclyl.
32. The method of any one of claims 20-31, wherein R^1 and $R^{1'}$ are each H.
33. The method of any one of claims 20-31, wherein n is 0, and R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4- to 8-membered monocyclic or bicyclic cycloalkyl or cycloalkenyl ring which is unsubstituted or substituted, e.g., with one or more hydroxy.
34. The method of claim 33, wherein R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4- to 8-membered monocyclic or bicyclic cycloalkyl.
35. The method of claim 33, wherein R^1 and $R^{1'}$, together with the atoms to which they are attached, form a 4- to 8-membered monocyclic or bicyclic cycloalkenyl.
36. The method of claim 33, wherein the cycloalkyl ring is a cyclopentyl ring.
37. The method of claim 33, wherein the cycloalkyl ring is substituted with hydroxyl or hydroxyalkyl.
38. The method of any one of claims 20-37, wherein R^2 is selected from H, halo, alkyl, alkoxy, amidoalkyl, aminoalkyl, alkylamino, cyano, and hydroxyl.
39. The method of any one of claims 20-38, wherein R^2 is C_{1-3} alkyl.
40. The method of claim 39, wherein R^2 is substituted with one or more substituents selected from amino, amido, cyano, hydroxy, and heterocyclyl.
41. The method of any one of claims 20-40, wherein $R^{2'}$ is C_{1-3} alkyl.
42. The method of any one of claims 20-40, wherein $R^{2'}$ is H.

43. The method of any one of claims 20-31, wherein R^1 and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring.
44. The method of any one of claims 20-31, wherein $R^{1'}$ and R^2 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring.
45. The method of any one of claims 20-31, wherein R^2 and $R^{2'}$, taken together with the carbon atom to which they are attached, form a 3- to 8-membered cycloalkyl or heterocyclyl ring.
46. The method of any one of claims 20-45, wherein R^3 is C_{1-3} alkyl.
47. The method of any one of claims 20-45, wherein R^3 is H.
48. The method of any one of claims 20-31, wherein R^2 and R^3 , together with the atoms to which they are attached, form a 3-8 membered cycloalkyl or heterocyclyl ring.
49. The method of any one of claims 20-48, wherein R^4 is H.
50. The method of any one of claims 20-31, wherein R^1 and R^5 , together with the atoms to which they are attached, form a 6-8 membered cycloalkyl or heterocyclyl ring.
51. The method of any one of claims 20-31, wherein R^2 and R^5 , together with the atoms to which they are attached, form a 5-8 membered cycloalkyl or heterocyclyl ring.
52. The method of any one of claims 20-51, wherein Y is monocyclic heteroaryl.
53. The method of claim 52, wherein Y is selected from pyridyl, pyridinyl, pyrazinyl, pyrimidinyl, and thiazolyl.

54. The method of claim 52, wherein Y is selected from triazenyl, oxazolyl, isoxazolyl, imidazolyl, pyrazolyl, and triazolyl.
55. The method of any one of claims 52-54, wherein the monocyclic heteroaryl is unsubstituted or substituted with one or more substituents selected from alkyl, thioalkyl, alkoxy, alkoxycarbonyl, amido, carboxy, cyano, halo, aryl, heteroaryl, heterocyclyl, nitro, sulfonamido, and thioalkyl.
56. The method of claim 55, wherein the monocyclic heteroaryl is substituted with a 6-membered aryl, heteroaryl or heterocyclyl selected from phenyl, pyridinyl, 2-hydroxypyridinyl, piperidinonyl, 2-hydroxy-1-methylpyridinyl, triazolyl, imidazolidinonyl, pyrimidonyl, 2-hydroxyisoquinolinyl, 3-hydroxypyridazinyl, pyrrolidinonyl, pyrazolyl, and morpholinonyl.
57. The method of claim 56, wherein the monocyclic heteroaryl is substituted with an heteroaryl or heterocyclyl that is substituted with one or more substituents selected from halo, CN, alkyl, alkoxy, hydroxy, carboxy, -CO₂alkyl, and tetrazolyl.
58. The method of claim 55, wherein the monocyclic heteroaryl is disposed on the para position of A relative to X.
59. The method of any one of claims 20-51, wherein Y is bicyclic heteroaryl.
60. The method of claim 59, wherein Y is selected from benzothiazolyl, benzoxazolyl, benzimidazolyl, triazolopyridinyl, thiazolopyrindinyl, quinolinyl, and quinoxalinyl.
61. The method of claim 59 or 60, wherein the bicyclic heteroaryl is unsubstituted, or substituted with one or more substituents selected from alkyl, haloalkyl, hydroxyalkyl, thioalkyl, alkoxy, alkoxycarbonyl, amido, carboxy, cyano, halo, heteroaryl, nitro, and sulfonamido.

62. The method of claim 59 or 60, wherein the bicyclic heteroaryl is unsubstituted, or substituted with one or more substituents selected from thioalkyl, alkoxycarbonyl, amido, carboxy, halo, and heteroaryl.

63. The method of any one of claims 20-62, wherein Y is substituted with an amido substituent of the formula $-C(O)NR^8R^9$ or $-NR^9C(O)R^{10}$, wherein R^8 and R^9 are each independently selected from H, alkyl, heterocyclyl and heteroaryl; or R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a 4-, 5-, 6-, or 7-membered heterocyclic or heteroaryl ring; and R^{10} is alkyl.

64. The method of any one of claims 20-61, wherein Y is substituted with a sulfonamido substituent of the formula $-S(O)_2NR^8R^9$ or $-NR^9S(O)_2R^{10}$; wherein R^8 and R^9 are each independently selected from H, alkyl, and heteroaryl; or R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a 4-, 5-, 6-, or 7-membered heterocyclic ring; and R^{10} is alkyl.

65. The method of claim 63 or 64, wherein R^8 and R^9 are each independently selected from H, methyl, ethyl, triazolyl, and pyrazolyl.

66. The method of any one of claims 63-65, wherein one or both of R^8 and R^9 are alkyl, and each alkyl is independently unsubstituted, or substituted with one or more substituents selected from methyl, methoxy, carboxy, cyano, hydroxy, dimethylamino, ethoxycarbonyl, phenyl, methoxyphenyl, oxadiazolyl, tetrazolyl, 2-methyl-tetrazolyl, triazolyl, 1-methyltriazolyl, 4-methyltriazolyl, and 2,4-dihydro-3H-1,2,4-triazol-3-onyl.

67. The method of claim 63 or 64, wherein R^8 and R^9 , taken together with the nitrogen atom to which they are attached, form a heterocyclic ring selected from aziradine, isothiazolidine-1,1-dioxide, azetindine, thiazol-4(5Hn)-one, morpholine,

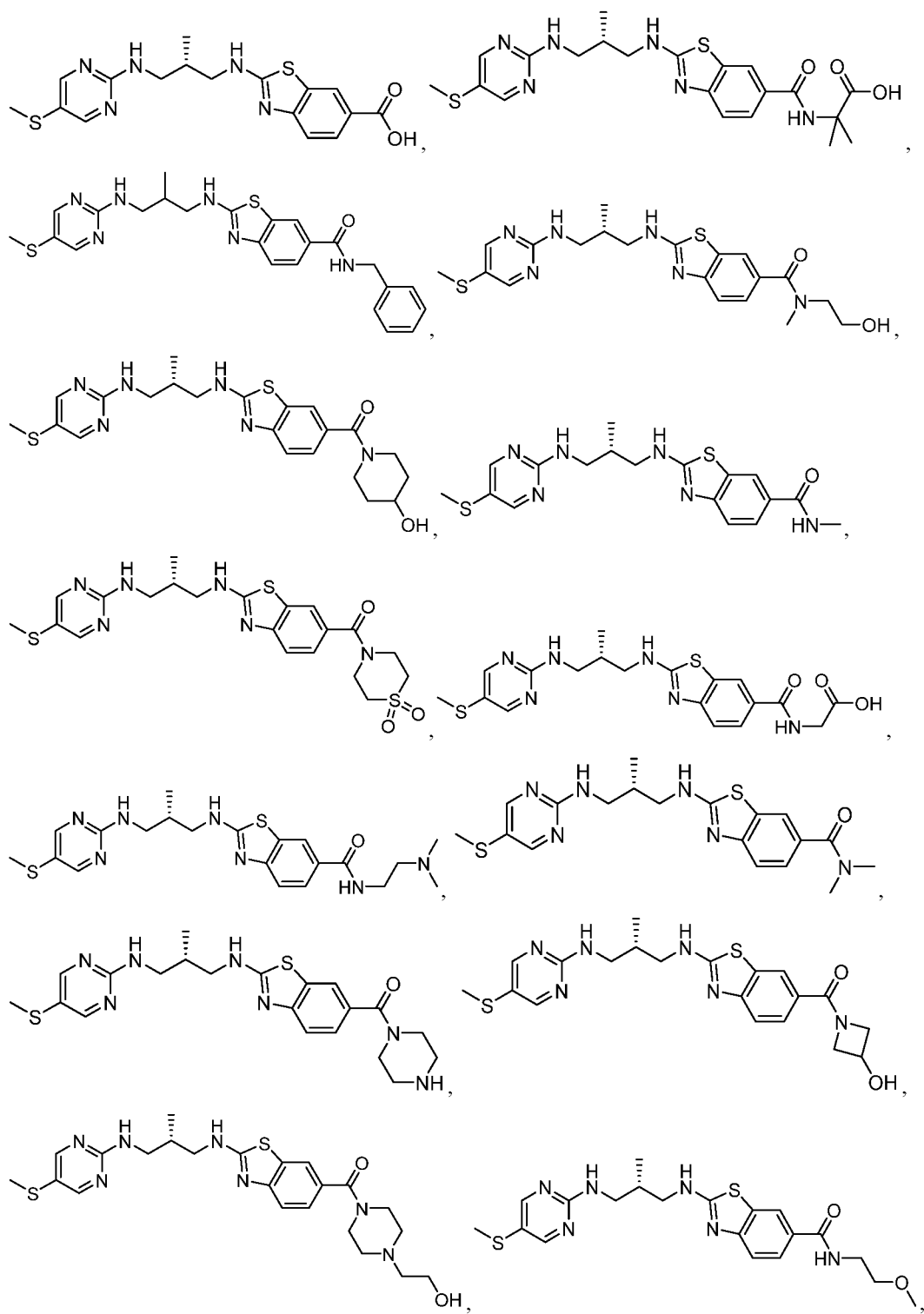
piperidine, piperazine, pyrrolidine, thiomorpholine-1,1-dioxide, 2-oxa-6-azaspiro[3.3]heptane.

