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Title: PYRROLOPYRIMIDINE DERIVATIVES AS NR2B NMDA RECEPTOR ANTAGONISTS

Abstract: Disclosed are chemical entities of formula 1: [INSERT CHEMICAL FORMULA HERE] wherein X, Y, Z, R1, R3, R4, R5 and R6 are defined herein, as NR2B subtype selective receptor antagonists. Also disclosed are pharmaceutical compositions comprising a chemical entity of formula 1, and methods of treating various diseases and disorders associated with NR2B antagonism, e.g., diseases and disorders of the CNS, such as depression, by administering a chemical entity of formula 1.
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PYRROLOPYRIDINE DERIVATIVES AS NR2B NMDA RECEPTOR ANTAGONISTS

BACKGROUND

{001} Non-selective NMDA receptor antagonists, originally developed in stroke and head trauma, have more recently shown clinical efficacy in treating depression. The nonselective NMDA receptor antagonist, ketamine, has been shown to have rapid onset and efficacy in depression resistant to standard monoamine reuptake inhibitor therapy (Mathews and Zarate, 2013, *J. Clin. Psychiatry* 74:516-15S). However, nonselective NMDA receptor antagonists such as ketamine have a range of undesirable pharmacological activities which limit application in humans, in particular dissociative or psychogenic side effects are particularly prominent for nonselective NMDA receptor antagonists. More recently, NR2B-subtype selective NMDA receptor antagonists have demonstrated potential in a wide range of clinical indications. In particular, NR2B antagonists have also demonstrated antidepressant activity in early stage clinical trials (Ibrahim et al, 2012, *J. Clin. Psychopharmacol.* 32, 551-557; Prescom et al., 2008, *J. Clin. Psychopharmacol.* 28, 631-637). Furthermore, -selective NR2B antagonists have advantages over nonselective NMDA receptor antagonists such as ketamine due to greatly diminished dissociative side effects. However, NR2B antagonists described to date have generally exhibited drawbacks with regard to other drug properties which have limited potential use in human drug therapy.

SUMMARY

{002} For broad scope of application and safe human use in a range of clinical indications including depression, improved NR2B subtype selective antagonists are needed. The present invention, among other things, addresses the need for NR2B receptor antagonists that are improved in one or more aspects exemplified by pharmacokinetic performance, oral activity, cardiovascular safety, and in vitro and in vivo therapeutic safety index measures.

{003} In some embodiments, the present invention encompasses the insight that chemical entities of formula I:
wherein \( X, Y, 2, R^f, R^5, R^*, R^8 \) and \( R^6 \) are defined herein, are NR2B subtype selective receptor antagonists. Chemical entities of formula I, and pharmaceutically acceptable compositions thereof, are useful for treating a variety of diseases and disorders associated with NR2B receptor antagonism. Such diseases and disorders include those described herein.

**BRIEF DESCRIPTION OF THE DRAWING**

[0041] FIG. 1 shows the results of compound C-178 in the forced swim test as described in Example 2.4.1.

[0051] FIG. 2 shows the results of compound C-179 in the forced swim test as described in Example 2.4.2.

[0061] FIG. 3 shows the results of compound C-6 in the faaiperoxol-induced catalepsy model as described in Example 2.5.1.

[0071] FIG. 4 shows the results of compound C-12 in the haloperidol-induced catalepsy model as described in Example 2.5.2.

[0081] FIG. 5 shows the results of compound C-5 in the haloperidol-induced catalepsy model as described in Example 2.5.3.

[0091] FIG. 6 shows the results of compound C-11 in the electroconvulsive threshold test as described in Example 2.6.1.

[0101] FIG. 7 shows the results of compound C-127 in the electroconvulsive threshold test as described in Example 2.6.2.
FIG. 8 shows the results of compound C-179 in the electroconvulsive threshold test as described in Example 2.6.3.

FIG. 9 shows the results of compound C-179 in the 6 Hz seizure test as described in Example 2.7.1.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

General Description of Chemical Entities

In some embodiments, the present invention provides chemical entities of formula I:

![Chemical Structure](image)

wherein;

Y and Z are independently N or C(R^2);

X is -H; halo; C_1-C_6 alkyl optionally substituted with 1 to 6 fluoro; C_3-C_6 cycloalkyl;

C_1-C_4 alkoxy optionally substituted with 1 to 6 fluoro; -CN; -NO_2; -N(R^7)(R^8); -SR^7;

-S(0)_2R^9; or -C(0)OR^7;

R^1 is -H; halo; C_1-C_4 alkyl optionally substituted with 1 to 3 fluoro; C_3-C_6 cycloalkyl;

C=C alkene optionally substituted with 1 to 3 fluoro; -CN; -NO_2; -N(R^7)(R^8);

-C(0)OR^7; or -C(0)N(R^7)(R^8);

R^2 is -H; halo; C_1-C_4 alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; or

C_1-C_4 alkoxy optionally substituted with 1 to 3 fluoro;

R^3 is -H, -F, -Cl, -CHs, -CF, or -OCH_3;
R⁴ is -H; -F; -Cl; C₁-C₃ alkyl optionally substituted with 1 to 3 fluoro; or cyclopropyl;

R⁵ is -H or -Cl-S;

R⁶ is -H, -F or -CH₃;

each instance of R⁷ independently is C₁-C₄ alkyl;

each instance of R⁸ independently is -E or C₁-C₄ alkyl; and

R⁹ is C₁-C₄ alkyl optionally substituted with 1 to 3 fluoro.

[Gl4] Unless otherwise specified or clear from context, the term "chemical entity" refers to a compound having the indicated structure, whether in its "free" form (e.g., "free compound" or "free base" or "free acid" form, as applicable), or in a salt form, particularly a pharmaceutically acceptable salt form, and furthermore whether in solid state form or otherwise. Tints, in some embodiments the term "chemical entity" refers to a compound having the indicated structure, or a pharmaceutically acceptable salt thereof. In some embodiments, a solid state form is an amorphous (i.e., noncrystalline) form; in some embodiments, a solid state form is a crystalline form. In some embodiments, a crystalline form (e.g., a polymorph, pseudohydrate, or hydrate). Similarly, the term encompasses the compound whether provided in solid form or otherwise. Unless otherwise specified, all statements made herein regarding "compounds" apply to the associated chemical entities, as defined.

Chemical Entities and Definitions

[0151] Unless otherwise specified, the word "includes" (or any variation thereon, e.g., "include", "including", etc.) is intended to be open-ended. For example, "A includes 1, 2 and 3" means that A includes but is not limited to 1, 2 and 3.

[i0IS] Unless otherwise specified, the phrase "such as" is intended to be open-ended. For example, "A can be a halogen, such as chlorine or bromine" means that A can be, but is not limited to, chlorine or bromine.
Chemical entities of this invention include those described generally above, and are further illustrated by the classes* subclasses, and species disclosed herein. As used herein, the following definitions shall apply unless otherwise indicated. For purposes of this invention, the chemical elements are identified in accordance with the Periodic Table of the Elements, CAS version. Handbook of Chemistry* and Physics, 75th Ed., inside cover, and specific functional groups are generally defined as described therein. Additionally, general principles of organic chemistry, as well as specific functional moieties and reactivity, are described in Thomas Sorrell, Organic Chemistry, University Science Books, Sausalito, 1999; Smith and March, March*Advanced Organic Chemistry, 5th Edition, John Wiley & Sons, Inc., New York, 2001; Larock, Comprehensive Organic Transformations, VCH Publishers, Inc., New York, 1989; and Camsihere, Some Modern Methods of Organic Synthesis, 3rd Edition, Cambridge-University Press, Cambridge, 1987.

The term "alkyl", as by itself or as part of another substituent, means a substituted - or unsubstituted, linear or branched, univalent hydrocarbon chain that is completely saturated or that contains one or more units of unsaturation. Unless otherwise specified, alkyl groups contain 1 to 7 carbon atoms ("C1-C7 alkyl"). In some embodiments, alkyl groups contain 1 to 6 carbon atoms ("C1-C6 alkyl"). In some embodiments, alkyl groups contain 1 to 5 carbon atoms ("C1-C5 alkyl"). In some embodiments, alkyl groups contain 1 to 4 carbon atoms ("C1-C4 alkyl"). In some embodiments, alkyl groups contain 3 to 7 carbon atoms ("C3-C7 alkyl"). Examples of saturated alkyl groups include methyl, ethyl, n-propyl, i-propyl, n-butyl, t-butyI, i-butyI, s-butyI, homologs and isomers of, for example, n-pentyl, n-hexyl, n-heptyl, n-octyl, and the like. An unsaturated alkyl group is one having one or more carbon-carbon double bonds or carbon-carbon triple bonds. Examples of unsaturated alkyl groups include allyl, vinyl, 2-propenyl, crotyl, 2-isopropenyl 2-(butadienyI), 2,4-pentadienyI, 3-(1,4-pentadienyI), ethylI, 1- and 3-propynyl, 3-butyI, and the like. The term 'lower alkyl' refers to alkyl groups having 1 to 4 (if saturated) or 2 to 4 (if unsaturated) carbon atoms. Exemplary lower alkyl groups include methyl ethyl, n-propyl, i-propyl, n-butyl, s-butyI, t-butyI, i-buIyi and the like. The term "alkenyl" refers to alkyl groups having at least two carbon atoms and at least one carbon-carbon double bond. The term "alkynyl" refers to alkyl groups having at least two carbon atoms and at least one carbon-carbon triple bond.
The terra "cycloalkyl", by itself or as part of another substituent, refers to a monocyclic univalent hydrocarbon that is completely saturated or that contains one or more units of unsaturated, but which is not aromatic, that has a single point of attachment to the rest of the molecule. In some embodiments, cycloalkyl groups contain 3 to 8 ring carbon atoms ("C4-C8 cycloalkyl"). Examples of cycloalkyl include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, 1-cyclohexeny1, 3-cyclohexeny1, cyclohepty1, and the like.

The term "alkoxy", by itself or as part of another substituent, refers to the group -O-alkyl.

The term "halogen" or "halo", by itself or as part of another substituent, refers to fluorine, chlorine, bromine or iodine.

As used herein, the term "pharmaceutically acceptable salt" refers to those salts which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of humans and lower animals without undue toxicity, irritation, allergic response and the like, and are commensurate with a reasonable benefit/risk ratio. Pharmaceutically acceptable salts are well known in the art. For example, S. M. Berge et al., describe pharmaceutically acceptable salts in detail in J. Pharmaceutical Sciences, 1977, 66:1-19, incorporated herein by reference. Pharmaceutically acceptable salts of the compounds of this invention include those derived from suitable inorganic and organic acids and bases. Examples of pharmaceutically acceptable, non-toxic acid addition salts are salts of an amino group formed with inorganic acids such as hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid and perchloric acid or with organic acids such as acetic acid, oxalic acid, maleic acid, tartaric acid, citric acid, succinic acid or malonic acid or by using other methods used in the art such as ion exchange. Other pharmaceutically acceptable salts include adipate, alginate, ascorbate, aspartate, benzenesulfonate, benzoate, hisulfaie, borate, butyrate, camphorate, camphorsulfonate, citrate, cyclopentanePropionate, digluconate, dodecyl sulfate, ethanesulfonate, formate, fumarate, glucoheptonate, glycerophosphate, gluconate, hemisulfate, heptanoate, hexanoate, hydroiodide, 2-hydroxy-ethanesulfonate, lactobionate, lactate, laurate, lauryl sulfate, malate, maieate, malonate, metllariesulfonate, 2-naphthalenesulfate, uicinolate, nitrate, olate, oxalate, palmitate, pamoate, pectinate.
persulfate, 3-phenylpropionate, phosphate, pivaiate, propionate, stearate, succinate, sulfate, tartrate, thiocyanate, p-toluenesulfonate, undecanoate, valerate salts, and the like.

0231 Salts derived from appropriate bases include alkali metal, alkaline earth metal, ammonium and \(N(C_{1-4} \text{ alkyl})_4\) salts. Representative alkali or alkaline earth metal salts include sodium, lithium, potassium, calcium, magnesium, and the like. Further pharmaceutically acceptable salts include, when appropriate, nontoxic ammonium, quaternary ammonium, and amine cations formed using counterions such as halide, hydroxide, carboxylase, sulfate, phosphate, nitrate, lower alkyl sulfonate and aryl sulfonate.

0241 Unless otherwise stated, structures depicted herein are also meant to include all isomeric (e.g., enantiomeric, diastereomeric, and geometric (or conformational)) forms of the structure; for example, the R and S configurations for each asymmetric center, Z and E double bond isomers, and Z and E conformational isomers. Therefore, single stereocchemical isomers as well as enantiomeric, diastereomeric, and geometric (or conformational) mixtures of the present compounds are within the scope of the invention. Unless otherwise stated, all tautomeric forms of the compounds of the invention are within the scope of the invention. Additionally, unless otherwise stated, structures depicted herein are also meant to include compounds that differ only in the presence of one or more tisotopically enriched atoms. For example, compounds having the present structures including the replacement hydrogen, carbon, nitrogen, oxygen, chlorine or fluorine with \(^2\text{H}, \ ^{3}\text{H}, \ ^{11}\text{C}, \ ^{12}\text{C}, \ ^{13}\text{C}, \ ^{14}\text{N}, \ ^{15}\text{N}, \ ^{16}\text{O}, \ ^{18}\text{O}, \ ^{35}\text{Cl} \) or \(^8\text{F}, \) respectively, are within the scope of this invention. Such compounds are useful, for example, as analytical tools, as probes in biological assays, or as therapeutic agents in accordance with the present invention. Additionally, incorporation of heavier isotopes such as deuterium (\(^{2}\text{H})\) can afford certain therapeutic advantages resulting from greater metabolic stability, for example, increase in vivo half-life, or reduced dosage requirements.

Exemplary Embodiments of Chemical Entities

028 In some embodiments, the present invention provides chemical entities of formula 1:
Y and Z are independently N or C(R²);

X is -H; halo; C₁-C₆ alkyl optionally substituted with 1 to 6 fluoro; C₃-C₆ cycloalkyl;
CrC₄ alkoxy optionally substituted with 1 to 6 fluoro; -CN; -NO₂; -N(R)(R')(R''); -SR₇;
-S(O)₂R⁹; or -LOOR⁷;

R¹ is -H; halo; CrC* alkyl optionally substituted with 1 to 3 fluoro; C₁-C₆ cycloalkyl;
C₁-C₄ alkoxy optionally substituted with 1 to 3 fluoro; -CN; -NO₂; -N(R')(R''');
-C(O)OR⁷; or -C(O)N(R')(R''');

R² is -H; halo; C₁-C₄ alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; or
C₁-C₄ alkoxy optionally substituted with 1 to 3 fluoro;

R₃ is -H, -F, -Cl, -CF₃ or -OCH₃;

R₄ is -H; -F; -Cl; C₁-C₃ alkyl optionally substituted with 1 to 3 fluoro; or cyclopropyl;

R₅ is -H or -Ci₃₄;

R₆ is -H, -F or -CH₃;

each instance of R⁷ independently is C₁-C₄ alkyl;

each instance of R⁸ independently is -H or C₁-C₄ alkyl; and

R⁹ is C₁-C₆ alkyl optionally substituted with 1 to 3 fluoro.

[026] In some such embodiments, at least one of Y and Z is N.
In some embodiments, Y and Z are independently N or C(E$_2^2$);

X is -H; halo; C1-C4 alkyl optionally substituted with 1 to 6 fluoro; cyclopropyl;

$\text{C}_1\text{-C}_2$ alkoxyl optionally substituted with 1 to 3 fluoro; -CM; -NO$_2$; -N(R$_7^7$)(R$_8^8$); -$\text{SR}_7^7$; or

$-\text{S(O)}_2\text{R}^9^9$;

R$_1^1$ is -$\text{E}$; halo; C$_1$-C$_4$ alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl;

$\text{C}_\times\text{C}_2$ alkoxyl optionally substituted with 1 to 3 fluoro; -CN; -N(O)$_4$; -N(R$_7^7$)(R$_8^8$);

$-\text{C}(\text{O})\text{OR}$; or $-\text{C}(\text{O})\text{N}(\text{R})^7(\text{R})^8$:

R$_2^2$ is -H; halo; C$_1$-C$_4$ alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; or

C$_1$-C$_2$ alkoxyl optionally substituted with 1 to 3 fluoro;

R$_3^3$ is -H, -F, -Cl, -(CH$_3$)$_2$, -CF$_3$ or -OCH$_3$;

R$_4^4$ is -H; -F; -Cl; C$_1$-C$_3$ alkyl optionally substituted with 1 to 3 fluoro; or cyclopropyl;

R$_5^5$ is -H or -C$_3$;

R$_6^6$ is -H, -F or -CH$_3$;

each instance of R$_7^7$ independently is C$_1$-C$_2$ alkyl;

each instance of R$_8^8$ independently is -H or C$_1$-C$_2$ alkyl; and.

R$_9^9$ is C$_1$-C$_2$ alkyl optionally substituted with 1 to 3 fluoro.

[027] In some embodiments, at least one of Y and 2 is N.

[Q29] In some embodiments, Y and Z are independently N or C(E$_2^2$);

X is -H, -F, -Cl, -CH$_3$, -CH$_2$CH$_3$, -CH(CH$_3$)$_2$, -CF$_3$, -CHF$_2$, -CH$_2$F, -CF$_2$CF)$_3$,

-C$_3$CF$_2$CF$_3$, -CH(CF$_3$)$_3$, cyclopropyl, -OCH$_3$, -OCF$_3$, -OCHF$_2$, -OCF$_2$H, -CN, -N(O)$_2$,

-NH(C$_3$H$_4$)$_2$, -N(CH$_3$)$_2$, -N(CI$_4$)(CI$_4$C$_3$)$_4$, -SCH$_3$, -SCH$_2$CH$_3$, -SO$_2$CH$_3$, -SO$_2$CH$_2$CH$_3$ or

-SO$_2$CF$_3$;
R₁ is -H, -F, -Cl, -C¾, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OC¾, -OCF₃, -OBF₂, -Q₃F₂, -CN, -NC₃, -CO₂CH₃, -CO₂CH₂CH₃, -C(O)N(CH₃)₂, -C(O)N(CH₃) or -C(O)N(CH₃)CF₃;

R₂ is -H, -F, -Cl, -C¾, -CH₂C¾, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₃, -OBF₂ or -OCF₂;

R₃ is -H, -F, -Cl, -CH₃, or -OCF₃;

R₄ is -H, -F, -Cl, -CH₃ or cyclopropyl;

R₅ is -H or -CH₃; and

R₆ is -H, -F or -C¾.

In some embodiments, at least one of Y and Z is N.

In some embodiments, Y and Z are independently N or C(R²);

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -C₃F₇, -CF₂C₃F₇, -CH₂CF₂CF₅, -CH₂CH₂CF₅, -CH₂CF₃, -CF₃, cyclopropyl, -OCF₃, -OBF₂, -OCF₂ or -OCF₃;

R₁ is -H, -F, -Cl, -C₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OBF₂, -OCF₃, -OBF₇, -OCF₈, -OCF₂ or -OCF₃;

R₂ is -H, -F, -Cl, -C₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OBF₂, -OCF₃, -OBF₇, -OCF₈, -OCF₂ or -OCF₃;

R₃ is -H, -F, -Cl, -C₃, -C₃ or -OCF₃;

R₄ is -H, -F, -Cl, -CH₃ or cyclopropyl;

R₅ is -H or -C₃; and

R₆ is -H, -F or -C₃.
In some such embodiments, at least one of Y and 2 is N.

£0331 In some embodiments, Y and Z are independently N or C(E²);

X is -H, -F, -Cl, -CH₃, -CH₂CH₃₄, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, cyclopropyi, -GCH₃, -OCh₃, -QCHF₂, -CN or -SCF³;

R¹ is -H, -F, -Cl, -CH₃ or -CF₃;

R² is -H, -F, -Cl, -C³ or -CF₃;

R³ is -H, -F, -Cl, -C³ or -CF₃;

R⁴ is -H, -Cl or -CH₃;

R⁵ is -H or -CH₃; and

R⁶ is -H, -F or -CF³.

£0341 In some such embodiments, at least one of Y and 2 is N.

(035) In some embodiments, X is -H; halo; C₁-C₄ alkyl optionally substituted with 1 to 6 fluoro; cyclopropyi; C₁-C₂ alkoxy optionally substituted with 1 to 3 fluoro; -CN; -NO₂; -N(R')(R); -SR; or -S(0)₂R. In some embodiments, X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃, -CB₂CF₂CF₃₄, -CH(CF₃)₂, cyclopropyi, -OCH₃, -OCF₃, -OCHF₂, -OCFH₂, -CN, -NO₂, -NH(CH₃)₂, -N(CH₃)₂, -N(CH₂)(CH₂CH₃), -SCH₃, -SCH₂CH₃, -SO₂CH₂CH₃ or -S<CF₃v In some embodiments, X is -H, -F, -C₁, -CH₃, -CH₂CH₄, -CH(CH₃)₂, -CF₃, -CHF₃₄, -CH₂F, -C₃CF₃₅, -C₃CF₃₂CF₅, -CH(CF₃)₂, cyclopropyi, -OCH₃, -OCHF₂, -OCHF₂, -CN, -NO₂, -CH(=O)(CH₂CH₃), -SCH₃, -S₂O₂CF₃, or -S<CF₃v In some embodiments, X is -B, -F, -Cl, -CH₃, -CF₃, -CH₂F, -CH₂F, cyclopropyi, -OCH₃, -OCHF₂, -CN or -SCH₃.

£0361 In some embodiments, X is -H.

(037) In some embodiments, X is halo. In some embodiments, X is -F or -Cl.
[038] In some embodiments, X is Cj-Cs alkyl optionally substituted with 1 to 6 fluoro. In some embodiments, X is C1-C4 alkyl optionally substituted with 1 to 6 fluoro. In some embodiments, X is -C34, -C6H5, -CH(C34)2, -CF3, -CHF2, -CH2F, -CF2CF3, -C2CF2CF3, or -CH(CH3)2. In some embodiments, X is CH3, -C6H5, -CH(CH3)2, -CF3, -CHF2 or -C34F.

[039] In some embodiments, X is C3vC< cycloalkyl. In some embodiments, X is cyclopropyl.

[040] In some embodiments, X is CrG< alkyl optionally substituted with 1 to 6 fluoro. In some embodiments, X is C1-C2 alkyl optionally substituted with 1 to 3 fluoro. In some embodiments, X is -Q3C4, -OCF3, -OQIF2 or -OCF4. In some embodiments, X is -Q3C4, -OCF3 or -OCHF2.

[041] In some embodiments, X is -CN.

[042] In some embodiments, X is -NO2.

[043] In some embodiments, X is -N(R7)(R8). In some embodiments, X is -NH(C34), -N(CH3)2 or -N(CH3)(CH2CH3). In some embodiments, X is -N(C6H5)2.

[044] In some embodiments, X is -SR7. In some embodiments, X is -SC34 or -SC6H5CH3. In some embodiments, X is -SCF3.

[045] In some embodiments, X is -S(O)2R9. In some embodiments, X is -SO2CH2CH3 or -SO2CF3. In some embodiments, X is -SO2CH3 or -SO3CF3.

[046] In some embodiments, R< is -H; halo; CV C3 alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; C1-C2 alkoy optionally substituted with 1 to 3 fluoro; -CN; -NO2; -N(R7)(R8); -C(0)GR7; or -C(0)N(R7)(R8). In some embodiments, R< is -H, -F, -Cl, -C34, -C2CH3, -CH(C34)2, -CF3, cyclopropyl, -OCF4, -OCF3, -OCHF2, -OCF2H, -CM, -NO2, -C6H5, -C34CH2CH3, -C(0)N(CH3)2, -C(0)NH(CH3) or -C(0)N(CH3)(CH2CH3). In some embodiments, R< is -11, -F, -Cl, -CH3, -CH2Cl, -CH(CH3)2, -CF2, cyclopropyl, -OC3H3, -OCF3, -OCHF2, -OCF2H, -CN, -NO2, -C2O2CH3, -C02CH2CH3, -C(0)N(CH3) or -C(0)NH(CH3). In some embodiments, R< is -C4F -F, -Cl, -C34 or -CF3.
In some embodiments, \( R^1 \) is -H.

In some embodiments, \( R^1 \) is halo. In some embodiments, \( R^1 \) is -F or -Cl.

In some embodiments, \( R^1 \) is \( C_1-C_4 \) alkyl optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^1 \) is \( \text{-CH}_3, \text{-CH}_2\text{CH}_3, \text{-CH}(\text{CH}_3)_, \text{-CF}_3 \) or \( \text{-CF}_3 \).

In some embodiments, \( R^1 \) is \( C_3-C_6 \) cycloalkyl. In some embodiments, \( R^1 \) is cyclopropyl.

In some embodiments, \( R^1 \) is \( C_1-C_4 \) alkoxy optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^1 \) is \( C_1-C_2 \) alkoxy optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^1 \) is -OCH\(_3\), -OCF\(_3\), -OCH\(_2\)F or -OCF\(_2\)H.

In some embodiments, \( R^1 \) is -CN.

In some embodiments, \( R^1 \) is -NO\(_2\).

In some embodiments, \( R^1 \) is -N(R\(^7\))(R\(^8\)).

In some embodiments, \( R^1 \) is -C(Q)OR\(^7\). In some embodiments, \( R^1 \) is -CO\(_2\)CH\(_3\) or -CO\(_3\)CH\(_2\)CH\(_3\).

In some embodiments, \( R^1 \) is -C(0)N(C\(^4\))\(_2\), -C(0)NH(CH\(_3\)) or -C(0)N(CH\(_2\)\(_3\))(CH\(_3\))\(_2\). In some embodiments, \( R^1 \) is -C(0)N(C\(^4\))\(_2\) or -C(0)NH(CH\(_3\)).

In some embodiments, \( R^2 \) is -H; halo; C1-C4 alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; or C1-C2 alkoxy optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^2 \) is -H, -F, -Cl, -CH\(_3\), -CH\(_2\)CH\(_3\), -CH\(_2\)C\(_3\)\(_4\), -CH\(_2\)(C\(^3\)\(_4\))\(_2\), -CH\(_3\), cyclopropyl, -OCH\(_3\), -OCF\(_3\), -OCHF\(_2\) or -OCF\(_2\). In some embodiments, \( R^2 \) is -H, -F, -Cl, -CH\(_3\) or -CF\(_3\).

In some embodiments, \( R^2 \) is -H.

In some embodiments, \( R^2 \) is halo. In some embodiments, \( R^2 \) is -F or -Cl.
In some embodiments, \( R^2 \) is C\(_1\)–C\(_4\) alkyl optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^2 \) is -CH\(_3\), -CH\(_2\)CH\(_3\), -CH(CH\(_3\))\(_2\) or -CF\(_3\). In some embodiments, \( R^2 \) is -0 \( \frac{3}{4} \) or -CF\(_3\).

**[061]** In some embodiments, \( R^2 \) is cyclopropyl.

In some embodiments, \( R^2 \) is C\(_1\)–C\(_4\) alkoxy optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^2 \) is C-rCs alkoxy optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^2 \) is -OCH\(_3\), -OCF\(_3\), -GCHF\(_2\) or -QCFH\(_2\).

In some embodiments, \( R^3 \) is -IF, -F, -Cl, -0\( \frac{3}{4} \), -CF\(_3\) or -OCH\(_3\). In some embodiments, \( R^3 \) is -H, -F, -Cl, -CH\(_3\) or -CF\(_3\).

**[064]** In some embodiments, \( R^3 \) is -H.

**[065]** In some embodiments, \( R^3 \) is -F or -Cl.

In some embodiments, \( R^3 \) is -C\(_\frac{3}{4}\) or -CF\(_3\).

**[067]** In some embodiments, \( R^3 \) is -OC\(_\frac{3}{4}\).

In some embodiments, \( R^4 \) is -H, -F, -Cl, C\(_1\)–C\(_3\) alkyl optionally substituted with 1 to 3 fluoro; or cyclopropyl. In some embodiments, \( R^4 \) is -H, -F, -Cl, -CH\(_3\) or cyclopropyl. In some embodiments, \( R^4 \) is -H, -Cl or -CH\(_3\).

**[069]** In some embodiments, \( R^4 \) is -H.

**[070]** In some embodiments, \( R^4 \) is -F or -Cl.

In some embodiments, \( R^4 \) is C\(_1\)–C\(_3\) alkyl optionally substituted with 1 to 3 fluoro. In some embodiments, \( R^4 \) is -CH\(_3\).

**[071]** In some embodiments, \( R^4 \) is cyclopropyl.

**[073]** In some embodiments, \( R^5 \) is -H or -C\(_\frac{3}{4}\).

**[074]** In some embodiments, \( R^6 \) is -H.
In some embodiments, $R^4$ is -CF$_3$.

In some embodiments, $R^i$ is -H, -F or -CH$_3$.

In some embodiments, $R^6$ is -H.

In some embodiments, $R^{ii}$ is -F.

In some embodiments, $R^6$ is -CH$_3$.

In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (Ia):

\[
\text{(Ia),}
\]

wherein each of $R^1$, $X$, $R^3$ and $R^2$ is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.

In some embodiments of formula (Ia):

$X$ is -H, -F, -Cl, -CH$_3$, -CH(CF$_3$)$_2$, -CF$_3$, -CFH$_2$, -CH$_2$F, -CF$_2$CF$_3$,

-CH$_2$CF$_2$CF$_3$, -CFH(CF$_3$)$_2$, cyclopropyl, -OCH$_3$, -OCF$_3$, -OCHF$_2$, -OCF$_2$H, -CN, -N$\equiv$O$_2$,

-N(CF$_3$)$_2$, -SCH$_3$, -SO$_2$CF$_3$ or -SO$_2$CF$_2$;

$R^1$ is -H, -F, -Cl, -CH$_2$CH$_3$, -CH(CH$_3$)$_2$, -CF$_3$, cyclopropyl, -OCF$_3$, -OCF$_3$, -OCHF$_2$,

-OCF$_2$H, -CN, -N$\equiv$O$_2$, -CO$_2$CH$_3$, -CO$_2$CH$_2$CH$_3$, -C(0)N(CF$_3$)$_2$ or -C(0)H$_2$CH$_3$;

$R^4$ is -H, -F, -Cl, -C$_2$F$_4$ or cyclopropyl; and

$R^5$ is -H or -C$_2$F$_4$.

In some embodiments of formula (Ia):
X is -a, -F, -Cl, -CH₃, -C₇H₄CHi, -CH(CH₃)₂, -CF₃, -CHF₂, -C₃F₇, cyclopropyl -OCH₃, 
-OCF₃, -OCHF₂, -CN or -SC₃F₇;

R¹ is -H, -F, -Cl, -CH₃; or -CF₃;

R⁴ is -H, -Cl or -ClF; and

R⁵ is -H or -C₃F₇.

[083] In some embodiments of formula (Ia):

X is -CL -OF or -CF₃;

R¹ is -H or -F;

R⁴ is -Cl or -C₃F₇; and

R⁵ is -H.

[084] In some embodiments of formula (Ia):

X is -CL -OF or -CF₃;

R¹ is -H;

R⁴ is -H; and

R⁵ is -C₃F₇.

[085] In some embodiment, a chemical entity of formula (I) is a chemical entity of
formula (Ii):

![Chemical structure](II)
wherein each of R\(^1\), R\(^2\), X and R\(^3\) is as described in embodiments of formula (I), *supra*, or described in embodiments herein, both singly and in combination.

In some embodiments of formula (II):

- X is -H, -F, -Cl, -C\(\text{F}_3\), -C\(\text{F}_2\)C\(\text{F}_3\), -CH\(_2\)CF\(_2\)CF\(_3\), -CH\(_2\)(CF\(_3\))\(_2\), cyclopropyl, -OC\(\text{F}_3\), -OCH\(_2\)F, -OCF\(_2\)H\(_2\), -CN, -N\(\text{O}_2\) or -N\(\text{O}\)C\(\text{H}_3\)\(_2\), -SCH\(_3\), -S\(\text{G}_2\)C\(\text{F}_3\); -S\(_2\)C\(\text{F}_3\); -S\(_0\)C\(\text{F}_3\); -OCH\(_3\). (086)

- R\(^1\) is -H, -F, -Cl, -C\(\text{F}_3\), -C\(\text{F}_2\)C\(\text{F}_3\), -CH\(_2\)C\(\text{F}_3\), -CH\(_3\), cyclopropyl, -OC\(\text{F}_3\), -OCH\(_2\)F, -OCF\(_2\)H\(_2\), -CN, -N\(\text{O}_2\) or -N\(\text{O}\)C\(\text{H}_3\)\(_2\), -SCH\(_3\), -S\(\text{G}_2\)C\(\text{F}_3\); -S\(_2\)C\(\text{F}_3\); -S\(_0\)C\(\text{F}_3\); -OCH\(_3\). (087)

- R\(^2\) is -H, -F, -Cl, -C\(\text{F}_3\), -C\(\text{F}_2\)C\(\text{F}_3\), -CH\(_2\)C\(\text{F}_3\), -CH\(_3\), cyclopropyl, -OC\(\text{F}_3\), -OCH\(_2\)F, -OCF\(_2\)H\(_2\), -CN, -N\(\text{O}_2\) or -N\(\text{O}\)C\(\text{H}_3\)\(_2\), -SCH\(_3\), -S\(\text{G}_2\)C\(\text{F}_3\); -S\(_2\)C\(\text{F}_3\); -S\(_0\)C\(\text{F}_3\); -OCH\(_3\). (088)

In some embodiments of formula (II):

- X is -F, -Cl, -C\(\text{F}_3\), -C\(\text{H}_3\), -CH\(_3\), cyclopropyl, -OC\(\text{F}_3\), -OCH\(_2\)F, -OCF\(_2\)H\(_2\), -CN, -N\(\text{O}_2\) or -N\(\text{O}\)C\(\text{H}_3\)\(_2\), -SCH\(_3\), -S\(\text{G}_2\)C\(\text{F}_3\); -S\(_2\)C\(\text{F}_3\); -S\(_0\)C\(\text{F}_3\); -OCH\(_3\).
0891 $R^3$ is -H, -F, -Cl, or -CH₃. In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (Ha);

![Chemical Structure](Image)

wherein each of $R^1$ and $X$ is as described in embodiments of formula (I), *supra*, or described in embodiments herein, both singly and in combination.