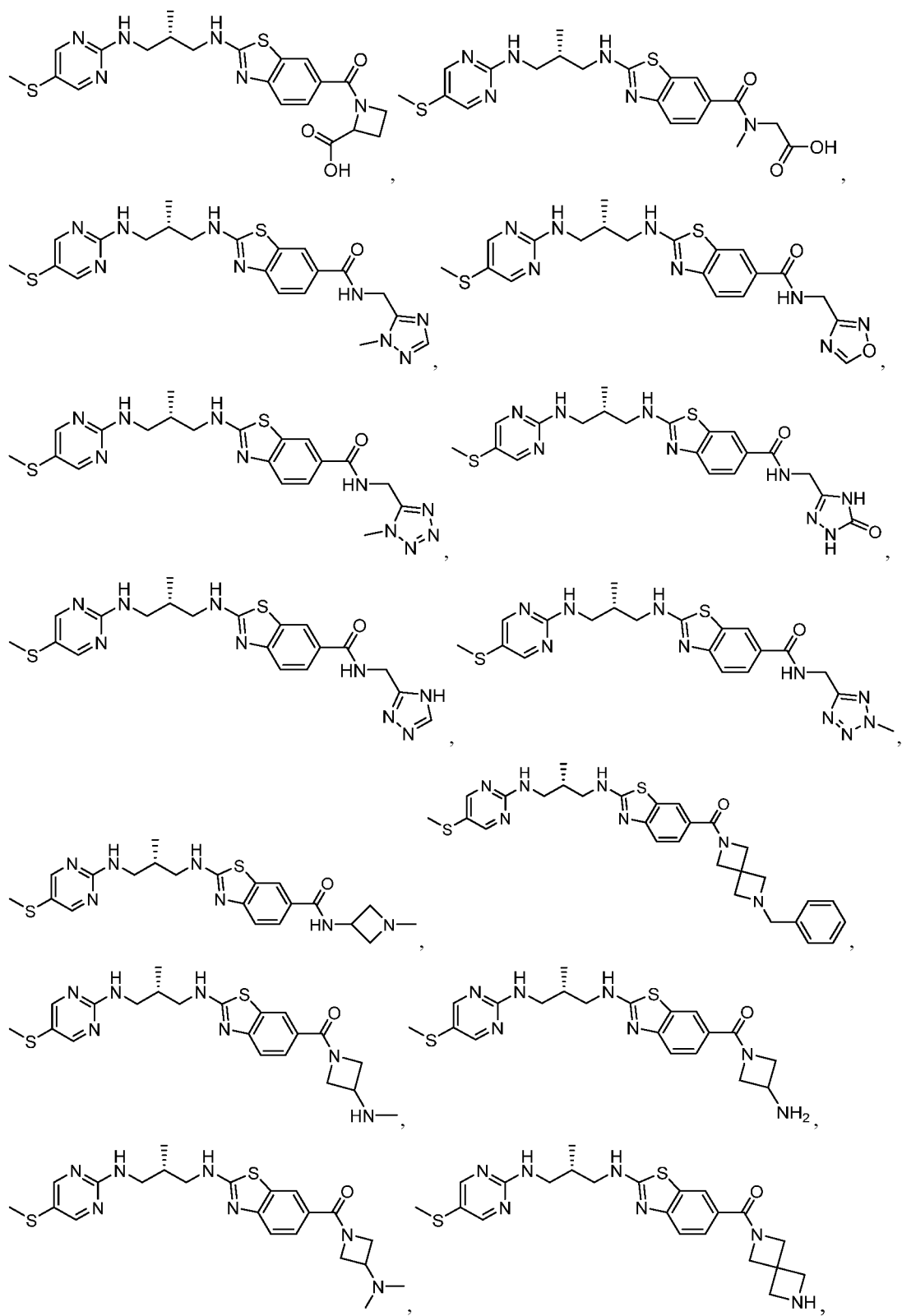
68. The method of claim 63 or 64, wherein R⁸ and R⁹, taken together with the nitrogen atom to which they are attached, form a heterocyclic ring selected from 2,8-diazaspiro[5.5]undecene, tetrahydroimidazo[1,2-a]pyrazine, octahydropyrazino[2,1-c][1,4]oxazine, tetrahydropyrido[3,4-d]pyrimidine, 2-oxa-8-azaspiro[4.5]decane, tetrahydropyrrolo[3,4-c]pyrazole, thiomorpholine, 2-oxa-7-azaspiro[3.5]nonane, 2,8-diazaspiro[4.5]decan-3-one, tetrahydro-1,7-naphthyridine, 1-oxa-4,9-diazaspiro[5.5]undecan-3-one, tetrahydropyrrolo[3,4-d]imidazole, pyrimidine, 8-oxa-2-azaspiro[4.5]decane, hexahydro-3H-oxazolo[3,4-a]pyrazin-3-one, 1-oxa-7-azaspiro[3.5]nonane, octahydrocyclopenta[c]pyrrole, tetrahydro-[1,2,4]triazolo[4,3-a]pyrazine, 2,7-diazaspiro[4.4]nonane, 2,6-diazaspiro[3.4]octane, 7-oxa-2-azaspiro[3.5]nonane, 1-oxa-8 λ^2 -azaspiro[4.5]decane, 2-oxa-6-azaspiro[3.3]heptane, tetrahydrofuran, oxadiazole, triazole, pyridinone, tetrahydro-[1,2,4]triazolo[4,3-a]pyrazin-3(2H)-one, piperidinone, 3,6-diazabicyclo[3.1.1]heptane, 5-oxa-2,7-diazaspiro[3.5]nonane, pyrazole, and pyridazin-3(2H)-one.

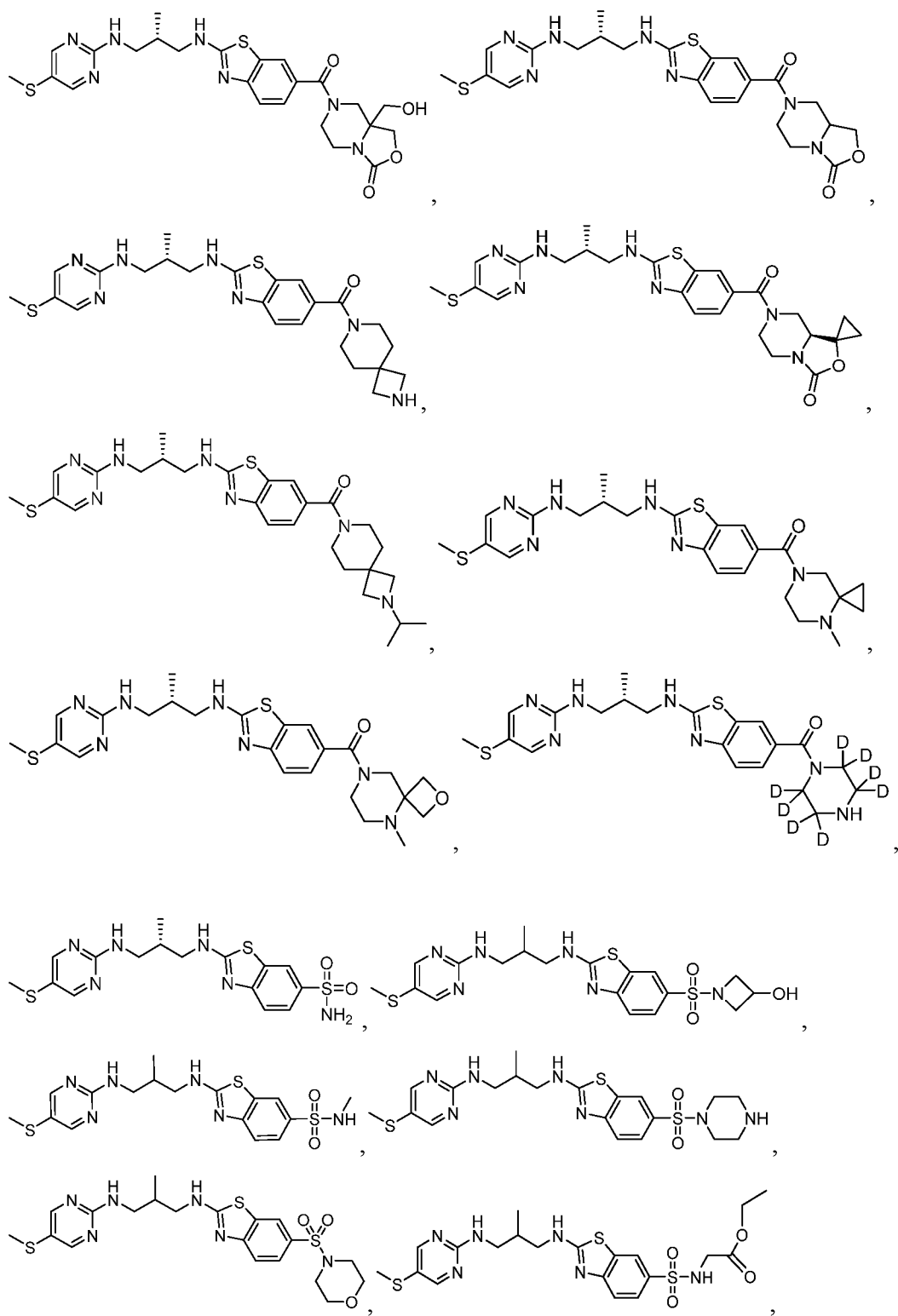
69. The method of claim 67, wherein the heterocyclic ring is unsubstituted, or substituted with one or more substituents selected from alkyl, alkoxycarbonyl, halo, hydroxy, cyano, carboxy, and heterocyclyl.

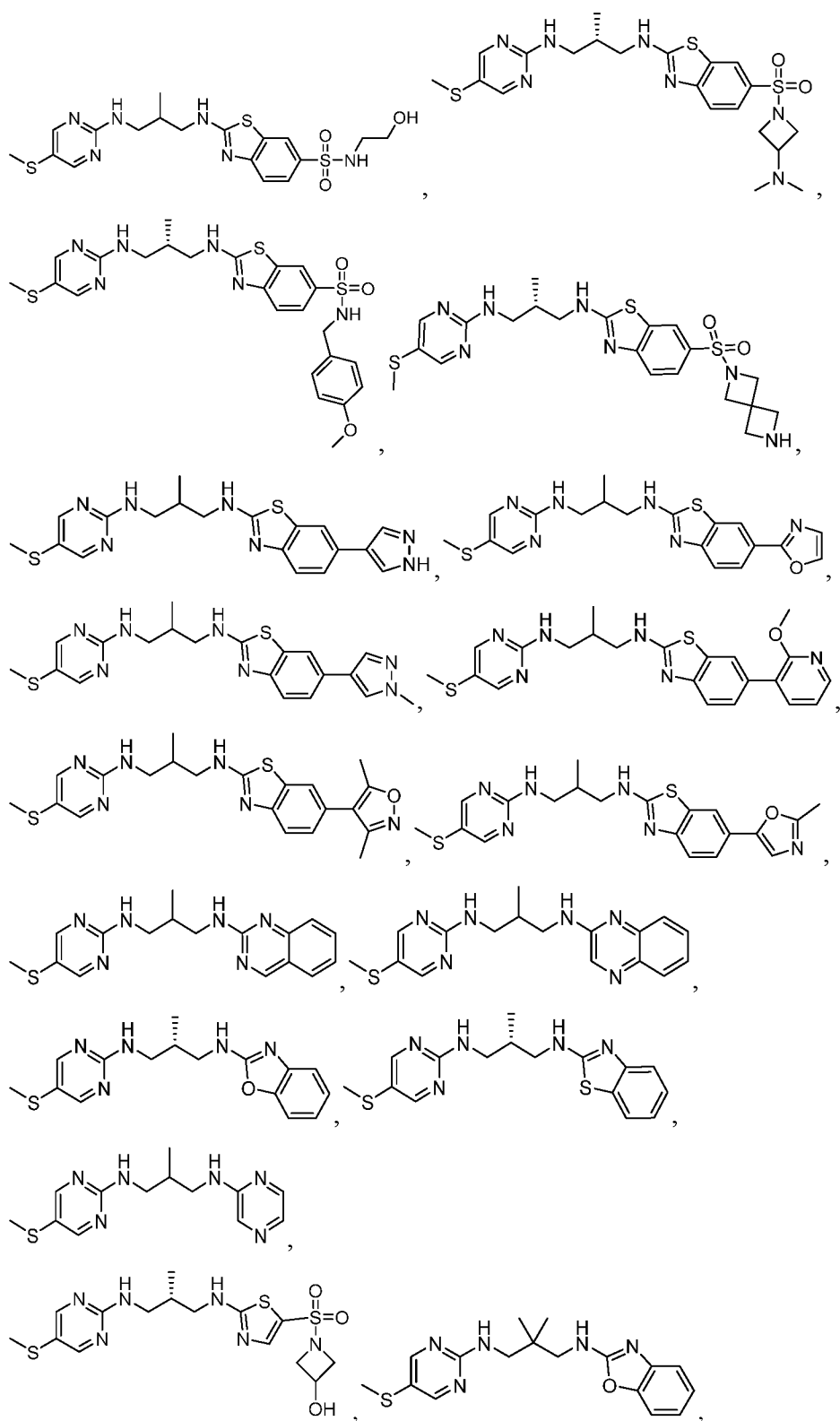
70. The method of claim 67, wherein the heterocyclic ring is unsubstituted, or substituted with one or more substituents selected from methyl, ethoxycarbonyl, halo, hydroxy, cyano, carboxy, and oxetanyl.

71. The method of claim 20, wherein the inhibitor is selected from

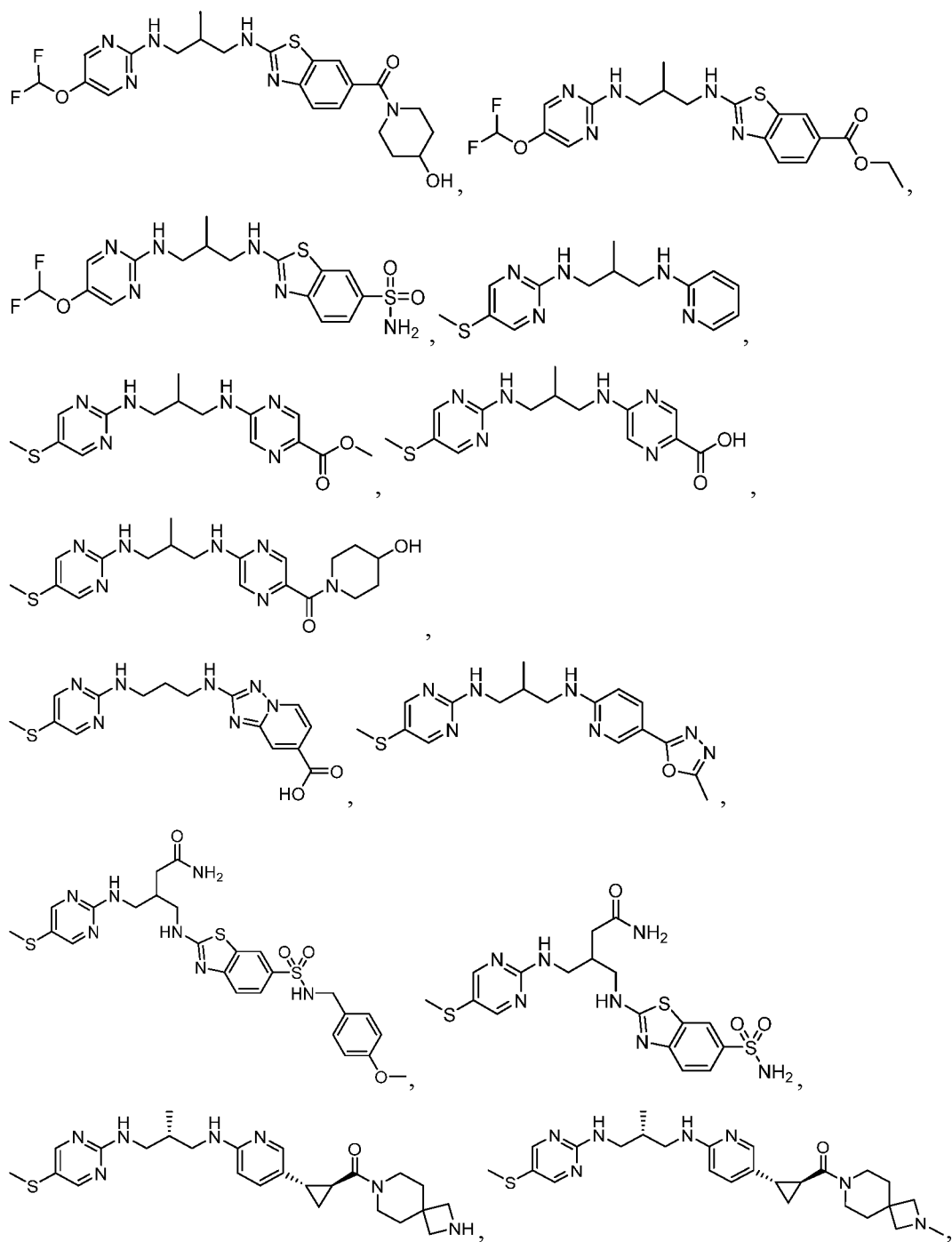


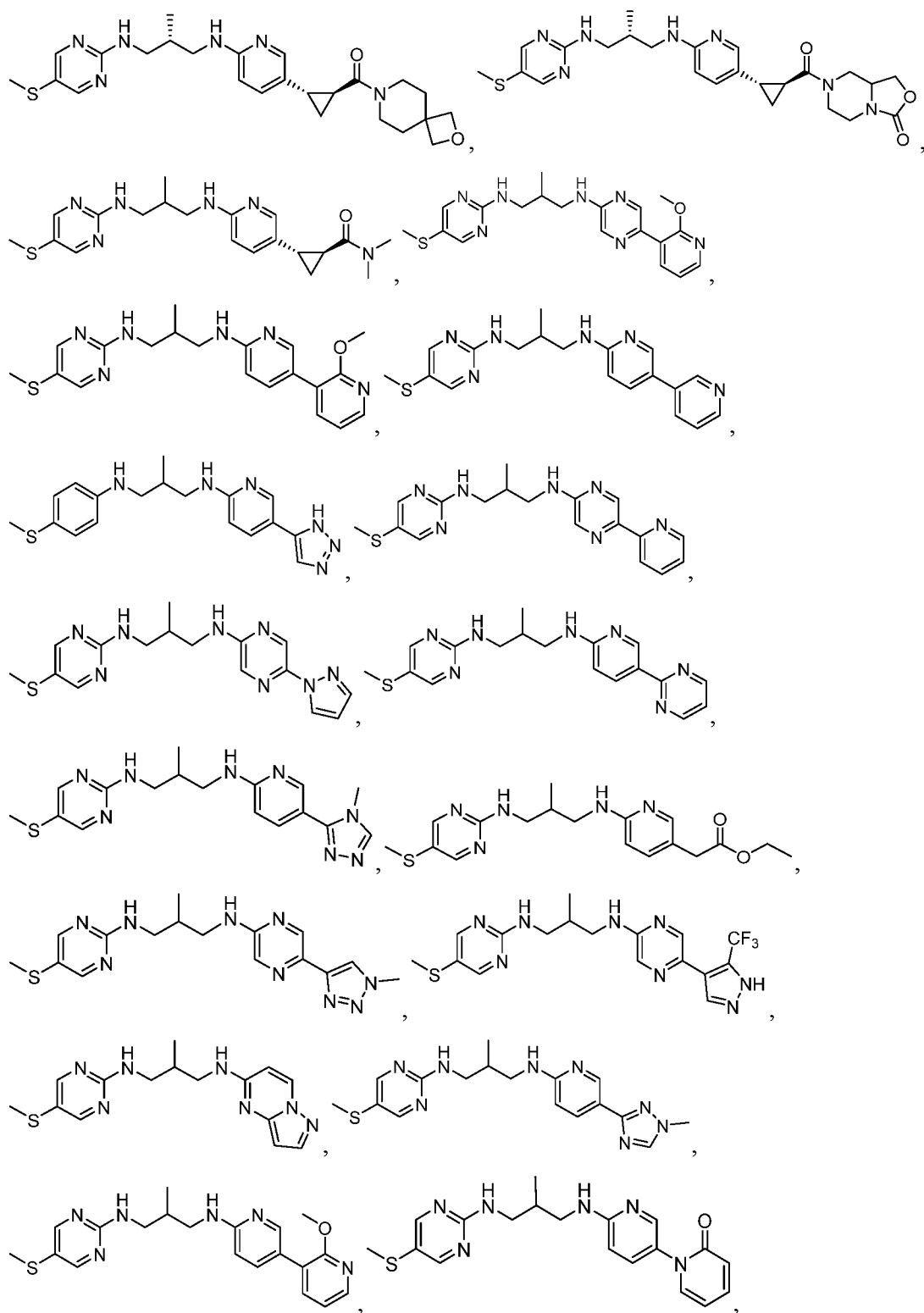


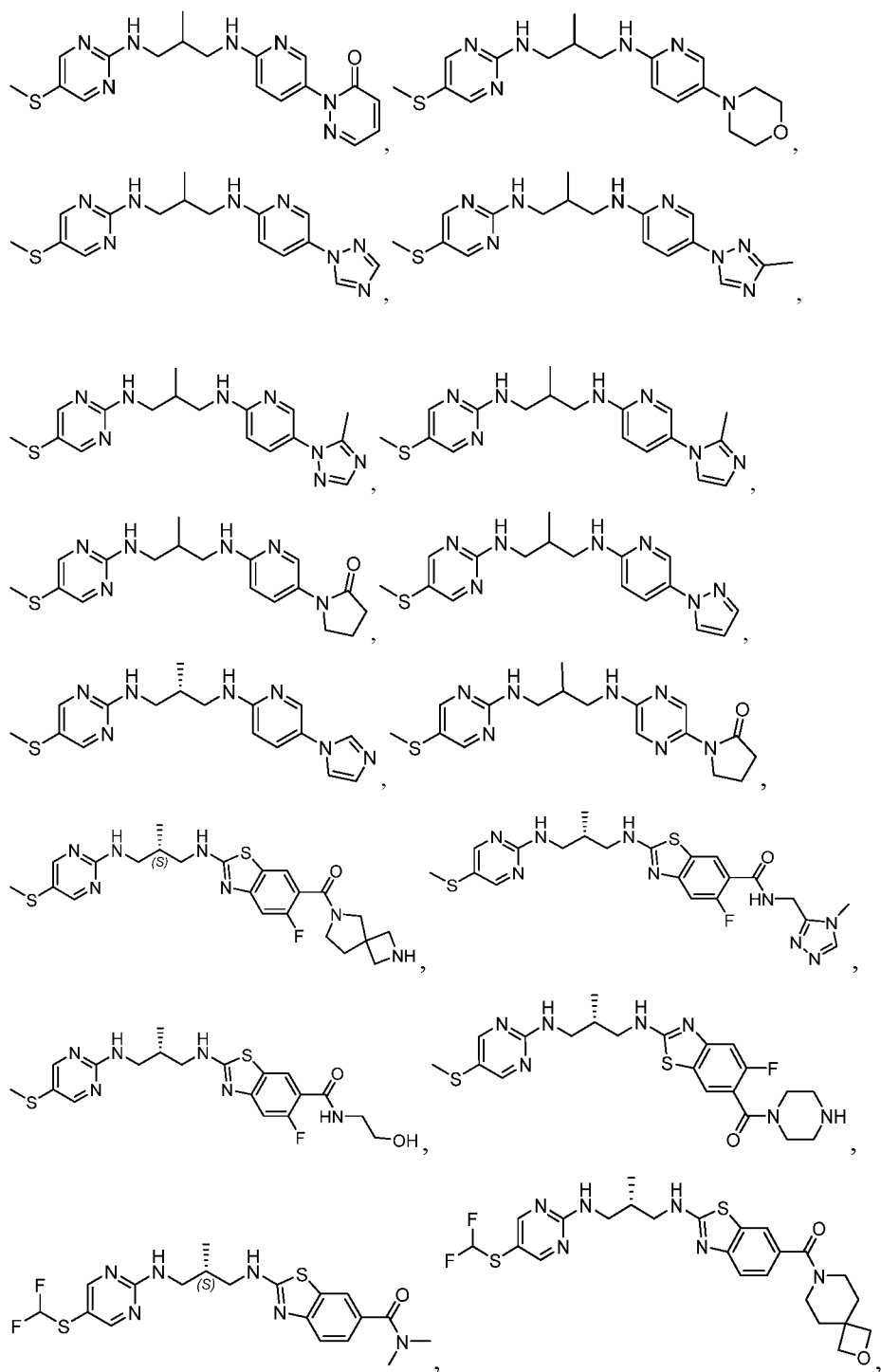


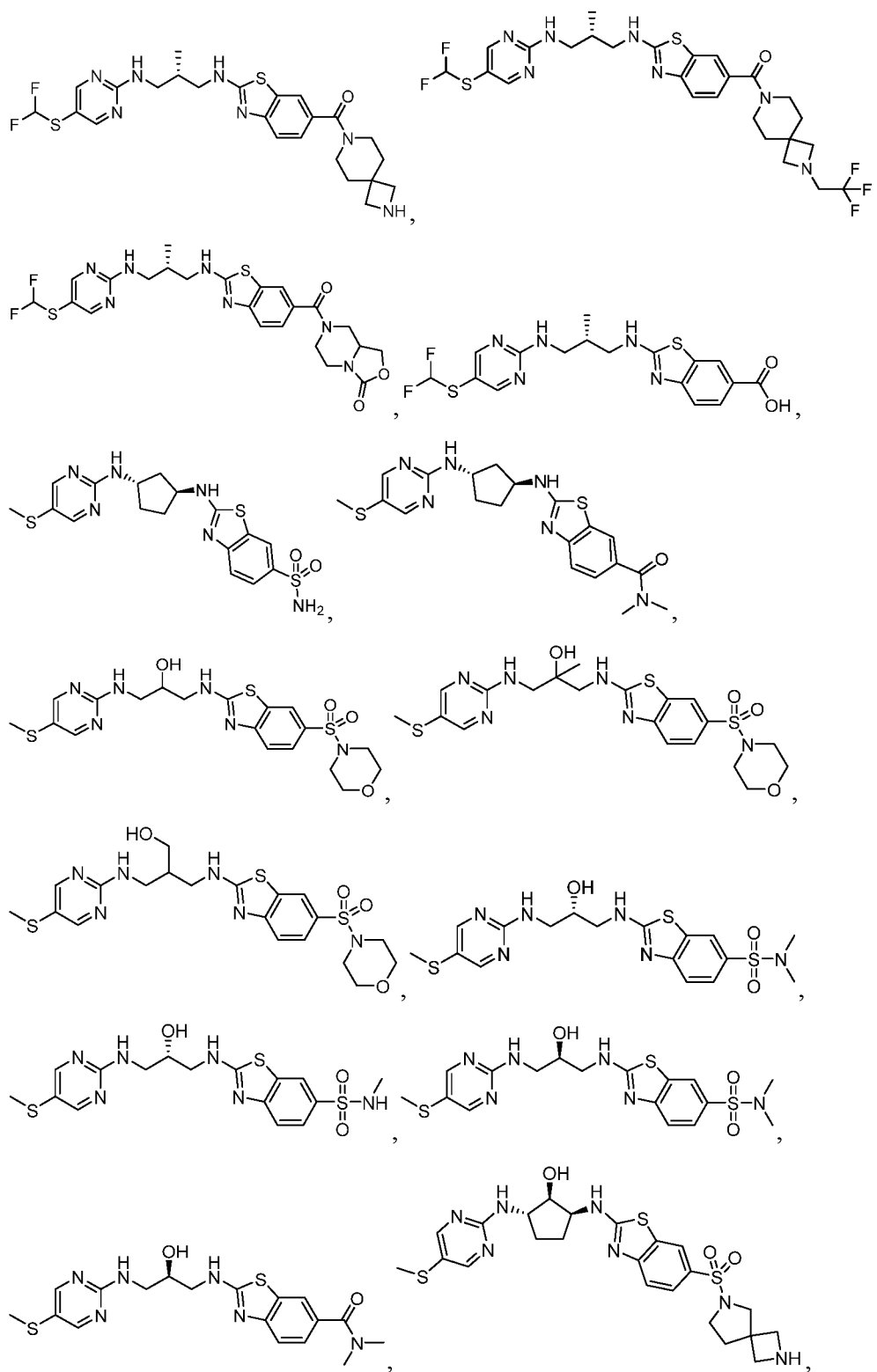


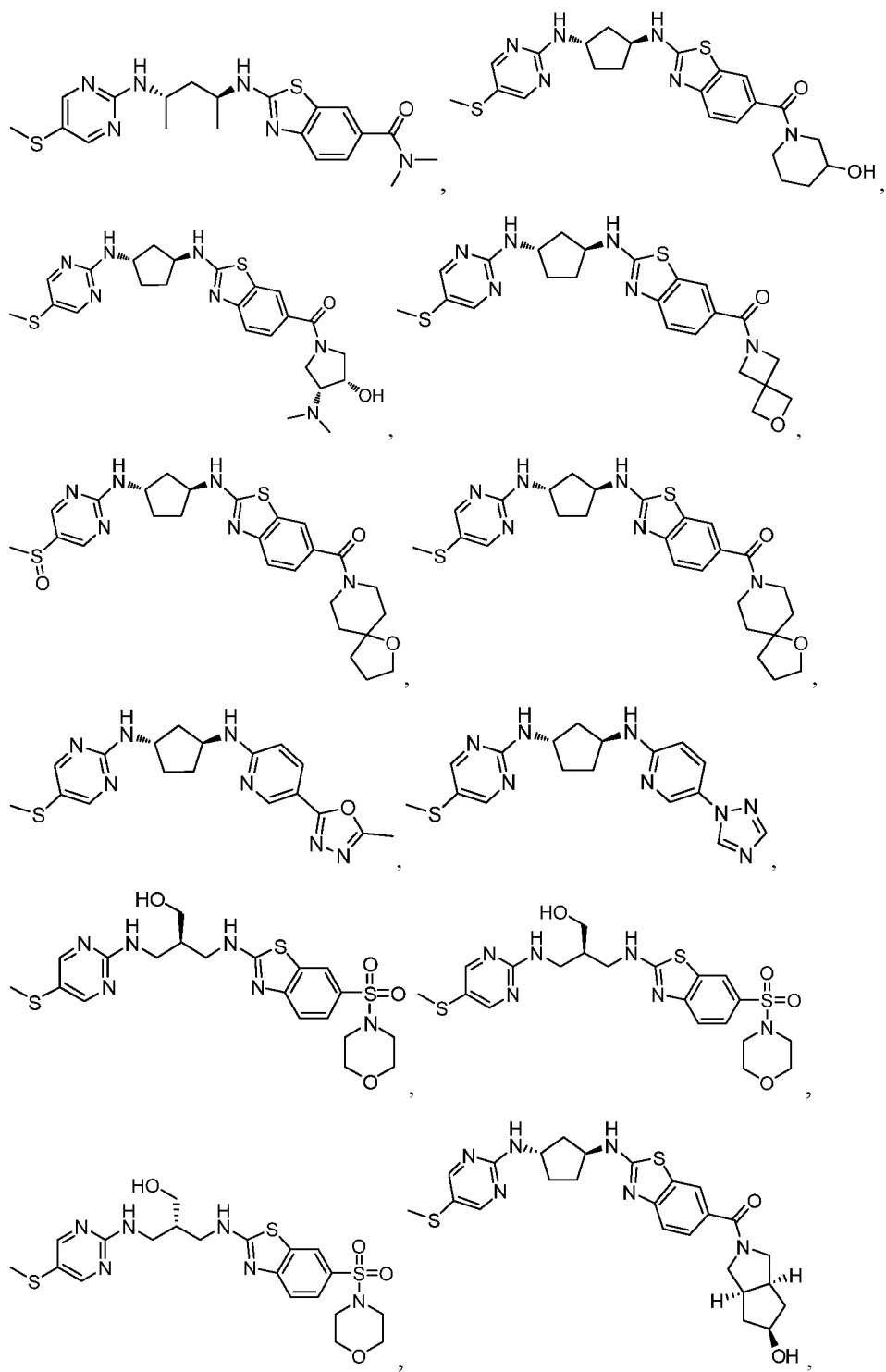




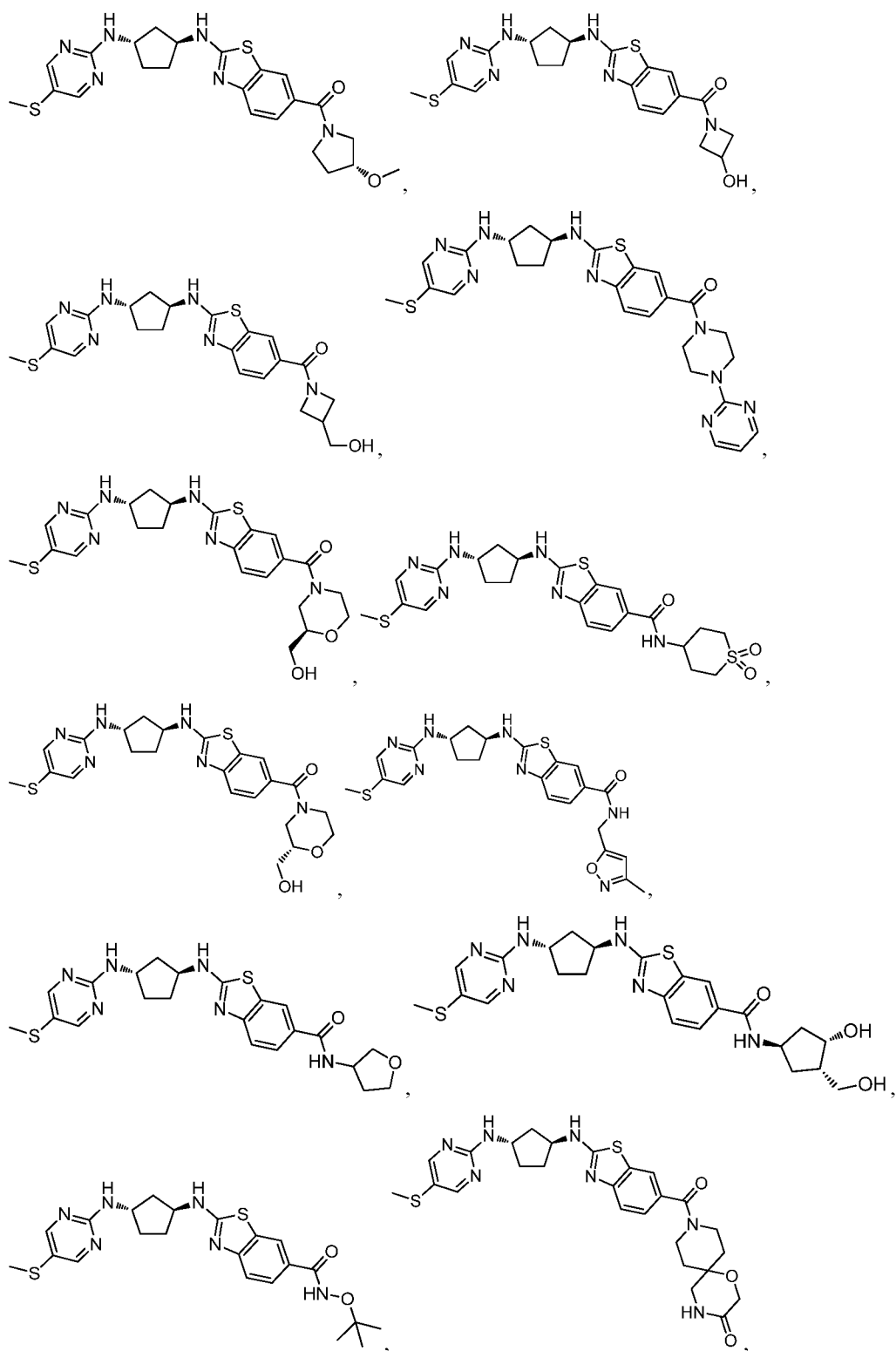


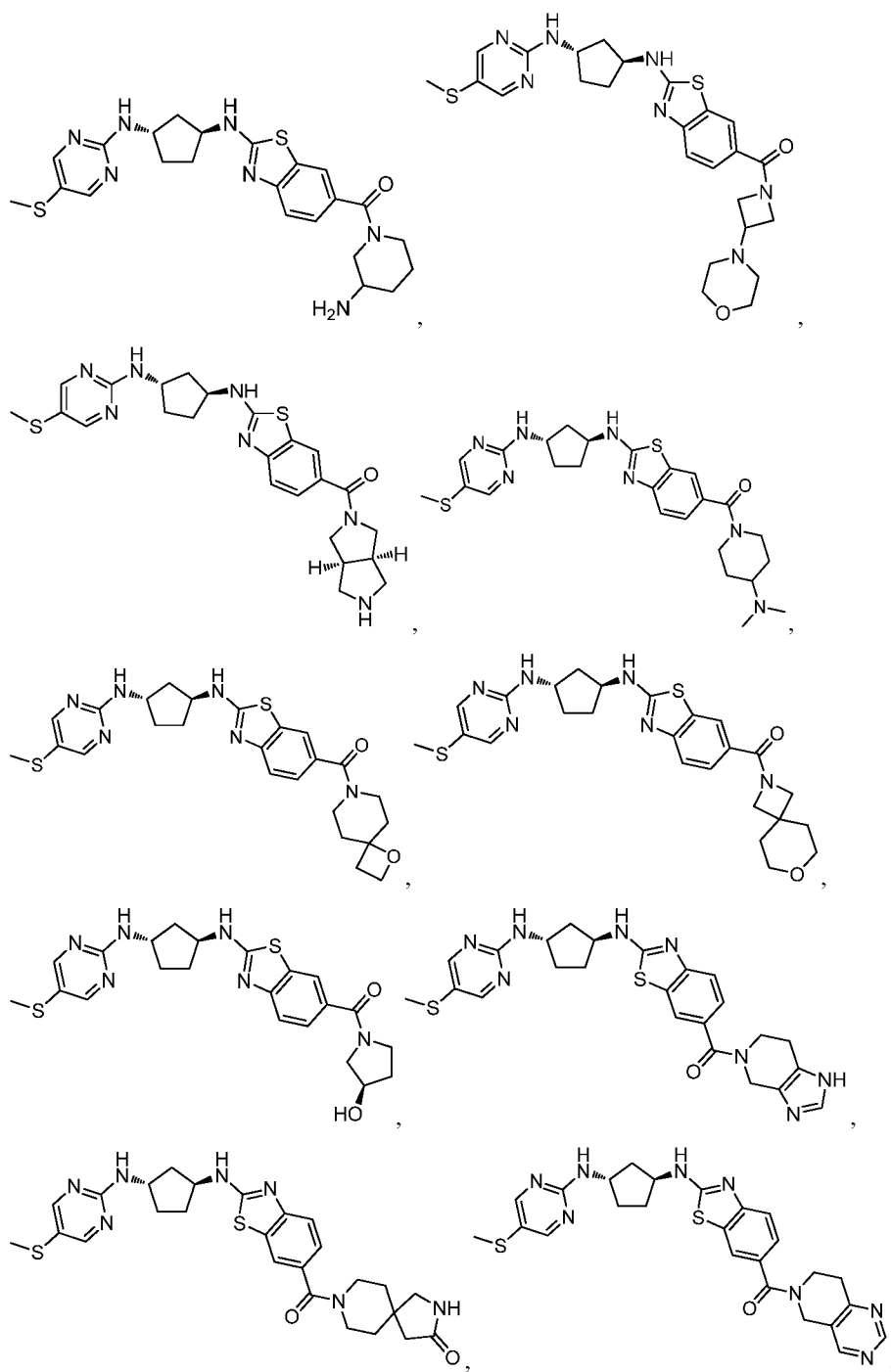


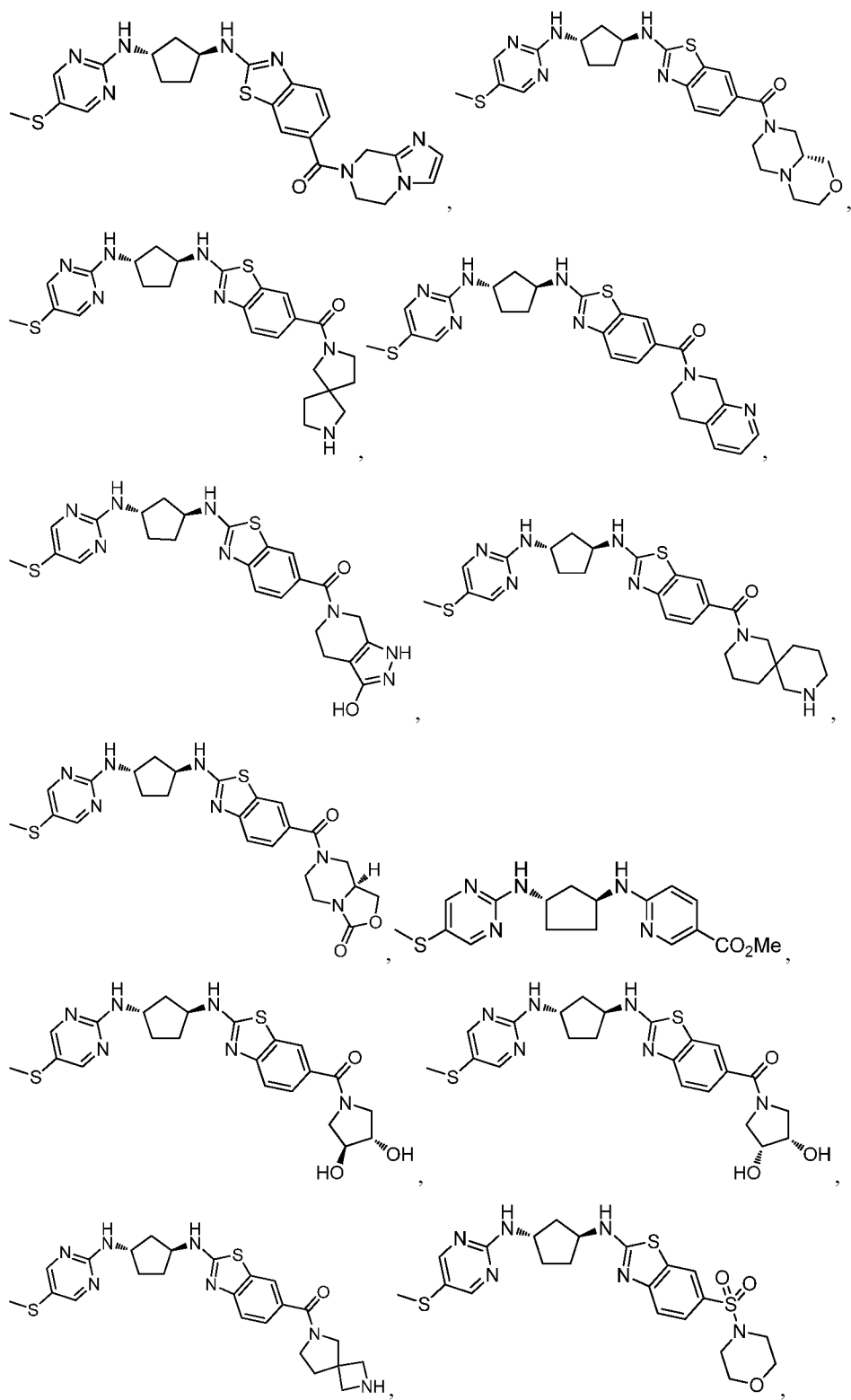


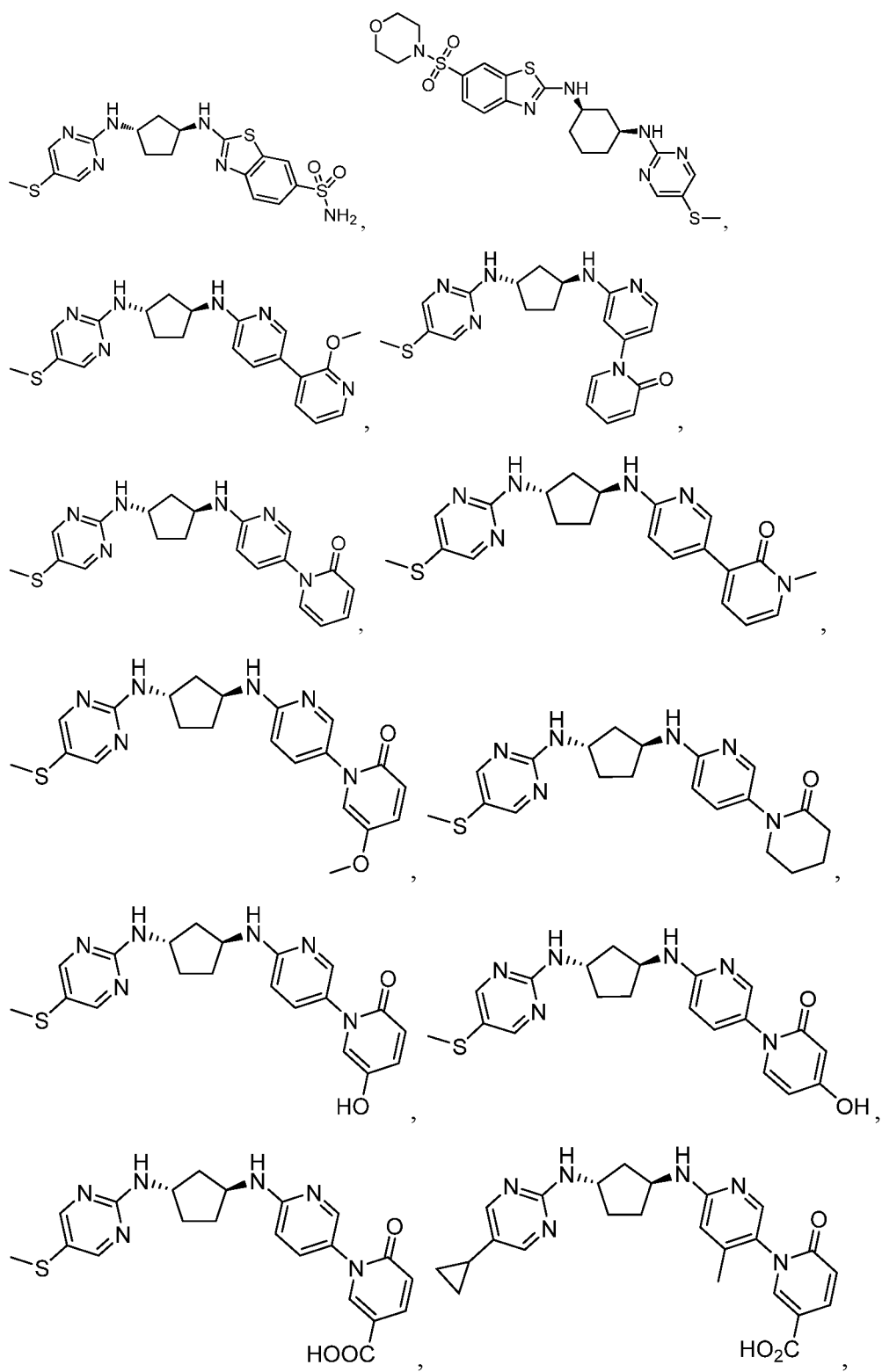


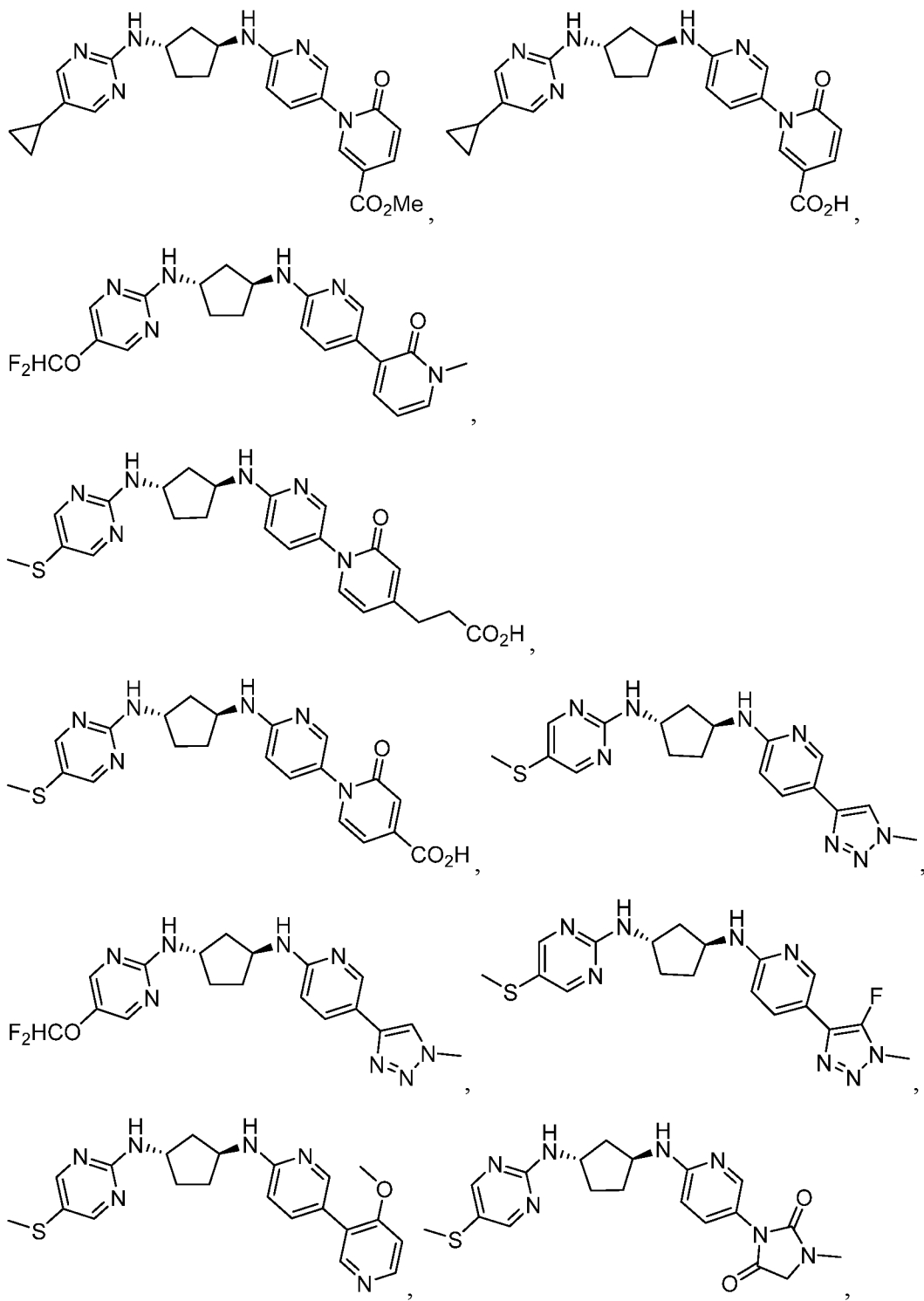