[0901] In some embodiments of formula (Ha):

$X$ is -H, -F, -Cl, -CH₃, -C₃H₃, -CH(CF₃), -CF₃, -CHF₂, -CH₂F, -CF₂CF₃, -CH₂CF₂CF₃, -CH₂CF₂CF₃₂, cyclopropyl, -GCH₃, -OCF₃, -OCHF₂, -OCF₁₃₄, -CN, -NO₂, -N(CH₃)₂, -SCBF₃, -SO₂CH₃ or -SO₂CF₃; and

$R^1$ is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₃, -OCHF₂, -OCF₂CF₃, -CN, -NO₂, -C₃H₃, -C₂H₅ or -C₂H₄C₂F₄, and

[0911] In some embodiments of formula (I!a):

$X$ is -H, -F, -Cl, -C₃H₃, -CH₂C₃H₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, cyclopropyl, -OCH₃, -OCF₃, -SCBF₃, -CM or -SCBF₃; and

$R^1$ is -IF, -F, -Cl, -CH₃ or -C₃H₃.

[092J] In some embodiments of formula (IIa):

$X$ is -H, -F, -Cl, -C₃H₃, -CF₃, -CBF₂, -CH₂F, cyclopropyl, -OCH₃, -OCBF₃, -OCHF₂, -CM or -SCBF₃; and

$R^1$ is -H, -F, -Cl, or -C₃H₃.

[0931] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (III);
wherein each of \( R^5, R^2, X \) and \( R^3 \) is as described in embodiments of formula (I), supra, or described herein, both singly and in combination.

[094] In some embodiments of formula (III):

- \( X \) is \(-H, -F, -Cl, -C\text{I}, -C\text{H}_3, -C\text{H}_2\text{CH}_3, -C\text{H}(C\text{H}_3)_2, -CF_3, -CHF_2, -CH_2F, -CF_2CF_3, -CH_2CF_2CF_3\),
- \( -\text{C}_3\text{H}_2\text{CF}_2\text{CF}_3\) or \( -\text{C}(\text{CF}_3)_2\), cyclopropyl, -OCH_3, -OCHF_3, -OCF_2, -OCHF_2, -CN, -N\text{O}_2, -SC\text{I}^{3/4}, -SO_2\text{CH}_3 \) or \(-SO_2\text{CF}_3\);

- \( R^1 \) is \(-H, -F, -Cl, -CH_3, -CH_2\text{CH}_3, -C\text{H}(C\text{H}_3)_2, -\text{CF}_3, -\text{cyclopropyl}, -\text{OCH}_3, -\text{OCF}_3, -\text{OCHF}_2, -\text{OCF}_2\text{H}_2, -\text{CN}, -\text{NNO}_2, -\text{C}_3\text{H}_2\text{CF}_3, -\text{C}(\text{OCF}_3)\text{H}_3, -\text{C}(\text{C}(\text{OCF}_3)_3)\text{H}_3\) or \(-\text{C}(\text{C}(\text{OCF}_3)_2)\text{CH}_3\);

- \( R^2 \) is \(-\text{Pi}, -F, -\text{Cl}, -C\text{I}, -C\text{H}_3, -C\text{H}_2\text{C}\text{H}_3, -C\text{H}(C\text{H}_3)_2, -\text{CF}_3, -\text{cyclopropyl}, -\text{OCF}_3, -\text{GCF}_3, -\text{OCHF}_2\text{H}_2 \) and

- \( R^3 \) is \(-H, -F, -\text{Cl}, -C\text{I}, -\text{OF}, -\text{or} -\text{GCH}_3\);

[095] In some embodiments of formula (Hi):

- \( X \) is \(-H, -F, -\text{Cl}, -\text{CH}_3, -\text{CH}_2\text{CH}_3, -\text{CH}(\text{CH}_3)_2, -\text{CF}_3, -\text{CHF}_2, -\text{CH}_2\text{F}, -\text{cyclopropyl}, -\text{OCH}_3, -\text{OCHF}_2, -\text{CN}, -\text{SC}\text{I}^{3/4}, -\text{or} -\text{SC}\text{I}^{3/4};\)

- \( R^1 \) is \(-H, -F, -\text{Cl}, -\text{CH}_3 \) or \(-\text{CF}_3;\)

- \( R^3 \) is \(-H, -F, -\text{Cl}, -C\text{I}, -\text{OF} \) or \(-\text{CF}_3;\)

[036] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (IIia):
wherein each of \( R^1 \) and \( X \) is as described in embodiments for formula (I), \textit{supra}, or described in embodiments herein, both singly and in combination.

[0971] \textit{In} some embodiments of formula (IIIa):

\[
X \text{ is } -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, -CHF_2, -C\text{\textsubscript{2}}F_3, \\
-C\text{\textsubscript{2}}CF_3, -CF\text{\textsubscript{3}}_4, -CH(CF_3)_2, \text{ cyclopropyl } -OCH_3, -OCF_3, -OCHF_2, -OCFH_2, -CN, -NO_2, \\
-N(C\text{\textsubscript{3}}H_5)_2, -SCH_3, -SO_2CH_3 \text{ or } -SO_2CF_3; \text{ and}
\]

\[
E^1 \text{ is } -H, -F, -Cl, -C\text{\textsubscript{3}}F_3, -C\text{\textsubscript{4}}\text{\textsubscript{2}}F_4, \text{ cyclopropyl } -OC\text{\textsubscript{3}}H_4, -OCB\text{\textsubscript{4}}F_2, \\
-OCFH_2, -CN, -NO_2, -CO_2CH_4, -CO_2C\text{\textsubscript{3}}F_3, -CO_2CH_3, -C(0)N(C\text{\textsubscript{3}}H_5)_2 \text{ or } -C(0)NH(CH_3).
\]

[0981] \textit{It} some embodiments of formula (IIIa):

\[
X \text{ is } -H, -F, -C\text{\textsubscript{3}}F_3, -C\text{\textsubscript{3}}\text{\textsubscript{4}}F_4, \text{ cyclopropyl } -OCH_3, \\
-OCF_3, -OCHF_2, -CM \text{ or } -SCH_3; \text{ and}
\]

[0991] \( R^1 \) is -H, -F, -Cl, -C\text{\textsubscript{3}}F_3. \textit{In} some embodiments of formula (IIIa):

\[
X \text{ is } -F, -Cl, -CH_3, -C\text{\textsubscript{3}}F_3, -CHF_2, -C\text{\textsubscript{2}}F_2, \text{ cyclopropyl } -OCF_3, -OCHF_2; \text{ and}
\]

\[
R^1 \text{ is } -H \text{ or } -F.
\]

[01003] \textit{In} some embodiments, a chemical entity of formula (!) is a chemical entity of formula (IIIb):

\[
(\text{IIIb}),
\]
wherein each of \( R_1 \) and \( X \) is as described in embodiments for formula (I), *supra*, or described in embodiments herein, both singly and *in combination*.

**[01013] In some embodiments of formula (1Kb),**

\[
X = -H, -F, -Cl, -C\equiv, -CH_2CH_3, -CH(CH_3)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃, -CH₂CS₃CF₃, -CH(CH₃)₂, \text{cyclopropyl}, -OC₃, -OCH₃, -OCHF₂, -OCF₃, -CN, -N₂, -N(CH₃)₂, -SCH₃, -SC₃, -SCF₂; \text{and}
\]

\( R_1 \) is -F, -Cl, -CHs, -CH₂CH₁, -CH(CH₃)₂, -CF₁, cyclopropyl, -OC₃H₃, -O CF₃, -OCF₃, -OCF₂, -OCF₄, -CN, -NO₂, -CO₂CH₃, -CO₂CH₂Cl, -CO₂CH₂CF₃, -CN, -SC₃; \text{and}

**[0102] In some embodiments of formula (10b):**

\[
X = -H, -F, -Cl, -CH₃, -C₃H₄, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -C₃H₄, \text{cyclopropyl}, -OC₃H₄, -OCHF₃, -OCHF₃, -CN or -SC₃; \text{and}
\]

\( R_1 \) is -H, -F, -Cl, -CH₃ or -CF₃.

**[01031] In some embodiments of formula (10b):**

\[
X = -F, -Cl, -C₄H₅, -C₃H₄, -CF₃, -CHF₂, -CH₂F, \text{cyclopropyl}, -OCF₃, -OCF₂; \text{and}
\]

\( R_1 \) is -H or -F.

**[0104] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (IV):**

\[
\text{(IV),}
\]

wherein each of \( R_1 \), \( R_2 \), \( X \) and \( R_3 \) is as described in embodiments of formula (I), *supra*, or described in embodiments herein, both singly and in combination.
In some embodiments of formula (IV):

X is -H, -F, -Cl, -CH₃, -C₃H₄CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃,
-CH₂CF₂CF₃, -CH(CH₂CF₃)₂ cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -N=O₂,
-N(C₃H₄)₂, -SCH₃, -SO₂CH₃ or -SCF₃;

R¹ is -H, -F, -Cl, -CH₃, -CH₂CF₄, -CH(CH₃)₂, -CF₃ cyclopropyl, -OCH₃, -OCF₃, -OCHF₂,
-GCF₄, -CM, -N=O₂, -CO₂CH₃, -CO₂C₃H₃, -C(0)M(CH₃)₂ or -C(0)NH(CH₃);

R² is -F, -F, -Cl, -C₃H₄ -CH₂CH₃, -CH(CH₂CF₃)₂ cyclopropyl, -OCH₃, -OCF₃, -OCHF₂ or
-GCF₄; and

R³ is -H, -F, -Cl, -CH₂, -CF, or -OCF₃.

In some embodiments of formula (IV):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -C₃F₇, cyclopropyl, -GCH₃,
-OCF₃, -OCHF₂-CN or -SCF₃;

R¹ is -H, -F, -Cl, -CB₃ or -CF₄;

R² is -H, -F, -Cl, -CHS or -CF₃; and

R³ is -H, -F, -Cl, -CB₃ or -CF₃.

In some embodiments, a chemical entity of formula (I) is a chemical entity of
formula (IVa);

![Diagram](IVa)

wherein each of R¹ and X is as described in embodiments for formula (I), *supra*, or described
in embodiments herein, both singly and in combination.
[0108] In some embodiments of formula (IVa):

X is -H, -F, -Cl, -CH₃, -C₃H₇, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃,
-CH₂CF₂CF₃, -CH(CF₃)₃, -CHF(F), cyclopropyl, -OCF₃, -OCF₂F, -OCF₂H, -CF₃, -CN, -N₂O,
-N(C₃H₇), -SC₃H₇, -SO₂CH₃ or -SiCF₃; and

R¹ is -H, -F, -Cl, -CH₃, -CH₂CF₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₃, -OCF₂F, -OCF₂H,
-OCF₂H₂, -CN, -N₂O, -H₂C₂H₃, -CO₂CH₃, -CO₂CH₂CH₃, -C(0)N(CH₃)₂ or -C(0)NH(CH₃).

[0109] In some embodiments of formula (IVa):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, cyclopropyl, -OCF₃,
-OCF₂F, -OCF₂H, -CN or -SCH₃; and

E¹ is -H, -F, -Cl, -CF₃ or -CF₃.

[0110] In some embodiments of formula (IVa):

X is -F, -Cl, -C₃H₇, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -C₃F₇, cyclopropyl, -OCF₃, -OCF₂F,
-C₆H₄F₂; and

R¹ is -H or -F.

[0111] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (IVb):

![Chemical Structure](IVb),

wherein each of R¹ and X is as described in embodiments for formula (I), supra, or described in embodiments herein, both singly and in combination.

[0112] In some embodiments of formula (IVb):
X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃, -CH₂CF₂CF₃, -CH(CF₃)₂, cyclopropyl, -OC₃F₄, -OCF₂F₂, -OCHF₂, -CF₂CH₂CF₃, -N(CH₃)₂, -SCF₃, -SO₂CF₂; and

R¹ is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OCF₃, -SCF₃, -CF₂CH₂CF₃, -OCHF₂, -CN, -NO₂, -CO₂CH₃, -CO₂CF₃, -CF₂CF₂CF₃, -C₇H₅, -C₆H₄, -C₅H₃, -C₃H₂, -C₂H₃, -C₁H₂, -C₀H₁, and -CF₃.

R¹ is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OCHF₂, -CF₂CH₂CF₃, -OCHF₂, -CN, -NO₂, -CO₂CH₃, -CO₂CF₃, -CF₂CF₂CF₃, -C₇H₅, -C₆H₄, -C₅H₃, -C₃H₂, -C₂H₃, -C₁H₂, -C₀H₁, and -CF₃.

[0113] In some embodiments of formula (IVb):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OC₃F₄,

-OCF₂F₂, -OCHF₂, -CF₂CH₂CF₃, -N(CH₃)₂, -SCF₃, -SO₂CF₂; and

R¹ is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OCHF₂, -CF₂CH₂CF₃, -OCHF₂, -CN, -NO₂, -CO₂CH₃, -CO₂CF₃, -CF₂CF₂CF₃, -C₇H₅, -C₆H₄, -C₅H₃, -C₃H₂, -C₂H₃, -C₁H₂, -C₀H₁, and -CF₃.

[0114] In some embodiments of formula (IVb):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₂, -OCHF₂, -CF₂CH₂CF₃, -OCHF₂, -CN, -NO₂, -CO₂CH₃, -CO₂CF₃, -CF₂CF₂CF₃, -C₇H₅, -C₆H₄, -C₅H₃, -C₃H₂, -C₂H₃, -C₁H₂, -C₀H₁, and -CF₃.

[0115] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (V):

![Chemical structure](image)

(V),

wherein each of R¹, R², X, R³ and R⁴ is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.

[0116] In some embodiments of formula (V):
\[
X \text{ is } -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, -CHF_2, -CF_2CF_3, \\
-CH_2CF_2CF_3, -CH(CF_3)_2, \text{ cyclopropyl, -OCH}_3, -OCF\text{ }, -OCHF_2, -OCFH_2, -CN, -NO_2, \\
-N(CH_3)_2, -SCF_3, -SOCF_3 \text{ or } -SO_2CF_3;
\]

\[R^1 \text{ is } -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, \text{ cyclopropyl, -OCH}_3, -OCF\text{ }, -OCHF_2, \\
-OCFH_2, -CN, -NO_2, -CO_2CH_3, -CO_2CH_2CH_3, -C(0)N(CH_3)_2 \text{ or } -C(0)NH(CH_3);\]

\[R^2 \text{ is } -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, \text{ cyclopropyl -OCH}_3, -OCF\text{ }, -OCHF_2 \text{ or } \\
-OCFH_2;\]

\[R^3 \text{ is } -IF, -F -Cl, -CHF, -i-\text{CF}_3 \text{ or } -OCH_2, \text{ and }\]

[0117] \[R^4 \text{ is } -H, -F, -Cl, -CH_3 \text{ or cyclopropyl in some embodiments of formula } (V):\]

\[X \text{ is } -H, -C\text{ or } -C\text{; } R^1 \text{ is } -F, -Cl, -CH_3, -CF; \]

[0118] In some embodiments of formula (V):

\[X \text{ is } H, -CH_3 \text{ or -C\text{; } R^1 \text{ is } -IF, -F or -CF}_3; \]

\[R^2 \text{ is } -F; \]

\[R^3 \text{ is } -H \text{ or -CF}_3; \text{ and }\]

\[R^4 \text{ is } -Cl \text{ or -C\text{.}}\]
In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (Va):

![Chemical structure](image)

wherein each of \( R^2 \) and \( X \) is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.

In some embodiments of formula (Va):

\[
\begin{align*}
R^2 \text{ is } & -H, -F, -Cl, -CF_2, -CF_3, -CH(CH_3), -CH(CH_3)_2, -CH_2CH_3, -CH_2CF_3, -CF_2CF_3, -CH_2CF_2CF_3, -CH(CF_3) \text{, cyclopropyl, -OCH_3, -OCHF}_2, -OCF_3, -OCF_2, -OCF_3, -N(CF_3)_2, -SCF_3, -SCF_2CF_3; \text{ and}
\end{align*}
\]

\[
\begin{align*}
X \text{ is } & -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH_2CF_3, -CF_3, -CHF_2, -CH_2F, \text{ cyclopropyl, -OCH_3, -OCHF}_2, -OCF_3, -OCHF_2, -OCF_2, -OCF_H_2. \text{ }
\end{align*}
\]

In some embodiments of formula (Va):

\[
\begin{align*}
X \text{ is } & -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CH_2CF_3, -CF_3, -CHF_2, -CH_2F, \text{ cyclopropyl, -OCH}_3, -OCHF_2, -OCF_3, -OCHF_2, -OCF_3, -CM \text{ or } -SCB_3; \text{ mid}
\end{align*}
\]

\[
\begin{align*}
R^2 \text{ is } & -E, -F, -Cl, -CH_3 \text{ or } -C_3F_7 .
\end{align*}
\]

In some embodiments of formula (Va):

\[
\begin{align*}
X \text{ is } & -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, \text{ cyclopropyl, -OCH}_3, -OCHF_2, -OCF_3, -OCF_2, -SCCH_3; \text{ and}
\end{align*}
\]

\[
\begin{align*}
R^2 \text{ is } & -B, -F \text{ or } -CF_3 .
\end{align*}
\]

In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (VI):
wherein each of R¹, R², X and R₃ is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.

[01253 In some embodiments of formula (VI);

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F₂, -CF₂CF₃, -C₃F₇ CF₃ -CH(CF₃)₂, cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -N₂O₂, -N(SCH₃), -SCH₂ or -SO₂CF₃;

E¹ is -H₁, -F₁, -Cl₁, -C₃F₇, -C₃F₇ -Ce(CF₃)₂, -C₃F₇ cyclopropyl, -OCF₃, -OCF₂H₂, -OCF₂H₃, -CN, -N₂O₂, -C₀₂CH₃, -CO₂C₃F₇ CH₃, -C(0)N(C₃F₇)₂ or -C(0)NH(C₃F₇);

R² is -H₁, -F₁, -Cl₁, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCF₃, -OCH₃ or -OCH₂F;

and

R³ is -H₁, -F₁, -Cl₁, -OCH₂ or -OCF₃.

[0126] In some embodiments of formula (VI);

X is -H₁, -F₁, -Cl₁, -C₃F₇, -C₃F₇ CH₃, -CH(CF₃)₂, -CF₃, -CHF₂, -CH₂F₂, cyclopropyl, -OCH₃ -QCF₃, -OCBF₂, -CN or -SCH₃;

R¹ is -H₁, -F₁, -Cl₁, -CH₃ or -CF₃;

R² is -B₁ -F₁, -Cl₁, -CH₃ or -CF₃; and

R³ is -H₁, -F₁, -Cl₁, -CH₃ or -CF₃.

[0127] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (Via):
wherein each of \( R^2 \) and \( X \) is as described in embodiments for formula (I), supra, or described in embodiments herein, both singly and in combination.

In some embodiments of formula (Ia):

\[
X = -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, -CHF_2, -C\text{CF}_3, -C\text{CF}_3CF_3, -CH(CH_3)_2, \text{cytopropyl}, -OCH_3, -OCF_3, -OCHF_3, -OCF\text{H}2, -CN, -NO_2, -N(\text{CF}_3)_2, -SCH_3, -SO_2CH_3 \text{ or } -SG_2CF_3; \text{ and}
\]

\[
R^2 = -H, -F, -Cl, -C\text{CF}_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, \text{cytopropyl}, -OCH_3, -OCF_3 \text{ or } -SCH_3 \text{ or } -CF_3.
\]

In some embodiments of formula (Ia):

\[
X = -H, -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, \text{cytopropyl}, -OCH_3, -OCF_3, -OCF\text{H}2, -CM \text{ or } -SCH_3; \text{ and}
\]

\[
R^2 = -H, -F, -Cl, -CH_3 \text{ or } -CF_3.
\]

In some embodiments of formula (Ia):

\[
X = -C\text{CF}_3, -CH_2C\text{CF}_3, \text{cyclopropyl}, -OCH_3, -OCF_3 \text{ or } -SCH_3; \text{ and}
\]

\[
R^2 = -H, -F, -Cl, -CH_3 \text{ or } -CF_3.
\]

In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (Ib):

\[
(V\text{Ib}),
\]
wherein each of \( R^2 \) and \( X \) is as described in embodiments for formula (I), supra, or described in embodiments herein, both singly and in combination.

[0132] In some embodiments of formula (VIb):

\[
X = -H, -F, -Cl, -C\equiv, -CH\equivCH_3, -CH(CH_3)_2, -CF_3, -CHF_2, -CH_2F, -CF_2CF_3, -CH_2CS\equivCF_3, -CH(CHF_3)_2, cyclopropyi, -OC\equiv, -OCF_3, -OCHF_2, -OCF_2 or -SC\equivCF_3; \text{ and}
\]

\[
R^2 = -F, -Cl, -CH_3, -CH_2CH_3, -CH(CH_3)_2, -CF_3, cyclopropyi, -OC\equiv, -OCF_3, -OCHF_2 or -SC\equivCF_3.
\]

[0133] In some embodiments of formula (Vlb):

\[
X = -H, -F, -Cl, -CH_3, -C\equiv, -CH\equivCH_3, -CH(CH_3)_2, -CF_3, -CHF_2, -C\equivF, cyclopropyi, -OC\equiv, -GCF_3, -OCHF_3, -CN or -SC\equiv; \text{ and}
\]

\[
R^2 = -H, -F, -Cl, -CH_3 \text{ or } -F_3.
\]

[0134] In some embodiments of formula (Vlb):

\[
X = -CH_3, -CH_2CH_3, -CF_3, cyclopropyi, -OCH_3, -OCF_3 \text{ or } -SCH_3; \text{ and}
\]

\[
R^2 = -H.
\]

[0135] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (VII):

![Chemical Entity](image)

(VII),

wherein each of \( R^1, R^2, X \) and \( R^3 \) is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.
[0136] In some embodiments of formula (VK):

\[ X \text{ is } -H, -F, -Cl, -CH_3, -CH_2\text{-Cl}, -CH_2F, -CF_2, -CF_3, -CH_2CF_2, -CH(CF_3)_2, -CH(F)CF_3, -OCH_3, -OCF_3, -OCHF_2, -OCFHF_2, -CN, -NO_2, -N(CF_3)_2, -SCH_3, -SOCH_3 or -SCF_3; } \]

\[ R^1 \text{ is } -H, -F, -Cl, -CH_3, -CH_2F, -CF_3, \text{ cyclopropyi, -OCH}_3, -OCF_3, -OCHF_2, -OCFHF_2, -CM, -NO_2, -CO_2\text{CH}_5, -CO_2\text{C}_3\text{e}^{34}, -\text{C}(\text{0} )\text{M(CH}_3)_2 \text{ or } -\text{C}(\text{0} )\text{NH(CH}_3)_2; \]

\[ R^2 \text{ is } -F, -C\text{-Cl, -C\text{-Br or -CF; } \text{ and } \text{ cyclopropyi, -OCH}_3, -OCF_3, -OCHF_2 \text{ or } -OCFHF_2; } \]

\[ R^3 \text{ is } -H, -F, -Cl, -CH_3, -CF, \text{ or } -OCF_3; } \]

[0137] In some embodiments of formula (VII):

\[ X \text{ is } -H, -F, -Cl, -CH_3, -CH_2\text{-Cl}, -CH_2F, -CF_3, -CF_2, \text{-C}_4\text{-F, cyclopropyi, -GC}_3, -OCHF_3, -OCHF_2\text{ or } -OCF\text{HF}_2; } \]

\[ R^1 \text{ is } -H, -F, -Cl, -CB\text{ or CF; } \]

\[ R^2 \text{ is } -H, -F, -Cl, -CHS \text{ or CF; and } \]

\[ R^3 \text{ is } -H, -F, -Cl, -CB \text{ or CF. } \]

[0138] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (VIIa):

![Chemical structure](image)

(VIIa),

wherein each of \( R^2 \) and \( X \) is as described in embodiments for formula (I), supra, or described in embodiments herein, both singly and in combination.
In some embodiments of formula (Vila):

\[ X \text{ is } -H, -F, -Cl, -CH_3, -\text{C}_3\text{H}_4 \text{CH}_3, -\text{CH} (\text{C}_3\text{H}_4)_2, -\text{CF}_3, -\text{CHF}_2, -\text{CH}_2\text{F}, -\text{CF}_2\text{CF}_3, \]
\[ -\text{CH}_2\text{CF}_2\text{CF}_3, -\text{CH}(\text{CF}_3)_2 \text{cyclopropyl}, -\text{OCH}_3, -\text{OCF}_3, -\text{OCHF}_2, -\text{OCHF}_2, -\text{CN}, -\text{N}_2, \]
\[ -\text{N}\left( \text{CH}_3 \right)_2, -\text{SC}_3\text{H}_4, -\text{SOCH}_3 \text{or } -\text{SOF}_3 \text{; and} \]
\[ R^2 \text{ is } -H, -F, -Cl, -\text{CH}_3, -\text{CH}_2\text{CH}_3, -\text{CH}(\text{CH}_3)_2, -\text{CF}_3, \text{cyclopropyl}, -\text{QCS}_3, -\text{OCF}_3, -\text{OCHF}_2 \text{ or } -\text{OCF}_2 \text{H}_2. \]

In some embodiments of formula (Vila):

\[ X \text{ is } -\text{H}, -\text{F}, -\text{Cl}, -\text{C}_3\text{H}_4, -\text{CH}_2\text{CH}_3, -\text{CH}(\text{C}_3\text{H}_4)_2, -\text{CF}_3, -\text{CHF}_2, \text{cyclopropyl}, -\text{OC}_3\text{H}_4, \]
\[ -\text{OCF}_3, -\text{OCHF}_2, -\text{CN} \text{ or } -\text{SCH}_3; \text{ and} \]
\[ R^2 \text{ is } -\text{H}, -\text{F}, -\text{Cl}, -\text{C}_3\text{H}_4 \text{ or } -\text{CF}_3. \]

In some embodiments of formula (VIIa):

\[ X \text{ is } -\text{C}_3\text{H}_4, -\text{CH}_2\text{C}_3\text{H}_4, -\text{CF}_3, \text{cyclopropyl}, -\text{OCH}_3, -\text{OCF}_3 \text{ or } -\text{SCH}_3; \text{ and} \]
\[ R^2 \text{ is } -\text{H}. \]

In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (VIIb);

\[
\text{(VIIb),}
\]

wherein each of \( R^2 \) and \( X \) is as described in embodiments for formula (I), supra, or described in embodiments herein, both singly and in combination.

In some embodiments of formula (VIIb),
X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃,
-CH₂CF₂CF₃, -CH(CF₃)₂, cyclopropyl, -OCF₃, -OCHF₂, -OCFH₃, -CM, -NQ₂,
-N(CH₃)₂, -SCF₃, -SO₂CH₃ or -SO₂CF₃; and

R² is -H, -F, -Cl, -C₃H₇, -C₄H₉, -CH(CH₃)₂, -CF₃, cyclopropyl, -OCH₃, -OCF₃, -OCHF₂ or
-OCFH₂.

[0144] In some embodiments of formula (VIIb):

X is -H, -F, -Cl, -C₃H₇, -C₄H₉, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, cyclopropyl, -OCH₃,
-OCF₃, -OCHF₂, -CN or -SCF₃ and

R² is -H, -F, -Cl, -CH₃ or -CF₃.

[0145] In some embodiments of formula (VIb):

X is -CH₃, -C₄H₇, -C₃H₇, -CF₃, cyclopropyl, -OCH₃, -OCF₃ or -SCH₃; and

R² is -H.

[0146] In some embodiments, a chemical entity of formula (I) is a chemical entity of
formula (VIII):

(VIII),

wherein each of R¹, R², X and R³ is as described in embodiments of formula (I), supra, or
described in embodiments herein, both singly and in combination.

[0147] In some embodiments of formula (VIb):
X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CH₂F, -CF₂CF₃,
-CH₃CF₂CF₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CHF, -CF₂CH₃,
-CH₂CH₃, -CF₃, -CHF₂, -CH₂CH₂F, -CF₃, -CH₂CH₂CF₃, -CH₃,
-CH₂CF₂CF₃, -OCF₃, -OCF₂H, -OCF₂, -CF₃, -CHF₂, -N(CH₃)₂,
-SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃, -SCF₃,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
-cyclopropyl, -OCH₃, -OCF₃, -OCHF₂, -OCF₂H₂, -CN, -NO₂,
-N(CH₃)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃, -SCF₂H₂, -CF₃,
-SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂, -CF₃,
-SCF₂H₂, -CF₃, -SCF₃, -N(C₃H₇)₂, -SCF₃, -SCF₂H or -SCF₂H₂,
wherein each of $R^1$ and $X$ is as described in embodiments of formula (I), *supra*, or described in embodiments herein, both singly and in combination.

[0151] In some embodiments of formula (ViOa):

$$X$$ is -H, -F, -Cl, -CH$_3$, -CH$_2$CH$_3$, -CH(CH$_3$)$_2$, -CF$_3$, -CHF$_2$, -C$_2$F$_4$, -CF$_2$CF$_3$, -C$_3$F$_7$, -CF$_2$CF$_3$, -CH(CF$_3$)$_2$, cyclopropyl, -OC$_3$H$_7$, -OCF$_3$, -OFCH$_2$, -OCF$_2$, -CN, -NO$_2$, -N(OH)(CH$_3$)$_2$, -SCH$_3$, -SCH$_2$CH$_3$ or -SG$_3$CF$_3$; and

$$E^1$$ is -H, -F, -Cl, -C$_3$F$_7$, -CF$_3$, -CH$_2$CF$_3$, -CH(CF$_3$)$_2$, -CH(CF$_3$)$_2$, -C$\equiv$CF, -OCHF$_2$, -OCF$_3$, -CF$_2$CF$_3$, -OCF$_2$, -CN, -NO$_2$, -O$_2$CCF$_2$, -O$_2$CF$_3$, -O$_2$CO, -C(0)N(C$_3$)$_2$ or -C(0)CNH(C$_3$)$_2$.

[0152] In some embodiments of formula (Villa):

$$X$$ is -H, -F, -Cl, -CH$_3$, -CH$_2$CH$_3$, -CH(H$_2$CH$_3$)$_2$, -CF$_3$, -CHF$_2$, cyclopropyl, -OC$_3$H$_7$, -OCF$_3$, -OFCH$_2$, -CM or -SCH$_3$; and

$$R^1$$ is -H, -F, -Cl, -CH$_3$, -H or -CF$_3$.

[0153] In some embodiments of formula (VIIIa):

$$X$$ is -H, -F, -Cl, -C$_3$F$_7$, -CF$_3$, -CH$_2$F, cyclopropyl, -OC$_3$F$_3$, -OCF$_3$, -OCBF$_2$, -CN or -SCFS$_3$; and

$$R^1$$ is -H, -F, -Cl or -C$_3$F$_7$.

[0154] In some embodiments, a chemical entity of formula (I) is a chemical entity of formula (IX):
wherein each of X and R⁴ is as described in embodiments of formula (I), supra, or described in embodiments herein, both singly and in combination.

[0155] In some embodiments of formula (IX):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, -CF₂CF₃,
-CH₂CF₂CF₃, -CH(CF₃)₂ cyclopropyl -OCH₃, -OCF₃, -OCF₂H₂, -OCHF₂, -CN, -NO₂,
-N(CH₃)₂, =SCE₃, =SO₂CH₃ or =SO₄CF₃; and

R⁴ is -H, -F, -Cl, -CH₃ or cyclopropyl.

[0156] In some embodiments of formula (IX):

X is -H, -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, -CH₂F, cyclopropyl -OCH₃,
-OCF₃, -OCHF₂, -CN or -SCH₃; and

R⁴ is -H, -Cl or -C₃H₃.

[0157] In some embodiments of formula (IX):

X is -F, -Cl, -CH₃, -CH₂CH₃, -CH(CH₃)₂, -CF₃, -CHF₂, cyclopropyl -OCF₃ or -OCHF₂; and

R⁴ is -H or -(CH₃)₃.

[0158] Exemplary chemical entities of formula I are shown in Tables I.C to I.1.C, below.
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Glutamate (GLU) is a fundamental excitatory neurotransmitter in the mammalian brain and central nervous system (CNS). The effects of this endogenous neurotransmitter are mediated through binding to and activation of GLU to glutamate receptors (GLURs), which are broadly classified into metabotropic G-protein coupled (mGLURs) and ligand gated ion channels or ionotropic GluRs. The ionotropic GLURs are pharmacologically classified into three main types based on the actions of selective receptor agonists; NMDA (N-methyl D-aspartate selective), KA (kainic acid selective) and AMPA (α-aminoo-3-hydroxy-5-methyl -4-isoxazoiepropionic acid) receptors whose structure and pharmacological function has been recently reviewed in detail (S. F. Traynelis et al. Pharmacology Reviews, 2010, 62, 405-496). Electrophysiology studies have demonstrated NMDARs to be cation ion channels that are subject to voltage-dependent channel block by endogenous Mg$^{2+}$. Activation of NMDARs by glutamate in the presence of glycine as a co-agonist results in opening of the receptor ion channel. This in turn allows for the flow of Na$^+$ and Ca$^{2+}$ into the cell generating excitatory postsynaptic potentials (EPSPs) and Ca$^{2+}$ activated second messenger signaling pathways in neurons. By virtue of their permeability to Ca$^{2+}$, activation of NMDA receptors regulates long-term changes in neuronal communication such as learning and memory and synaptic plasticity.

Since the original pharmacological characterization with selective ligands, molecular biology and cloning studies have enabled detailed characterisation of NMDARs at the molecular level (Paoletti et al., 2013, Nat Rev. Neurosci. 14:383-400). Thus, NMDARs are heterotetramers comprised of two NR1 subunits and two NR2 subunits. NR1 subunits contain the binding site for the glycine co-agonist while NR2 subunits contain the binding site for glutamate. The existence of multiple splice variants for NR1 and four isoforms of NR2 (NR2A, NR2B, NR2C and NR2D) from different genes results in a diverse molecular array and of NMDARs. The pharmacological and electrophysiological properties of NMDARs vary depending on the particular NR1 isoform and NR2 subtype composition. Furthermore, the NR2 subtype isoforms are differentially expressed across cell types and
brain regions. Thus, compounds that interact selectivity with NR2 subunits can exert specific pharmacological effects in particular brain regions and have potential to treat CMS diseases with a high degree of specificity and selectivity (e.g. vz side effects). For example the low expression of the NR2B subtype in the cerebellum relative to other brain structures (CuH-Caady et al., 1998, *Neuropharmacol.* 37:1369-1380) indicated lower motor side effects for this subtype.

**01613** NMDA receptor antagonism has been extensively investigated for its potential to treat a variety of CNS diseases including stroke, epilepsy, pain, depression Parkinson's Disease and Alzheimer's disease (Paoletti et al., Nat. Rev. Neurosci 14:383-400; Sancora, 2008, *Nature Rev. Drug Disc*, 7, 426-437). The NMDA receptor offers a number of pharmacological entry points for developing receptor inhibitors. Direct blockers of the NMDAR ion channel pore represent one family of antagonist compounds for which efficacy could be demonstrated in diverse *in vitro* and *in vivo* CNS disease models including, epilepsy, pain and neurodegeneration/stroke. However, compounds from this class, as exemplified by phencyclidine (PCP), MK-886, and ketamine, are generally categorized as unselective across the diversity of NMDA receptor subtypes.

![MK801 (dizocilpine), Ketamine, Phencyclidine (PCP)](image)

**0162** In humans unselective, high-affinity NMDAR antagonists have generally been associated with serious clinical side effects including hallucinations, dysphoria and lack of coordination. Nevertheless, ketamine, an intravenous drug originally approved for use in anesthesia (Haas et al., 1992, *Anesthesia Prog.*, 39, 61-68) has more recently demonstrated clinical efficacy as an antidepressant therapy (Katainen et al., 2013, *Ami. N. Z. J. Psychiatry*, 47, 710-727). The antidepressant action of acute ketamine therapy has an essentially immediate onset compared to approximately six weeks required for standard serotonin reuptake inhibitor (SSRI) drug therapy. Thus, intravenous administration of the drug has shown rapid onset and prolonged
efficacy that can be maintained with continued intermittent administrations (Zarate et al., 2006, Arch. Gen. Psychiatry 63, 856-864). Finally, ketamine has been shown to be effective in cases of depression resistant to standard drug therapies (Murrough et al., 2013, American J. Psychiatry, 170, 1134-1142) including bipolar depression (Zarate et al. 2012, Biol Psychiatry, 71, 939-946). However, as an intravenous drug with serious side effects (Gianni et al 1985, Psychiatric Medicine, 3, 197-217; Curran et al 2000, Addiction, 95, 575-590) and potential chronic toxicity (Hardy et al, 2012, J. Clin. Oncol 30:3611-3617; Hoppers et al., 2011, Pain 152:2173-2178) ketamine therapy is of limited utility and restricted to acute or intermittent administration. To have broader scope of application and utility as a therapy for depression and other CNS diseases, orally active selective HMDA antagonists with reduced side effects are needed that can be administered chronically.

[0163] Ifenprodil, a vasodilator α1-<br>adrenergic antagonist drug, was determined to have a novel allosteric modulator mechanism of action at the NR2B NMDA receptor subtype (Reynolds et al. 1989, Mol. Pharmacol., 36, 758-765). This new mechanism held promise for a new class of NMDA antagonist drugs having therapeutic efficacy without the limiting side effects of subtype unselective ion channel blockers. Following this discovery, NR2B selective antagonist analogs of ifenprodil (Borza et al, 2006, Current Topics in Medicinal Chemistry, 6, 687-695; Layton et al Current Topics in Medicinal Chemistry, 6, 697-709) optimized against the undesirable α1-adrenergic activity included Ro-2.5,6981 (Fischer et al. 1997, J. Pharmacol Exp. Ther., 283, 1285-1292) and CP-101,606 otherwise known as traxoprodil (Cheîard et al, 1995, Journal of Medicinal Chemistry, 38, 3138-3145; Mēnpiü et al 1998, CNS Drug Reviews., 4, 307-322). In a clinical study, CP-101,606 evidenced antidepressant activity in humans after intravenous administration with a favorable dissociative side effect profile relative to unselective NMDA antagonists (Preskom et al 2008, Journal of Clinical Psychopharmacology, 28, 631-637). However, CP-101,606 has suhoptima! pharmacokinetic properties and requires limiting intravenous administration. For CP-101,606 a slow intravenous infusion protocol was required for optimal results in the aforementioned antidepressant clinical study (Preskom et al 2008, Journal of Clinical Psychopharmacology, 28, 631-637).
Other NR2B antagonists which have been described as reviewed by B. Ruppa et al. (K.B. Ruppa et al., Annual Reports in Medicinal Chemistry 2012, 47:89-103) include MK0657 (J.A. McCauley et al, S<sup>rd</sup> Anglo-Swedish Medicinal Chemistry Symposium, Åre, Sweden, Mar. 11-14, 2007; L. Mony et al., British J. of Pharmacology 2009, 157:1301-1317; see also Intl. Appl. Publ. No. WO 2004/108705; U.S. Parent No. 7,592,360) and compounds of formula LX (Intl. Appl. Publ. No. WO 2006/113471), below, including the specific analog LX-1 depicted below.
The difficulties presented by NR2B antagonists having basic amine moieties with regard to overcoming hERG and CYP2D6 safety liabilities while maintaining NR2B in vitro and in vivo potency are well established as noted by Kawai et al. (M. Kawai et al., Bioorganic and Medicinal Chem. Lett. 2007, v17:5533-5536) and Brown et al. (Brown et al., Bioorganic and Medicinal Chem. Lett. 2011, v21:3399-3403). Compound inhibition of hERG channels and associated QT prolongation in the electrocardiograph (ECG) represents a well recognized serious cardiovascular safety risk (Hancox et al., Molecular Pharmacology 2008, 73:1592-1595). QT prolongation can lead to torsades de pointes (TdP) cardiac arrhythmia which can degenerate into ventricular tachycardia and sudden death.

Compound Inhibition of human metabolic cytochrome P-450 enzymes including CYP2D6 represents a risk with regard to human drug safety due to drug-drug interactions (Drug Metabolism Handbook: Concepts and Applications, ed. Ala F. Nassar copyright 2009 Wiley à Sons, Hoboken, NJ). Thus, the clearance of drugs that are substrates of CYP2D6 can be reduced by compounds that inhibit. CYP2D6. The result can be toxic or side effect overload due to accumulation of the given CYP2D6 drug substrate. CNS drugs including antidepressant drugs feature prominently among the established CYP2D6 substrates. Therefore, CYP2D6 inhibition is highly undesirable for an NR2B antagonist as given the common application of comedication or polypharmacy in CNS indications including depression. Examples of cy2D6 substrates include antidepressants from the SSRI class such as fluoxetine, paroxetine, and flixofaxamine, duloxetine, an antidepressants from the SSNI class, numerous antipsychotics including haloperidol, risperidone and aripiprazole, numerous beta-blocker antihypertensives including rataxiprol, propranolol, timolol and alprenolol and the Alzheimer’s disease anticholinesterase inhibitor drug donepezil (Tockhar DA (2007). "Drug Interactions: Cytochrome P450 Drug interaction Table", Indiana University School of Medicine, accessed at <http://medicine.upui.edu/ciinpharm/ddisA/> on May 28, 2014).

MK0657 and closely related analogs (Liverton et al. J. Med. Chem. 2007, v50:807-819) represent an improved generation of NR2B antagonists with respect to human oral bioavailability. However, drug-related systolic as well as diastolic blood pressure elevation cardiovascular side effect for MK0657 after oral dosing have been described in a published
clinical efficacy trial in patients with Parkinson’s Disease (Addy et al., J. Clin. Pharm. 2009, v49:856-864). Similar blood pressure effects were reported to have also been observed after single doses of MK0657 in safety studies with healthy elderly subjects. Compound LX-1 demonstrates oral bioavailability in animals and lacks a phenolic group which can compromise oral bioavailability in humans. However, as noted herein, compound LX-1, which has a basic piperidine nitrogen atom, exhibits human hERG channel inhibition with an IC₅₀ < 10 μM (4.5 μM), and exhibits human CYP2D6 metabolic enzyme inhibition activity (IC₅₀ ~1.0 μM).

[01681] For broad scope of application and safe human use, improved NR2B selective antagonists are needed, as noted in a recent review (K.B. Ruppa et al., Annual Reports in Medicinal Chemistry 2012, 47:89-103). There is a need for NR2B antagonist compounds which are improved in one or more aspects exemplified by pharmacokinetic, absorption, metabolism, excretion (ADME, e.g., oral activity), improved efficacy, off-target activity, improved therapeutic safety Index relative and compatibility with chronic oral therapy.

[01693] Provided chemical entities are antagonists of the NR2B receptor and have technical advantages with regard to one or more pharmaceutical drug properties, such as oral bioavailability, pharmacokinetic parameters, ADME properties (e.g., CYP inhibition), cardiac ion channel (e.g., hERG) activity and other non-NMDA off-target side effect mediating receptors. In some embodiments, the present invention encompasses the discovery that a provided chemical entity can exhibit low human CYP2D6 inhibition and/or low hERG inhibition while exhibiting potent human NR2B receptor inhibition antagonism, and as such is favorable for application in humans.

[0170] In some embodiments, a provided chemical entity has NR2B functional NMDA receptor selectivity versus NR2A (“NR2B selectivity”, determined as the ratio NR2A IC₅₀/ NR2B IC₅₀, in which the IC₅₀ values are measured according to the procedure of Example 2.1) ≥ 300. In some embodiments, a provided chemical entity has NR2B selectivity ≥ 250. In some embodiments, a provided chemical entity has NR2B selectivity ≥ 200. In some embodiments, a provided chemical entity has NR2B selectivity ≥ 150.
chemical entity has NR2B selectivity $\geq 100$. In some embodiments, a provided chemical entity has NR2B selectivity $\geq 50$.

[0171] In some embodiments, a provided chemical entity has hERG activity (determined as hERG IC$_{50}$ measured according to the procedure of Example 2.2) $\geq 5$ µM. In some embodiments, a provided chemical entity has hERG IC$_{50} < 10$ µM. In some embodiments, a provided chemical entity has hERG IC$_{50} \geq 15$ µM. In some embodiments, a provided chemical entity has hERG IC$_{50} \geq 20$ µM. In some embodiments, a provided chemical entity has hERG IC$_{50} > 25$ µM.

[0172] In some embodiments, a provided chemical entity has NR2B functional antagonist activity (determined as NR2B IC$_{50}$ measured according to the procedure of Example 2.1) $\leq 100$ nM and hERG activity (determined as hERG IC$_{50}$ measured according to the procedure of Example 2.2) $\geq 5$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and hERG IC$_{50} \geq 10$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and hERG IC$_{50} \geq 15$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and hERG IC$_{50} \geq 20$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and hERG IC$_{50} \geq 25$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 50$ nM and hERG IC$_{50} \geq 5$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 50$ nM and hERG IC$_{50} \geq 10$ µM.

[0173] In some embodiments, a provided chemical entity has NR2B functional antagonist activity (determined as NR2B IC$_{50}$ measured according to the procedure of Example 2.1) $\leq 100$ nM and CYP2D6 inhibition (measured as CYP2D6 IC$_{50}$ determined according to the procedure of Example 2.3) $\geq 2$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and CYP2D6 IC$_{50} \geq 3$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and CYP2D6 IC$_{50} \geq 4$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and CYP2D6 IC$_{50} \geq 5$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and CYP2D6 IC$_{50}$ of about 5-10 µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 100$ nM and CYP2D6 IC$_{50} \geq 10$ µM. In some embodiments, a provided chemical entity has NR2B IC$_{50} \leq 50$ nM and CYP2D6 IC$_{50} \geq 2$ µM. In some embodiments, a provided chemical entity
has NR2B IC₅₀ ≤ 50 nM and CYP2D6 IC₅₀ ≥ 3 µM. In some embodiments, a provided chemical entity has NR2B IC₅₀ ≤ 50 nM and CYP2D6 IC₅₀ ≥ 4 µM. In some embodiments, a provided chemical entity has NR2B IC₅₀ ≤ 50 nM and CYP2D6 IC₅₀ ≥ 5 µM. In some embodiments, a provided chemical entity has NR2B IC₅₀ ≤ 50 nM and CYP2D6 IC₅₀ of about 5-10 µM. In some embodiments, a provided chemical entity has NR2B IC₅₀ ≤ 50 nM and CYP2D6 IC₅₀ ≥ 16 µM.

Uses, Formulation and Administration, -and Pharmaceutically Acceptable Compositions

In some embodiments, the invention provides a composition comprising a chemical entity of the invention or a pharmaceutically acceptable derivative thereof and a pharmaceutically acceptable carrier, adjuvant or vehicle. The amount of chemical entity in compositions of this invention is such that is effective to measurably inhibit NR2B, in a biological sample or in a patient. In some embodiments, the amount of chemical entity in compositions of this invention is such that is effective to measurably inhibit NR2B, in a biological sample or in a patient. In some embodiments, a composition of this invention is formulated for administration to a patient in need of such composition. In some embodiments, a composition of this invention is formulated for oral administration to a patient.

The term "patient," as used herein, means an animal, preferably a mammal, and most preferably a human.

The term "pharmaceutically acceptable carrier, adjuvant, or vehicle" refers to a non-toxic carrier, adjuvant, or vehicle that does not destroy the pharmacological activity of the chemical entity with which it is formulated. Pharmaceutically acceptable carriers, adjuvants or vehicles that may be used in the compositions of this invention include ion exchangers, alumina, aluminum stearate, lecithin, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycine, sorbic acid, potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulfate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate, polyvinyl pyrrolidone, cellulose-based substances, polyethylene glycol, sodium carboxymethylcellulose, polyacrylates, waxes, polyethylene-polyoxypropylene-bk>ck polymers, polyethylene glycol and wool fat.
A "pharmaceutically acceptable derivative" means any non-toxic ester, salt of an ester or other derivative of a chemical entity of this invention (e.g., a prodrug) that, upon administration to a recipient, is capable of providing, either directly or indirectly, a chemical entity of this invention or an inhibitorily active metabolite or residue thereof.

As used herein, the term "inhibitorily active metabolite or residue thereof" means that a metabolite or residue thereof is also an inhibitor of NR2B.

Compositions of the present invention may be administered orally, parenterally, by inhalation spray, topically, rectally, nasally, buccally, vaginally or via an implanted reservoir. The term "parenteral" as used herein includes subcutaneous, intravenous, intramuscular, intra-articular, intra-synovial, intraserial, intrahepatic, intralesional and intracranial injection or infusion techniques. Preferably, the compositions are administered orally, intraperitoneally or intravenously. Sterile injectable forms of the compositions of this invention may be aqueous or oleaginous suspension. These suspensions may be formulated according to techniques known in the art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenteraiyi acceptable diluent or solvent, for example as a solution in !,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer’s solution and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium.

For this purpose, any bland fixed oil may be employed including synthetic mono- or di-glycerides. Fatty acids, such as oleic acid and its glyceride derivatives are useful in the preparation of mjeetahles, as are natural pharmaceutically-acceptable oils, such as olive oil or castor oil, especially in their polyoxyethylated versions. These oil solutions or suspensions may also contain a long-chain alcohol diluent or dispersaat, such as carboxymethyl cellulose or similar dispersing agents that are commonly used in the formulation of pharmaceutically acceptable dosage forms including emulsions and suspensions. Other commonly used surfactants, such as Tweens, Spans and other emulsifying agents or bioavailability enhancers which are commonly used in the manufacture of pharmaceutically acceptable solid, liquid, or other dosage forms may also be used for the purposes of formulation.
Pharmaceutically acceptable compositions of this invention may be orally administered in orally acceptable dosage form including capsules, tablets, aqueous-suspensions or solutions. In the case of tablets for oral use, carriers commonly used include lactose and corn starch. Lubricating agents, such as magnesium stearate, are also typically added. For oral administration in a capsule form, useful diluents include lactose and dried cornstarch. When aqueous suspensions are required for oral use, the active ingredient is combined with emulsifying and suspending agents. If desired, certain sweetening, flavoring - or coloring agents may also be added.

Alternatively, pharmaceutically acceptable compositions of this invention may be administered in the form of suppositories for rectal administration. These can be prepared by mixing the agent with a suitable non-irritating excipient that is solid at room temperature but liquid at rectal temperature and therefore will melt in the rectum to release the drug. Such materials include cocoa butter, beeswax and polyethylene glycols.

Pharmaceutically acceptable compositions of this invention may also be administered topically, especially when the target of treatment includes areas or organs readily accessible by topical application, including diseases of the eye, the skin, or the lower intestinal tract. Suitable topical formulations are readily prepared for each of these areas or organs.

Topical application for the lower intestinal tract can be effected in a rectal suppository formulation (see above) or in a suitable enema formulation. Topically-transdermal patches may also be used.

For topical applications, provided pharmaceutically acceptable compositions may be formulated in a suitable ointment containing the active component suspended or dissolved in one or more carriers. Carriers for topical administration of compounds of this invention include mineral oil, liquid petrolatum, white petrolatum, propylene glycol, polyoxyethylene, polyoxypropylene compound, emulsifying wax and water. Alternatively, provided pharmaceutically acceptable compositions can be formulated in a suitable lotion or cream containing the active components suspended or dissolved in one or more pharmaceutically acceptable carriers. Suitable carriers include mineral oil, sorbital monostearate, polysorbate 60, cetyl esters wax, cetearyl alcohol, 2-octyldecanol, benzyl alcohol and water.
For ophthalmic use, provided pharmaceutically acceptable compositions may be formulated as micronized suspensions in isotonic, pH adjusted sterile saline, or, preferably, as solutions in isotonic, pH adjusted sterile saline, either with or without a preservative such as benzylalkonium chloride. Alternatively, for ophthalmic uses, the pharmaceutically acceptable compositions may be formulated in an ointment such as petrolatum.

Pharmaceutically acceptable compositions of this invention may also be administered by nasal aerosol or inhalation. Such compositions are prepared according to techniques well-known in the art of pharmaceutical formulation and may be prepared as solutions in saline, employing benzyl alcohol or other suitable preservatives, absorption promoters to enhance bioavailability, fluorocarbons, and/or other conventional solubilizing or dispersing agents.

Most preferably, pharmaceutically acceptable compositions of this invention are formulated for oral administration. Such formulations may be administered with or without food. In some embodiments, pharmaceutically acceptable compositions of this invention are administered without food. In other embodiments, pharmaceutically acceptable compositions of this invention are administered with food.

The amount of compounds of the present invention that may be combined with the carrier materials to produce a composition in a single dosage form will vary depending upon a variety of factors, including the host treated and the particular mode of administration. Preferably, provided compositions should be formulated so that a dosage of between 0.01 - 100 mg/kg body weight/day of the inhibitor can be administered to a patient receiving these compositions.

It should also be understood that a specific dosage and treatment regimen for any particular patient will depend upon a variety of factors, including the activity of the specific compound employed, the age, body weight, general health, sex, diet, time of administration, rate of excretion, drug combination, and the judgment of the treating physician and the severity of the particular disease being treated. The amount of a compound of the present invention in the composition will also depend upon the particular compound in the composition.
Uses of Chemical Entities and Pharmaceutically Acceptable Compositions


[0192] The activity of a chemical entity utilized in this invention as an antagonist of NR2B or a treatment for a disease or disorder of the central nervous system (CNS) may be assayed in vitro or in vivo. An in vivo assessment of the efficacy of the compounds of the invention may be made using an animal model of a disease or disorder of the CNS, e.g., a rodent or primate model. Cell-based assays may be performed using, e.g., a cell line isolated from a tissue that expresses NR2B, or a cell line that recombinantly expresses NR2B. Additionally, biochemical or mechanism-based assays, e.g., measuring cAMP or cGMP levels, Northern blot, RT-PCR, etc., may be performed. hi vitro assays include assays that determine cell morphology, protein expression, and/or the cytotoxicity, enzyme inhibitory activity, and/or the subsequent functional consequences of treatment of cells with chemical entities of the invention. Alternate in vitro assays quantify the ability of the inhibitor to bind to protein or nucleic acid molecules within the cell. Inhibitor binding may be measured by radiolabelling the inhibitor prior to binding, isolating the inhibitor/target molecule complex and determining the amount of radioactivity bound. Alternatively, inhibitor binding may be determined by running a competition experiment where new inhibitors are incubated with purified proteins or nucleic acids bound to known radioligands. Detailed conditions for assaying a compound utilized in this invention as an antagonist of NR2B are set forth in the Examples below. The aforementioned assays are exemplary and not intended to limit the scope of the invention. A person skilled in the art can appreciate that modifications can be made to conventional assays to develop equivalent assays that obtain the same result.
As used herein, the terms "treatment," "treat," and "treating* refer to reversing, alleviating, delaying the onset of, or inhibiting the progress of a disease or disorder, or one or more symptoms thereof, as described herein. In some embodiments, treatment may be administered after one or more symptoms have developed. In other embodiments, treatment may be administered in the absence of symptoms. For example, treatment may be administered to a susceptible individual prior to the onset of symptoms (e.g., in light of a history of symptoms and/or in light of genetic or other susceptibility factors). Treatment may also be continued after symptoms have resolved, for example to prevent or delay their recurrence.

The chemical entities and compositions, according to the method of the present invention, may be administered rising any amount and any route of administration effective for treating or lessening the severity of a CNS disease or disorder.

In some embodiments, the chemical entities and compositions, according to the method of the present invention, may be administered using any amount and any route of administration effective for treating or lessening the severity of a disease or disorder associated with NR2B.

In some embodiments, the chemical entities and compositions, according to the method of the present invention, may be administered using any amount and any route of administration effective for treating or lessening the severity of a CNS disease or disorder.

In some embodiments, the disease or disorder is depression with or without concomitant anxiety disorder, e.g., single-episode and recurrent depressive disorder, dysthymic disorder, major depressive disorder, psychotic depression, premenstrual dysphoric disorder, postpartum depression, seasonal affective disorder (SAD), mood disorder, treatment-resistant depression (TRD, i.e., major depressive disorder that has not responded to other drug therapies), depression caused by a chronic medical condition such as cancer or chronic pain, chemotherapy, chronic stress, and post traumatic stress disorders.

In some embodiments, the disease or disorder is an acute affective disorder, e.g., selected from bipolar disorders including bipolar] and bipolar II manic disorders.
In some embodiments, the present invention provides a method of treating substance abuse disorders, wherein treatment results in decreased tolerance and/or dependence to opioid treatment of pain, and/or by treating withdrawal syndrome of e.g., alcohol, opioids, heroin, and cocaine. As used herein, the term "substance abuse disorders" includes substance dependence or abuse with or without physiological dependence. The substances associated with these disorders include: alcohol, amphetamines (or amphetamine-like substances), caffeine, cannabis, cocaine, hallucinogens, inhalants, marijuana, nicotine, opioids, phencyclidine (or phencyclidine-like compounds), sedative-hypnotics or benzodiazepines, and other (or unknown) substances and combinations of all of the above.

In some embodiments, a substance abuse disorder includes drug withdrawal disorders such as alcohol withdrawal with or without perceptual disturbances; alcohol withdrawal delirium; amphetamine withdrawal; cocaine withdrawal; nicotine withdrawal; opioid withdrawal; sedative, hypnotic or anxiolytic withdrawal with or without perceptual disturbances; sedative, hypnotic or anxiolytic withdrawal delirium; and withdrawal symptoms due to other substances. It will be appreciated that reference to treatment of nicotine withdrawal includes the treatment of symptoms associated with smoking cessation. Other substance abuse disorders include substance-induced anxiety disorder with onset during withdrawal; substance-induced mood disorder with onset during withdrawal; and substance-induced sleep disorder with onset during withdrawal.

In some embodiments, the disease or disorder is pain, e.g., selected from pain states arising from a variety of sources including neuropathic pain (such as post herpetic neuralgia, nerve injury/damage, the "dysias", e.g., vulvodynia, phantom limb pain, root avulsions, painful diabetic neuropathy, compressive mononeuropathy, ischemic neuropathy, painful traumatic mononeuropathy, or painful polyneuropathy), central pain syndromes (potentially caused by virtually any lesion at any level of the nervous system), and postsurgical pain syndromes (e.g., postmastectomy syndrome, postthoracotomy syndrome, stump pain), bone and joint pain (osteoarthritis, rheumatoid arthritis, ankylosing spondylitis), repetitive motion pain, carpal tunnel syndrome, dental pain, cancer pain, myofascial pain (muscular injury, fibromyalgia), perioperative pain (general surgery, gynecological), chronic pain, dysmenorrhea, as well as pain associated with angina, and inflammatory pain of varied
origins (e.g. osteoarthritis, rheumatoid arthritis, rheumatic disease, teno-synovitis and gout), headache, migraine and cluster headache. In some embodiments, the disease or disorder is associated with intractable pain, such as migraine, fibromyalgia, and trigeminal neuralgia.

[0202] In some embodiments, the disease or disorder is selected from sleep disorders and their sequelae including insomnia, narcolepsy and idiopathic hypersomnia.

[0203] In some embodiments, the disease or disorder is selected from CNS disorders characterized by neuronal hyperexcitability, such as epilepsy, convulsions, seizures, partial seizure disorders, generalized seizure disorders such as absence seizures, atonic, myoclonic, ionic, tonk-donic or "grand-mal" seizures, status epileptus, cortical spreading depression, migraine headaches, cerebral palsy, Ohtahara Syndrome, Fragile X Syndrome, pediatric or genetic seizures such as West syndrome, Lennox-Gastaut syndrome and Angieman syndrome, tuberosclerosis, intracranial hypertension, central nervous system edema, neuronal toxicity, such as toxicity induced by alcohol exposure, pathophysiological effects of head trauma, stroke, ischemia, hypoxia and other conditions resulting from or producing ionic imbalances in the central nervous system, or synchronized discharges of neuronal populations.

[0204] In some embodiments, the disease or disorder is characterized by the occurrence of a seizure. Seizures are a result of uncontrolled discharges of electrical activity in the brain. A seizure typically manifests as sudden, involuntary, disruptive, and often destructive sensory, motor, and cognitive phenomena. Seizures are frequently associated with physical harm to the body (e.g., tongue luting, jaw breakage, and burns), a complete loss of consciousness, and incontinence. A typical seizure, for example, might begin as spontaneous shaking of an arm or leg and progress over seconds or minutes to rhythmic movement of the entire body, loss of consciousness, and voiding of urine or stool. There are both convulsive and non-convulsive seizures. Convulsive seizures can be generalized seizures or partial seizures. There are six main types of generalized seizures: tonic-clonk-, tonic, clonic, myoclonic, absence, and atonic seizures. A non-convulsive seizure, for example an absence seizure, presents as a decreased level of consciousness and usually lasts about 10 seconds.
In some embodiments, the disease or disorder is epilepsy. Epilepsy is a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures and by the neurobiologic, cognitive, psychological, and social consequences of this condition. (R. S. Fisher et al., *Epilepsia*, 2005, 46(4):470-472). Epilepsy can be the occurrence of at least one epileptic seizure. An epileptic seizure is a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain. Epilepsy affects people of all ages; however, epilepsy most often occurs in childhood and older adulthood (Institute of Medicine 2012). The exact cause of epilepsy is uncertain. Some known causes of epilepsy include head trauma, stroke, tumors, infection, or abnormalities of the brain.

Epilepsy is categorized as idiopathic (genetic cause) or symptomatic (cause unknown), and is further grouped into either generalized, affecting both hemispheres of the brain, or partial epilepsy; which affects one hemisphere of the brain. Examples of idiopathic generalized epilepsy include childhood absence epilepsy, juvenile myoclonic epilepsy and epilepsy with grand mal seizures. Examples of idiopathic partial epilepsy include benign focal epilepsy of childhood. Symptomatic generalized epilepsy includes West syndrome, Lennox-Gastaut syndrome and others. Symptomatic partial epilepsy includes temporal lobe epilepsy; frontal lobe epilepsy and others.

In some embodiments, the seizure disorder is a pediatric seizure disorder. The ability to categorize a case of a seizure disorder; e.g. epilepsy- into a specific syndrome occurs more of the time with children since the onset of seizures is commonly early. Less serious examples- are. benign rolandic epilepsy, childhood absence epilepsy and juvenile myoclonic epilepsy (A. Neligan et at, *Handbook of clinical neurology* 2012, 107;] 13-33). Other examples of pediatric seizures include febrile seizures, infantile spasms and neonatal seizures.

In some embodiments, the seizure disorder is frontal lobe epilepsy, juvenile myoclonic epilepsy, myoclonic epilepsy, absence epilepsy, Lennox-Gastaut syndrome, Landau-Kleffner syndrome, Dravet syndrome, progressive myoclonus epilepsies, reflex epilepsy, Rasmus-serfs syndrome, temporal lobe epilepsy, limbic epilepsy, status epilepticus, abdominal epilepsy, massive bilateral myoclonus, encephalitis epilepsy, Jacksonian seizure disorder, Lafora disease or photosensitive epilepsy, or a combination of one or more of these.
For most cases of epilepsy, the disease is chronic and requires chronic medications for treatment. Antiepileptic drugs (AEDs) generally suppress neural activity by a variety of mechanisms, including altering the activity of excitatory membrane ion channels and the propensity of action potentials or bursts of action potentials to be generated. These desired therapeutic effects are often accompanied by the undesired side effect of sedation. Other medications have significant non-neurological side effects, such as gingival hyperplasia, a cosmetically undesirable overgrowth of the gums, and/or a thickening of the skull, as occurs with phenytoin. While chronic usage of AEDs has proven to be effective for a majority of patients suffering from epilepsy, the persistent side effects can cause a significant impairment to a patient's quality of life. Furthermore, in spite of the currently available arsenal of old and new AEDs, almost one-third of epileptic patients are non-responsive (e.g. refractory) to all pharmacological regimens. (M.M. Castel-Branco et al., Methods Find Exp Clin Pharmacol 2009, 31(2):101-106). Subsequently, there is a substantial need to develop new and more effective AEDs.

In some embodiments, the seizure disorder is refractory to treatment. Severe syndromes with diffuse brain dysfunction, also referred to as epileptic encephalopathies, are refractory to current treatment. Epileptic encephalopathies constitute a group of disorders in which the epileptic activity itself is considered to contribute to severe cognitive impairment or decline above and beyond what might be expected from the underlying pathology alone. In Further embodiments, the refractory seizure disorder is a disorder associated with neuronal migration, such as human microgyria. (S. Bandyopadhyay et al., Epilepsy Research, 2006, 72; 127-139). Another important disturbance in a subgroup of patients surgically treated for intractable seizures is focal dysplasia of the cerebral cortex. Anticonvulsant drug therapy is often ineffective in patients with such cortical malformations. In some embodiments, the seizure disorder involves cortical hyperexcitability in focal cortical dysplasia (malformations). (S. Bandyopadhyay et al., Epilepsy Research, 2006, 72; 127-139).

In some embodiments, the seizure or epilepsy disorder is caused by a generic abnormality. Genetics is believed to play an important role in epilepsies by a number of mechanisms. Simple and complex modes of inheritance have been identified for some of them. Recent exome and genome sequencing studies have begun to reveal a number of de
novo gene mutations that are responsible for some epileptic encephalopathies, including CHD2 and SYNGAP1 and DMN1, GABBR2, FASN and RYR3. Patients with the epileptic encephalopathy. West syndrome, present distinct clinical electrophysiological features usually manifesting between 3 and 12 months as clusters of infantile spasms (IS) and a characteristic electroencephalogram (EEG) pattern called hypsarrhythmia. West syndrome has been associated with mutations in ARX, CDKL5, STXBP1, and ST3GAL3 as well as various copy number variations (CNVs). (J. R. Lemke et al., Ann Neurol, 2014, 751, 174-157). Mutations in GRIN2A and GRIN2B encoding the NR2A and NR2B of the NMDA receptor are associated with several neurodevelopmental disorders. Mutations in GRIN2A have recently been detected in idiopathic focal epilepsy with Rolandic spikes and related epileptic encephalopathies, that is, in Landau-Kleffner syndrome, epilepsy with continuous spike-and-waves during slow sleep syndrome, and nonsyndromic epilepsy associated with intellectual disability. By contrast, GRIN2B has not been described as an epilepsy gene to date but has repeatedly been considered as a putative candidate gene for seizures, and mutations were detected in patients with ID and schizophrenia. (J. R. Lemke et al. Ann Neurol, 2014, 751, 174-157).

[0212] In some embodiments, the disease or disorder is a movement disorder. Movement disorders include Parkinson's disease, dyskinesias (including the side effects accompanying norma! doses of L-Dopa), tardive dyskinesia, drug-induced parkinsonism, postencephalitic parkinsonism, progressive supranuclear palsy, multiple system atrophy, corticobasal degeneration, parkinsonian-ALS dementia complex, basal ganglia calcification, akinesia, akinetic-rigid syndrome, bradykinesia, dystonia, medication-induced parkinsonian, Gilles de la Tourette syndrome, Hrmington's disease, tremor, chorea, myoclonus, tick disorder and dystonia.

[0213] In some embodiments, the movement disorder is one or more of akinesias and akinetic-rigid syndromes, dyskinesias and medication-induced parkinsonism (such as neuroleptic-induced parkinsonism, neuroleptic malignant syndrome, neuro!eptic-induced acute dystonia, neuroleptic-induced acute akathisia, neuroleptic-induced tardive dyskinesia and medication-induced postural tremor). Examples of "akinetic-rigid syndromes" include Parkinson's disease, drug-induced parkinsonism, postencephalitic parkinsonism, progressive supranuclear
palsy, multiple system atrophy, corticobasal degeneration, parkinsonism-ALS dementia complex and basal ganglia calcification. Examples of dyskinesias include tremor (including rest tremor, postural tremor and intention tremor), chorea (such as Sydenham’s chorea, Huntington’s disease, benign hereditary chorea, neoroacanthoeytosis, symptomatic chorea, drug-induced chorea and hemiballism), myoclonus (including generalized myoclonus and focal myoclonus), tics {including simple tics, complex tics and symptomatic tics}, and dystonia (including generalised dystonia such as iodiopathic dystonia, drug-induced dystonia, symptomatic dystonia and paroxymal dystonia, and focal dystonia such as blepharospasm, otomandibular dystonia* spasmody dysphonia, spasmodic torticollis, axial dystonia, dystonic writer's cramp and hemiplegic dystonia).

[0214] In some embodiments, the disease or disorder is Huntington’s disease.

[0215] In some embodiments, the disease or disorder is cognitive dysfunction associated with disorders including schizophrenia, Alzheimer’s disease, frono-temporal dementia. Pick’s disease, Lewy body disease, and other senile dementias (e.g., vascular dementia).