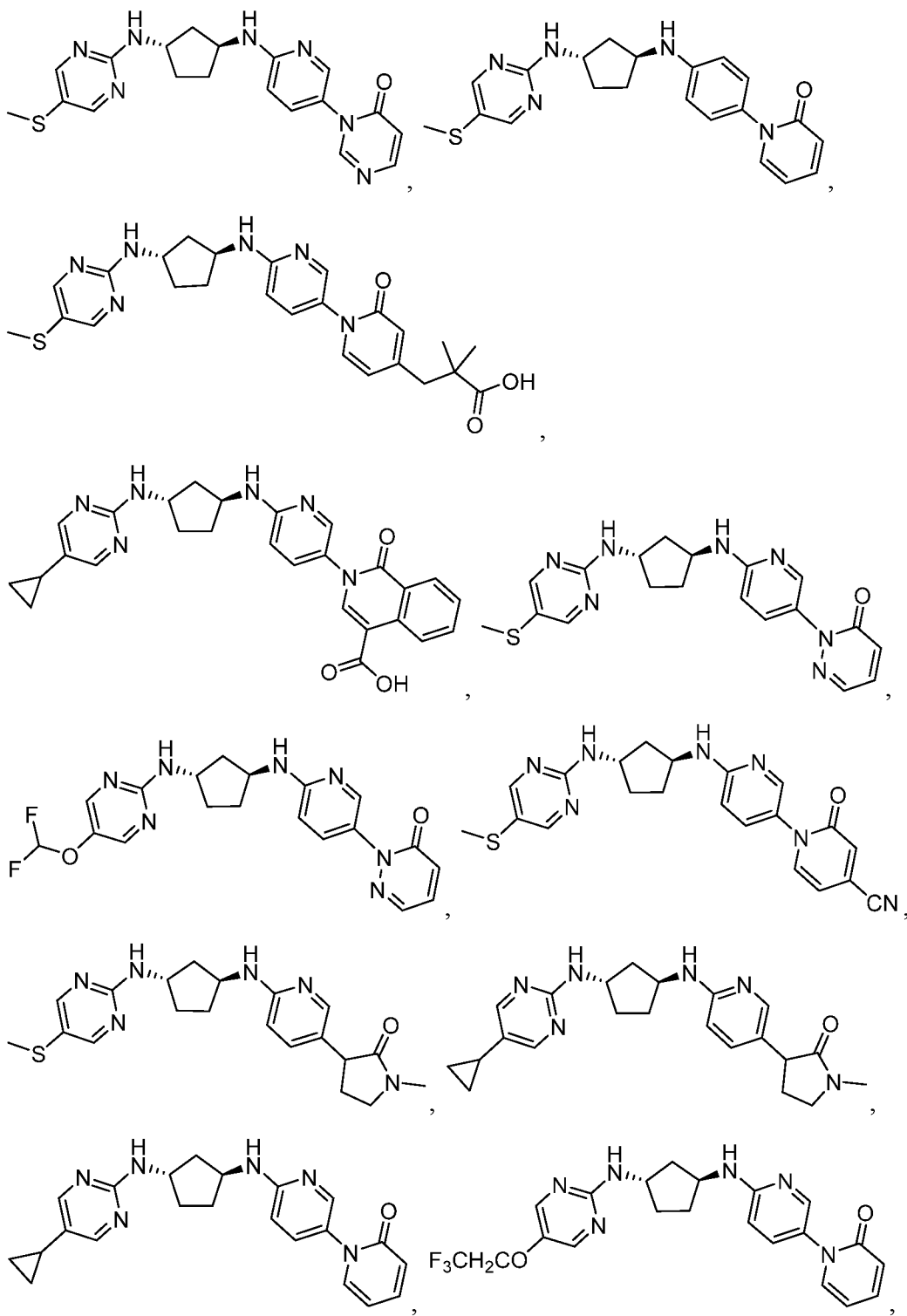


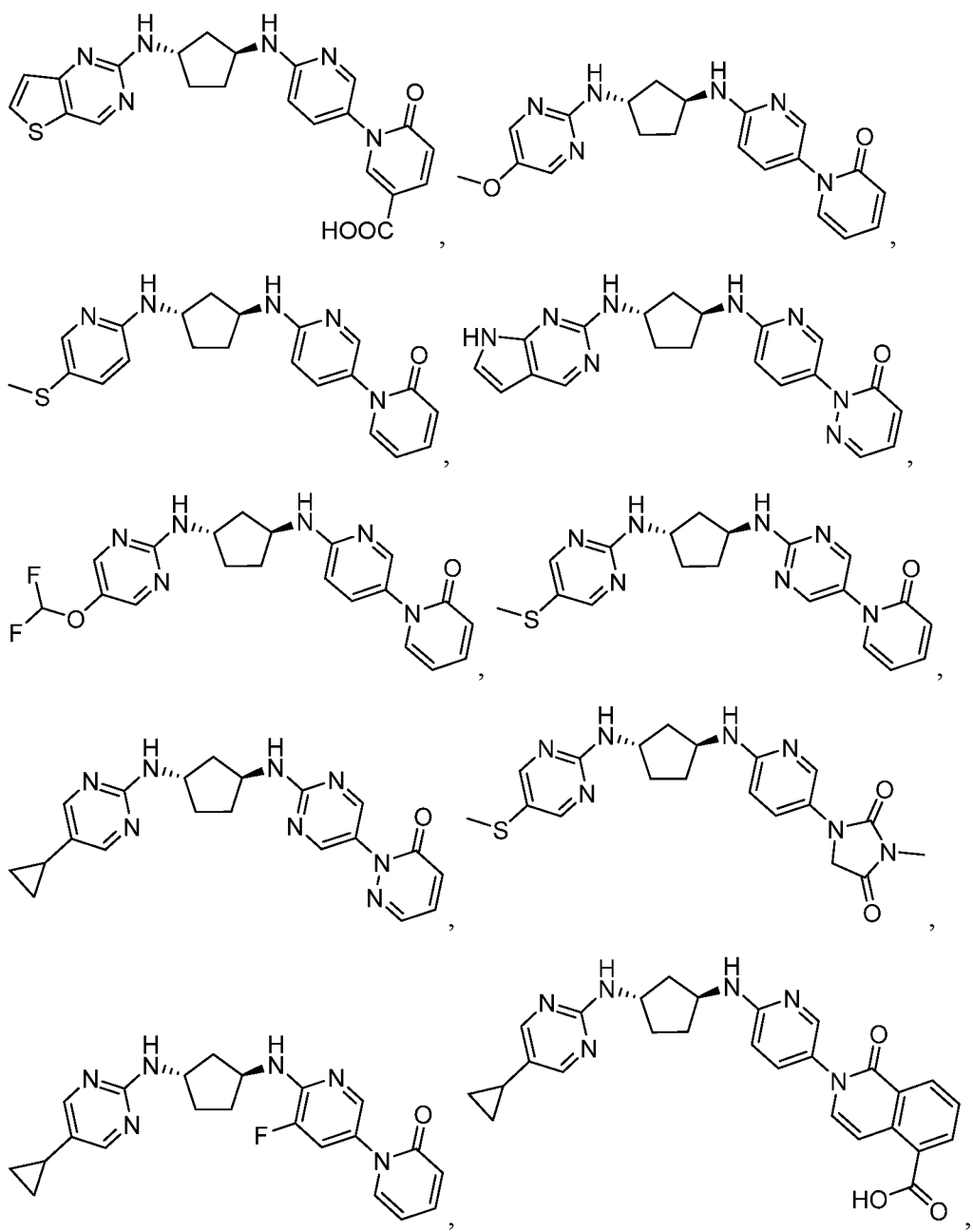


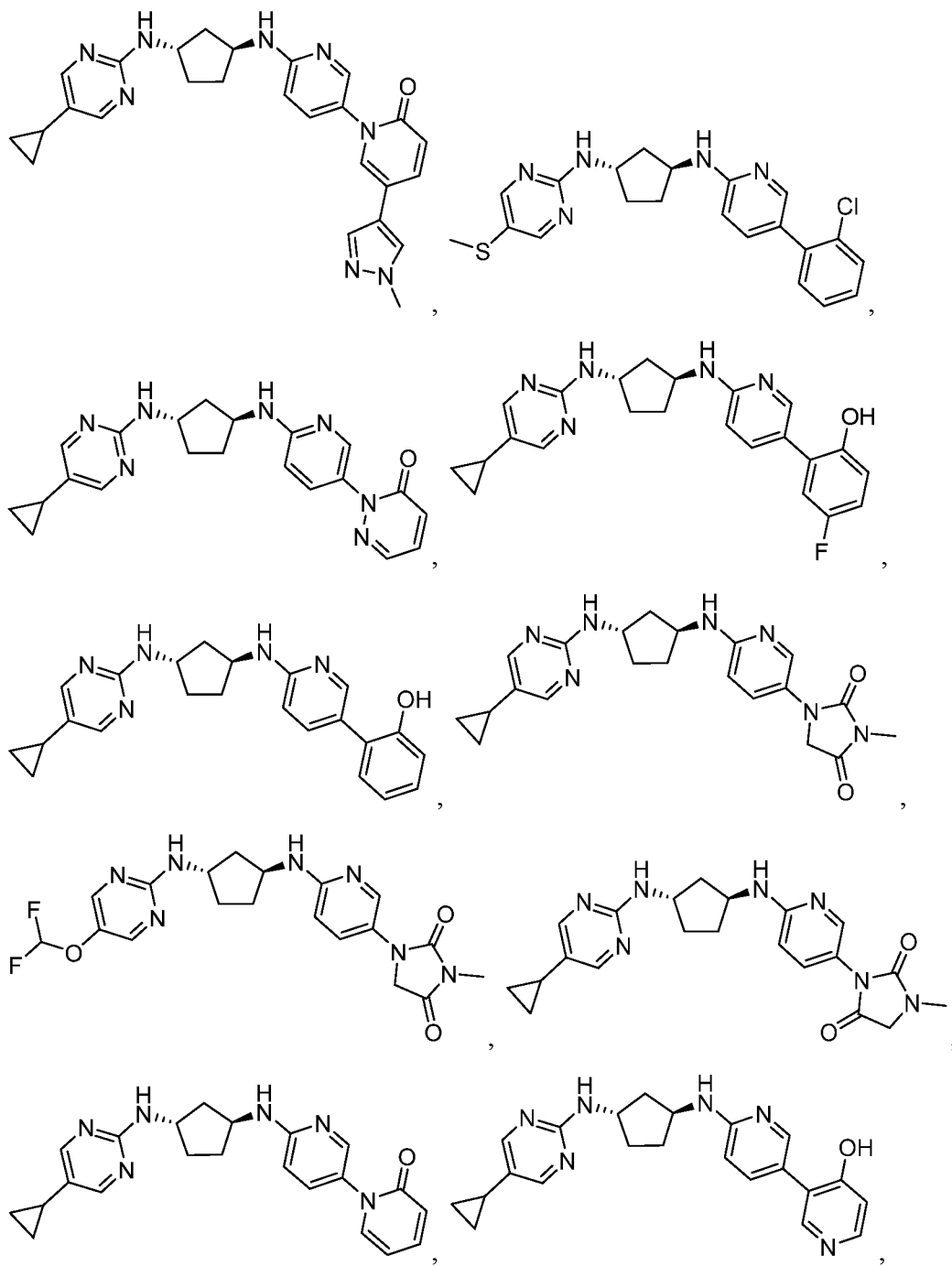


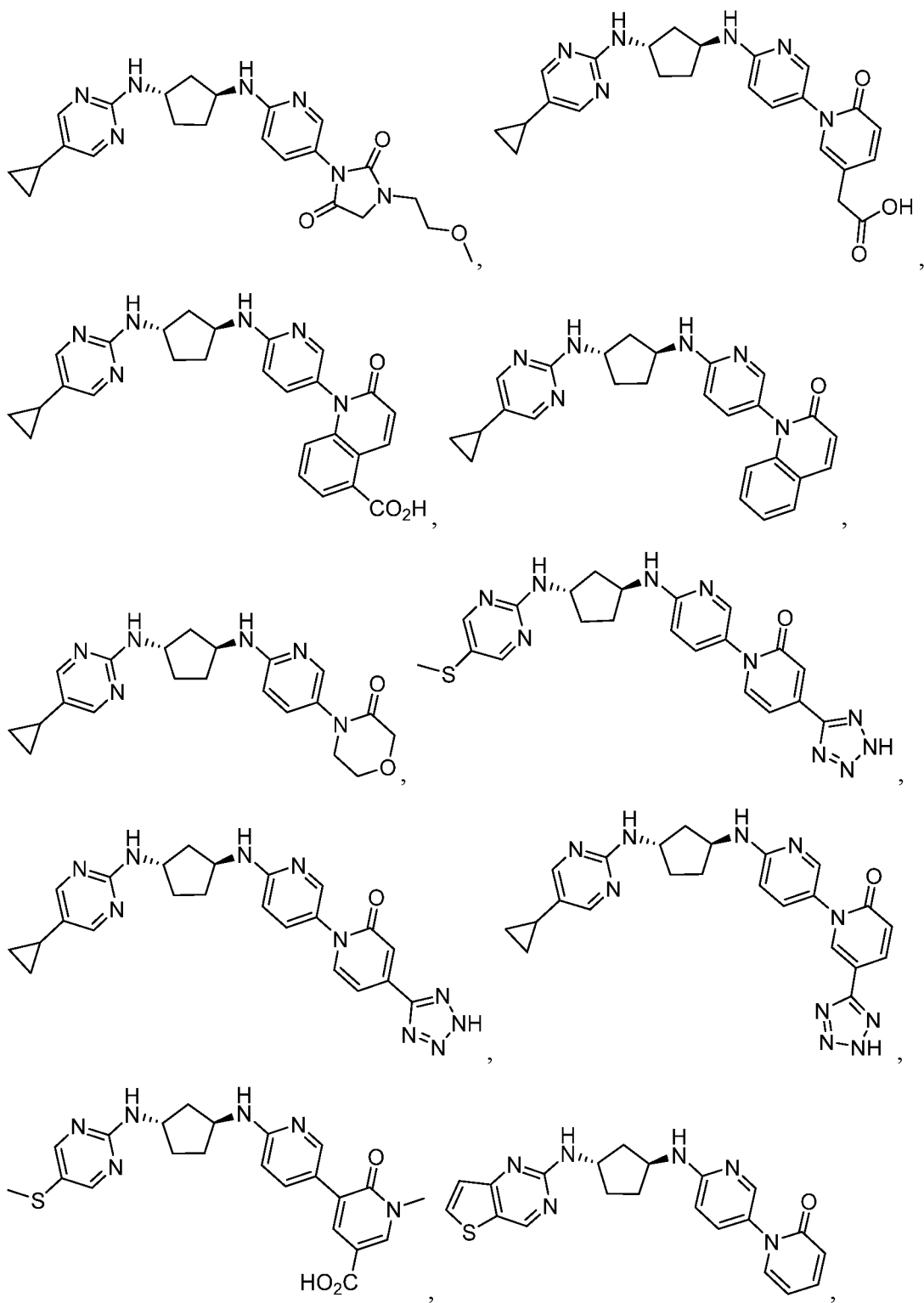


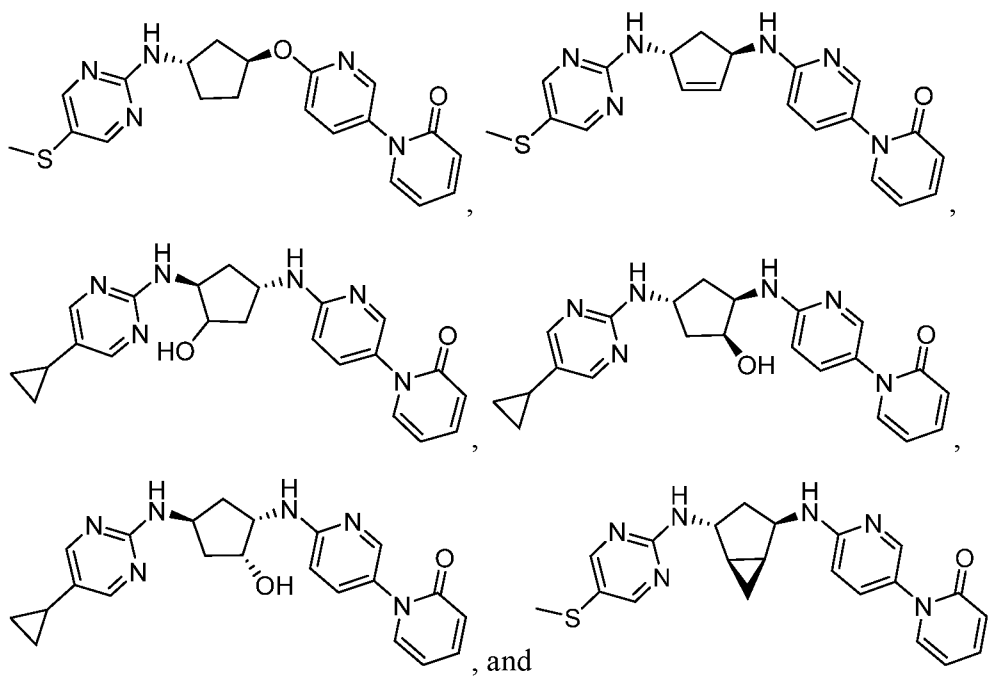




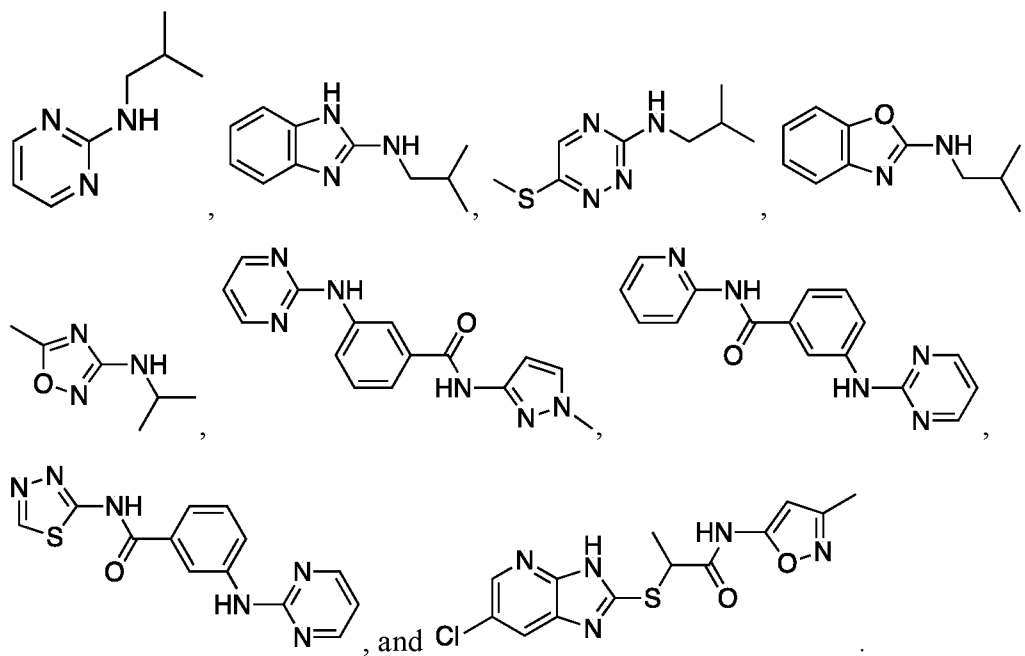








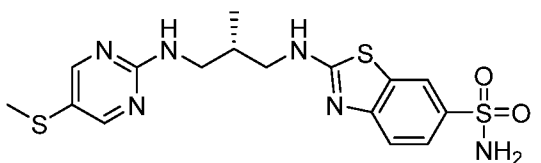
72. The method of claim 20, wherein the inhibitor is selected from:



73. A pharmaceutical composition comprising a compound according to any one of claims 1-72, or a pharmaceutically acceptable salt thereof, and one or more pharmaceutically acceptable excipients.

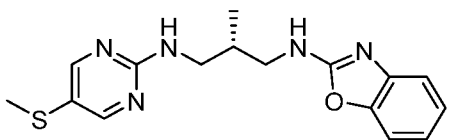
74. The method of claim 10, wherein the inhibitor has one H-bond acceptor moiety disposed to bind with amino acid residue Ser642, one H-bond acceptor moiety disposed to bind with amino acid residue Val644, and one H-bond donor moiety disposed to bind with amino acid residue Ala637.

75. The method of claim 74, wherein the inhibitor is



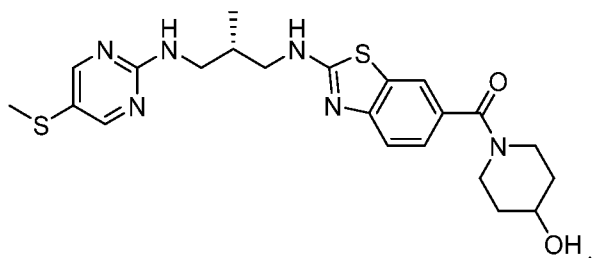
76. The method of claim 10, wherein the inhibitor has one H-bond donor moiety disposed to bind with amino acid residue Ala637, and one cation-pi stacking interaction moiety disposed to bind with amino acid Arg495.

77. The method of claim 76, wherein the compound is



78. The method of claim 10, wherein the inhibitor has one H-bond donor moiety disposed to bind with amino acid residue Ala637, one H-bond donor moiety disposed to bind with amino acid residue Thr641, one H-bond acceptor moiety disposed to bind with amino acid residue His643, one cation-pi stacking interaction moiety disposed to bind with amino acid residue Arg495, and cation-pi stacking interaction moiety disposed to bind with amino acid residue His591.

79. The method of claim 78, wherein the compound is



80. The method of claim 10, wherein the inhibitor has one H-bond donor moiety disposed to bind with amino acid residue Ala637, one H-bond acceptor moiety disposed to bind with amino acid residue Val644, and one cation-pi stacking interaction moiety disposed to bind with amino acid 591.