[0216] In some embodiments, the present invention provides a method of treating a disorder described herein, comprising administering a chemical entity of the invention in conjunction with one or more pharmaceutical agents. Suitable pharmaceutical agents that may be used in combination with the chemical entities of the present invention include selective serotonin reuptake inhibitors (SSRls), e.g., in the treatment of depression; dopamine replacement therapy regimens and dopamine agonists, e.g., in the treatment of Parkinson’s disease; typical antipsychotics; atypical antipsychotics: anticonvulsants; stimulants; Alzheimer’s disease therapies; anti-migraine agents; and anxiolytic-agents.

[0217] Suitable SSRls include citalopram, dapoxetine, escitalopram, fluoxetine, fluvoxamine, indalpine, paroxetine, sertraline, vilazodone and zimelidine.

[0218] Suitable dopamine replacement therapy regimens include replacement of L-D0 PA with a DOPA decarboxylase inhibitor such as carbidopa.
Suitable dopamine receptor agonists include aplmdore, apomorphine, bromocriptine, cabergoline, ciladopa, dihydroergocryptine, lisuride, pardoprunox, pergolide, piribedil, pramipexole, ropinirole and rotigotkse.

Suitable typical antipsychotics include chiorproniazine, thioridazine, mesoridazine, fevomeptomazine, loxapine, molindone, perphenazine, thiothixene, trifluoperazine, haloperidol, fluphenazine, droperidol, zuclopenthixol, flupentixol and prochlorperazine.

Suitable atypical antipsychotics include amisulpiride, aripiprazole, asenapine, blonanserin, clozapine, clozapine, ioperidone, llurasidone, mosapramine, olanzapine, paliperidone, perospirone, quetiapine, risperidone, serdinolpe, sulpiride, ziprasidone, zotepine, bifeprutux, pemisavenserin ant! vabicaserin.

Suitable anticonvulsants include phenytoin, carbamazepine, barbiturates, phenobarbital, phenobarbital, mephobarbital, trimethadione, mephenytoin, paramethadione, phenthenylate, phenaemldde, raetherbital, benzchoiropamide, phensuximide, primidone, methsuximide, ettiotoin, ammoglutetnufide, diazepam, clonazepam, clorazepate, fosphenytoin, ethosuxiffilde, valproate, felbamate, gabapentin, lamotrigine, topiramaie, vigrbatrin, tiagabiae, ziandmide, clobazam, thiopental, midazolam, propofol, l'etetiracetam, oxcarbazepme, CCPene, and GYKI 52466.

Suitable stimulants include Adderall (ampheamine, dextroamphetamine mixed salts), methylphenidate, dextroamphetamine, dexamethyphenidate and lisdexamfetamine.

Suitable Alzheimer's disease therapies include acetycholinesterase inhibitors such as rivasiigmne, donepezil, galanihamine and ḱuprażine; alpha-? nicotinic agonists such as ence.ni.clme; and drugs that reduce Aβ42 such as BACE inhibitors, gamma secretase modulators and beta amyloid peptide antibodies.

Suitable anti-migraine drugs include ergotamine and 5-HT1D agonist triptans such as sumiihipian.

Suitable anxiolytic drugs include benzodiazepine receptor modulators such as diazepam, alprazolam, lorazepam and clonazepam.
Other suitable agents for use in conjunction with a chemical entity of the invention include memantine and modafinil.

The exact amount required will vary from subject to subject, depending on the species, age, and general condition of the subject, the severity of the infection, the particular agent, its mode of administration, and the like. The chemical entities of the invention are preferably formulated in dosage unit form for ease of administration and uniformity of dosage. The expression "dosage unit form" as used herein refers to a physically discrete unit of agent appropriate for the patient to be treated. It will be understood, however, that the total daily usage of the chemical entities and compositions of the present invention will be decided by the attending physician within the scope of sound medical judgment. The specific effective dose level for any particular patient or organism will depend upon a variety of factors including the disorder being treated and the severity of the disorder; the activity of the specific chemical entity employed; the specific composition employed; the age, body weight, general health, sex and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific chemical entity employed; the duration of the treatment; drugs used in combination or coincidental with the specific chemical entity employed, and like factors well known in the medical arts. The term "patient", as used herein, means an animal, preferably a mammal, and most preferably a human.

The pharmaceutically acceptable compositions of this invention can be administered to humans and other animals orally, rectally, parenterally, intraesiternally, intravaginally, intraperitoneally, topically (as by powders, ointments, or drops), buccally, as an oral or nasal spray, or the like, depending on the severity of the infection being treated. In certain embodiments, the chemical entities of the invention may be administered orally or parenterally at dosage levels of about 0.01 mg/kg to about 50 mg/kg and preferably from about 1 mg/kg to about 25 mg/kg, of subject body weight per day, one or more times a clay, to obtain the desired therapeutic effect.

Liquid dosage forms for oral administration include pharmaceutically acceptable emulsions, microemulsions, solutions, suspensions, syrups and elixirs. In addition to the active compounds, the liquid dosage forms may contain inert diluents commonly used in the
art such as water or other solvents, solubilizing agents and emulsifiers such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol 1,3-butylene glycol, diniethylfbrmaniide, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor, and sesame oils), glycerol tetrahydrofurfuryl alcohol, polyethylene glycols and fatty add esters of sorbiiart, and mixtures thereof. Besides inert diluents, the oral compositions can also include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, and perfuming agents.

[0231] Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution, suspension or emulsion in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-bitanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, U.S.P. and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides, in addition, fatty acids such as oleic acid are used in the preparation of injectables.

[0232] The injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter, or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium prior to use.

[0233] In order to prolong the effect of a chemical entity of the present invention, it is often desirable to slow the absorption of the chemical entity from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the chemical entity then depends upon its rate of dissolution that, in turn, may depend upon crystal size and Crystalline form. Alternatively, delayed absorption of a parenterally administered chemical entity form is accomplished by dissolving or suspending the chemical entity in an oil vehicle. Injectable depot forms are made by forming microencapsule matrices of the chemical entity...
in biodegradable polymers such as polylaetide-polyglycolide. Depending upon the ratio of chemical entity to polymer and the nature of the particular polymer employed, the rate of chemical entity release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are also prepared by entrapping the chemical entity in liposomes or microemulsions that are compatible with body tissues.

Corapositories for rectal or vagmal administration are preferably suppositories which can be prepared by mixing the chemical entities of this invention with suitable non-irritating excipients or carriers such as cocoa butter, polyethylene glycol or a suppository wax which are solid at ambient temperature but liquid at body temperature and therefore melt in the rectum or vaginal cavity and release the active chemical entity.

Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active chemical entity is mixed with at least one inert, pharmaceutically acceptable carrier such as sodium citrate or dicalcium phosphate and/or a) fillers or extenders such as starches, lactose, sucrose, glucose, mannitol, and silicic acid, b) binders such as carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidine, sucrose, and acacia, c) humectants such as glycerol, d) disintegrating agents such as agar-agar, calcium carbonate, potato or tapioca starch, alginate acid, certain silicates, and sodium carbonate, e) solution retarding agents such as paraffin, f) absorption accelerators such as quaternary ammonium compounds, g) wetting agents such as cetyl alcohol and glycerol monostearate, h) absorbents such as kaolin and bentonite clay, and i) lubricants such as talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate, and mixtures thereof. In the case of capsules, tablets and pills, the dosage form 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 sugar as well as high molecular weight polyethylene glycols and the like. The solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings and other coatings well known in the pharmaceutical formulating art. They may
optionally contain opacifying agents and can also be of a composition that they release the active ingredients) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions that can be used include polymeric substances and waxes. Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules us.bg such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like.

[0237] The active chemical entities can also be in micro-encapsulated form with one or more excipients as noted above. The solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings, release controlling coatings and other coatings well known in the pharmaceutical formulating art. In such solid dosage forms the active chemical entity may be admixed with at least one inert diluent such as sucrose, lactose or starch. Such dosage forms may also comprise, as is normal practice, additional substances other than inert diluents, e.g., tableting lubricants and other tableting aids such as magnesium stearate and microcrystalline cellulose. In the case of capsules, tablets and pills, the dosage forms may also comprise buffering agents. They may optionally contain opacifying agents and can also be of a composition that they release the active ingredients(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions that can be used include polymeric substances and waxes.

[0238] Dosage forms for topical or transdermal administration of a chemical entity of the invention include ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants or patches. The active chemical entity is admixed under sterile conditions with a pharmaceutically acceptable carrier and any needed preservatives or buffers as may be required. Ophthalmic formulation, ear drops, and eye drops are also contemplated as being within the scope of the invention. Additionally, the present invention contemplates the use of transdermal patches, which have the added advantage of providing controlled delivery of a chemical entity to the body. Such dosage forms can be made by dissolving or dispensing the chemical entity in the proper medium. Absorption enhancers can also be used to increase the flux of the chemical entity across the skin. The rate can be controlled by either providing a rate controlling membrane or by dispersing the chemical entity in a polymer matrix or gel.
As used herein, the term "combination," "combined," and related terms refers to the simultaneous or sequential administration of therapeutic agents in accordance with this invention. For example, a chemical entity of the present invention may be administered with another therapeutic agent simultaneously or sequentially in separate unit dosage forms or together in a single unit dosage form. Accordingly, the present invention provides a single unit dosage form comprising a chemical entity of formula I and an additional therapeutic agent, and a pharmaceutically acceptable carrier, adjuvant, or vehicle.

The amount of both, a provided chemical entity and additional therapeutic agent (in those compositions which comprise an additional therapeutic agent as described above), that may be combined with the earlier materials to produce a single dosage form will vary depending upon the host treated and the particular modes of administration. Preferably, compositions of this invention should be formulated so that a dosage of between 0.01 - 100 mg/kg body weight/day of a provided chemical entity can be administered.

In those compositions which comprise an additional therapeutic agent, that additional therapeutic agent and the chemical entity of this invention may act synergistically. Therefore, the amount of additional therapeutic agent in such compositions will be less than that required in a monotherapy utilizing only that therapeutic agent. In such compositions a dosage of between 0.01 ~ 100 μg/kg body weight/day of the additional therapeutic agent can be administered.

The amount of additional therapeutic agent present in the compositions of this invention will be no more than the amount that would normally be administered in a composition comprising that therapeutic agent as the only active agent. Preferably the amount of additional therapeutic agent in the presently disclosed compositions will range from about 50% to 100% of the amount normally present in a composition comprising that agent as the only therapeutically active agent.

In some embodiments, the present invention provides a medicament comprising at least one chemical entity of formula I and a pharmaceutically acceptable carrier, adjuvant or vehicle.
In some embodiments, the present invention provides the use of a chemical entity of formula I in the manufacture of a medicament for the treatment of a CNS disease or disorder.

General synthetic methods

Chemical entities of formula I can be synthesized according to Scheme 1 or Scheme 2 and/or using methods known in the art.

Scheme 1

a. base (e.g. diisopropylethylamine), organic solvent (e.g. dichloromethane), heat b. optional functional group conversion(s) c. removal of J when it is a protecting group (e.g. 50% NaOH/THF heat for J = tosyl)

In the method depicted in Scheme 1, in a first step, compounds of formula XI may be prepared by piperidine nitrogen alkylation of intermediates of general formula X, wherein J is hydrogen or a suitable protecting group (e.g. tosyl = Ts) and R¹, R² and R³ are as defined above, with intermediates of general formula XI wherein X', R¹', R²' and R³' are as defined above for X, R¹, R² and R³, or are independently suitably masked equivalents thereof. The leaving group (LG) in alkylation intermediates of general formula XI represents an anionic leaving group such as halogen (chlorine, bromine or iodine) or a sulfonate group such as mesylate, tosylate, inflate (OSO₂CF₃) or nonaflate (OSO₂CF₂CF₂CF₂CF₃). The alkylation
reaction can be conducted in suitable protic (e.g. isopropanol, tvbutanol) or aprotic (e.g. CH₂Cl₂, DMF, DMSO, CH₃CN) solvents at temperatures from ambient to 160 °C, preferably between 50 °C and 130 °C in the presence of a suitable base (e.g. triethylamine, diisopropylethylamine). In the case where intermediates of formula X have J = H and X', R¹', R²' and R³' in the intermediates of formula XI are as defined above for X, R¹, R² and R³, the alkylation products of formula XII are compounds of formula I. Alternatively in an optional step or steps, compounds of formula XII containing one or more X', R¹', R²' or R³' substituents as suitably masked groups can be converted using methods known in the art to yield compounds of formula XIII wherein X, R¹, R² and R³ are as defined above (e.g. for a compound of formula XII in which X' = N<sub>3</sub>, a hydrogenation step yields a compound of formula XIII in which X = N<sub>3</sub>). Intermediates of formula XIII in which J is a protecting group can be converted to compounds of formula I using methods known in the art (e.g. 50% NaOH/THF heat for J = tosyl).

[024] An alternate method to synthesizing compounds of formula I is depicted in Scheme 2.
Scheme 2

XX
\[ Y = N \text{ or } CR^2 \]
\[ Z = N \text{ or } CR^2 \]

XXI
\[ \text{LG} = \text{Cl, Br} \]
\[ J = \text{H or a protecting group e.g. Ts} \]

XXII

I

a. base or Buchwald reaction mediated amine coupling reaction conditions  
b. optional steps e.g. functional group conversions and removal of J protecting group  
c. base \( R' \text{LG} \)  
d. removal of J protecting group

[0248] In a first step, base or Buchwald reaction mediated coupling of intermediates of formula XX, wherein \( X', R^{1'}, R^{2'} \) and \( R^{3'} \) in the intermediates of formula XI are as defined above for \( X, R^{1}, R^{2} \) and \( R^{3} \), or are independently suitably masked equivalents thereof, with pyrazolopyrimidine intermediates of formula XXI wherein \( J \) is hydrogen or a suitable protecting group, \( R^{4} \) is as defined above and \( \text{LG} \) is suitable leaving group, yields compounds of formula XXII. In certain cases base mediated coupling is suitable and can be conducted in an organic solvent (e.g. NMP, DMF, DMSO, C\( \equiv \)CN) at temperatures from 50 °C to 180 °C, preferably between 70 °C and 120 °C in the presence of a suitable tertiary amine base (e.g. Methyl amine, diisopropylethylamine). In certain cases Buchwald conditions using a palladium catalyst can be used for the coupling reaction. To prepare intermediates of formula XIII in which \( R^{5} \) is methyl, compounds of formula XXII can be treated with a suitable base (e.g. NaH) in a suitable profile organic solvent (e.g. DMF) followed by the addition of a methylating reagent (e.g. methyl iodide or dimethyl sulfate) at a suitable temperature. Intermediates of formula XIII in which \( J \) is a protecting group can be converted
to compounds of formula I using methods known in the art (e.g. 50% NaOH/THF heat for J = tosyl).

Intermediates of general formula XI wherein $X^1$, $R^1'$, $R^2'$ and $R^3'$ are as defined above for $X$, $R^1$, $R^2$ and $R^3$, or are independently suitably masked equivalents thereof, can be synthesized according to Scheme 3 and/or using methods known in the art.

Scheme 3

XXXI

L = Cl or Br
$Y = N$ or $CR^2$
$Z = N$ or $CR^2$

XXXI

XXXII

XXXIII

XXXIV

XI

a. Cu, DMSO 80°C  b. NaBH₄, EthOH 0°C c. $\text{Et}_2\text{O}$, DIPEA 0°C

Starting material compounds of ibruSa XXXI can be purchased, or synthesized using methods known in the art e.g. by Sandmeyer reaction. Copper mediated coupling of compounds of formula XXXI with ethyl 2,2-difluoro-2-iodoacetate at elevated temperature in dry DMSO yields intermediates of general formula XXXII. Subsequent ester group reduction under appropriate conditions e.g. using sodium borohydride in ethane! yields corresponding alcohols of general formula XXXIII. The alcohol group in compounds of general formula XXXIII can be converted to a suitable leaving group e.g. iodide or tritluoromethanesulfonate using methods known in the art. For example treatment with triflic anhydride in ether solvent with $N_2N$-diisopropylethyl amine at 0°C can be used to prepare...
trifluoromethanesulfonates of formula XI (Y ≈ OSO\(\text{CF}_3\)). Alkylation of 4-Boc amino piperidines of formula XXXIV with intermediates of formula XI yields compounds of formula XX. The alkylation reaction can be conducted in suitable aprotic (e.g. \(\text{CH}_2\text{Cl}_2\), DMF, DMSO, \(\text{C}_6\text{CN}\)) solvents at temperatures -from \(-10 \degree\text{C}\) to \(100 \degree\text{C}\) (preferably from \(0 \degree\text{C}\) to \(80 \degree\text{C}\)) in the presence of a suitable base (e.g. triethylamine, diisopropylethylamine).

**0251** Intermediates of general formula X can be synthesized according to Scheme 4 and/or using methods known in the art.

**Scheme 4**

\[
\begin{array}{c}
\begin{array}{c}
L \quad \text{+} \quad \text{XXI} \quad \xrightarrow{\text{a}} \quad \text{LI} \\
\text{J} = \text{H} \text{or a protecting group eg Ts}
\end{array}
\end{array}
\]

a, base or Buchwald reaction mediated amine coupling reaction conditions  b, optional introduction of \(R^5\) group using alkylation conditions e.g. base, \(R^5\text{I}\) c, Boc removal e.g. with \(2N \text{ HCl} / \text{MeOH}\)

[0252] In a first step, starting 4-amino-N-t-biioxycarbonyl protected piperidines of formula L can be coupled with intermediates of formula XXI under base or Buchwald reaction conditions to give intermediates of general formula LI. In an optional second step when \(J\) is a protecting group (e.g. Ts), an \(R^5\) group can be introduced by alkylation reaction to give intermediates of general formula LII in which \(R^5\) is methyl. In the final step the Boc
protecting group can be removed by under standard acidic conditions or alternative methods known in the art to give intermediates of general formula X.

[0253] Intermediates of general formula XXI can be synthesized according to Scheme 5 and/or using methods known in the art.

Scheme 5

\[
\begin{array}{ccc}
\text{Cl} & \text{Hal} & \text{R}^4 \\
\text{N} & \text{N} & \\
\end{array}
\]

LIV

\[
\begin{array}{ccc}
\text{Hal} = \text{Cl, Br, I} \\
\text{J} = \text{H or protecting group e.g. trityl} \\
\end{array}
\]

a. NCS, NBS or NIS, ether  
b. optional protection e.g. with base/triyl chloride  
c. optional Bu'i exchange and alkylation reaction or Suzuki coupling reaction  
d. optional function group conversion of R^4 or J group deprotection

[0254] In a first step 4-chloro-2H-pyrrolo[2,3-d]pyrimidine can be halogenated using an N-halosuccinimide to give corresponding intermediates with R^4 as chloro, bromo or iodo. These intermediates may be then protected e.g. with J = trityl. To prepare analogs where R^4 can be introduced by nucleophilic displacement (e.g. when R^4 is methyl), bromo intermediates can be metallated with Bul-i followed by treatment with a suitable alkylating agent, e.g. methyiiodide or fluorinating agent, e.g. Selectfluor® (1-chloromethyl-4-fluro-1,4-diazoniabiclyco[2.2.2]octane bisitetratfluoroborate)). To prepare analogs where R^4 can be introduced by palladium mediated coupling reactions e.g. Suzuki reaction (e.g. when R^4 is cyclopropyl)., bromo or iodo intermediates can be subject to coupling with a suitable intermediate, e.g. an alkylboric acid. For example, intermediates of formula XXI wherein R^4 is cyclopropyl and J is a trityl protecting group can be prepared according to Intl. Patent Appl. Ptb. No. WO 2010/015637.
EXAMPLES

£0255] As depicted in the Examples below, in certain exemplary embodiments, chemical entities are prepared according to the following procedures. It will be appreciated that, although the general methods depict the synthesis of certain chemical entities of the present invention, the following methods, and other methods known to persons skilled in the art, can be applied to all chemical entities and subclasses and species of each of these chemical entities, as described herein.

{0256} Temperatures are given in degrees centigrade. If not mentioned otherwise, all evaporations are performed under reduced pressure, preferably between 15 mm Hg and 100 mm Hg. The structures of intermediates and final products are confirmed by standard analytical methods, for example, mass spectrometry and NMR spectroscopy.

[0257] Abbreviations;

aq         aqueous
BOc         t-butoxycarbonyl
Cbz         benzyloxycarbonyl
DA.ST       diethyl amino sulfur trifluoride
DCM         dichloromethane
DCE         1,2-dichloroethane
PIPEA       N,N-diisopropylethylamine
DMF         N,N-dimethylformamide
DMSO        dimethyl sulfoxide
EtjO        diethyl ether ("ether")
EtOAc       ethyl acetate
EtQH        ethanol
eq          equivalents
h           hours
HPLC        high performance liquid chromatography
LC          liquid chromatography
Me          methyl
Example 1. Chemical Entities.

Example 1.A. intermediates.

Example 1.A.1. intermediate 1: N-(piperidin-4-y l)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidine-2,3-di-pyrimidin-4-

amine

Step 1. 4-chloro-7-tosyl-7H-pyrrolo[2,3-d]pyrimidine

[0258] A mixture of 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (10.0 g, 65 mmol), TsCl (13.7 g, 72

mmol) and NaOH (40 ml, 2N) in acetone (100 mL) was stirred at room temperature

overnight. The resulting solid was collected by filtration and washed with acetone and then

with water to give the title compound as a white solid (16 g, 80%). ^1H NMR (400 MHz,
Step 2, tert-butyl 4-(7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-yl amino)piperidine-1-carboxylate

[CDC13] δ 8.7? (s, 1H), 8.09 (d, J=8.0 Hz, 2H), 7.77 (d, J=4.0 Hz, 1H), 7.33 (4, J=8.03 Hz, 2H), 6.70 (d, J=4.0 Hz, 2H), 2.40 (s, 3H).

Step 3, N-(piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine

[0259] A mixture of 4-chloro-7-tosyl-7H-pyrrolo[2,3-d]pyrrole-dipyrrolidile (10.0 g, 32 mmol), tert-butyl 4-aminopiperidine-carboxylate (6.4 g, 32 mmol) and DIP.EA (1.0 mL) in NMP (100 mL) was heated under reflux overnight. The mixture was filtered. The solid was then washed with ethyl acetate and dried to afford the title product as a white solid (10 g, 67%).

[0260] To a mixture of tert-butyl 4-(7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-yl amino)-piperidine-1-carboxylate (10.0 g, 21 mmol) in MeOH (100 mL) was added HCl/MeOH (50 mL, 2N, 100 mmol). The resulting solution was stilled at room temperature overnight and then evaporated to dryness. The residue was then dissolved in DCM and washed with sat. NaHCO3, water, brine, dried and filtered. The filtrate was concentrated to afford the title product as a white solid (7.4 g, 95%). MS (ESI) calcd for C18H4N2O2S: 371.1; found: 372.3 [M+H]. H NMR (400 MHz, CDCl3) δ 8.45 (s, 1H), 8.08 (d, J=8.0 Hz, 2H), 7.48 (d, J=4.0 Hz, 1H), 7.31 (d, J=8.0 Hz, 2H), 1.18 (t, J=8.0 Hz, 6H), 1.32-1.36 (m, 2H).
J=5.0 Hz, 2H), 6.43 -a. J=4.0 Hz, 1H. 4.87-4.92 (m, 1H), 4.16-4.23 (m, 1H), 3.12-3.15 (m, 2H), 2.76-2.82 (m, 2H), 2.40 (s, 3H), 2.07-2.12 (m, 2H), 1.40-1.44 (m, 2H).

**Example 1.1.** N-(1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-anine (C-1).

![Chemical Structure](image)

**Step 1.** Ethyl 2,2-difluoro-2-(pyridin-2-yl)acetate

[0261] To a stirred solution of 2-bromopyridine (1.0 g, 6.3 mmol) arid ethyl 2-bromo-2,2-difluoroacetate (1.2 mL, 1.5 mmol) in DMSO (10 mL) was added copper powder (800 mg, 13 mmol). The mixture was heated to 90 °C, and stirred overnight. The mixture was poured into water, and stirred for additional 1 h at room temperature. The final suspension was filtered through a pad of celite, and the filter mass was washed with EtOAc. The combined organic phases were washed with water and brine, dried over Na₂SO₄ and concentrated in vacuo to afford the crude product as a yellow oil (1.1 g, 86%) which was directly used for reduction in the next step.

**Step 2.** 2,2-difluoro-2-(pyridin-2-yl)ethanol

[8262] To a stirred solution of ethyl 2,2-difluoroO-(pyridin-2-yl)acetate (1.1 g, 59 mmol) in ethanol (25 mL) was added the NaBH₄ (330 mg, 8.7 mmol) at room temperature. After
stirring for 30 min, the mixture was quenched with aqueous 1M HQ under ice-water bath cooling. The mixture was basified with aqueous 1M NaOH, and extracted with EiOAc. The combined EiOAc phases were washed with brine, dried over Na₂SO₄ and concentrated in vacuo. The crude product was purified by column chromatography over silica gel (hexane/EiOAc =2/1) to afford the title compound as a white solid (520 mg, 60%). ¹H NMR (400 MHz, CDCl₃) δ 8.61 (d, J = 4.7 Hz, 1H), 7.88 (id, J = 7.8, 1.7 Hz, 1H), 7.73 (d, J = 7.8 Hz, 1H), 7.43 (dd, J = 7.2 and 4.7 Hz, 1H), 4.26 (dt, J = 7.0 and 4.7 Hz, 2H), 3.50 (t, J = 7.0 Hz, 1H).

Step 3, 2,2-diﬂuoro-2-(pyrRin-2-yl)ethy1trifluoromethanesulphonate

To a stirred solution of 2,2-diﬂuoro-2-(pyridin-2-yl)ethanol (220 mg, 1.25 mmol) and DIPEA (0.35 mL, 1.88 mmol) in ether (10 mL) was added Tf₂O (0.25 mL, 1.50 mmol) dropwise at 0 °C under N₂ atmosphere. The pink suspension thus obtained was stirred for 2 hours at room temperature. The suspension was filtered through a pad of celite. The filtrate was concentrated in vacuo, and purified by column chromatography over silica gel (hexane/EtOAc=10/1) to afford the title compound as a colorless oil (320 mg, 87%). ¹H NMR (400 MHz, CDCl₃) δ 8.67 (d, J = 4.3 Hz, 1H), 7.89 (id, J = 7.8 and 1.6 Hz, 1H), 7.75 (d, J = 7.8 Hz, 1B), 7.47 (dd, J = 7.8 and 4.3 Hz, 1H), 5.12 (t, J = 12.0 Hz, 2H).

Step 4, tert-buty1 1-(2,2-di&1oro-2-(pyridin-2-yl)ethy1)&piperidin-4-ylcarbamate

A mixture of 2,2-diﬂuoro-2-(pyridin-2-yl)ethy1trifluoromethanesulphonate (365 mg, 1.25 mmol) and tert-buty1 piperidiri-4-ymethylicarbamate (274 mg, 1.37 mmol) and DIPEA (0.6
ml, 3.8 mmol) in DCM (5 mL) was heated to 40 °C. After stirring overnight at 40 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 10/1) to afford the title compound as a white solid (340 mg, 80%). MS (ESI) calcd for CT-H₂₃F₂N₃O₂: 341.2; found: 342.2 [M+H].

Step 5. 1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-amine

![Chemical structure](image)

[0265] To the solution of ten-butyl 1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-ylcarbamate (340 mg, 0.99 mmol) in DCM (4 mL) was added TFA (3 mL) under ice-water bath cooling. After stirring for 30 min at rt, the starting material was consumed, and the mixture was concentrated. The concentrate was basified with 1 N NaOH, and extracted with ethyl acetate. The organic phase was washed with brine, dried, Na₂SO₄, and concentrated to afford the title compound as an off-white powder (230 mg, 100%) which was used in the next step without further purification. MS (ESI) calcd for C₁₃H₁₇F₂N₅: 309.5; found: 310.3 [M+H].

Step 6. N-(1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-amine

![Chemical structure](image)

[0266] A mixture of 1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-amine (230 mg, 0.93 mmol), 4-chloro-7H-pyrrolo [2,3-d]pyrimidine (160 mg, 1.05 mmol) and DIPEA (0.33 mL, 1.91 mmol) in butyl alcohol (4 mL) was heated to 130 °C. After stirring overnight at 130 °C, the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 1:1) to afford the title compound as a gray powder (140 mg, 41%). MS (ESI) calcd for C₁₈H₁₄F₂N₆: 358.2; found: 359.2 [M+H].
NMR (400 MHz, CD3OD) 8 8.65 (d, J = 4.4 Hz, 1B), 8.07 (s, 1B), 7.98 (dt, J = 8.0 and 1.6 Hz, 1H), 7.76 (d, J = 8.0 Hz, 1B), 7.52-7.55 (m, 1H), 7.95 (d, J = 3.6 Hz, 1H), 6.58 (d, J = 3.6 Hz, 1B), 4.05 – 3.95 (m, 1H), 3.26 (t, J = 14.4 Hz, 2H), 2.94 (d, J = 12.0 Hz, 2H), 2.45-2.52 (m, 2H), 1.96 − 1.87 (m, 2H), 1.50-1.60 (m, 2H).

**Example 1.1a** (HCl salt). N-(1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amiTe hydrochloride (C-1-HCl)

[0267] To a solution of N-{1-(2,2-difluoro-2-(pyridin-2-yl)ethyl)piperidin-4-yl}-7H-pyrrolo[2,3-d]pyrimidin-4-amide (96 mg, 0.27 mmol) in MeOH (3.0 mL) was added HCl/MeOB (2.0M, 0.14 mL) at rt. After stirring for 15 min, the mixture was concentrated to afford the title compound as an off-white powder (96 mg, 98%). MS (ESI) calcd for C_{18}H_{12}Cl_{12}N_{6}: 358.2; found: 359.3[M+H]. \(^1\)H NMR (400 MHz, C\text{DOD}) \(\delta\) 8.73 (d, J = 4.4Hz, 1H), 8.32 (s, 1H), 8.07 (dt, J = 8.0 and 1.6 Hz, 1H), 7.86 (d, J = 8.0 Hz, 1H), 7.65 – 7.57 (m, 1H), 7.36 (d, J = 3.6 Hz, 1H), 6.96 (d, J = 3.6 Hz, 1H), 4.28 (brs, 1H), 4.01-4.10 (ra, 2H), 3.60-3.70 (m, 2E), 3.32- 3.21 cm, 2H), 2.26-2.32 (ra, 2H), 2.17- 1.98 (m, 2H).

**Example 1.2**. A-(1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-i]-pyrimidin-4-amide (C-2).

**Step 1.** 2-bromo-5-fluoropyridine
To a 3-neck flask equipped with a dropping funnel and thermometer, 48% Br (26.2 mL) was added. 5-Fluoropyridine (6.0 g, 0.05 mol) was added dropwise at 0°C. Br₂ (8.0 mL, 0.16 mol) was then added at 0°C dropwise over 20 min. The reaction mixture was cooled to -1.0°C and a solution of NaNO₂ (9.3 g, 0.14 mol) in water (30 mL) was added over 1.5 hours. The resulting mixture was stirred for an additional 30 minutes. A solution of NaOH (20 g, 0.50 mol) in water (30 mL) was added over 30 minutes. The reaction mixture was warmed to 5°C and then extracted with ether (3*100 mL). The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=1:0.1) to afford the title compound as a colorless liquid (3.37 g, 36%). ¹H NMR (400 MHz, CDCl₃) δ 8.2? (d, J = 3.0 Hz, 1H), 7.48 (dd, J = 8.7, 4.0 Hz, 1H), 7.35 – 7.28 (m, 1H).

Step 2, ethyl 2-(5-(1H-pyrrolo[2,1-b]pyridin-2-yl)acetate.

To the solution of 2-bromo-5-fluoropyridine (3.0 g, 17 mmol) and ethyl 2-bromo-2,2-difluoroacetate (3.46 g, 17 mmol) in DMSO (45 mL) was added Cu powder (2.17 g, 34 mmol). The mixture was heated to 80°C overnight. After stirring overnight the reaction mixture was poured into a solution of dibasic potassium hydrogen phosphate, trihydrate (3.8 g, 170 mmol) in water (380 mL) with vigorous stirring. The suspension was filtered and the solid was rinsed with EtOAc. The filtrate was added to brine and extracted with EtOAc (50 mL×2). The combined organic phases were washed with brine dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=5:1) to afford the title compound as a colorless liquid (2.83 g, 76%). ¹H NMR (400 MHz, CDCl₃) δ 8.50 (d, J = 2.7 Hz, 1H), 7.78 (dd, J = 8.7, 4.2 Hz, 1H), 7.57 (td, J = 8.3, 2.8 Hz, 1H), 4.41-4.35 (q, 2H), 1.34 (m, 3B).
Step 3. 2,2-difluoro-2-(5-fluoropyrid-2-yl)ethanol

[0270] To a solution of ethyl 2,2-difluoro-2-(5-fluoropyrid-2-yl)acetate (1.0 g, 4.6 mmol) in ethanol (23 mL) was added NaB₃/₄ (250 mg, 6.6 mmol) slowly at rt. The mixture was stirred for 30 min at rt. After 30 min, the reaction mixture was quenched with IN HCl under ice-water bath cooling. The mixture was concentrated and extracted with EtOAc. The organic layer was washed with water and ether, dried and concentrated to afford the title compound as a white solid (805 mg, 99%). ¹H NMR (400 MHz, CDCl₃) δ 8.48 (s, 1H), 7.77 (dd, J = 8.6, 4.2 Hz, 1E), 7.58 (m, 1H), 4.24 (ra, 2H), 3.00 (d, J = 6.5 Hz, 1H).

Step 4. 2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl trifluoromethanesulfonate

[021] To a stirred solution of 2,2-difluoro-2-(5-fluoropyridin-2-yl)ethanol (805 mg, 4.54 mmol) and DiPEA (2.38 mL, 13.6 mmol) in dried ether (45 mL) was added Tf₂O (1.52 mL, 9.08 mmol) slowly at 0 °C. The reaction mixture was warmed to rt. Altar stirring for 1 h at rt, the orange suspension was filtered through celite, and the solid was washed with ether. The filtrate was concentrated to afford the title compound as a pale yellow oil (1.2 g, 85%) which was used in the next step without further purification.