81. The method of claim 80, wherein the compound is

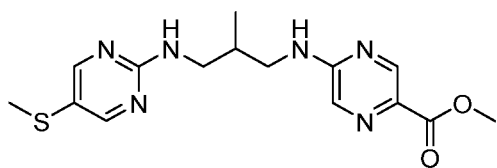


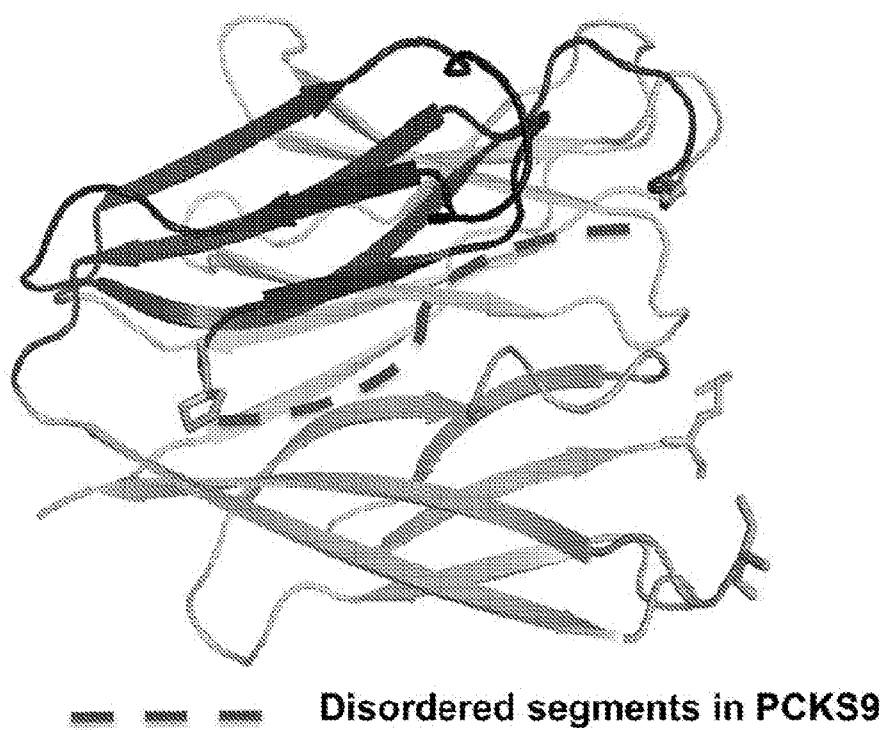
FIG. 1

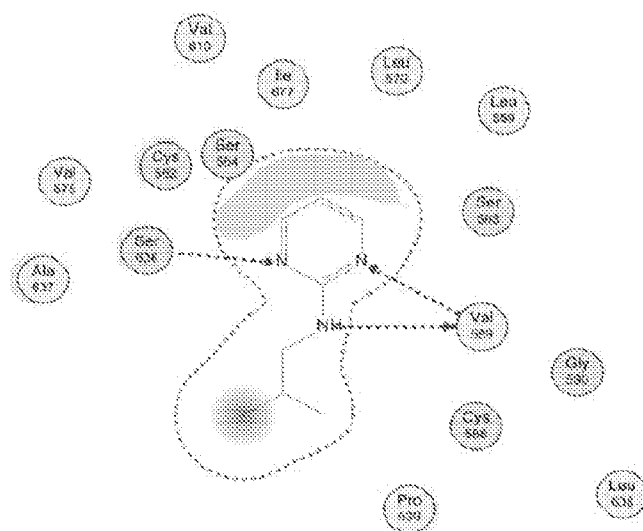
FIG. 2

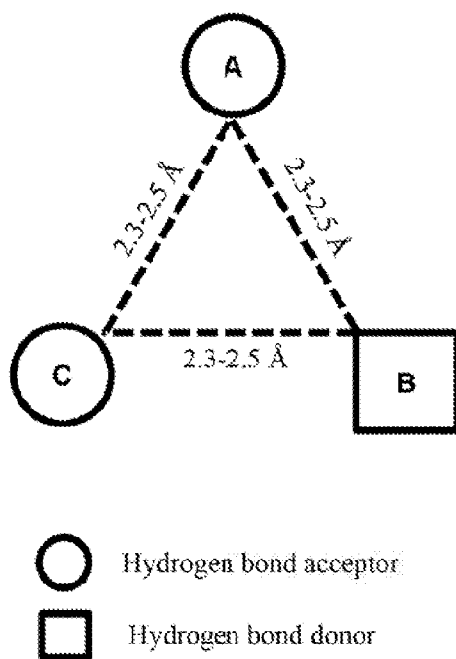
FIG. 3

FIG. 4

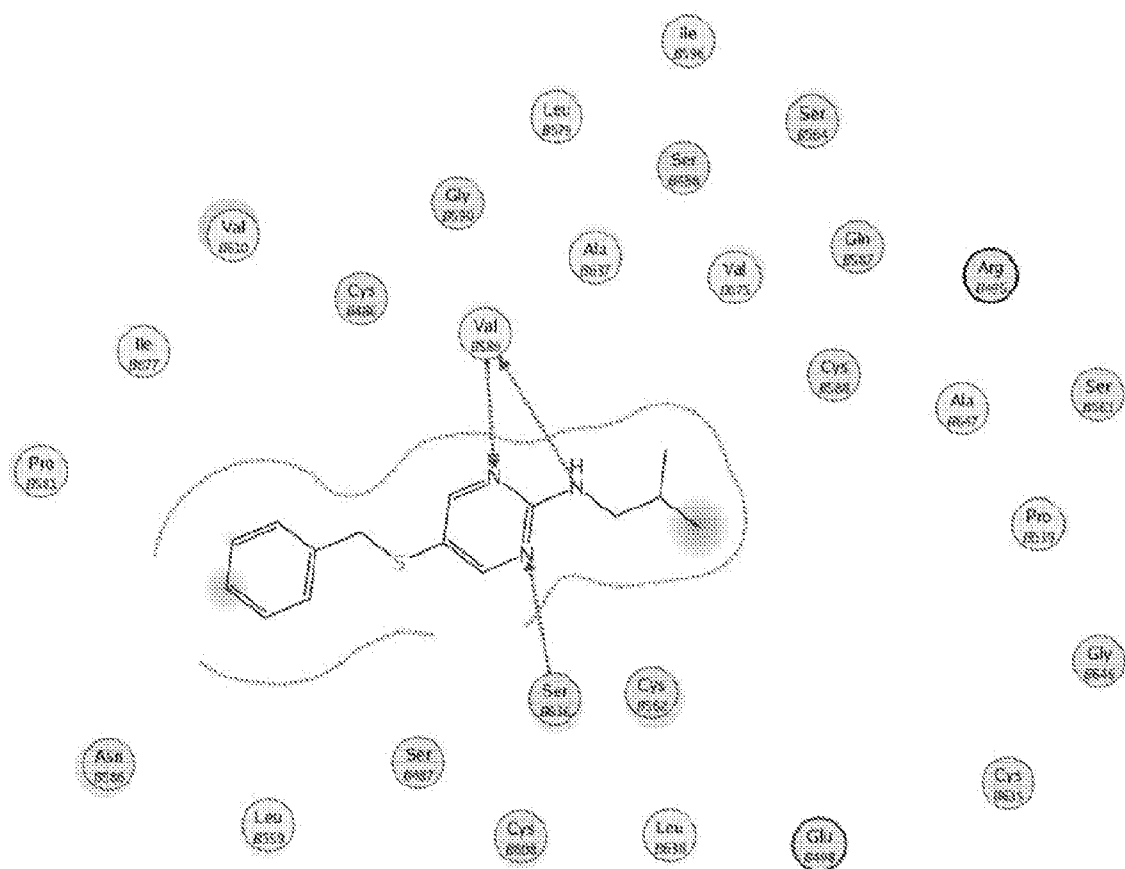


FIG. 5

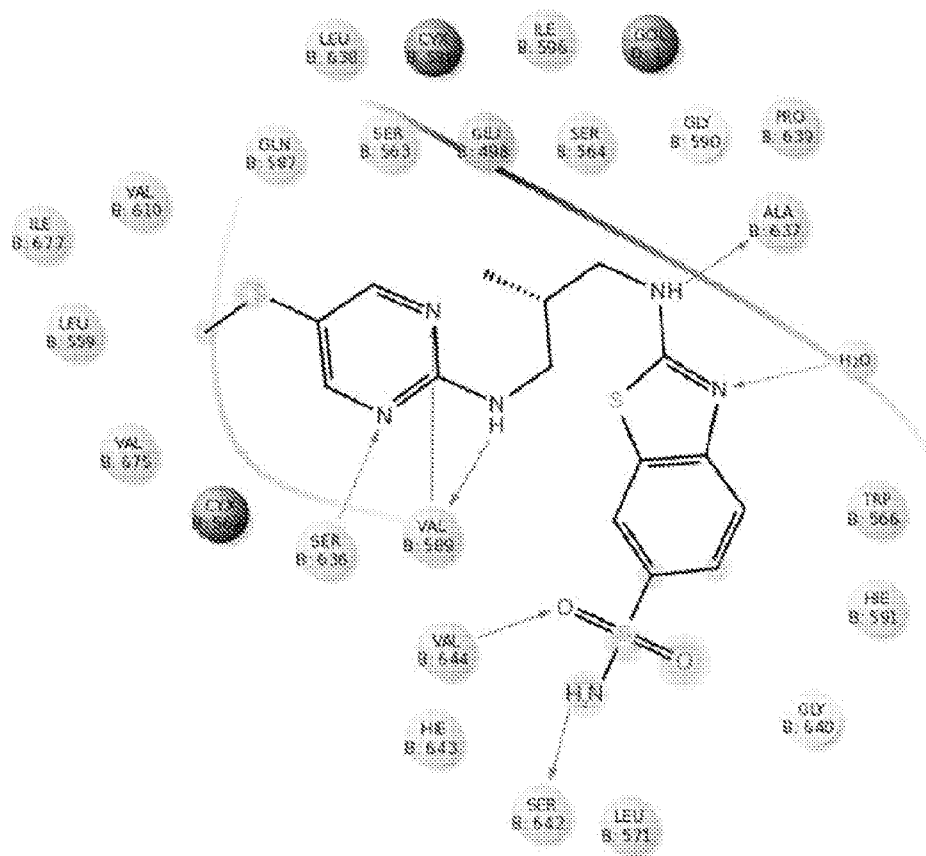


FIG. 6

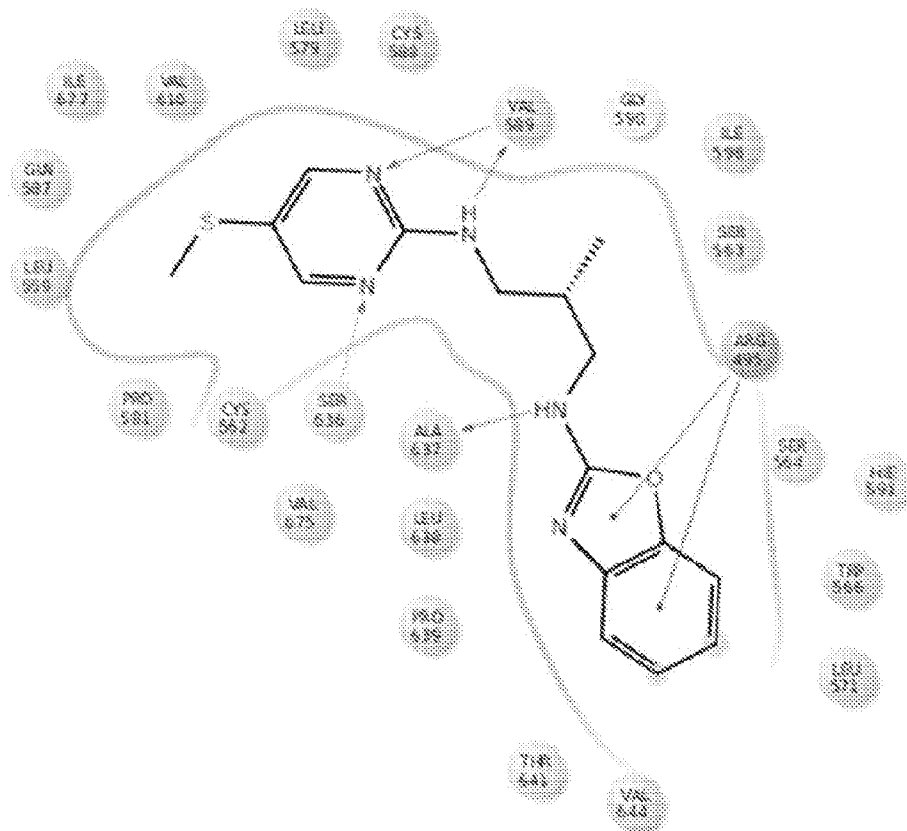


FIG. 7

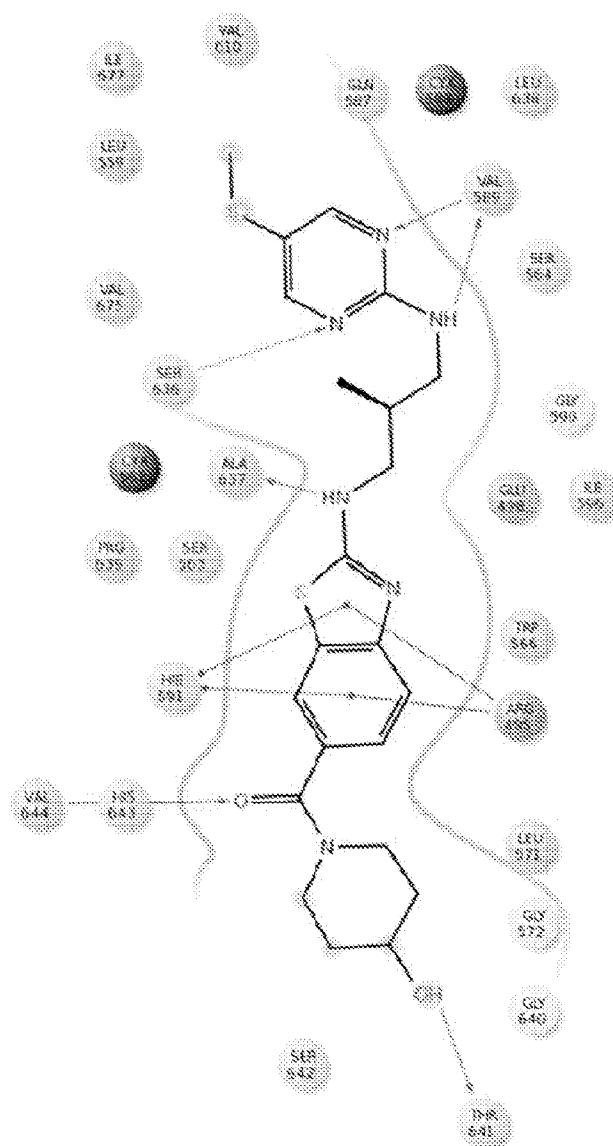


FIG. 8

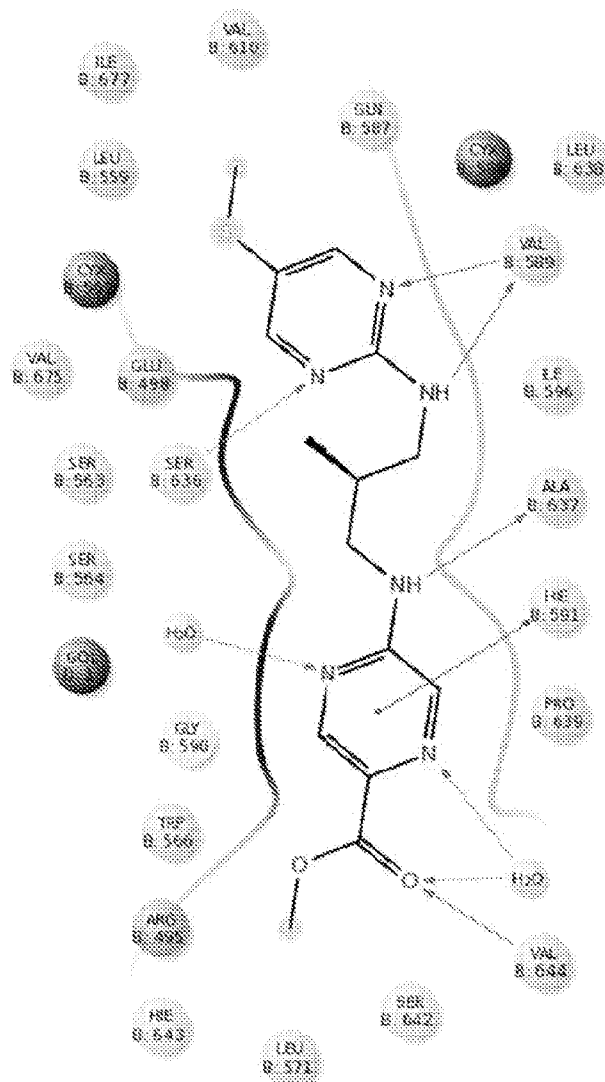


FIG. 9