Step 5. tert-butyl 1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-yl carbamate
A mixture of 2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyltrifluoromethanesulphonate (1.2 g, 3.9 mmol), tert-butyl piperidin-4-ylcarbamate (1.56 g, 7.8 mmol) and DIPEA (2.1 mL, 12 mmol) in DCM (20 mL) was heated to 40°C. After stirring overnight at 40°C, the mixture was concentrated and extracted with EtOAc. The organic layer was washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc 10:1) to afford the title compound as a white solid (844 mg, 61%).

MS (ESI) calcd for C_{17}H_{14}F_{3}N_{3}O_{2}: 359.2; found: 360.3[M+H]^+. H NMR (400 MHz, CDCl3) δ 8.49 (d, J = 2.7 Hz, 1H), 7.67 (dd, J = 8.7, 4.3 Hz, 1H), 7.49 (dt, J = 8.4, 2.8 Hz, 1H), 4.35 (s, 1H), 3.39 (s, 1H), 3.19 (t, J = 14 Hz, 2H), 2.75-2.82 (m, 2H), 2.32-2.41 (m, 2H), 1.75-1.85 (m, 2H), 1.43 (s, 9H), 1.24-1.32 (m, 2H).

Step 6. 1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-amine

To the solution of tert-butyl 1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-ylcarbamate (844 mg, 2.35 mmol) in DCM (12 mL) was added TFA (6 mL) under ice-water bath cooling. After stirring for 30 min at rt, the mixture was concentrated. The concentrate was basified with 1 N NaOH, and extracted with EtOAc. The organic phase was washed with brine, dried Na2SO4, and concentrated to afford the title compound as a yellow solid (634 mg, 100%). MS (ESI) calcd for C_{12}H_{16}F_{3}N_{3}: 259.1; found: 260.3[M+H]^+. 1H NMR (400 MHz, CDCl3) δ 8.49 (d, J = 2.7 Hz, 1H), 7.67 (dd, J = 8.7, 4.3 Hz, 1H), 7.49 (dt, J = 8.4, 2.8 Hz, 1H), 3.18 (t, J = 14 Hz, 2H), 2.85 - 2.77 (m, 2H), 2.67 - 2.57 (m, 1H), 2.28-2.32 (m, 2H), 1.74 - 1.64 (m, 2H), 1.20-1.30 (m, 2H).

Step 7. A-(1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-i]/pyrimidin-4-amine
A mixture of 1-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-amine (609 mg, 2.35 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyridine (301 mg, 1.96 mmol) and DIPEA (0.7 mL, 3.92 mmol) in n-butyl alcohol (12 mL) was heated to 130 °C. After stirring overnight at 130 °C, the reaction solution was concentrated and extracted with EtOAc. The organic layers were washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc 3/1) to afford the title compound as a white solid (282 mg, 38%). MS (ESI) calcd for C376.2; found: 377.3. H NMR (400 MHz, CD3OD) δ 8.57 (d, J = 2.7 Hz, 1H), 8.07 (s, 1H), 7.82 (dd, J = 8.7 and 4.4 Hz, 1H), 7.76 (dt, J = 8.5 and 2.7 Hz, 1H), 7.05 (d, J = 3.5 Hz, 1H), 6.58 (d, J = 3.5 Hz, 1H), 4.06 - 3.95 (m, 1H), 3.27 (i, J = 14 Hz, 2E), 2.92-2.96 (m, 2H), 2.45-2.52 (m, 2H), 1.88-1.94 (m, 2H), 1.50-1.60 (m, 2H).

Example 1.2a (HCl salt). N-(i-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine hydrochloride (C2-HCl).

To the solution of N-(i-(2,2-difluoro-2-(5-fluoropyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine (120 mg, 0.32 mmol) in MeGH (2 mL) was added HCl/MeOH (2M, 0.16 mL, 0.32 mmol) at it. After stirring for 10 min, the mixture was concentrated to afford the title compound as a pale yellow solid (129 mg, 98%). MS (ESI) calcd for C18H18F3N6: 376.2; found: 377.3. H NMR (400 MHz, CD3OD) δ 8.61 (d, J = 2.5 Hz, 1H), 8.27 (s, 1H), 7.89 (dd, J = 8.7 and 4.4 Hz, 1H), 7.83 (dt, J = 8.5 and 2.7 Hz,
1H). 7.34 (d, J = 3.5 Hz, 1H), 6.91 (d, J = 3.5 Hz, 1H), 4.10 (brs, 1H), 3.76 (his. 2H), 3.38 (ra, 2H), 2.98 (brs, 2H), 2.16 (m, 2H), 1.90 (m, 2H).

Example 13. N-(1-(2-(5-chloropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo-[2,3-i]pyrimidin-4-amine (C-3).

Step 1. ethyl 2-(5-chloropyridin-2-yl)-2,2-difluoroacetate

10276/ To a solution of 5-chloro-2-iodopyridine (2.50 g, 10.4 mmol) and ethyl 2-bromo-2,2-difluoroacetate (2.1 g, 10.4 mmol) in DMSO (26 mL) was added Cu powder (1.33 g, 20.8 mmol). The mixture was heated to 50 °C overnight. The reaction mixture was poured into a solution of dibasic potassium hydrogen phosphate, trihydrate (24 g, 104 mmol) in water (240 mL) with vigorous stirring. The suspension was filtered and the solid was rinsed with EtOAc. The filtrate was diluted with brine and extracted with EtOAc (20 mL × 2). The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=100:1) to afford the title compound as a colorless oil (885 mg, 36%). MS (ESI) calcd for C_{9}H_{14}ClF_{2}N_{2}O_{2}: 235.0; found: 236.2[M+H]. \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) δ 8.61 (d, J = 2.0 Hz, 1H), 7.85 (dd, J = 8.4 and 2.0 Hz, 1H), 7.71 (d, J=8.4 Hz, 1H), 4.37 (37 J=7.2 Hz, 2H), 1.34 (t, 1-7.2 Hz, 3H).

Step 2. 2-(5-chloropyridin-2-yl)-2,2-difluoromethanol
[0277] To a solution of ethyl 2-(5-chloropyridin-2-yl)-2,2-difluoroethyle (780 mg, 3.3 mmol) in ethanol (16.5 mL) was added NaBH₄ (180 mg, 4.76 mmol) slowly at rt. The mixture was stirred for 30 min at rt. The reaction mixture was quenched with 1N HQ under ice-water bath cooling. The mixture was concentrated and extracted with EtOAc. The organic layer was washed with water and brine, dried and concentrated to afford the title compound as a white solid (538 mg, 83%). ¹H NMR (400 MHz, CDCl₃) δ 8.58 (s, 1H), 7.85 (d, J=8.4 Hz, 1H), 7.69 (d, J=8.4 Hz, HI), 4.23 (t, J=7.4 Hz, 2B).

Step 3. 2-(5-chloropyridin-2-yl)-2,2-difluoroethyl trifluoromethanesulfonate

[0278] To the solution of 2-(5-chloropyridin-2-yl)-2,2-difluoroethanol (538 mg, 2.78 mmol) and DIPEA (1.5 mL, 5.56 mmol) in ether (28 mL) was added T&O (0.94 mL, 5.56 mmol) slowly at 0 °C. After stirring for 1 h at rt, the reaction mixture was filtered through celite, and the filter mass was washed with ether. The combined organic phases were concentrated to afford the crude title compound as a pale yellow solid (905 mg, 100%).

Step 4. tert-buty li piperidin-4-ylcarbamate

[0279] The mixture of 2-(5-chloropyridin-2-yl)-2,2-difluoroethyl trifluoromethanesulfonate (905 mg, 2.77 mmol), tert-butyli piperidin-4-ylcarbamate (1.11 g, 5.56 mmol) and DIPEA (1.46 mL, 8.34 mmol) in DCM (15 mL) was heated to 40 °C. After stirring overnight at 40 °C, the
mixture was concentrated and extracted with EtOAc. The organic phases were washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc~1G: 1) to afford the title compound as a white solid (922 mg, 89%). MS (ESI) calcd for C_{17}H_{24}ClF_{2}N_{3}O_{2}: 375.2; found: 376.2[M+H]. ^{1}H NMR (400 MHz, CDCl_{3}) δ 8.59 (4 J = 2.4 Hz, 1H), 7.77 (dd, J = 8.4 and 2.4 Hz, 1H), 7.60 (d, J = 8.4 Hz, 1H), 4.35 (s, 1H), 3.38 (s, 1H), 3.18 (t, J = 14.3 Hz, 2B), 2.84 - 2.76 (m, 2H), 2.37 (m, 2H), 1.80 (m, 2H), 1.43 (s, 9H), 1.27 (m, 3H).

Step 5. 1-(2,5-dichloropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-amine

[0280] To the solution of tert-butyl 1-(2-(5-chloropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl carbamate (919 mg, 2.45 mmol) in DCM (14 mL) was added TFA (7 mL) under ice-water bath cooling. After stirring for 30 min at r.t., the mixture was concentrated. The concentrate was basified with 1N NaOH, and extracted with EtOAc. The organic phase was washed with brine, dried over Na_{2}SO_{4}, and concentrated to afford the title compound as a white solid (674 mg, 100%). MS (ESI) calcd for C_{17}H_{16}ClF_{2}N_{3}: 275.1; found: 276.2[M+H]. ^{1}H NMR (400 MHz, CDCl_{3}) δ 8.59 (4 J = 2.4 Hz, 1H), 7.77 (dd, J = 8.4 and 2.4 Hz, 1H), 7.59 (d, J = 8.4 Hz, 1H), 3.80 (s, 4H), 3.18 (t, J = 14.1 Hz, 2H), 2.85 (m, 2H), 2.81 - 2.74 (m, 1H), 2.33 (m, 2H), 1.75 (m, 2H), 1.37 (m, 2H).

Step 6. N-(1-(2-(5-morpholin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine
A mixture of 1-(2-(5-chloropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-amine (674 mg, 2.45 mmol), 4-chloro-7//-pyrrolo[2,3-△]pyridine (314 mg, 2.04 mmol) and DIPEA (0.72 ml, 4.08 mmol) in n-butyl alcohol (10 mL) was heated to 130 °C. After stirring overnight at 130 °C, the reaction solution was concentrated and extracted with EtOAc. The combined organic layers were washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexaae/EtOAc-i/3) to afford the title compound as a white solid (306 mg, 38%). MS (ESI) calcd for C_{13}H_{14}ClF_{2}N_{6}: 392.1; found: 393.2[M+H]. H NMR (400 MHz, CD_{3}OD) δ 8.66 (d, J = 2.4 Hz, 1H), 8.07 (s, 1H), 8.01 (dd, J = 8.4 and 2.4 Hz, 1H), 7.75 (d, J = 8.4 Hz, 1H), 7.05 (d, J = 3.5 Hz, 1H), 6.58 (d, J = 3.5 Hz, 1H), 4.05 – 3.95 (m, 1H), 3.27 (t, J = 14.3 Hz, 2H), 2.95 (m, 2H), 2.49 (m, 2H), 1.92 (ra, 2H), 1.54 (m, 2H).

Example 1.3a (HCl salt). N-(1-(2-(5-chloropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-△]pyridin-4-amine hydrochloride (C-3-HCl),

Example 1.4. N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-△]pyrimidine-4-amine (C-4).
Step 1: ethyl 2,2-difluoro-2-(5-methylpyridin-2-yl)acetate

[0283] To a solution of ethyl 24xromo-5-methylpyridine (4.0 g, 24 mmol) and ethyl 2-biomo-2,2-difluoroacetate (4.8 g, 24 mmol) in DMSO (80 mL) was added Cu powder (3.0 g, 47 mmol). The mixture was heated at 60°C overnight. The reaction mixture was filtered through celite. The filtrate was extracted with ethyl acetate. The combined ethyl acetate layers were dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate =100:1) to afford the title compound as a colorless oil (3.7 g, 74%). 1H NMR (400 MHz, CDCl3) δ 8.47 (s, 1H), 7.69 - 7.57 (ar, 2H), 4.37 (q, J= 7.1 Hz, 2H), 2.40 (s, 3H), 1.33 (t, J= 7.1 Hz, 3H).

Step 2: 2,2-difluoro-2-(5-methylpyridin-2-yl)ethanol

[0284] To a solution of ethyl 2, 2-difluoro-2-(5-methylpyridin-2-yl) acetate (2.0 g, 9.3 mmol) in ethanol (45mL) was added NaBH4 (500 mg, 13.4 mmol) slowly. The mixture was stirred for 30min at r.t. After 30mm, the reaction mixture was quenched with 1N HCl under ice-water bath cooling, concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water and brine, then dried and concentrated to afford the title compound as a white solid (1.6 g, 100%). 1H NMR (400 MHz, CDCl3,) δ 8.44 (s, 1H), 7.71 (d, J= 8Hz, 1H), 7.64 (d, J= 8Hz, 1H), 4.22 (t, J= 12.4Hz, 2H), 3.03 (hrs, 1H), 2.41 (s, 3H).
Step 3: 2, 2-difluoro-2-(5-ethylpyridin-2-yl) ethyl trifluoromethanesulfonate

To a solution of 2, 2-difluoro-2-(5-methylpyridin-2-yl) ethanol (800 mg, 4.6 mmol) and DIPEA (2.8 ml, 13.8 mmol) in anhydrous ether (40 ml) was added Tf₂O (1.5 ml, 9.2 mmol) at 0 °C. After stirring for 1 hr at rt, the white suspension was filtered through celite, and the filtered mass was washed with ether. The combined filtrates were concentrated and purified by column chromatography over silica gel (hexane) to afford the title compound as a colorless oil (1.0 g, 70%). ^1H NMR (400 MHz, CDCl₃) δ 8.47 (s, 1H), 7.65 (m, 2H), 5.10 (t, J = 12.0 Hz, 2H), 2.42 (s, 3H).

Step 4: tert-butyl 1-(2, 2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl-carbamate

[0285] A mixture of 2, 2-dihydro-2-(5-methylpyridin-2-yl)ethyl trifluoromethanesulfonate (i.0 g, 3.3 mmol), tert-butyl piperidin-4-ylmethylcarbamate (1.3 g, 6.6 mmol) and DIPEA (2.0 ml, 9.9 mmol) in DCM (16 ml) was heated to 40 °C with stirring. After stirring overnight at 40 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 10/1) to afford the title compound as a yellow solid (1.0 g, 83%). MS (ESI) calcd for C₁₈H₂₄F₂N₃O₂: 355.2; found: 356.2[M+H]. ^1H NMR (400 MHz, CDCl₃) δ 8.46 (s, 1H), 7.60 - 7.50 (m, 2H), 3.72 - 3.61 (m, 2H), 2.85 - 2.80 (m, 2H), 2.38 (s, 3H), 2.32 - 3.40 (m, 2H), 1.82 - 1.78 (m, 2H), 1.43 (s, 9H), 1.25 - 1.30 (m, 2H).

Step 5: 1-(2, 2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-amine
[0283] To a solution of tert-butyl 1-(2, 2-difluoro-2-(5-methylpyridin-2-yl)ethyl) piperidin-4-yl carbamate (1.0 g, 2.8 mmol) in DCM (15 ml) was added TFA (12.5 ml) at 0 °C. After stirring for 30 min at rt, the mixture was concentrated. The concentrate was basified with 1 N NaOH and extracted with ethyl acetate. The organic phase was washed with brine, dried over a, and concentrated to afford the title compound as an off-white powder (400 mg, 60%). MS (ESI) calc for C_{13}H_{16}F_{2}N_{3}: 255.2; found: 256.2 [M+H]. ¾ NMR (400 MHz, CDCl₃) δ 8.47 (s, 1H), 7.59-7.52 (m, 2H), 3.18 (i, J = 14.6 Hz, 2H), 2.85-2.82 (m, 2H), 2.64-2.54 (m, 1H), 2.38 (s, 3H), 2.35-2.28 (m, 2H), 1.69-4.66 (m, 2H).

Step 6: N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine

[02883] A mixture of 142, 2-difluoro-2-(5-imethylpyridin-2-yl)ethyl piperidin-4-amine (400 mg, 1.60 mmol), 4-difluoro-7H-pyrrolo [2, 3-d] pyrimidine (200 mg, 1.30 mmol) and DPEA (0.5 mL, 2.6 mmol) in butyl alcohol (8 mL) was heated to 130 °C. After stirring overnight at 130 °C, the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate 1:3) to afford the title compound as a white solid (130 mg, 24%). MS (EST) calc for C_{19}H_{22}F_{2}N_{6}: 372.2; found: 373.3 [M+H]. H NMR (400 MHz, CDCl₃) δ 10.44 (s, 1H), 8.48 (s, 1H), 8.31 (s, 1H), 7.62-7.55 (m, 2H), 7.07 (d, J = 3.5 Hz, 1H), 6.34 (d, J = 3.5 Hz, 1H), 4.12 (m, 1H), 3.26 (i, J = 14.6 Hz, 2H), 2.95-2.92 (m, 2H), 2.56-2.50 (m, 2B), 2.39 (s, 3H), 2.00-2.01 (m, 2H), 1.57-1.48 (m, 2H).
Example 1.4a (HCl salt). N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-4-HCl).

[0289] To a stirred solution of N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (100 mg, 0.26 mmol) in MeOH (1.3 mL) was added HCl/Et$_2$O (2M, 0.13 mL, 0.26 mmol) at rt. After stirring for 15min, the mixture was concentrated to afford the title compound as an off-white powder (109 mg, 98%). MS (ESI) calcd for C$_{19}$H$_{25}$F$_2$N$_6$: 372.2: found 373.3 [M+H]. $^1$H NMR (400 MHz, CD$_3$OD) δ 8.52 (s, 1H), 8.22 (s, 1H), 7.84 (d, $J = 8.0$ Hz, 1H), 7.68 (d, $J = 8.0$ Hz, 1H), 7.29 (d, $J = 3.5$ Hz, 1H), 6.85 (d, $J = 3.5$ Hz, 1H), 4.02 (s, 1H), 3.60-3.53 (m, 2H), 3.26 (m, 2H), 2.83 (m, 2H), 2.45 (s, 3H), 2.08-2.05 (m, 2H), 1.90 – 1.73 (m, 2H).

Example 1.5. N-(1-(2,2-difluoro-2-(5-trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-S).

Step 1: ethyl 2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)acetate
To a solution of ethyl 2,2-difluoro-2-iodoacetate (5.5 g, 22 mmol) and 2-hromo-5-trifluoromethyl-pyridine (5.0 g, 22 mmol) in DMSO (110 mL) was added Cu powder (2.8 g, 44 mmol). The mixture was heated at 80 °C for 20 hours. The reaction mixture was filtered through celite and the solid cake was extracted with ethyl acetate. The combined filtrates were extracted with ethyl acetate. The ethyl acetate layers were combined, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 100:1) to afford the title compound as a colorless oil (2.5 g, 42%). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.93 (s, 1H), 8.13 (d, $J$ = 7.9 Hz, 1H), 7.90 (d, $J$ = 8.1 Hz, 1H), 4.39 (q, $J$ = 7.1 Hz, 2H), 1.34 (t, $J$ = 7.1 Hz, 3H).

Step 2: 2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethanol

To a solution of ethyl 2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)acetate (1.0 g, 3.7 mmol) in ethanol (19 mL) was added NaB$_3$H$_4$ (200 mg, 5.3 mmol) slowly. The mixture was stirred for 30 min at rt. The stirred reaction mixture was cooled, quenched with 1 N HO, concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water and brine, dried over sodium sulfate and concentrated to afford the title compound as a white solid (850 mg) which was used in the next step without further purification. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.92 (s, 1H), 8.13 (d, $J$ = 8.0 Hz, 1H), 7.88 (d, $J$ = 8.0 Hz, 1H), 4.28 (t, $J$ = 12 Hz, 2H), 2.42 (s, 3H).

Step 3: 2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl trifluoromethanesulfonate

To a solution of 2,2-difluoro-2^5-(trifluoromethyl)pyridin-2-ylethanol (750 mg, 3.3 mmol) and DIPEA (2.0 mL, 9.9 mmol) in anhydrous ether (33 mL) was added TFA (1.1 mL, too)
6.6 mmol) at 0 °C. After stirring for 1 h at rt, the white suspension was filtered through celite. The solid mass was extracted with ether. The filtrate was concentrated and purified by column chromatography over silica gel (hexane) to afford the title compound as a colorless liquid (760 mg, 75%). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.95 (s, 1H), 8.16 (d, $J = 8.2$, 1H), 7.91 (d, $J = 8.2$ Hz, 1H), 5.14 (t, $J = 11.8$ Hz, 2H).

Step 4: tert-butyl-1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-ylcarbamate

![Chemical structure of the product](image)

[0293] A mixture of 2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl trifluoromethanesulfonate (1.04 g, 2.9 mmol), tert-butyl pipetidift-4-ylcarbamate (1.16 g, 8.8 mmol) and DIPEA (1.5 mL, 8.7 mmol) in DCM (20 mL) was heated to 40 °C. After stirring overnight at 40 °C, the mixture was concentrated and extracted with EtOAc. The organic layer was washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=5:1) to afford the title compound as a white solid (1.05 g, 92%). MS (ESI) calcd for C$_{18}$H$_{24}$F$_{5}$N$_{3}$O$_{2}$: 409.2; found: 410.2 [M+H].

$^3$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.91 (s, 1H), 8.05 (d, $J = 8.2$ Hz, 1H), 7.78 (d, $J = 8.2$ Hz, 1H), 4.34 (brs, 1H), 3.39 (m, 1H) 3.22 (t, $J = 14.2$ Hz, 2H), 2.83-2.78 (m, 2H), 2.41-2.35 (m, 2E%), 1.81-1.77 (m, 2H), 1.42 (s, 9H), 1.20-1.30 (m, 2H),

Step 5: 1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-amine

![Chemical structure of the product](image)
To a solution of tert-butyl 1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-ylcarbamate (300 mg, 0.73 mmol) in DCM (8 mL) was added TFA (4.4 mL) at ice-water bath temperature. After stirring for 15 min at r.t., the mixture was concentrated. The concentrate was basified with IN NaOH, and extracted with EtOAc. The organic phase was washed with brine, dried over Na₂SO₄, and concentrated to afford the title compound as a pale yellow oil (226 mg) which was used directly in the next step. MS (ESI) calcd for C₁₃H₁₆F₅N₅; 309.1; found: 310.3[M +H]. ¹H NMR (400 MHz, CDCl₃) δ 8.92 (s, 1H), 8.04 (d, J = 8.2 Hz, 1H), 7.79 (d, J = 8.2 Hz, 1H), 3.22 (t, J = 14.1 Hz, 2H), 2.82-2.79 (m, 2H), 2.64-2.54 (m, 1H), 2.35-2.29 (m, 2H), 1.68-1.65 (m, 2H), 1.29-1.23 (m, 2H), 1.21-1.18 (m, 2H).

**Step 6:** N-(1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine

![Chemical structure](image)

[0295] A mixture of 1-(2, 2-dMuoro-2-(5-(trifTuoromeihyl) pyridiri-2-yi) ethyl) piperidin-4-amine (600 mg, 1.9 mmol), 4-chloro-7H-pyrrololo (2, 3-d)pyrimidine (245 mg, 1.6 mmol) and DIPEA (0.6 mL, 3.2 mmol) in butyl alcohol (10 mL) was heated to 130 °C. After stirring overnight at 130 °C, the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate =1:3) to afford the title compound as a gray powder (270 mg, 34%). MS (ESI) calcd for C₁₉H₁₉F₅N₆: 426.2; found: 427.2[M+H]. ¹H NMR (400 MHz, CDCl₃) δ 10.24 (s, 1H), 8.93 (s, 1H), 8.32 (s, 1H), 8.07 (dd, J = 8.2 and 1.9 Hz, 1H), 7.82 (d, J = 8.2 Hz, 1H), 7.06 (d, J = 3.5 Hz, 1H), 6.32 (d, J = 3.5 Hz, 1H), 4.92 (brs, 1H), 4.18 - 4.03 (m, 1H), 3.29 (t, J = 14.2 Hz, 2H), 2.93-2.90 (m, 2H), 2.56-2.50 (m, 2H), 2.08 - 1.96 (m, 1H), 1.50-1.40 (m, 2H).

**Example 1.5a (HCl salt), N-(1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidine hydrochloride (C-5-HQ).**
[0296] To the solution of N-(1-(2,2-difluoro-2-(5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-2-(5-ttoloropyrrolo[2,3-d]pyrimidin-4-yl)pyridine (237 mg, 0.56 mmol) in MeOH (3.0 mL) was added HCl/EtOH (2M, 0.28 mL, 0.56 mmol) at rt. After stirring for 15 min, the mixture was concentrated to afford the title compound as an off-white powder (260 mg, 98%). MS (ESI) calcd for C_{19}H_{15}F_{2}N_{5}: 426.2; found 427.2 [M+H]. H NMR (400 MHz, CD_{3}OD) δ 9.03 (s, 1H), 8.35 (dd, J = 8.3, 1.9 Hz, 1H), 8.22 (s, 1H), 7.99 (d, J = 8.3 Hz, 1H), 7.32 (d, J = 3.5 Hz, 1H), 6.87 (d, J = 3.5 Hz, 1H), 3.94 (m, 2H), 3.45 (m, 2H), 3.10 (m, 2H), 2.69 (m, 2H), 1.95 (m, 2H), 1.65 (m, 2H), 1.30 (m, 2H).

**Example 1.6.** N-(1-[(2-difluoromethyl)pyridin-2-yl]-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-6).

[0297] To a stirred solution of 6-bromonicotinaldehyde (10 g, 54 mmol) in DCM (300 mL) was added DAST (11 mL, 164 mmol) dropwise under ice bath cooling. The mixture was stirred at room temperature for 13 hours, quenched with ice-water under ice-water bath cooling; and neutralized with aqueous NaHCO_{3}. The aqueous phase was extracted with DCM. The
combined organic phases were washed with brine, dried over anhydrous Na₂SO₄ and concentrated. The residue was purified by column chromatography over silica gel (EtOAc / Hex = 1/10) to afford the title compound as a colorless oil (8.1 g, 72%). ¹J NMR (400 MHz, CDCl₃) 8.52 (s, 1H), 7.72-7.69 (m, 1H), 7.61 (d, J= 8.4 Hz, 1H), 6.70 (t, J= 55.6 Hz, 1H).

Step 2. ethyl 2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroacetate

To a solution of ethyl 2-bromo-2,2-difluoroacetate (800 mg, 3.94 mmol) and 2-bromo-5-(difluoromethyl)pyridine (823 mg, 3.94 mmol) in DMSO (16 mL) was added Cu powder (500 mg, 7.88 mmol). The mixture was heated to 80 °C under ¾ with stirring for 20 hours. The mixture was cooled to room temperature and water was added. The mixture was stirred at ambient temperature for additional 30 minutes. The resulting suspension was filtered through a pad of celite and washed with ethyl acetate. The filtrate was extracted with ethyl acetate. The combined organic phases were washed with water, brine, dried over sodium sulfate, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane / ethyl acetate =100:1) to afford the title compound as a colorless liquid (597 mg, 60%). ¾ NMR (400 MHz, CDCl₃) δ 8.79 (s, 1H), 8.03 (d, J= 8.4 Hz, 1H), 7.86 (d, J= 8.4 Hz, 1H), 6.77 (t, J= 55.6 Hz, 1H), 4.41-4.36 (m, 2H), 1.34 (t, J= 7.2 Hz, 3H).

Step 3. 2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroethanoni-
and extracted with ethyl acetate. The ethyl acetate layer was washed with water, brine, dried and concentrated to afford the title compound as a white solid (455 mg, 9.2%). MS (ESI) calcd for \(M+H^+\) \(\text{F}_7\text{NO}\); 209.1; found: 210.2. 

**Step 4**: 2-(5-(difuoromethyl)pyridin-2-yl)-2,2-difluoroethyl trifluoromethanesulfonate

![Chemical Structure](image)

(400 MHz, CDCl\(\text{3}\)) \(\delta\) 8.77 (s, 1H), 8.03 (d, \(J = 8.0\) Hz, 1H), 7.84 (d, \(J = 8.0\) Hz, 1H), 6.77 (t, \(J = 55.6\) Hz, 1H), 4.30 - 4.22 in, 2H), 3.08 (t, \(J = 6.8\) Hz, 1H).

**Step 5**: N-(1-(2-(5-(difuoromethyl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7-tosyl-7H-pyrrolo[3,4-a]pyrimidine

A stirred mixture of 2-(5-(difuoromethyl)pyridin-2-yl)-2,2-difluoroethyl trifluoromethanesulfonate (1.1 g, 3.3 mmol), N-(piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (Intermediate 1, 1.2 g, 3.3 mmol) and DIPEA (1.2 mL, 6.6 mmol) in DCM/DMF solvent mixture (10 mL/6 mL) was heated to 40 °C. After stirring overnight at
40 °C, the mixture was cosicenixated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc = 1:1) to afford the title compound as a white powder (720 mg, 70%). $^1$H NMR (400 MHz, CDCl$_3$) 6.879 (s, 1H), 8.40 (s, 1H), 8.05 (d, $J = 8.4$ Hz, 2H), 7.96 (d, $J = 8.0$ Hz, 1H), 7.76 (d, $J = 8.0$ Hz, 1H), 7.44 (d, $J = 4.0$ Hz, 1H), 7.28 (d, $J = 8.4$ Hz, 2H), 6.77 (t, $J = 55.6$ Hz, 1H), 6.37 (d, $J = 4.0$ Hz, 1H), 4.78 - 4.76 (m, 1H), 3.96 (a, LB), 3.26 (t, $J = 14.4$ Hz, 2H), 2.90 - 2.87 (m, 2H), 2.52 - 2.46 (m, 2H), 2.38 (s, 3H), 1.95 - 1.93 (m, 2H), 1.44 - 1.35 (m, 2H).

Step 6: N-(1-(2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-H]pyrimidin-4-amine

To a stirred solution of N-(1-(2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (720 mg, 1.28 mmol) in THF (6 mL) was added 50% NaOH (6 mL) at room temperature. The mixture was stirred for 4 hours at 60 °C and then partitioned into DCM and water. The organic phase was washed with water and brine, dried over Na$_2$SO$_4$ and concentrated. The concentrate was purified by column chromatography over silica gel (DCM/MeOH = 40:1) to afford the title compound as a white powder (360 mg, 69%). MS (ESI) caucd for C$_{19}$H$_2$F$_4$N$_6$; 408.2; found: 409.24M+H]. $^1$H NMR (400 MHz, CD$_3$OD) δ 8.84 (s, 1H), 8.16 (d, $J = 8.0$ Hz, 1H), 8.07 (s, 1H), 7.89 (d, $J = 8.0$ Hz, 1H), 7.05 (d, $J = 3.6$ Hz, 1H), 7.00 (t, $J = 55.2$ Hz, 1H), 6.58 (d, $J = 3.6$ Hz, 1H), 4.04 - 3.96 (m, 1H), 3.32 - 3.22 (m, 2H), 2.97 - 2.94 (m, 2H), 2.52 - 2.46 (m, 2H), 1.93 - 1.90 (m, 2H), 1.58 - 1.48 (m, 2H).

Example 1.6a (HCl salt). N-(1-(2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-6·HG),
To a stirred solution of N-(1-(2-(5-(difluoromethyl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (345 mg, 0.84 mmol) in MeOH (4 mL) was added 2M MeOH/HCl (0.42 mL, 0.84 mmol). The mixture was stirred for 30 min. The solution was concentrated to afford the title compound as an off-white powder (370 mg, 99%). MS (ESI) calcd for C_{19}H_{20}F_{4}N_{6}: 408.2; found: 409.2 M+H. ^1H NMR (400 MHz, CD_{3}OD) δ 8.8 (s, 1H), 8.24 (s, 1H), 8.20 (d, J = 8.0 Hz, 1H), 7.93 (d, J = 8.0 Hz, 1H), 7.32 (d, J = 3.2 Hz, 1H), 7.02 (d, J = 53.2 Hz, 1H), 6.88 (d, J = 3.2 Hz, 1H), 4.02 ~ 3.97 (m, 3H), 3.63 ~ 3.56 (m, 2H), 3.25 ~ 3.22 (m, ZH), 2.81 ~ 2.76 (m, 2H), 2.08 ~ 2.05 (m, 2H), 1.82 ~ 1.73 (m, 2H).

Example 1.7. N-(1-(2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-7).

Step 1. Ethyl 2,2-diF\_\textsubscript{2}uoro-2'-(5-(hydroxyn ethyl)pyridin-2-yl)acetate

A mixture of (64%omopyridin-3-yl)methanol (15.0 g, 79.8 mmol), ethyl 2-bromo-2,2-difluoroacetate (19.4 g, 95.7 mmol) and copper powder (10.2 g, 160 mmol) in DMSO (100 mL) was stirred at 80 °C overnight. After the mixture was cooled to rt, it was poured into
water (300 mL). After stirring for 30 minutes, the solid was removed by filtration. The filter cake was extracted with ethyl acetate. The combined organic phases were washed with water, brine, dried over NaSO₄ and concentrated. The residue was purified by column chromatography over silica gel (eluent Hexane:EtOAc = 4:1) to afford the title compound as a yellow oil (3.66 g, 20%). ¹H NMR (400 MHz, CDCl₃) δ 8.62 (s, 1H), 7.89 (dd, J = 2.0 and 8.0 Hz, 1H), 7.73 (d, J = 8.0 Hz, 1H), 4.81 (s, 2H), 4.37 (q, J = 7.2 Hz, 2H), 1.32 (t, J = 7.2 Hz, 3H).

**Step 2, Ethyl 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)acetate**

![Structural diagram](image)

[03053] To a stirred solution of ethyl 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)acetate (3.66 g, 15.8 mmol) in DCM (50 mL) was slowly added DAST at 0 °C. The resulting mixture was warmed to rt. and stirred overnight. The reaction mixture was quenched by water under ice-water bath cooling, followed by addition of saturated aqueous Na₂CO₃ to adjust to pH=8-9. The aqueous layer was extracted with DCM. The combined organic layers were dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was purified by column chromatography over silica gel (eluent Hexane:EtOAc = 10:1) to afford the title compound as a yellow oil (1.51 g, 41%). ¹H NMR (400 MHz, CDCl₃) δ 8.64 (s, 1H), 7.89 (d, J = 8.4 Hz, 1H), 7.78 (d, J = 8.4 Hz, 1H), 5.48 (d, J = 47.2 Hz, 2H), 4.37 (q, J = 7.2 Hz, 2H), 1.32 (t, J = 7.2 Hz, 3H).

**Step 3, 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethanol**

![Structural diagram](image)

[0306] To a stirred solution of ethyl 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)acetate (1.51 g, 6.48 mmol) in ethanol was slowly added NaBH₄ (370 mg, 9.72 mmol) at 0 °C. The resulting
suspension was stirred for 1 hour. The reaction mixture was quenched by addition of 1M HCl under ice-water bath. The mixture was concentrated and the residue was adjusted to pH=10. The aqueous phase was extracted with EtOAc. The organic layers were combined and dried over Na2SO4. The solvent was removed, and the crude product was purified by column chromatography over silica gel (eluent; Hexane:EtOAc = 30:1-15:1) to afford the title compound as a yellow oil (11 g, 96%). 3J NMR (400 MHz, CDCl3) δ 8.62 (s, 1H), 7.89 (d, J = 8.0 Hz, 1H), 7.77 (d, J = 8.0 Hz, 1H), 5.48 (d, J = 47.2 Hz, 2H), 4.28-4.22 (m, 21H), 3.28-3.28 (m, 1H).

Step 4, 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl fluoromethanesulfonate

[0307] To a stirred solution of 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl fluoromethanesulfonate (800 mg, 4.18 mmol) in anhydrous diethyl ether (10 mL) was slowly added DIPEA and Tf2O successively under N2 atmosphere at 0 °C. After stirring at 0 °C for 10 min, the resulting suspension was warmed to rt and stirred for additional 1 hour. The suspension was filtered through a pad of celite and the filter cake was extracted with ether. The combined filtrates were concentrated under reduced pressure. The residue was purified by column chromatography over silica gel (eluent; Hexane:EtOAc = 50:1) to afford the title compound as a colorless oil (750 mg, 56%). 2H NMR (400 MHz, CDCl3) δ 8.66 (s, 1H), 7.91 (d, J = 8.0 Hz, 1H), 7.79 (d, J = 8.0 Hz, 1H), 5.50 (d, J = 47.2 Hz, 2H), 5.12 (t, J = 12.0 Hz, 2H).

Step 5, N-(1-(2,2-difluoro-2-(S-fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrroso[2,3-d]pyrimidin-4-amine
A mixture of 2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl trifluoromethanesulfonate (300 mg, 0.93 mmol), N-(piperdin-4-yl)-7-tosyl-7H-pyrido[2,3-d]pyrimidin-4-amine (380 mg, 1.02 mmol) and DIPEA (0.24 mL, 1.39 mmol) in DCM/DMF (V:V = 3 mL: 1 mL) was warmed to 60 °C and stirred overnight. The mixture was concentrated and the residue was purified by column chromatography over silica gel (elucent: Hexane:EtGAE = 1:1) to afford the title compound as a white powder (370 mg, 73%). $^1$H NMR (400 MHz, CDCl$_3$) δ 8.65 (s, 1H), 8.40 (s, 1H), 8.05 (d, J = 8.4 Hz, 2H), 7.83 (d, J = 8.0 Hz, 1H), 7.69 (d, J = 8.0 Hz, 1H), 7.45 (d, J = 4.0 Hz, 1H), 7.28 (d, J = 8.0 Hz, 2H), 6.36 (d, J = 4.0 Hz, iH), 5.47 (d, J = 47.2 Hz, 2H), 4.78-4.68 (m, 1H), 4.08-3.98 (m, 1H), 3.25 (d, J = 14.4 Hz, 2H), 2.90-2.88 (m, 2H), 2.52-2.45 (m, 2H), 2.38 (s, 3H), 1.99-1.89 (m, 2H), 1.46-1.36 (m, 2H).

Step 6. N-(1-(2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrido[2,3-d]pyrimidin-4-amine

A mixture of N-(1-(2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrido[2,3-d]pyrimidin-4-amine (360 mg, 0.66 mmol) and NaOH (50%, 3 mL) in THF was stirred at 60 °C for 1.5 hours. The green suspension was concentrated. The residue was adjusted to pH = 10 with dilute aqueous HCl under ice-water bath cooling. The aqueous layer was extracted with DCM. The organic layers were combined, dried over Na$_2$SO$_4$, and concentrated. The crude product was purified by column chromatography over silica gel (elucent: DCM:MeOH = 30:1) to afford the title compound as a yellow powder (207 mg, 80%). MS (ESI) calc'd for C$_{16}$H$_{21}$F$_3$N$_6$: 390.2; found: 391.3 [M+H]. $^1$H NMR (400 MHz, CDC$_3$) δ 10.47 (s, 1H), 8.67 (s, 1H), 8.32 (s, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.72 (d, J = 8.0 Hz, 1H), 7.68-7.05 (m, 1H), 634-630 (m, iH), 5.48 (d, J = 47.2 Hz, 2H), 4.86-4.85 (m, 1H), 4.17-4.04 (m, 1H), 3.27 (d, J = 14.4 Hz, 2H), 2.96-2.87 (m, 2H), 2.55-2.50 (m, 2H), 2.03-2.00 (m, 2H), 1.52-1.42 (m, 2H).
Example 1.7a (HCl salt). N-(1-(2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-y1)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-7-HCl).

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\text{\[\text{Structure Image}\]}
\]

To a solution of N-(1-(2,2-difluoro-2-(5-(fluoromethyl)pyridin-2-yl)ethyl)piperidin-4-y1)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (207 mg, 0.53 mmol) in MeOH (3 mL) was added HCl solution in MeOH (0.27 mL, 2 M, 0.53 mmol). The mixture was stirred at rt for 30 min. The solution was concentrated to afford the title compound as a white powder (226 mg, 100%).

Mass (ESI) calcd for C_{10}H_{14}F_{5}N_{2}: 309.2; found: 319.3 [M+H]. 1H NMR (400 MHz, CD_{3}OD) \( \delta \) 8.72 (s, 1H), 8.25 (s, 1H), 8.06 (d, \( J = 8.4 \) Hz, 1H), 7.85 (4 \( J = 8.4 \) Hz, 1H), 7.32 (d, \( J = 3.6 \) Hz, 1H), 6.89 (d, \( J = 3.6 \) Hz, 1H), 5.55 (d, \( J = 47.2 \) Hz, 2H), 4.11-4.07 (m, 1H), 3.79-3.76 (m, 2H), 3.43-3.40 (m, 2H), 3.00-2.98 (m, 2H), 2.17-2.13 (m, 2H), 1.95-1.86 (m, 2H).

Example 1.11. N-(1-(2,2-difluoro-2-(5-(trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-11).

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\text{\[\text{Structure Image}\]}
\]

Step 1i ethyl 2,2-difluoro-2-(5-(trifluoromethoxy)pyridin-2-yl)acetate

[0311i] To a stirred solution of 2-bromov5-(trifluoromethoxy)pyridine (2.0 g, 8.3 mmol) and ethyl 2-bromo-2,2-difluoroacetate (1.1 mL, 8.7 mmol) in DMSO (4 mL) was added copper
powder (1.1 g, 17 mmol). The mixture was heated to 80 °C overnight, cooled to rt and poured into water. The suspension was filtered through a pad of celite and the filter mass was extracted with EtOAc. The combined organic phases were washed with water, brine, dried over Na₂SO₄ and concentrated under vacuum. The residue was purified by column chromatography over silica gel to afford the title compound as a colorless oil (1.48 g, 62%).

**Step 2:** 2,2-difluoro-2-((S-(trifluoromethoxy)pyridin-2-yl)ethanol

[03123] To a stirred solution of ethyl 2,2-difluoro-2-((S-(trifluoromethoxy)pyridin-2-yl)acetate (1.47 g, 5.18 mmol) in ethanol (25 mL) was added NaBH₄ (290 mg, 7.77 mmol) at room temperature. The reaction was exothermic, and gradually a clear solution was obtained. After stirring for 30 rain, the ester was consumed. The reaction was quenched with ice water at 0 °C, followed by concentration. The residue was extracted with EtOAc. The combined organic phases were washed with brine, dried over Na₂SO₄ and concentrated. The residue was purified by column chromatography over silica gel (hexane/EtOAc = 10:1) to give the title compound as a colorless oil (820 mg, 65%). ¹H NMR (400 MHz, CDCl₃) δ 8.56 (d, J = 2.0 Hz, 1H), 7.81 (d, J = 8.8 Hz, 1H), 7.73 (dd, J = 8.8 and 2.0 Hz, 2H), 4.31 – 4.20 (m, 2H), 2.84 (t, J = 7.2 Hz, 3H).

**Step 3:** 2,2-difluoro-2-((S-(trifluoromethoxy)pyridin-2-yl)ethyl trifluoromethanesulphonate

£0313] T₆O (0.75 mL, 4.38 tamo) was added dropwise to a stirred solution of 2,2-difluoro-2-((S-(trifluoromethoxy)pyridin-2-yl)ethanol (820 mg, 3.37 mmol) and DIPEA (1.7 mL, 10 mmol)
in dry ether (15 mL) at 0 °C under N₂ atmosphere. The mixture was stirred for 1 h at room temperature, filtered through a pad of celite, and the filter mass was extracted with ether. The combined organic phases were concentrated and the residue was purified by column chromatography over silica gel (hexane/EtOAc = 40/1) to yield the title compound as a colorless oil (1.17 g, 92%). ^1H NMR (400 MHz, CDCl₃) δ 8.59 (d, J = 1.9 Hz, 1B), 7.84 (d, J = 8.6 Hz, 1B), 7.76 (d, J = 8.6 and 1.9 Hz, 1B). 5.11 (t, J = 12.0 Hz, 2H).

Step 4: N-(1-(2,2-difluoro-2-(5-(trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-anilae

[0314] A mixture of 2,2-difluoro-2-(5-(trifluoromethoxy)pyridin-2-yl)ethyltrifluoromethanesulfonate (620 mg, 1.65 mmol), N-(piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (Intermediate 1, 740 mg, 1.98 mmol) and DIPEA (0.4 mmol, 2.47 mmol) in mixed DMF/DCM solvent (v/v = 5 mL / 10 mL) was warmed to 60 °C. After stirring overnight, the solution was cooled down to room temperature and concentrated. The residue was purified by column chromatography over silica gel (hexane/EtOAc = 2/1) to afford the title compound as a white powder (750 mg, 76%). MS (ESI) calcd for C₂₅H₂₅F₃N₄O₃S: 596.2; found: 597.2 [M+H]. ^1H NMR (400 MHz, CDCl₃) δ 8.57 (d, J = 2.0 Hz, 1H), 8.40 (s, 1B), 8.06 (d, J = 8.4 Hz, 2B), 7.72 (d, J = 8.0 Hz, 1H), 7.67-7.65 (m, 1H), 7.44 (d, J = 4.0 Hz, 1H), 7.28 (d, J = 8.4 Hz, 2H), 6.37 (d, J = 4.0 Hz, 1H), 4.85-4.76 (m, 1H), 4.08 - 3.97 (m, 1H), 3.24 (t, J = 14.4 Hz, 2H), 2.92-2.89 (m, 2H), 2.53 - 2.44 (m, 2H), 2.38 (s, 3H), 1.97 - 1.94 (m, 2H), 1.46 - 1.34 (ra, 2H).

Step 5: N-(i-(2,2-difluoro-2-(5-(trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-anilae
N-(1-(2,2-difluoro-2-(5-( trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (750 mg, 1.25 mmol) was dissolved in THF (6 mL), followed by addition of 50% aqueous NaOH (3 mL). The mixture thus obtained was heated to 60 °C. After stirring for 3 hours, the mixture was allowed to cool to room temperature and was concentrated. The residual aqueous phase was acidified to pH=10 and extracted with EtOAc. The combined organic phases were washed with brine, dried over Na₂SO₄ and concentrated. The residue was purified by column chromatography over silica gel (DCM/MeOH = 30/1) to yield the title compound as an off-white powder (460 mg, 82%). MS (ESi) calcd for C₁₉H₁₅F₅N₅O; 442.2; found: 443.3. ¹H NMR (400 MHz, CD₃OD) δ 8.64 (d, J = 2.0 Hz, 1H), 8.05 (s, 1H), 7.93 (dd, J = 8.0, 2.0 Hz, 1H), 7.86 (d, J = 8.0 Hz, 1H), 7.02 (d, J = 4.0 Hz, 1H), 6.56 (d, J = 4.0 Hz, 1H), 4.03 – 3.93 (m, 1H), 3.25 (t, J = 14.3 Hz, 2H), 2.99 – 2.90 (m, 2H), 2.52 – 2.41 (m, 2H), 1.93 – 1.86 (m, 2H), 1.58 – 1.45 (m, 2H).

Example 1.11a (HCl salt). N-(1-(2,2-difluoro-2-(5-( trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-1, TICl).

To a solution of N-(1-(2,2-difluoro-2-(5-( trifluoromethoxy)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (450 mg, 1.0 a mol) in methanol (5 mL) was added methanoic HCl (2.0 M, 0.51 mL, 0.51 mmol) at room temperature. After stirring for 30 min, the solution was concentrated to afford the title compound as an off-white powder (460 mg, 94%). MS (ESi) calcd for C₁₉H₁₅F₅N₅O; 442.2; found: 443.3 [M+H]. ¹H NMR (400...
$M_{il.}$, CD$_3$OD $\delta$ 8.68 (d, $J = 2.0$ Hz; H1), 8.23 (s, 1H) 7.98 (d, $J = 8.8$ and 2.0 Hz, 1H), 8.91 (d, $J = 8.7$ Hz, 1H), 7.30 (d= $J = 3.6$ Hz, 1H), 6.85 (d, $J = 3.6$ Hz, 1H), 4.07 - 3.93 (m, 1H), 3.60 (t, $J = 14.0$ Hz, 2H), 3.29 - 3.19 (m, 2H), 2.88 - 2.74 (m, 2H), 2.11 - 2.03 (m, 2E), 1.85 - 1.71 (m, 2H).

**Example 1.12.** N-(1-(2-(5-(difluoromethoxy) pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-12).

![Chemical Structure](image)

**Step 1. Ethyl-2-(5^diiluoronethoxy)pyridin.-2-yl)-2 2'-difluoroacetate**

[0317] To a stilled solution of 2-bromo-5-(difluoromethoxy)pyridine (12.0 g, 54 mmol) and ethyl 2-bromo-2,2-difluoroacetate (7.6 mL, 59 mmol) in DMSO (130 mL) was added copper powder (6.90 g, 107 mmol). The resulting mixture was stirred at 50 °C overnight. The mixture was then poured into water, and stirred for 30 min. The suspension was filtered through a pad of eelite, and the filter mass was extracted with ethyl acetate. The combined organic phases were washed with brine, dried over Na$_2$SO$_4$ and concentrated in vacuo. The residue was purified by column chromatography over silica gel to afford the title compound as a colorless oil (12.0 g, 84%).

**Step 2. 2-($(d$-difluoromedioxy)pyridin-'2-yl)-2'2'-difluoroethanol**

![Chemical Structure](image)
To a stirred solution of ethyl 2-(5-(difluoromethoxy)pyridin-2-yl)-2,2-difluoroacetate (1.4 g, 5.7 mmol) in ethanol (20 mL) was added NaBH₄ (300 mg, 7.9 mmol) slowly under ice-water bath cooling. The mixture was stirred for 30 min and quenched with 1N HCl under ice-water bath cooling. The mixture was concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water, brine, dried over Na₂SO₄ and concentrated to afford the title compound as a white solid (1.06 g, 91%). ¹H NMR (400 MHz, CDCl₃) δ 8.48 (4 J = 2.8 Hz, 1H), 7.76 (d, J = 8.4 Hz, 1H), 7.65 (dd, J = 8.4, 2.8 Hz, 1H), 6.61 (t, J = 72.0 Hz, 1H), 4.28-4.20 (m, 2H), 3.02 ft, J = 7.2 Hz, 1H).

Step 3, 2-(5-(difluoromethoxy)pyridin-2-yl)-2,2-difluoroethyltrifluoromethanesulfonate
A mixture of 2-(S-(diltron ethoxy)pyridin-2-yl)-2,2-difluoroethyltrifluoromethane-sulfonate (500 mg, 1.4 mmol), N-(piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (Intermediat e 1, 623 mg, 1.68 mmol) and DIPEA (0.36 mL, 2.1 mmol) in a DCM/DMF solvent mixture (6 mL/3 mL) was heated to 60 °C. After stirring overnight at 60 °C, the mixture was concentrated. The concentrate was purified by column chromatography over silica gel to afford the title compound as a white powder (580 mg, 16%). \(^1\)H NMR (400 MHz, CDCl₃) \(\delta\) 8.50 (d, \(J = 2.4\) Hz, 1H), 8.40 (s, 1H), 8.05 (d, \(J = 8.4\) Hz, 2H), 7.68 (d, \(J = 8.8\) Hz, 1H), 7.57 (dd, \(J = 8.8\) and 2.4 Hz, 1B), 7.45 (d, \(J = 4.0\) Hz, 2H), 7.28 (d, \(J = 8.4\) Hz, 2H), 6.60 (t, \(J = 72.0\) Hz, 1B), 6.37 (d, \(J = 4.0\) Hz, 1H), 4.79-4.72 (m, 1B), 4.08-3.99 (m, 1H), 3.23 (t, \(J = 14.8\) Hz, 2H), 2.93-2.85 (m, 2H), 2.53-2.46 (m, 2H), 2.38 (s, 3H), 1.99-1.93 (m, 2H), 1.47-1.37 (m, 2H).

Step 5, N-1-(1-(2-(5-(diltronethoxy) pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine

To a stirred solution of N-(1-(2-(5-(difluoromethoxy)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7-tosylW H-pyrrolo[2,3-d]pyrimidin-4-amine (580 mg, 1.03 mmol) in THF (5 mL) was added the 50% NaOH (5 mL) at room temperature. The mixture was stirred at 60 °C for 4 hours, cooled to room temperature and then partitioned into DCM and water. The organic phase was washed with water, brine, dried over Na₂SO₄ and concentrated. The concentrate was purified by column chromatography over silica gel (DCM/MeOH=80:1) to afford the title compound as a white powder (360 mg, 78%). MS (ESI) calcd for C₉H₂₀F₄N₆O: 424.2; found: 425.2[M+H]. \(^1\)H NMR (400 MHz, CD₃OD) \(\delta\) 8.52 (d, \(J = 2.4\) Hz, 1H), 8.07 (s, 1H), 7.85-7.75 (m, 2H), 7.06 (t, \(J = 70\) Hz, 1H), 7.05 (s, iH), 6.58 <d, J=3.6 Hz, 1H), 4.05-3.95 (m, 2H), 3.30 (t, \(J = 14.4\) Hz, 2H), 2.98-2.92 (m, 2H), 2.52-2.46 (m, 2H), 1.94-1.90 (m, 2H), 1.60-1.50 (m, 2H).
Example 1,12a (HO salt). N-(1-(2-(5-(difluoromethoxy)pyridin-2-yl)-2,2-difluoroethy)l)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-12·HCl).

Step 1: 2-bromo-5-chloro-3-fluoropyridine

[0323] To a stirred solution of N-(1-(2-(5-(difluoromethoxy)pyridin-2-yl)-2,2-difluoroethy)l)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (360 mg, 0.84 mmol) in MeOH (5 mL) was added 2M HCl (0.42 mL, 0.84 mmol). The mixture was stirred for 30 min. The solution was concentrated to afford the title compound as an off-white powder (345 mg, 96%). MS (ESI) calcd for C_{19}H_{28}F_{4}N_{5}O_{2}: 424.2; found: 425.2 [M+H].

Example 1,16. N-(1-(2-(5-chloro-3-iluro)ropyridin-2-yl)-2,2-ifluoroethy)l)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimklin-4-amine (C-16).

Step 1: 2-bromo-5-chloro-3-fluoropyridine

[0323] 5-chloro-3-ilt]oropyridin-2-aniine (5.0 g, 34 mmol) was slowly added to 48% HBr solution (20 mL) with stirring at 0 °C. To the resulting mixture B(4) (5.24 mL, 102.3 mmol)
was then added over 20 minutes at 0 °C. The reaction mixture was cooled to -10 °C. A solution of NaNO₂ (5.88 g, 85.3 mmol) in water (20 mL) was added over 1.5 hours, and the mixture stirred for additional 30 minutes. A solution of NaOH (12 g, 306 mmol) in water (20 mL) was added over 30 minutes and the mixture was allowed to warm to room temperature. The mixture was extracted with ether (3×100 mL), The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated to afford the title compound as a pale yellow solid (6.43 g, 90%). 1H NMR (400 MHz, CDCl₃) δ 8.23 (d, J = 2.1 Hz, 1H), 7.48 (dd, J = 7.1, 2.1 Hz, 1H).

**Step 2**: ethyl 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroacetate:

![Chemical structure](image)

[0324] To the solution of 2-1iromo-5-chloro-3-fluoropyridine (2.0 g, 9.5 mmol) and ethyl 2-bromo-2,2-difluoroacetate (1.93 g, 9.5 mmol) in DMSO (40 mL) was added Cu powder (1.2 g, 19 mmol). The mixture was heated to 80 °C for 20 hours and poured into a solution of dibasic potassium hydrogen phosphate trihydrate (21 g, 95 mmol) in water (200 mL) with vigorous stirring. The reaction mixture was filtered through celite and the solid cake was extracted with ethyl acetate. The filtrate was extracted with ethyl acetate. The ethyl acetate layers were combined, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 50:1) to afford the title compound as a colorless oil (2.08 g, 86%). MS (ESI) cale for C₇H₇ClF₃NO₂: 253.0; found: 254.2 [M+H]. 1H NMR (400 MHz, CDCl₃) δ 8.42 (d, J = 1.8 Hz, 1H), 7.61 (dd, J = 9.4, 1.8 Hz, 1H), 4.46 ~ 4.39 (q, J = 7.1 Hz, 2H), 1.37 (t, J = 7.1 Hz, 3H).

**Step 3**: 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethanol

![Chemical structure](image)
To a solution of ethyl 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroacetate (2.1 g, 8.2 mmol) in ethano! (40 mL) was added NaBH₄ (341 mg, 9.02 mmol) slowly at 0 °C. The mixture was stirred for 1 hour at room temperature. The stirred reaction mixture was cooled, quenched with 1N HQ, concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water and brine, dried over sodium sulfate and concentrated to afford the title compound as a white solid (1.72 g, 99%). MS (ESI) calcd for C7H5ClF3NO: 212.2; found: 212.2 [M+H]+. ¹H NMR (400 MHz, CDCl₃) δ 8.40 (d, J = 1.3 Hz, 1H), 7.63 (dd, J = 9.5, 1.3 Hz, 4H), 4.26 (ra, 2H).

Step 4: 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethyli trifluoromethanesulfonate

To the solution of 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethanol (1.0 g, 4.7 mmol) and DIPEA (2.5 mL, 14 mmol) in anhydrous ether (45 mL) was added T₄0 (1.6 mL, 9.5 mmol) slowly at 0 °C. The reaction mixture was allowed to warm to rt and stirred for 1 h. The orange suspension was filtered through celite, and the solid was washed with ether. The filtrate was concentrated to afford the crude title compound as a pale yellow oil (1.65 g, 100%). The compound was used directly in the next step without further purification.

Step 5: tert-butyl 1-(2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-ylcarbamate

A mixture of 2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethane-sulfonate (1.65 g, 4.7 mmol), tert-butyl piperidino-4-ylcarbamate (1.92 g, 9.6 mmol) and DIPEA (2.5 mL, 14 mmol) in DCM (25 mL) was heated to 40 °C. After stirring overnight at
40 °C, the mixture was concentrated and extracted with EtOAc. The organic layer was washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=10:1) to afford the title compound as a pale yellow solid (1.64 g, 87%). MS (ESI) calcd for C_{17}H_{23}ClF_{3}N_{3}O_{2}: 393.1; found: 394.2 [M+H]. 1H NMR (400 MHz, CDCl$_3$) δ 8.43 (s, 1H), 7.54 (dd, $J$ = 9.8, 1.8 Hz, 1H), 4.34 (s, 1H), 3.38 (s, 1H), 2.91 - 2.80 (m, 2H), 2.42-2.35 (m, 2H), 1.85 - 1.75 (m, 2H), 131 - 1.22 (m, 2H).

Step 6: L-(2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-amine

Step 7: N-(1-(2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine
The mixture of 1-(2-(5-chloro-3-yl)pyridin-2-yl)-2,2-difluoroethyl)piperidin-4-amine (200 mg, 0.68 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (87.2 mg, 0.567 mmol) and DIPEA (0.2 mL, 1.13 mmol) in n-butyl alcohol (3 mL) was heated to 130 °C. After stirring overnight at 13.0 °C, the reaction solution was concentrated and extracted with EtOAc. The organic layers were washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=i/3) to afford the title compound as a white solid (35 mg, 13%). MS (ESI) calcd for C_{18}H_{18}ClF_{3}N_{6}: 410.1; found: 411.2[M+H]. ^{1}H NMR (400 MHz, CD_{3}OD) δ 8.52 (s, 1H), 8.08 (s, 1H), 7.99 -7.93 (m, 1H), 7.05 (d, J= 3.5 Hz, 1H), 6.58 (d, J= 3.5 Hz, 1H), 4.01 (m, 1H), 3.27 (m, 2H), 3.01 (m, 2H), 2.50 (m, 2H), 1.93 (m, 2H), 1.53 (m, 2H).

Example 1.16a (HCl salt). N-(1-(2-(5-chloro-3-fluoropyridin-2-yl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidine-5-n-4-amine hydrochloride (C-16-HCl).

To a stirred solution of N^{1}-1-(2-(Schloro-3-fluoropyridin-2-yi)-2,2-difluoroethyl)-piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (24.5 mg, 0.060 mmol) in MeOH (1 mL) was added HCl/MeOH (2M, 0.03 mL, 0.060 mmol) at rt. After stirring for 10 rain, the mixture was concentrated to afford the title compound as a pale yellow solid (26 mg, 100%). MS (ESI) calcd for C_{18}H_{18}ClF_{3}N_{6}: 410.1; found: 411.2[M+H]. ^{1}H NMR (400 MHz, CD_{3}OD) δ 8.43 (s, 1H), 8.13 (s, 1B), 7.91 (dd, J= 10.3, 1.7 Hz, 1H), 7.22 (d, J= 3.5 Hz, 1H), 6.78 (d, J= 3.5 Hz, 1B), 3.89 (s, 1H), 3.50 (s, 2H), 3.16 (s, 2H), 2.69 (s, 2H), 2.02 - 1.92 (m, 2H), 1.67 (ra, 2H).

Example 1.17. N-(1-(2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-17).
Step 1: Ethyl 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)acetate

To a solution of 2-bromo-3-fluoro-5-methylpyridine (1.8 g, 9.5 mmol) and ethyl 2-bromo-2,2-difluoroacetate (1.8 mL, 14.2 mmol) in DMSO (30 mL) was added copper powder (1.2 g, 19 mmol). After stirring overnight at 80 ºC, the mixture was diluted with EtOAc. The mixture was poured into water, and stirred for 30 min. The suspension was filtered through a pad of celite. The organic phase was washed with water and brine, dried over Na₂SO₄ and concentrated. The concentrate was purified by column chromatography over silica gel (hexane) to afford the title compound as a white solid (1.6 g, 70%). ^1H NMR (400 MHz, CDCl₃) δ 8.26 (s, 1H), 7.36 (d, J = 10.6 Hz, 1H), 4.42 (q, J = 7.1 Hz, 2H), 2.42 (s, 3H), 1.36 (t, J = 7.1 Hz, 3H).

Step 2: 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethanol

To a solution of ethyl 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)acetate (1.68 g, 7.22 mmol) in ethanol (30 mL) was added the NaBH₄ (410 mg, 10.8 mmol) at room temperature. After stirring for 30 min, the reaction mixture was quenched with aqueous IN HCl at 0 ºC. The mixture was extracted with EtOAc. The combined organic phases were washed with brine, dried over Na₂SO₄ and concentrated to afford the product as a white powder (1.3 g,
100%). $^1$H NMR (400 MHz, CDCl₃) δ 8.22 (s, 1H), 7.39 (d, $J = 10.8 \text{ Hz}$, 1H), 4.32 – 4.20 (m, 2H), 3.45 – 3.35 (m, 1H), 2.43 (s, 3H).

Step 3: 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethyl trifluoromethanesulfonate

![Chemical structure](image)

To a solution of 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethanol (120 mg, 0.63 mmol) and DIPEA (0.15 mL, 0.95 mmol) in dry ether (5 mL) was added dropwise TFA (0.15 mL, 0.76 mmol) at 0 °C under N₂ atmosphere. After stirring for 1h, the suspension was filtered, and the filtrate was concentrated to afford the crude title compound (200 mg) which was used directly without further purification in the next step.

Step 4, N-(1-(2,2-difluoro-2-(3-5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-tosyl-1H-pyrazolo[3,4-d]pyridin-4-amine

![Chemical structure](image)

[0333] A mixture of 2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethyl trifluoromethanesulfonate (1.33 g, 3.9 mmol), N-(piperidin-4-yl)-7-benzo-7H-pyrindol[2,3-d]pyrimidin-4-amine (1.16 mg, 3.14 mmol) and DIPEA (1.0 mL, 5.9 mmol) in DCM (65 mL) was heated to 50 °C. After stirring overnight at 50 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (ethyl acetate, 100%) to afford the title compound as a white powder (500 mg, 62%). MS (ESI) calcd for C₂₆H₂₇F₃N₆O₂S: 544.2; ̃m; 545.2[M+H]. $^1$H NMR (400 MHz, CDCl₃) δ 8.41 (s, 1H), 8.27 (s, 1H), 8.05 (d, $J = 8.4\text{ Hz}$, 2H), 7.45 (d, $J = 4.0\text{ Hz}$, 1H), 7.37-7.21 (m, 3H), 6.37 (d, $J = 4.0\text{ Hz}$, 1H), 4.76-4.74 (m, 1H), 4.07-3.97 (m, 1H), 3.23 (t, $J = 14.4\text{ Hz}$, 2H), 2.97-
Step 5: N-(1-(2,2-difluoro-2^-fluoro-5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridinida-4-amine

[033S] To a stirred solution of N-(1-(2,2-difluoro-2^-fluoro-5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-1H-pyrrolo[3,4-d]pyrimidin-4-amine (41.0 mg, 0.75 mmol) in THF (4 mL) was added 50% NaOH (4 mL) at room temperature, and the mixture was warmed to 60 °C. After stirring for 4 hours at 60 °C, the mixture was partitioned between DCM and water. The organic phase was washed with water, brine, dried over Na₂SO₄ and concentrated. The concentrate was purified by column chromatography over silica gel (DCM/MeOH = 80:1) to afford the title compound as a white powder (246 mg, 84%). MS (ESI) calcd for C₁₉H₂₁F₃N₆: 390.2; found: 391.3 [M+H]. H NMR (400 MHz, CD₃OD) δ 8.31 (s, 1H), 8.07 (s, 1H), 7.60 (d, J = 11.6 Hz, 1H), 7.05 (d, J = 3.6 Hz, 1H), 6.58 (d, J = 3.6 Hz, 1H), 4.04-3.97 (m, 2H), 3.02-2.99 (m, 2H), 2.52-2.48 (m, 2H), 2.45 (s, 3H), 1.94-1.91 (m, 2H), 1.60-1.50 (na, 2H).

Example 1.17a (HCl salt). N-(1-(2,2-difluoro-2^-fluoro-5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-1H-pyrrolo[3,4-d]pyrimidin-4-yl)-H-pyrrolo[3,4-d]pyrimidin-4-yl)ethyl)piperidin-4-yl)-H-pyrrolo[3,4-d]pyrimidin-4-yl)ethyl)piperidin-4-yl)-H-pyrrolo[3,4-d]pyrimidin-4-yl)ethyl)piperidin-4-yl)-H-pyrrolo[3,4-d]pyrimidin-4-yl)ethyl)piperidin-4-yl)ethyl) hydrochloride (HCl).
To a stirred solution of N-(1-(2,2-difluoro-2-(3-fluoro-5-methylpyridin-2-yl)ethyl)-piperidin-4-yl)-7H-pyrrolo[3-d]pyridin-4-amine (246 mg, 0.63 mmol) in MeOH (3 mL) was added 2M methanesulfonic acid in methanol (0.35 mL, 0.63 mmol). The mixture was stirred for 30 min. The solution was concentrated to afford the product as an off-white powder (265 mg, 98%). MS (ESI) found: 39.13[M+H]+. H NMR (400 MHz, CD$_3$OD) $\delta$ 8.34 (s, 1H), 8.21 (s, 1B), 7.64 (d, $J = 9.6$ Hz, 1H), 7.29 (d, $J = 3.6$ Hz, 1H), 6.85 (d, $J = 3.6$ Hz, 1B), 4.04-3.97 (m, 1H), 3.63-3.50 (m, 2B), 3.28 (m, 2H), 2.81-2.75 (m, 2H), 2.46 (s, 3H), 2.07 (m, 2H), 1.82-1.73 (m, 2H).

**Example 1.18.** N-(1-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[3-d]pyridin-4-amine (CMS).

![Chemical Structure](attachment:image.png)

**Step 1; ethyl 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)acetate**

[0337] To the solution of ethyl 2-bromo-2,2-difluoroacetate (1.0 g, 4.8 mmol) and 2-bromo-3-fluoro-5-(trifluoromethyl)pyridine (1.1 g, 4.4 mmol) in DMSO (20 mL) was added Co powder (568mg, 8.8 mmol). The mixture was heated at 80 °C for 20 hours. The reaction mixture was filtered through celite and the filter pad was extracted with ethyl acetate. The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane / ethyl acetate =100:1) to afford the title compound as a colorless oil (980mg, 83%). $^1$H NMR (400 MHz, CDCU) $\delta$ 8.73 (s, 1H), 7.81 (d, $J = 9.6$ Hz, 1H), 4.45 (q, $J = 7.2$Hz, 2H), 1.38 (t, $J = 7.2$ Hz, 3H).
Step 2: 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethanol

[0338] To the solution of 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)acetate (980 mg, 3.41 mmol) in ethanol (20 mL) was added NaB₃H₄ (194 mg, 5.12 mmol) slowly at ice bath temperature and the mixture stirred for 30 min. The reaction mixture was quenched with 1N HQ, concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water and brine, then dried and concentrated to afford the title compound as a white solid (780 mg, 93%). ¹H NMR (400 MHz, CDCl₃) δ 8.72 (s, 1H), 7.84 (d, J = 9:2 Hz, 1H), 4.30 (t, J = 12.4 Hz, 2H), 2.86 (hrs, 1H).

Step 3: 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl trifluoromethanesulfonate

[10339] To the solution of 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethanol (780 mg, 3.18 mmol) and DIPEA (1.6 mL, 9.6 nmol) in dry ether (15 mL) was added P₄O₁₀ (0.9 mL, 6.36 mmol) at 0 °C. After stirring for 1 hr at rt, the white suspension was filtered through celite, and the filter mass was extracted with ether. The filtrate was concentrated and purified by column chromatography over silica gel (hexane) to afford the title compound as a colorless oil (870 mg) which was used for the next step directly.

Step 4, N-(1-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-tosyl-7H-pyrimidin-4-amine
A mixture of 2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl trifluoromethanesidfonate (760 mg, 2.02 mmol), N-{p.ipei didin-4-yl)-7-tosyi-7H-pyrrolo[2,3-d]pyrimid m-4-amine (Intermediate 1, 824 mg, 2.22 mmol) and DiPEA (0.53 mL, 3.02 mmol) in DMF/DCM (V/V 3:3, 0.3 mL) was warmed to 40 °C and stirred overnight. The mixture was concentrated and the crude product was purified by column chromatography over silica gel (eluent: Hexane:EtOAc = 3:1) to afford the title compound as a pale yellow powder (950 mg, 79%). MS (ESI) caicd for C26H26F10N8O3S: 598.2; found: 599.2 [M+H]. 1H NMR (400 MHz, CDCl3) δ 8.73 (s, 1H), 8.40 (d, J = 8.4 Hz, 2H), 8.06-8.01 (m, 3H), 7.77-7.74 (m, 3H), 7.45 (d, J = 4.0 Hz, 1H), 7.28 (d, J = 8.4 Hz, 2H), 6.36 (d, J = 4.0 Hz, 1H), 4.76-4.74(m, 2H), 4.10-3.97 (m, 3H), 3.26 (t, J = 14.0 Hz, 2H), 2.97-2.90 (m, 3H), 2.88 (s, 1H), 2.53-2.46 (ra, 2H), 2.38 (s, 3H), 1.97-1.94 (m, 2H) 1.42-1.35 (m, 2H).

Step 5. N-{1-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl}-7H-pyrrolo[2,3-d]pyridin-4-amine

A mixture of N-{1-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-3)-7-tosyi-7H-pyrrolo[2,3-d]pyrimid m-4-amine (950 mg, 1.60 mmol) and 50% aqueous NaOH (5 mL) in THE was stirred at 60 °C for 1.5 hours. The mixture was concentrated and the residue was adjusted to pH=10 with dilute aqueous HCl. The aqueous layer was extracted with DCM. The combined organic layers were dried over Na2SO4 and concentrated. The crude product was purified by column chromatography over silica gel (eluent: DCM:MeOH = 80:1~20:1) to afford the title compound as a yellow powder (380 mg,
54%). MS (ESI) caicd for \( \text{C}_{19}\text{H}_{18}\text{N}_6\text{F}_6 \): 444.2; found: 445.3 [M+H]. \( ^1\text{H} \) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 9.57 (s, 1H), 8.75 (s, 1H), 8.31 (s, 1H), 7.77 (d, \( J = 10.0 \) Hz, 1H), 7.05-7.03 (m, 1H), 6.32-6.31 (tt, 1H), 4.87-4.81 (m, 1H), 4.15-4.07 (m, 1H), 3.29 (t, \( J = 14.4 \) Hz, 2H), 2.98-2.95 (m, 2H), 2.57-2.51 (m, 2H), 2.05-2.01 (m, 2H), 1.48-1.9 (m, 2H).

**Example 1.18a (HCl salt).** N-(1-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-18'HCl).

\[
\text{HCl}
\]

[0342] To a stirred solution of N-(i-(2,2-difluoro-2-(3-fluoro-5-(trifluoromethyl)pyridin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (380 mg, 0.86 mmol) in MeOH (5 mL) was added the 2.0M hydrochloric acid (0.43 mL, 0.86 mmol). The resulting solution was stirred at rt for 30 min. The solution was concentrated to afford the title compound as a yellow powder (410 mg, 100%). MS (ESI) caicd for \( \text{C}_{19}\text{H}_{15}\text{ClN}_4 \): 444.2; found: 445.3 [M+H]. \( ^1\text{H} \) NMR (400 MEz, CDCl\(_3\)) \( \delta \) 12.12-1.18 (m, 1H), 9.09 (s, 1H), 8.74 (s, 1H), 8.43 (s, 1H), 7.79 (d, \( J = 9.2 \) Hz, 1H), 7.32 (s, 1H), 6.60 (s, 1H), 4.07-3.83 (m, 1H), 3.37-3.31 (m, 2H), 3.09-3.07 (m, 2H), 2.63-2.61 (m, 2H), 2.10-2.03 (m, 2H), 1.80-1.73 (m, 2H).

**Example 1.47.** N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-N-methyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (€-47).
Step 1: N-(1-(2,2-difluoro-2-(5-methylpyridin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine

![Molecule Image]

[0343] A mixture of 2, 2-difluoro-2-(5-methylpyridin-2-yl) ethyl trifluoromethanesulfonate (1.33 g, 3.9 mmol), N-(piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (1J 6 g, 3.2 mmol) and DIPEA (1 mL, 6 mmol) in DCM (65 mL) was heated to 50°C. After stirring overnight at 50°C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (ethyl acetate, 0% to 100%) to afford the title compound as a white powder (500 mg, 62%). MS (ESI) caicd for C_{28}H_{27}F_{3}N_{6}O_{2}S: 544.2; found: 545.2 [M-H].

H NMR (400 MHz CTX3) δ 8.41 (s, 1H), 8.27 (s, 1H), 8.05 (d, J = 8.4 Hz, 2H), 7.45 (d, J = 4.0 Hz, 1H), 7.37-7.21 (m, 3H), 6.37 (d, J = 4.0 Hz, 1H), 4.76-4.74 (m, 1H), 4.07-3.97 (m, 1H), 3.23 (t, J = 14.4 Hz, 2H), 2.97-2.93 (m, 2H), 2.53-2.47 (m, 2H), 2.41 (s, 3H), 2.38 (s, 3H), 1.97-1.94 (m, 2H), 1.44-1.38 (m, 2H).

Step 2: N-(1-(2,2-difluoro-2-(5-methylpyrimidin-2-yl)ethyl)piperidin-4-yl)-N-methyl-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine

![Molecule Image]

[0344] To a stirred solution of N-(1-(2,2-difluoro-2-(5-methylpyrimidin-2-yl)ethyl)piperidin-4-yl)-7-tosyl-7H-pyrrolo[2,3-d]pyrimidin-4-amine (100 mg, 0.189 mmol) in dry DMF (3 mL) was added 60% NaH in mineral oil (20 mg, 0.37 mmol) at 0°C under nitrogen atmosphere. After stirring for 15 min, Mel (24 μL, 0.38 mmol) was added. After the starting material was consumed, the reaction was quenched with water at 0°C. The mixture thus obtained was
partitioned into EtOAc and water. The organic phase was washed with brine, dried over 
Na$_2$SO$_4$ and concentrated raider vacuum. The residue was purified by column 
chromatography over silica gel (50% EtOAc in hexane) to afford the title compound as a pale 
yellow powder (30 mg, 30%). MS (ESI) calcd for C$_{27}$H$_{24}$F$_2$N$_6$O$_2$S: 540.2; found: 541.3 
[M +H]. $^1$H NMR (400 MHz, CDC$_3$) 3 8.47 (s, 1H), 8.36 (s, 1H), 8.05-8.03 (m, 2E), 7.62-
7.59 (m, 1H), 7.55 (d, $J$ = 8.0 Hz, 1H), 7.43 (d, $J$ = 4.0 Hz, 1H), 7.27 (d, $J$ = 8.0 Hz, 2H), 
6.59 (d, $J$ = 4.0 Hz, 1H).4.72-4.52 (m, 1H), 3.24 (t, $J$ = 14.8 Hz, 2H), 3.11 (s, 3H), 3.03-3.00 
(ra, 2H), 2.52-2.46 (ra, 2H), 2.39 (s, 3H), 2.3? (s, 3H), 1.82-1.72 (in, 2H), 1.61-1.58 (ra, 2H).

**Step 3:** N-((1-(2,2-difluoro-2-(5-methyl|pyridin-2-yl) ethyl)piperidin-4-yl)-N-methyl-7H-
pyrrrolo[2,3-d]pyrindine-4-yline

[034S] To a stirred solution of N-((1-(2,2-difluoro-2-(5-methyl|pyridin-2-yl)ethyl)piperidin-4-yl)-
N-methyl-7-tosyl-7H-pyrrolo[2,3-d|pyrindine-4-aniline (30 mg, 0.06 mmol) in THF (1 mL)
was added 50% aqueous NaOH. (1 mL). The mixture was heated to 60 °C. After the starting
material was consumed, the mixture was cooled down to rt and concentrated. The residue
was partitioned into EtOAc and water. The organic phase was washed with brine, dried over 
Na$_2$SO$_4$ and concentrated. The residue was purified by column chromatography over silica 
gel (B$_4$QAc/MeOH = 20/1) to afford the title compound as a pale yellow powder (15 mg, 
68%). MS (ESI) calcd for C$_{28}$H$_{24}$F$_2$N$_6$: 386.2; found: 387.2 [M+H]. $^1$H NMR (400 MHz,
CD$_3$OD) 8 8.48 (s, 1H), 8.08 (s, 1H), 7.81-7.79 (m, 1H), 7.64 (d, $J$ = 8.0 Hz, 1H), 7.08. (d, 
$J$ = 4.0 Hz, 1H), 6.61 (d, $J$ = 4.0 Hz, 1H), 4.73-4.67 (ra, 1H). 3.25 (t, $J$ = 14.4 Hz, 2H), 3.20 (s,
3H), 3.02-2.99 (ni, 2 t), 2.53-2.47 (m, 2H), 2.42 (s, 3H), 1.90-1.80 (m, 2 H), 1.65-1.62 (ra,
2H).

**Example i,47a (HCl salt).** N-((1-(2,2-difluoroQ-2-(5-methyl|pyridin-2-yl)ethyl)piperidin-4-yl)-N-
methyl!-7H-pyrrolo[2,3-d|pyrindin-4- amine hydrochloride (C-47 +H0 l).
To a stirred solution of N-[(1-(2,2-difluoro-2-(5-methyl[4-pyridin-2-yl]ethyl)piperidin-4-yl)]-N-methyl-7H-pyrazolo[2,3-d]pyridin-4-amine (23 mg, 0.06 mmol) in methanol (1 mL) was added the methanoic solution of HCl (2.0M, 30µL) at ambient temperature. After stirring for 30 min, the clear solution was concentrated to afford the title compound as a pale yellow powder (25 mg, 100%). MS (ESI) calcd for C20H2N2F2: 386.2; found: 387.2 [M+H]. 

Example 1. 127. N-(1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-yl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine (C-127).

Step 1: 5-iodo-2-(trifluoromethyl)pyridine

A solution of 6-(trifluoromethyl)pyridin-3-amine (9.96 g, 0.062 mol) in 5N HCl (70 mL) was cooled to -5°C and sodium nitrite (6.39 g, 0.093 mol) in 30 mL of water was added dropwise while maintaining the internal temperature below 5°C. After 10 min, KI (22.5 g, 0.136 mol) in 30 mL of water was added dropwise at -5°C while maintaining the internal
temperature below 10 °C over the course of the addition. The reaction mixture was warmed to rt and 250 mL of EtOAc was added. The pH of the aqueous layer was adjusted to 11 by the addition of 50 mL of 6N NaOH. The organic layer was separated and washed with 1.20 mL of 0.3M Na2S2O3. The EtOAc layer was concentrated and the concentrate was purified by column chromatography over silica gel (hexane/EtOAc =25/1) to afford the title compound as a white solid (14.6 g, 87%). MS (ESI) calcd for C6F4N2: 273.0; found: 274.0 [M+H]. 1H NMR. (400 MHz, CDCl3) δ 8.96 (s, 1H), 8.22 (d, J = 8.2 Hz, 1H), 7.47 (d, J = 8.2 Hz, 1H).

Step 2: ethyl 2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)acetate

[0348] To a solution of 5-iodo-2-(trifluoromethyl)pyridine (14.5 g, 53.2 mmol) and ethyl 2-bromo-2,2-difluoroacetate (10.8 g, 53.2 mmol) in DMF (250 mL) was added Cu powder (6.76 g, 6.6:mmol). The mixture was heated at 80 °C for 20 hours and the reaction mixture was poured into a solution of dibasic potassium hydrogen phosphate, trifluoride (121 g, 532 mmol) in water (1500 mL) with vigorous stirring. The suspension was filtered and the solid was extracted with ether. The filtrate was added to brine and extracted with ether (2x). The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc =50:1) to afford the title compound as a colorless liquid (8.96 g, 63%). MS (ESI) calcd for C11H7F3N2O2: 269.2; found: 270.3 [M+H]. 1H NMR (400 MHz, CDCE) δ 8.98 (s, 1H), 8.14 (d, J = 8.2 Hz, 1H), 7.81 (d, J = 8.2 Hz, 1H), 4.35 (q, J = 7.1 Hz, 2H), 1.34 (t, J = 7.1 Hz, 3H).

Step 3: 2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethanol
To the solution of ethyl 2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)acetate (8.86 g, 32.9 mmol) in ethanol (165 mL) was added NaBH* (1.79 g, 4.74 mmol) slowly at rt. The mixture was stirred for 30 min at rt. After 30 min, the reaction mixture was quenched with 1 N HCl at ice-water bath temperature. The mixture was concentrated and extracted with EtOAc. The EtOAc layer was washed with water and brine, then dried and concentrated to afford the title compound as a white solid (6.13 g, 82%). MS (ESI) calc'd \( \text{C}_8\text{H}_6\text{F}_3\text{NO} \): 227.0; found: 228.2 [M+H]. \(^1\text{H}\) NMR (400 MHz, CDCl\(_3\)) \( \delta 8.91 \) (s, 1 H), 8.06 (d, \( J = 8.2 \) Hz, 1 H), 7.79 (d, \( J = 8.2 \) Hz, 1 H), 4.06 (td, \( J = 12.4 \) and 7.0 Hz, 2 H), 2.16 (t, \( J = 7.0 \) Hz, 1 H).

Step 4: 2,2-difluoro-2-(6^trifluoromethyl)pyridin-3-yl)ethyl trifluoromethanesulfonate

[0350] To the solution of 2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethanol (1.0 g, 4.4 mmol) and DIPEA (2.39 mL, 13.2 mmol) in dry ether (44 mL) was added \( \text{TiCl}_4 \) (1.48 mL, 8.8 mmol) at 0°C. After stirring for 1 hr at rt, the orange suspension was filtered through celite, and the filter mass was extracted with ether. The combined organic phases were concentrated, and purified by column chromatography to afford the title compound as a pale yellow solid (1.47 g, 93%). \(^1\text{H}\) NMR (400 MHz, COC) \( \delta 8.92 \) (s, 1 H), 8.07 (d, \( J = 8.2 \) Hz, 1 H), 7.86 (d, \( J = 8.2 \) Hz, 1 H), 4.78 (i, \( J = 11.2 \) Hz, 2 H).

Step 5: tert-butyl 1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-yl-carbamate

[0351] A mixture of 2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl trifluoromethanesulfonate (1.46 g, 4.07 mmol), tert-butyl piperidin-4-ylcarbamate (1.63 g, 8.13 mmol) and
DPEA (2.2 nil, 12.2 mmol) in DCM (20 ml) was heated to 40 °C. After stirring overnight at 40° C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=10/1) to afford the title compound as a white solid (1.37 g, 83%). MS (ESI) calcd for C_{16}H_{24}F_{2}N_{3}O_{2}: 409.2; found: 410.4 [M+H]. H NMR. (400 MHz, CDCl_{3}) δ 8.89 (s, 1H), 8.01 (d, J = 8.2 Hz, 1H), 7.75 (d, J = 8.2 Hz, 1H), 4.37 (brs, 1H), 3.40 (brs, 1H), 2.97 (t, J = 13.2 Hz, 2H), 2.74-2.69 (m, 2H), 2.42-2.36 (m, 2H), 1.87-1.81 (m, 2H), 1.43 (s, 9 H). 1.36 – 1.23 (m, 2H).

Step 6: 1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-amine

Step 7/N-(i-(2,2-difuRO-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-yl)carbamate (1.36 g, 3.32 mmol) in DCM (16 nil) was added TFA (8 mL) under ice-water bath cooling. After stirring for 3 Grains at rt, the starting material was consumed, and the mixture was concentrated to afford the title compound as a white solid (1.0 g, 100%). MS (ESI) calcd for C_{13}H_{16}F_{2}N_{3}: 309.1; found: 310.3 [M+H]. H NMR (400 MHz, CD_{3}OD) δ 8.92 (s, 1H), 8.24 (d, J = 8.2 Hz, 1H), 7.95 (d, J = 8.2 Hz, 1H), 3.16 (t, J = 13.5 Hz, 2H), 3.06 – 2.94 (m, 2H), 2.91-2.84 (m, 2H), 2.47-2.38 (m, 2H), 1.92-1.86 (m, 2H), 1.56-1.45 (m, 2H), 1.36-1.30 (m, 2H).
The mixture of 1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-amine (625 mg, 2.02 mmol) and DIPEA (0.62 mL, 3.37 mmol) in n-butyl alcohol (10 mL) was heated to 130 °C. After stirring overnight at 130 °C, the reaction mixture was concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ EtOAc=1/1~1/3) to afford the product as a white solid (230 mg, 27%). MS (ESI) calcd for C₁₉H₁₉F₃N₆: 426.2; found: 427.4 [M+H]. ¹H NMR (400 MHz, CDCl₃) δ 8.94 (s, 1H), 8.30 (s, 1H), 8.05 (d, J = 8.2 Hz, 1H), 7.77 (d, J = 8.3 Hz, 1H), 7.06 (d, J = 3.5 Hz, 1H), 6.37 (s, 1H), 4.18-4.10 (t, 2H), 3.04 (J = 13.1 Hz, 2H), 2.86-2.80 (m, 2H), 2.58-2.51 (m, 2H), 2.09-2.00 (m, 2H), 1.61-1.45 (m, 2H).

Example 1.127a (HO. salt). N-(1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-y1)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-127-HCl).

To a stirred solution of N-(1-(2,2-difluoro-2-(6-(trifluoromethyl)pyridin-3-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (181 mg, 0.424 mmol) in MeOH (2 mL) was added HCl/Et₂O (2M, 0.21 mL, 0.424 mmol) at it. After stirring for 1Satin, the mixture was concentrated to afford the product as an off-white powder (197 mg, 100%). MS (ESI) calcd for C₁₉H₁₉F₃N₆: 426.2; found: 427.5 [M+H]. ¹H NMR (400 MHz, CDCl₃) δ 11.90 (hrs, 1H), 8.91 (s, 1H), 8.43 (s, 1H), 8.06 (d, J = 8.0 Hz, 1H), 7.79 (d, J = 8.1 Hz, 1H), 7.32 (s, 1H), 6.60 (s, 1H), 4.07 (brs, 1H), 3.08 (t, J = 13.1 Hz, 2H), 2.96-2.88 (m, 2H), 2.59 (t, J = 9.6 Hz, 2H), 2.09-2.02 (m, 2H), 1.82-1.78 (m, 2H).

Example 1.128. N-(1-(2,2-difluoro-2-(6-methylpyridin-3-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-128).
Step 1. **ethyl 2,2-difluoro-2-((6-methylpyridin-3-yl)acetate**

To a stirred solution of ethyl 2-bromo-2,2-difluoroacetate (1.94 g, 9.56 mmol) and 5-iodo-2-methylpyridine (2.00 g, 9.56 mmol) in DMSO (45 ml) was added Co powder (1.20 g, 18.8 mmol). The reaction mixture was heated at 80 °C for 20 hours. The mixture was allowed to cool to room temperature, filtered through celite and extracted with ethyl acetate. The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate = 5:1) to afford the title compound as a colorless oil (1.16 g, 59%). $^1$H NMR (400 MHz, CDCl$_3$) δ 8.75 (s, 1H), 7.81 (dd, J = 2.0 and 8.0 Hz, 1H), 7.26 (d, J = 8.0 Hz, 1H), 4.32 (q, J = 7.2 Hz, 2H), 2.62 (s, 3H), 1.33 (t, J = 7.2 Hz, 3H).

**Step 2.** 2,2-difluoro-2-(6-methylpyridin-3-yl)acetic acid hydrochloride

To the solution of ethyl 2,2-difluoro-2-(6-methylpyridin-3-yl)acetate (1.16 g, 5.39 mmol) in methanol (30 mL) was added 50% aqueous KOH (30 mL) at room temperature. After 2 hours, the reaction mixture was acidified with 3N HCl to pH=2. The mixture was concentrated, dissolved in ethyl acetate (30 mL), stirred for 30 min, filtered, and concentrated to give the title compound (550 mg, 46%). MS (ESI) calculated for C$_9$H$_7$F$_2$NO$_2$: 187; found: 188[M+H].
Step 3. Stir by i, d 2 ~

A mixture of 2,2-dif uoro-2-(6-ethylpyridin-3-yl)acetic acid hydrochloride (400 mg, 2.14 mmol), oxalyl chloride (0.22 mL, 2.56 mmol) and a drop of DMF in DCM (8 mL) was Stirred at room temperature for 1 hr. DIPEA (1.62 mL, 9.35 mmol) was added followed by tert-butyl piperidin-4-ylcarbarte (48(3 rag, 0.22 mmol). After 14 hours the reaction mixture was poured into 1M citric acid and extracted with ethyl acetate. The combined organic layers were washed with saturated sodium bicarbonate, water, brine, dried over sodium sulfate and concentrated. The concentrate was purified by column chromatography over silica gel (hexane / ethyl acetate -1:1) to afford the title compound as a white solid (520 mg, 68%).

$^1$H NMR (400 MHz, CDCl₃) δ 8.66 (d, J = 1.2 Hz, 1H), 7.73 (dd, J = 1.2 and 8.0 Hz, 1H), 7.25 (d, J = 8.0 Hz, 1H), 4.52 - 4.39 (m, 2H), 4.05-4.00 (m, 1H), 3.72 - 3.62 (m, 1H), 3.12 - 3.05 (m, 1H), 2.95-2.85 (m, 1H), 2.62 (s, 3H), 2.04 - 1.90 (m, 2H), 1.45 (s, 9H), 1.38 - 1.29 (m, 1H).

Step 4. i-(4-ammopiperid^ -yl)-2,2-dif uoro-2-(6-methylpyridin-3-yl)etherone hydrochloride

To a solution of tert-butyl 1-(2,2-dif uoro-2-(6-methylpyridin-3-yl)acetyl)piperidin-4-ylcarbamate (100 mg, 0.27 mmol) in DCM (1 mL) was added trifluoroacetic acid (1 mL) and the resulting solution was stirred at room temperature. After one hoar, the reaction mixture was concentrated, treated with a saturated solution of HCl in ether and concentrated to afford the title compound as a yellow solid (73 mg, 88%) which was used in the next step without further purification.
Step 5. 1-(2,2-difluoro-2-(6-methylpyridin-3-yl)ethyl)piperidin-4-amine

To a stirred solution of 1-(4-aminopiperidin-1-yl)-2,2-difluoro-2-(6-methylpyridin3-yl)ethanone hydrochloride (306 mg, 1.14 mmol) in THF (45 mL) was added 1M borane in THF (14 mL, 14 mmol) under nitrogen at room temperature. The reaction mixture was heated at 70 °C for 2 hours. The reaction mixture was cooled to room temperature, quenched with 6N HCl (43 mL) and heated to 70 °C. After 1 hour; the reaction mixture was basified to pH > 13 with SM NaOH and extracted with ethyl acetate. The ethyl acetate layer was dried over sodium sulfate, filtered, and concentrated to give the title compound as an off-white powder (100 mg, 93%). MS (ESI) caicd for C17H19F2N4: 255.1; found: 256.3 [M+H]. 

1H NMR (400 MHz, CDC¾) δ 8.64 (d, J = 1.6 Hz, 1 H), 7.72 (dd, J=2.0 and 8.0 Hz, 1H), 7.20 (d, J = 8.0 Hz, 1H), 2.94 (t, J = 13.6 Hz, 2H), 2.80 - 2.71 (m, 2H), 2.69 - 2.61 (m, 1B), 2.60 (s, 3H), 2.36 - 2.27 (m, 2H), 1.76 - 1.68 (m, 2E), 1.36 – 1.29 (m, 2H).

Step 6. N-(1-(2,2-difluoro-2-(6-methylpyridin-3-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidine

A mixture of i-(2,2-difluoro-2-(6-methylpyridin-3-yl)ethyl)piperidin-4-amine (64 mg, 0.25 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (40 mg, 0.25 mmol) and DiPEA (0.09 mL, 0.5 mmol) in butyl alcohol (1.5 mL) was heated to 130 °C with stirring overnight. The mixture was allowed to cool to room temperature and the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (hexane/ethyl acetate =3:1) to afford the title compound as a gray powder (20 mg, 28%), MS (ESI) caicd
for $C_{19}F_{22}$: 372.2; found: 373.3 [M+H]. \( \frac{7}{4} \) NMR (400 MHz, CD$_3$OD) \( \delta \) 8.62 (d, 1H), 8.08 (s, 1H), 7.93 (d, \( J = 8.0 \) Hz, 1H), 7.43 (d, \( J = 8.0 \) Hz, ill), 7.05 (d, \( J = 3.6 \) Hz, 1H), 6.61 (d, \( J = 3.6 \) Hz, 1H), 4.05 - 3.95 (m, 1H), 3.10 (t, \( J = 14.4 \) Hz, 2H), 2.94-2.86 (m, 2H), 2.60 (s, 3H), 2.55-2.45 (m, 2H), 1.96 - 1.87 (m, 2H), 1.62-1.55 (m, 2H).

**Example 1.175.** N-((2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-amine (C-I 75).

![Chemical Structure](image)

**Step 1.** ethyl 2,2-difluoro-2-(4-fluorophenyl)acetate

\[ \text{Step 2.} 2,2\text{-difluoro-2-(4-fluorophenyl)ethanolate} \]

[0361] A mixture of 1-fluoro-4-iodobenzene (15.0 g, 67.6 mmol), ethyl 2-bromo-2,2-difluoroacetate (1.45 g, 7.1 mmol) and copper powder (10.8 g, 35.6 mmol) in DMSO (50 mL) was heated to 90 °C. After Stirling overnight at 90 °C, the mixture was cooled down to rt, and diluted with EtOAc. A solution of $K_2HPO_4.3H_2O$ (10 g) in water (100 mL) was added into the above mentioned mixture. The mixture was stirred 6 x 30 mi., and filtered through a pad of celite. The filter mass was extracted with EtOAc. The combined organic phases were washed with water and brine, dried over Na$_2$SO$_4$ and concentrated. The concentrate was purified by column chromatography over silica gel (eluent: 100% hexane) to afford the title compound as a colorless oil (8.18 g, 55%). MS (ESI) calcd: $\text{C}_{19}F_{22}$: 218.20; found: $\text{[M+H]}$. \( \frac{7}{4} \) NMR (400 MHz, CD$_3$OD) \( \delta \) 7.61 (dd, \( J = 8.4, 5.2 \) Hz, 2H), 7.14 (t, \( J = 8.6 \) Hz, 2H), 4.30 (q, \( J = 7.6 \) Hz, 2H), 1.31 (t, \( J = 7.6 \) Hz, 2H).
To a stirred solution of ethyl 2,2-difluoro-2-(4-fluoropheny)acetate (7.6 g, 35 mmol) in ethanol (150 mL) was slowly added NaBiT (1.98 g, 52.3 mmol) at room temperature. After stirring for 30 min, the suspension was gradually transformed into the clear solution, and the ester was consimied. The reaction mixture was quenched with aqueous 3.CM HCl under ice-water bath cooling. The mixture was concentrated, and the concentrate was extracted with EtOAc. The combined organic phases were washed with brine, dried over Na2SO4 and concentrated to afford the title compound as a colorless oil (5.8 g, 90%). MS (ESI) calcd \( \text{C}_{11} \text{H}_{14} \text{F}_2 \text{O} \): 176.20; found: [M+H]. \( ^1 \text{H} \) NMR (400 MHz, CDCl3) \( \delta 7.52 \) (dd, \( J = 8.4, 5.2 \text{ Hz} \), 2H), 7.14 (t, \( J = 8.6 \text{ Hz} \), 2H). 4.00 (t, \( J = 13.2 \text{ Hz} \), 2H).

**Step 3.** 2,2-difluoro-2-(4-fluorophenyl)ethyl trifluoromethanesulfonate

To a stirred solution of 2,2-difluoro-2-(4-fluorophenyl)edanol (2.0 g, 11 mmol) and DIPEA (3 mL, 17 mmol) in dry ether (100 mL) was added T\( \text{F} \)Q (2.5 mL, 15 mmol) at 0 °C under N\( _2 \) atmosphere. After stirring for 1 h at 0 °C, the white suspension was stirred for another 1h. The suspension was filtered. The filtrate was concentrated and purified by column chromatography over silica gel (eluent: hexane/EtOAc=100% to 10%) to afford the title compound as a colorless oil (1.77 g, 77%). MS (ESI) calcd for \( \text{C}_{9} \text{H}_{6} \text{F}_{6} \text{O}_3 \text{S} \): 307.20; found: [M+B].

**Step 4.** tert-buty 1-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-ylcarbamate
A solution of 2,2-difluoro-2-(4-fluorophenyl)ethyl trifluoromethanesulfonate (1.7 g, 5.74 mmol), tert-butyl piperidin-4-ylcarbamate (2.3 g, 11 mmol) and DiPEA (2.2 mL, 13 mmol) in DCM (30 mL) was heated to 40 °C. After stirring overnight at 40 °C, the reaction mixture was concentrated, and purified by column chromatography over silica gel (eluent: hexane/EtOAc 0/1) to afford the title compound as a white powder (1.39 g, 70%). MS (ESI) calcd for C$_{16}$H$_{25}$F$_3$N$_2$O$_2$: 358.20; found: 359.4 [M+H]. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.48 (dd, $J = 8.6$, 5.4 Hz, 2H), 7.08 (t, $J = 8.6$ Hz, 2H), 4.37 (s, 1H), 3.40 (s, 1H), 2.91 (t, $J = 14.0$ Hz, 2H), 2.76-2.72 (m, 2H), 2.37-2.31 (m, 2H), 2.18-2.12 (d, $J = 1.6$ Hz, 2H), 1.39 (s, 9H), 1.38-1.29 (m, 2H).

**Step 5.** l-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-amine

To a stirred solution of tert-butyl l-(2,2-difluoro-2-K4-fluorophenyl)ethyl)piperidin-4-ylcarbamate (1.39 g, 3.87 mmol) in DCM (20 mL) was added TFA (10 mL) under ice-water bath cooling. After stirring for 1 h at room temperature, the starting material was consumed, and the reaction mixture was concentrated. The concentrate was basified with 1N aqueous NaOH and mixture was extracted with DCM. The combined organic phases were washed with brine, dried over Na$_2$SO$_4$ and concentrated to afford the title compound as an off-white powder (1.0 & 100%). MS (ESI) calcd for C$_{16}$H$_{25}$F$_3$N$_2$: 258.20; found: 259.3[M+H]. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.50 (dd, $J = 8.6$, 5.4 Hz, 2H), 7.08 (t, $J = 8.6$ Hz, 2H), 2.91 (t, $J = 13.8$ Hz, 2H), 2.76-2.73 (m, 2H), 2.65-2.58 (m, 1H), 2.32-2.26 (m, 2H), 1.71-1.68 (m, 2B), 1.35-1.28 (m, 2H).
Step 6. N-(1-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidine

A mixture of 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (200 mg, 1.30 mmol), i-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-amine (440 mg, 1.69 mmol) and DIPPEA (0.45 mL, 2.60 mmol) in t-BuOH (6 mL) was heated to 130 °C in a sealed tube. After stirring overnight, the brown solution was concentrated. The concentrate was purified by column chromatography over silica gel (eluent DCM/MeOH = 50/1) to afford the title compound as a powder (350 mg, 70%). MS (ESI) calcd for C₂₉H₂₃F₃N₅: 375.20; found: 376.4 [M+H]. 

1H NMR (400 MHz, CDCl₃) δ 8.03 (m, 1H), 7.52 (dd, J = 8.6, 5.4 Hz, 2H), 7.10 (t, J = 8.6 Hz, 2H), 7.06 (d, J = 3.6 Hz, 1H), 6.34 (d, J = 3.6 Hz, 1H), 4.98 (s, 1H), 4.15-4.07 (m, 1H), 2.97 (t, J = 14.0 Hz, 2H), 2.86-2.3 (m, 2H), 2.53-2.47 (m, 2H), 2.06-2.03 (m, 2H), 1.59-1.49 (m, 2H).

Example L175a (MCl salt). N-(1-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidine hydrochloride (C₁₉H₂₀F₃N₅.HCl).

To a stirred solution of N-(1-(2,2-difluoro-2-(4-fluorophenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (350 mg, 0.93 mmol) in MeOH (5 mL) was added 2M HCl in methanol (0.47 mL, 0.93 mmol) at room temperature. After stirring for 30 min, the clear solution was concentrated to afford the title compound as an off-white powder (370 mg, 98%). MS (ESI) calcd for C₁₉H₂₀F₃N₅: 375.20; found: 376.4 [M+H]. 

1H NMR (400 MHz,
Example 1.176, N-(1-(2-(4-chlorophenyl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-176).

To a stirred solution of 1-chloro-4-iodobenzene (15.0 g, 63 mmol) and ethyl 2-bromo-2,2-difluoroacetate (12.8 g, 63 mmol) in DMSO (300 mL) was added Co powder (8.0 g, 126 mmol). The mixture was heated to 80 °C, and stirred for 20 h. The mixture was cooled to rt, and poured into an aqueous solution of K$_2$HPO$_4$ (110 g) in water (1.5 L) under stirring. After stirring for 30 min at rt, the mixture was filtered through a pad of celite. The filter cake was extracted with ether. The combined organic phases were washed with water and brine, dried over Na$_2$SO$_4$ and concentrated. The concentrate was purified column chromatography over silica gel (eluent: hexane) to afford the title compound as a colorless oil (6.8 g, 46%). £H NMR (400 MHz, CDCl$_3$) δ 7.55 (d, $J$ = 8.4 Hz, 2H), 7.44 (d, $J$ = 8.4 Hz, 2H), 4.30 (q, $J$ = 7.1 Hz, 2H), 1.31 (t, $J$ = 7.1 Hz, 3H).

Step 2. 2-(4-chlorophenyl)-2,2-difluoroethanol
To a stirred solution of ethyl 2-(4-chlorophenyl)-2,2-difluoroacetate (6.7 g, 29 mmol) in EtOH (130 mL) was added NaEtOH (1.56 g, 41 mmol) at room temperature. The suspension was slowly transformed to a clear solution. After stirring for 30 min at rt, the ester was consumed. The reaction mixture was quenched with aqueous IN HCl under ice-water bath cooling. The mixture was extracted with EtOAc. The organic phases were washed with brine, dried over Na2SO4 and concentrated to afford the title compound as a colorless liquid (5.39 g, 95%). 1H NMR (400 MHz, CDCl3) δ 7.46 (d, J = 8.8 Hz, 2H), 7.42 (d, J = 8.8 Hz, 2H), 3.95 (t, J = 13.1 Hz, 2H).

Step 3. 2-(4-chlorophenyl)-2,2-difluoroethyl trifluoromethanesulfonate

To a stirred solution of 2-(4-chlorophenyl)-2,2-difluoroethanol (1.5 g, 7.8 mmol) and DIPEA (4.2 mL, 23 mmol) in dry ether (78 mL) was added the Ti(IV) (2.7 mL, 16 mmol) at 0 °C. After stirring for 2 hrs at rt, the white suspension was filtered through celite, and the filter mass was washed with ether. The filtrate was concentrated and purified by column chromatography over silica gel to afford the title compound as a colorless oil (0.8 g, 51%) which was used in the next step without further purification.

Step 4. tert-butyl-1-(2-(4-chlorophenyl)-2,2-difluoroethyl)piperidin-4-yl-carbamate
The mixture of 2,2-difluoro-2-p-tolyethyl trifluoromethanesulfonate (1.28 g, 3.9 mmol), tert-butyl piperidin-4-ylcarbamate (1.20 g, 5.9 mmol) and DPEA (2.1 mL, 12 mmol) in DCM (20 mL) was heated to 40 °C. After stirring overnight at 40 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc=50/1) to afford the title compound as a white solid (850 mg, 65%). MS (ESI) calcd for C_{18}H_{23}F_{2}N_{2}O_{2}: 374.1; found: 375.4 \,[M+H]. \textsuperscript{1}H NMR (400 MHz, CDCl_{3}) \delta 7.43 (d, \, J = 8.6 \text{ Hz}, 2H), 7.38 (d, \, J = 8.6 \text{ Hz}, 2H), 4.40 (s, \, 2H), 3.40 (H), 2.91 (d, \, J = 8.6 \text{ Hz}, 2H), 2.74 (m, 2H), 2.33 (m, 2H), 1.82 (m, 2H), 1.43 (s, 9H), 1.33 (m, 2H).

Step 5. 1-(2-(4-chlorophenyl)-2,2-difluoroethyl)piperidin-4-yl carbamate

Step 6. N-(1-(2-(4-chlorophenyl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-amine
The mixture of 1-(2-(4-chlorophenyl)-2,2-difluoroethyl)piperidin-4-amine (322 mg, 1.7 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyridine (150 mg, 0.98 mmol) and DIPEA (0.4 mL, 1.95 mmol) in isopropanol (6 mL) was heated to 85 °C. After stirring overnight at 85°C, the resulting orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (DCM/MeOH = 90:1~30/1) to afford the title compound as a gray powder (240 mg, 56%). MS (ESI) calcd for C177H37F3N5: 392.4 [M+H]+; found: 392.4; \( ^1H \) NMR (400 MHz, CDCl3) \( \delta \) 10.44 (s, 1H), 8.32 (s, 1H), 7.47 (d, \( J = 8.5 \) Hz, 2H), 7.40 (d, \( J = 8.5 \) Hz, 2H), 7.08 (d, \( J = 3.4 \) Hz, 1H), 6.36 (d, \( J = 3.4 \) Hz, 1H), 4.11 (s, 1H), 3.00-2.94 (m, 2H), 2.85-2.82 (m, 2H), 2.53-2.48 (m, 2H), 2.06-2.03 (m, 3H), 1.61 - 1.48 (m, 2H).

Example 1.177. N-(1-(2,2-difluoro-2-p-tolylethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-amine (C-177).

[0374] To a stirred solution of N-(1-(2,2-difluoro-2-p-tolylethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyridin-4-amine (210 mg, 0.54 mmol) in MeOH (3.0 mL) was added HCl/Et2G (2M, 0.30 mL, 0.60 mmol) at it. After stirring for 15 min, the mixture was concentrated to afford the title compound as an off-white powder (210 mg, 92%). MS (ESI) calcd for C177H37F3N5: 391.1; found: 392.4 [M-H]+. \( ^1H \) NMR (400 MHz, CD3OD) S 8.27 (s, 1H), 7.62-7.54 (m, 7.9 Hz, 4H), 7.35 (s, 1H), 6.93 (s, 1H), 4.08 (s, 1H), 3.50 (s, 2H), 2.92 (s, 2H), 2.14 (s, 2H), 1.93 (s, 2H), 1.31 (s, 1H).

Example 1.177. N-(1-(2,2-difluoro-2-p-tolylethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidin-4-amine (C-177).
Step 1, ethyl 2,2-difluoro-2-(p-tolyl)acetate

To a stirred solution of 1-iodo-4-methylbenzene (20.0 g, 91.7 mmol) and ethyl 2-bromo-2,2-difluoroacetate (19.7 g, 97.2 mmol) in DMSO (125 mL) was added Cu powder (13.4 g, 211 mmol). The mixture was heated to 50 °C for 14 hours. Isopropyl acetate (100 mL) was added to the mixture, and the reaction was quenched with an aqueous solution of K₂HPO₄·3H₂O (23 g) in water (250 mL). The mixture was stirred for 30 min at rt and filtered. The filter cake was washed with isopropyl acetate. The combined organic phases were washed with water and brine, dried over Na₂SO₄ and concentrated. The concentrate was purified by column chromatography over silica gel (100% hexane) to afford the title compound as colorless oil (14.7 g, 77%). ¹H NMR (400 MHz, CDCl₃) δ 7.49 (d, J = 8.0 Hz, 2H), 7.25 (d, J = 7.4 Hz, 2H), 4.29 (q, J = 7.1 Hz, 2H), 2.39 (s, 3H), 1.30 (t, J = 7.1 Hz, 3H).

Step 2, 2,2-difluoro-2-(p-tolyl)ethanol

To a stirred solution of ethyl 2,2-difluoro-2-(p-tolyl)acetate (14.5 g, 68 mmol) in the ethaio! (120 mL) was added NaBO₂ (3.7 g, 98 mmol) at ambient temperature. The suspension was slowly transformed into clear solution, and the reaction was exothermic. After stirring for 15 min at room temperature, the ester was consumed. The reaction was carefully quenched with 1N HQ under ice-water bath. The mixture was extracted with
EtOAc. The combined organic phases were washed with sat. N\textsubscript{a}HC\textsubscript{3}O\textsubscript{3} and brine, dried over Na\textsubscript{2}SO\textsubscript{4} and concentrated to afford the title compound as a white solid (11.5 g, 99%). \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \( \delta \) 7.40 (d, \( J = 8.0 \) Hz, 2H), 7.24 (d, \( J = 7.8 \) Hz, 2H), 3.97 - 3.89 (m, 2H), 2.38 (s, 3H), 2.13 (t, \( J = 6.1 \) Hz, 1H).

**Step 3. 2,2-difluoro-2-(p-tolyethyl)trifluoroethanesulfonate**

\[ \text{[0377]} \text{ To a stirred solution of } 2,2\text{-difluoro-2-(p-tolyethyl)ethanol (600 mg, 3.5 mmol) and DIPEA (1.9 mL, 11 mmol) in dried ether (35 mL) was added the TiftO (1.2 mL, 7.0 mmol) at 0 °C. After stirring for 2 hrs at rt, the white suspension was filtered through celite, and the filter mass was washed with ether. The filtrate was concentrated and purified by column chromatography over silica gel to afford the title compound as a colorless oil (860 mg, 86%).} \]

\[ \text{[0378]} \text{ A mixture of 2,2-difluoro-2-p-tolyethyl trifluoromethanesulfonate (860 mg, 2.8 mmol), tert-butyl pipendin-4-ylcarbamate (1.1 g, 5.6 mmol) and DIPEA (1.5 mL, 8.4 mmol) in DCM (14 mL) was heated to 40 °C. After stirring overnight at 40 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc-50/1). to afford the title compound as a white solid (650 mg, 70%). MS (ESI) calculated for C\textsubscript{18}H\textsubscript{28}F\textsubscript{2}N\textsubscript{2}O\textsubscript{2}: 354.21; found: 355.5| M\textsubscript{+}H\textsuperscript{+}, \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \( \delta \) 7.37 (d, \( i = 8.0 \) Hz, 2H), 7.20 (d, \( J = 8.0 \) Hz, 2B), 4.40 (brs, 1H), 3.40 (hrs, 1H), 2.92 (t, \( J = 14.4 \) Hz, 2H).} \]
To a stirred solution of tert-butyl 1-(2,2-difluoro-2-p-tolylethyl)piperidin-4-ylcarbamate (650 trig, 1.83 trnml) in DCM (9 mL) was added TFA (9 ml.) under ice-water bath cooling.

After stirring for 30 min at rt, the starting material was consumed, and the mixture was concentrated. The concentrate was basified with aq.NaCCl₃, and extracted with EtOAc. The organic phase was washed with brine, dried over Na₂SO₄, and concentrated to afford the title compound as an off-white powder (460 mg, 100%). MS (ESI) caiced for C₁₄H₂₀F₂N₂: 254.16; found: 255.4 [M+H]. ¹H NMR (400 MHz, CDCl₃) δ 7.35 (d, J = 8.0 Hz, 2H), 7.20 (d, J = 8.0 Hz, 2H), 3.05-2.95 (m, 2H), 2.93 (t, J=14.0 Hz, 2H), 2.88-2.84 (m, 2H), 2.37 (s, 3H), 2.33 (s, 3H). 1.89-1.56 (m, 2H), 1.66-1.56 (m, 2H).

Step 6. N-(1-(2,2-difluoro-2-(p-tolyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]-pyrimidine-4-amine

A mixture of 1-(2, 2-difluoro-2-p-tolylethyl) piperidin-4-anime (397 mg, 1.56 mmol), 4-coro-7H-pyrrolo[2, 3-d]pyrimidine (200 mg, 1.30 mmol) and DIPEA (0.45 mL, 2.60 mmol) in isopropanol (6 mL) was heated to 85 °C. After stirring overnight at 85°C, the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (DCM/MeOH=50/1–30/1) to afford the title compound as a gray powder (270...
a g, 56%). MS (ESI) ca!cd for C_{20}H_{23}F_{2}N_{5}: 371.19; found: 372.4[M+H]. ^1H NMR (400 MHz, CDCl_3) δ 10.38 (s, 1H), 8.32 (s, 1H), 7.40 (d, J = 8.0 Hz, 2H), 7.22 (d, J = 8.0 Hz, 2H), 7.08 (d, J = 3.3 Hz, 1H), 6.35 (d, J = 3.3 Hz, 1H), 4.11 (s, 1H), 2.97 (s, J=14.4Hz, 2H), 2.92-2.85 (ra, 2H), 2.53-2.48 (m, 2H), 2.39 (s, 3H), 2.06-2.04 (m, 2H), 1.62-1.53 (m, 2H).

Example 1.177a (HCl salt). N-((2,2-difluoro-2-(p-tolyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine hydrochloride (C-I77 -HCl).

[0381] To a stirred solution of N^1(2,2-difluoro-2-(p-tolyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine (240 mg, 0.64 mmol) in MeOH (3.5 mL) was added HCl/EtO (2M, 0.35 mL, 0.70 mmol) at rt. After stirrmg for 15min, the mixture was concentrated to afford the title compound as an off-white powder (235 rag, 96%). MS (ESI) caed for C_{10}H_{24}ClF_{2}N_{5}: 407.17; found: 407.5[M+H]. ^1H NMR (400 MHz, CD3OD) δ 8.19 (s, 1H), 7.45 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 7.25 (d, J = 3.5 Hz, 1H), 6.82 (d, J = 3.5 Hz, 1H), 4.0 (bs, 1H), 3.45-3.35 (m, 1H), 3.25-3.15 (m, 2H), 2.85-2.70 (m, 2H), 2.40 (s, 3H), 2.09-2.06 (m, 2H), 1.88-1.79 (ra, 2B).

Example 1.178. N-((1-(2,2-difluoro-2-(4-trifluoromethyl)phenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine (C-178).

Step 1. ethyl 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)acetate
[0382] A mixture of 1-iodo-4-(trifluoromethyl)benzene (10g, 36 mmol), ethyl 2-bromo-2,2-difluoroacetate (7.5 g, 36 mmol) and copper powder (4.60 g, 72 mmol) in DMSO (120 mL) was heated to 80°C. After stirring 6 hrs at 80°C, the mixture was cooled down to rt and diluted with EtOAc. The mixture thus obtained was poured into the water and stirred for 0.5h. The suspension was filtered through a pad of celite, and the filter mass was extracted with EtOAc. The combined organic phases were washed with water and brine, dried over Na₂SO₄ and concentrated. The concentrate was purified by column chromatography over silica gel (100% hexane) to afford the title compound as a pale brown oil (6.35 g, 64%). ¹H NMR (400 MHz, CDCCl₃) δ 7.78 – 7.70 (m, 4H), 4.31 (4 ¾ J = 7.1 Hz, 2H), 1.31 ¾ J = 7.1 Hz, 2H).

Step 2. 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)etilanol

[0383] To a suspension of LiBH₄ (3.25 g, 15 mmol) in dry THF (35 mL) was added a solution of ethyl 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)acetate (2.0 g, 7.5 mmol) in THF, dropwise at 0 °C. The mixture thus obtained was stirred for 30 min at room temperature. After the ester was consumed, the reaction was quenched with 1M aqueous HCl at 0 °C, and the mixture was extracted with EtOAc. The combined organic phases were washed with brine, dried over Na₂SO₄ and concentrated to afford the title compound as a brown liquid (1.68 g, 100%). ¹H NMR (400 MHz, CDC₁₃) δ 7.75 – 7.64 (m, 4H), 4.00 (t, J = 1.3 Hz, 2H).

Step 3. 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)ethyl trifluoromethanesulfonate
[0384] To a stirred solution of 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)ethanol (140 mg, 0.62 mmol) and DIPEA (0.3 mL, 1.7 mmol) in dry ether (5 mL) was added TFA (0.3 mL, 1.5 mmol) dropwise at 0°C under N₂ atmosphere. After stirring for 30 min at 0°C, the suspension was stirred an additional 1 h at ambient temperature. After the alcohol was consumed, the suspension was filtered through a pad of Ueelite. The filtrate was concentrated and purified by column chromatography over silica gel (100% hexane) to afford the title compound as a colorless oil (220 mg, 52%). ¹H NMR (400 MHz, CDCl₃) δ 7.78 (d, J = 8.2 Hz, 2H), 7.67 (d, J = 8.2 Hz, 2H), 4.72 (t, J = 11.6 Hz, 2H).

Step 4, tert-butyl 1-(2,2-difluoro-2-(4(U:fluoromet¾yl)phenyl)ethyl)piperidin-4-ylcarbamate

[0335] A solution of 2,2-difluoro-2-(4-(trifluoromethyl)phenyl)ethyl trifluoromethanesulfonate (220 mg, 0.61 mmol), tert-butyl piperidino-4-ylcarbamate (360 mg, 1.82 mmol) and DIPEA (0.15 mL, 0.91 mmol) in DCM (5 mL) was heated to 40 °C. After stirring overnight at 40 °C, the solution was concentrated and purified by column chromatography over silica gel (eluent: 10% of EtOAc in hexane) to afford the title compound as an off-white powder (200 mg, 80%). ¹H NMR (400 MHz, CDCl₃) δ 7.62 (d, J = 8.4 Hz, 2H), 7.62 (d, J = 8.4 Hz, 2H), 4.43 – 4.33 (m, 1H), 3.47 – 3.31 (m, 1H), 2.94 (t, J = 13.8 Hz, 2H), 2.77 – 2.69 (m, 2H), 2.40 – 2.31 (m, 2H), 1.87 – 1.78 (m, 2H), 1.59 (s, 1H), 1.43 (s, 9H), 1.38 – 1.26 (m, 2H).

Step 5, 1-(2,2-difluoro-2-(4-(trifluoromethyl)phenethyl)piperidin-4-amine
To a stirred solution of tert-butyl 1-(2,2-difluoro-2-(4-(trifluoronethyl)phenyl)ethyl)piperidin-4-ylcarbamate (200 mg, 0.49 mmol) in DCM (5 mL) was added TFA (5 mL). After stirring for 30 min, the mixture was concentrated, and the residue was dissolved in ice-water. The aqueous solution was basified with 1M aqueous NaOH. The aqueous phase was extracted with EtOAc. The combined organic phases were washed with brine, dried over Na$_2$SO$_4$ and concentrated to afford the title compound as an off-white powder (140 mg, 93%). MS (ESI) calcd for C$_{14}$B$_{17}$F$_5$N$_2$: 308.2; found: 309.2 [M+H]. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.70 - 7.60 (m, 4H), 2.94 (t, $J$ = 3.8 Hz, 2H), 2.79 - 2.70 (m, 2H), 2.66 - 2.57 (m, 1H), 2.35 - 2.24 (m, 2H), 1.73 - 1.66 (m, 2H), 1.62 (s, 2H), 1.53 - 1.23 (m, 2H).

Step 6. N-(1-(2,2-difluoro-2-(4-(trifluoronethyl)phenyl)ethyl)piperidin-4-yl)-7H-pyrrolo-[2,3-d]pyridin-4-amine

A mixture of 1-(2,2-difluoro-2-(4-(trifluorotethyl)phenyl)ethyl)piperidin-4-amine (1.0 g, 6.5 mmol) and 4-chloro-7H-pyrrolo-[2,3-d]pyrimidine (6.0 g, 19.5 mmol) in n-BuOH (32 mL) was heated to 130 °C. After stirring overnight at 130 °C, the reaction solution was concentrated and extracted with EtOAc. The organic layers were washed with water and brine, dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc =1/3) to afford the title compound as a white solid (1.62 g, 58%). MS (ESI) calcd for C$_4$H$_2$F$_5$N$_5$: 425.2; found: 426.4 [M+H]. $^1$H NMR (400 MHz, DMSO-d$_6$) $\delta$ 11.43 (s, 1H), 8.06 (s, 1H), 7.88 (d, $J$ = 8.3 Hz, 2H), 7.80 (d, $J$ = 8.2 Hz, 2H), 7.09 (d, $J$
Example 1.178a (mesylate salt). N-(1-(2,2-difluoro)-2-(4-trifluoromethyl)phenyl)ethyl)piperidin-4-yl)-7H-pyrrolo-[2,3-d]pyrimidin-4-amine methanesulfonate (C-178-CH₃SO₃H).

\[
\begin{array}{c}
\text{CH}_3\text{SO}_3\text{H} \\

\end{array}
\]

[0388] To a solution of N-(1-(2,2-difluoro)-2-(4-trifluoromethyl)phenyl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (800 trig. 1.88 mmol) in MeOH (9 mL) was added methanesulfonic acid (0.18 g, 1.88 mmol) at rt. After stirring for 10 min, the mixture was coocetraied to afford the title compound as a white solid (943 mg, 96%). MS (ESI) calcd for C₂₀H₂₀FsN₅: 425.16; found: 426.4 {[M+H].} \[^1\text{H}\] NMR (400 MHz, CD₃OD) d 8.26 (s, 1H), 7.87 - 7.79 (m, 4H), 7.35 (d, J = 3.5 Hz, 1H); 6.91 (d, J = 3.5 Hz, 1H), 4.02 (brs, 1B), 3.52-3.42 (m, 2H), 3.28-3.21 (m, 2H), 2.90-2.80 (ra, 2H), 2.74 (s, 3H), 2.16-2.08 (m, 2H), 1.91-1.82 (m, 2H).

Example L179. M-(i-(2-(4-(diiodoethyl)pipienyl)l)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine (C-179).
[0389] Diethylamino sulfur trifluoride (15.8 mL, 129 mmol) was added slowly to a solution of 4-iodobenzaldehyde (10 g, 43 mmol) in DCM (215 mL) at 0°C. The mixture was stirred for 1 hour before allowing to warm to rt. The reaction mixture was carefully quenched with sat. NaHCO₃ (50 mL) and extracted with DCM. The combined organic phases were dried and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc-100: 1) to afford the title compound as a white solid (8.52 g, 78%). ¹H NMR (400 MHz, CDCl₃) δ 7.81 (d, J = 8.2 Hz, 2H), 7.23 (d, J = 8.2 Hz, 2H), 6.60 (t, J = 6 Hz, 1H).

Step 2. Ethyl 2-(4-difluoromethylphenyl)-2,2-difluoroacetate

[0390] To a stirred solution of 2-(4-difluoromethyl)-4-iodobenzene (8.52 g, 33.6 mmol) and ethyl 2-bromo-2,2-difluoroacetate (6.82 g, 33.6 mmol) in DMSO (168 mL) was added Cu powder (4.27 g, 67.2 mmol). The mixture was heated at 80°C for 20 hours. After 20 hours, the reaction mixture was poured into a solution of dibasic potassium hydrogen phosphate, trihydrate (76.7 g, 336 mmol) in water (950 mL) with vigorous stirring. The suspension was filtered and the solid was rinsed with ether. The filtrate was added to brine and extracted with ether (2x). The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc-70: 1) to afford the title compound as a colorless oil (6.78 g, 81%).

Step 3. 2-(4-(difluoromethyl)phenyl)-2,2-difluoroethano

[0391] To a stirred solution of ethyl 2-(4-(difluoromethyl)phenyl)-2,2-difluoroacetate (6.78 g, 27 J mmol) in ethanol (140 mL) was added NaBH₄ (1.48 g, 39.1 mmol) slowly at rt. The mixture was stirred for 30 min at rt. After 30 min, the reaction mixture was quenched with
HCl under ice-water bath cooling. The mixture was concentrated and extracted with EtOAc. The EtOAc layer was washed with water and brine, then dried and concentrated to afford the title compound as a white solid (5.29 g, 94%). 1H NMR (400 MHz, CDCl3) δ 7.58-7.65 (m, 4H), 6.68 (t, J=56 Hz, 1H), 3.98 (i, J=13.2 Hz, 2H), 2.06 (bus, 1H).

Step 4, 2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyi trifluoromethanesulfonate

![Chemical structure](image)

[0392] To a stirred solution of 2-(4-(difluoromethyl)phenyl)-2,2-difluoroethanol (2.0 g, 9.6 mmol) and DIPEA (5.27 mL, 28.8 mmol) in dry ether (96 mL) was added THF (3.23 mL, 19.2 mmol) at 0°C. After stirring for 1 hr at rt, the orange suspension was filtered through silica and the filter mass was extracted with ether. The combined organic phases wereconcentrated, and purified by column chromatography over silica gel (hexane/EtOAc=50:1) to afford the title compound as a pale yellow solid (2.86 g, 88%). 1H NMR (400 MHz, CDCl3) δ 7.66 (d, J = 8.7 Hz, 2H), 7.63 (d, J = 8.7 Hz, 2H), 6.70 (i, J=56 Hz, 1H), 4.71 (t, J=14 Hz, 2H).

Step 5, tert-butyl (2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyl)piperidin-4-ylcarbamate

![Chemical structure](image)

[0393] A mixture of 2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyl trifluoromethanesulfonate (2.86 g, 8.41 mmol), tert-butyl piperidin-4-ylcarbamate (3.37 g, 16.8 mmol) and DIPEA (4.41 mL, 25.2 mmol) in DCM (40 mL) was heated to 40 °C. After stirring overnight at 40 °C, the mixture was concentrated to dryness. The concentrate was purified by column chromatography over silica gel (hexane/EtOAc-S/i) to afford the title compound as a white
solid (2.67 g, 82%). MS (ESI) calcd for C₁₉H₂₆F₄N₂O₂: 390.2; found: 391.2 [M+H]. ¹H NMR (400 MHz, CDCl₃) δ 7.60 (d, J = 8.3 Hz, 2H), 7.55 (d, J = 8.3 Hz, 2H). 6.68 (t, J = 6 Hz, 1H), 4.38 (s, 2H), 3.39 (brs, 2H), 2.94 (t, J = 14 Hz, 2H), 2.72-2.76 (m, 2H), 2.34-2.38 (m, 2H), 1.80-1.85 (m, 2H), 1.43 (s, 9H), 1.30-1.40 (m, 2H).

Step 6, 1-(2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyl)piperidin-4-amine

Step 7, N-(1-(2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidine-4-amine

[0393] A mixture of J-(2-(4-(difluoromethyl)phenyl)-2,2-difluoroethyl)piperidin-4-amine (218 mg, 0.75 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (96 mg, 0.63 mmol) and DIPA (0.22 mL, 1.26 mmol) in n-butyl alcohol (3.5 mL) was heated to 130 °C. After stirring
overnight at 130 °C, the reaction solution was concentrated. The concentrate was purified by column chromatography over silica gel (100% BtO Ao) to afford the title compound as a white solid (201 mg, 79%). 

Example 1.179a (HO salt). N-(1-(2-(4-(difluoromethyl)enyl)-2,2-difluoroethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine hydrochloride (C-179-HCl).

Example 1.230. N-(l-(2,2-difluoro-2-(5-methylpyrrolo-2,3- d)pyridindin-4-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[23 -dpyridinid -4-amine (C-230).
Step 1. ethyl 2,2-difluoro-2-(5-methylpyrazin-2-yl)acetate

[0397] To a stirred solution of ethyl 2-iodo-5-iiethylpyrazine (2.3 g, 10 mmol) and 2-bromo-5-(trifluoromethyl)pyridine (2.1 g, 10 mmol) in DMSO (25 mL) was added CMI powder (1.3 g, 21 mmol). The mixture was heated at 80 °C for 20 hours. The reaction mixture was allowed to cool to room temperature, filtered through celite and the filter pad was extracted with ethyl acetate. The combined organic phases were washed with brine, dried over sodium sulfate, filtered, and concentrated. The concentrate was purified by column chromatography over silica gel (hexane / ethyl acetate =10:1) to afford the title compound as a colorless oil (800 mg, 40%) which was used directly in the next step.

Step 2, 2,2-difluoro-2-(5-methylpyrazin-2-yl)ethanol

[0398] To a stirred solution of ethyl 2,2-difluoro-2-(5-methylpyrazin-2-yl) acetate (600 mg, 2.78 mmol) in ethanol (14 mL) was added NaBH₄ (150 mg, 4.0 mmol) slowly under ice-water bath cooling. The mixture was allowed to warm to room temperature and stirred for 30 min. The reaction mixture was then quenched with IN HCl under ice-water bath cooling. The mixture was concentrated and extracted with ethyl acetate. The ethyl acetate layer was washed with water and brine, then dried and concentrated to afford the title compound as a white solid (480 mg, 100%) which was used in the next step without further purification.

Step 3, 2,2-difluoro-2-(5-methylpyrazin-2-yl)ethyl trifluoromethanesulfonate
To a stirred solution of 2,2-difluoro-2-(5-methylpyra2m--2-yl)ethyl (480 mg, 2.7 mmol) and DIPEA (1.8 mL, 8.1 mmol) in dry ether (30 mL) was added the Tf₂O (0.9 mL, 2.7 mmol) at 0 °C. After stirring for 1 h at rt, the white suspension was filtered through celite, and the filter mass was washed with ether. The filtrate was concentrated to afford the title compound as a colorless oil (800 mg, 100%) which was used in the next step without further purification.

**Step 4**, tert-butyi-1-(2,2-difluoro-2-(5-methylpyrazin-2-yl)ethyl)piperidin-4-ylcarbamate

![Chemical Structure](image)

**Step 5**, i-(2,2-difluoro-2-(5-methylpyrazin-2-yl)ethyl)piperidin-4-amine

![Chemical Structure](image)
ice-water bath cooling. After stirring for 30 min at rt, the starting material was consumed, and the mixture was concentrated. The concentrate was basified with 1 N NaOH, and extracted with ethyl acetate. The organic phase was washed with brine, dried over Na$_2$SO$_4$, and concentrated to afford the title compound as an off-white powder (90 mg, 100%) which was used in the next step without further purification. MS (ESI) calcd for $\frac{3}{4}$ H$_{18}$P$_4$N$_4$: 256.2; found: 257.3 [M+H]. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.79 (s, 1H), 8.50 (s, 1H), 3.19 (t, $J = 14.0$ Hz, 2H), 2.80-2.88 (m, 2H), 2.66 (s, 3H), 2.60-2.65 (m, 1H), 2.30-2.38 (m, 2H), 1.65-1.72 (m, 2H), 1.20-1.29 (m, 2H).

Step 6. N-((2,2-difluoro-2-(5-methylpyrazin-2-y)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine

[04023 A mixture of i-(2,2-diitluoro-2-(5-methylpyrazina-2-y)ethyl)piperidin-4-amine (90 mg, 0.35 mmol), 4-chloro-7H-pyrrolo[2,3-d]pyrimidine (153 mg, 0.3 mmol) and DIFEA (0.25 mL, 0.6 mmol) in butyl alcohol (2 mL) was heated to 130 °C. After stirring overnight at 130 °C, the orange solution was concentrated. The concentrate was purified by column chromatography over silica gel (DCM/ MeOH=20T) to afford the title compound as a gray powder (58 mg, 41%). MS (ESI) calcd for C$_{18}$H$_{27}$F$_2$N$_7$: 373.2; found: 374.3 [M+H]. $^1$H NMR (400 MHz, CD$_3$OD) $\delta$ 8.80 (d, $J = 1.2$ Hz, 1H), 8.63 (s, 1H), 8.07 (s, 1H), 7.05 (d, $J = 3.5$ Hz, Me), 6.58 (d, $J = 3.5$ Hz, 1H), 4.06 - 3.95 (m, 1H), 3.27 (t, $J = 14.2$ Hz, 2H), 2.94 (d, $J = 12.0$ Hz, 2H), 2.65 (s, 3H), 2.46-2.52 (m, 2H), 1.88-1.94 (m, 2H), 1.48-1.56 (m, 2H).

Example 1.230a (HCl salt). N-((2,2-diitluoro-2-(5-methylpyrazin-2-y)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyrimidin-4-amine hydrochloride (C-2 30-HQ) .
To a stirred solution of N-(1-(2,2-difluoro-2-(5-methylpyrazin-2-yl)ethyl)piperidin-4-yl)-7H-pyrrolo[2,3-d]pyridin-4-amine (54 mg, 0.144 mmol) in MeOH (0.72 mL) was added HCl/MeOH (2M, 0.072 mL, 0.144 mmol) at room temperature. After stirring for 15 min, the mixture was concentrated to afford the title compound as a yellow powder (58 mg, 99%). MS (ESI) calcd for C_{18}H_{21}F_{2}N_{7}: 373.2; found: 374.3 [M+H]. \(^1\)H NMR (400 MHz, CD\(_3\)OD) \(^\delta\) 8.83 (d, \(J = 0.3\) Hz, 1E), 8.65 (s, 1H), 8.23 (s, 1H), 7.33 (d, \(J = 3.5\) Hz, 1E), 6.89 (d, \(J = 3.5\) Hz, 1H), 3.96 (brs, iH), 3.50 (brs, 2H), 3.10-3.20 (m, 2H), 2.68-2.73 (m, 2H), 2.66 (s, 3H), 2.02-2.10 (m, 2H), i.70-i.80 (m, 2H).

**Example 2.** Assays.

**Example 2.1, NR2B Antagonist Activity.**

HEK293 cell lines stably expressing cloned human NR1/KR2B and NR1/NR2A, respectively, were established according to standard previously described methods (Hansen et al., *Comb. Chem High Throughput Screen*. 11:304, 2008). Activation of the NR2A or NR2B subtype of NMDA receptor with glutamate as an agonist and glycine co-agonist on these cells results in calcium influx, which can be monitored with fluorescent indicator Ptø-4. A cell based assay has been implemented to evaluate the effect of a compound on HR2A and NR2B receptors by measuring the fluorescent changes (Hansen et al., *Comb. Chem High Throughput Screen*. 11:304, 2008).

IIEK293 cells stably expressing NR2A or NR2B receptors were cultured at 37 °C in a humidified CO\(_2\) incubator in DMEM supplemented with 10% fetal bovine serum (IBS) (Hyclone), 10 \(\mu\)M MK801 (Sigma-Aldrich) and 50 \(\mu\)M AP-5 (Tocris). For experiments, the cells were seeded onto poly-D-lysine-coated 96-well black plates with clear bottom
(Corning) at a density of ~50,000 cells/well. After overnight culture, the growth medium was removed from the wells and the cells were incubated at 37 °C for 60 min in Hanks buffer containing 4 µM fluo-4-AM (invitrogen) and 1% bovine serum albumin (BSA). After dye-loading, the cells were washed three times with Hanks buffer and incubated for 10 min at room temperature with various concentrations of test compounds prepared in Hanks buffer with 0.1% BSA. The cell plates were placed onto FDS5 μl fluorescence reader (Hamamatsu). After 20 sec reading of background fluorescence, agonist glutamate at final 100 µM and co-agonist glycine at final 50 µM were added to the cells to activate the receptor, and the resulting fluorescence changes were recorded and quantified. Based on the changes in fluorescence intensity, the pharmacological effect of test compounds were analyzed and the IC₅₀ values derived from a non-linear least squares fitting of the concentration-dependent response to a standard logistic equation using Prism (Graphpad, Inc):

\[
\text{Amplitude} = \frac{\text{Max Amplitude}}{1 - \text{KIC50}/[\text{antagonist}]^{n}}
\]

Results are shown in the table below.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Free Base Structure</th>
<th>NR2B IC₅₀</th>
<th>NR2A IC₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-2</td>
<td>![Image]</td>
<td>124 nM</td>
<td>&gt;10 µM</td>
</tr>
<tr>
<td>C-3</td>
<td>![Image]</td>
<td>22 nM</td>
<td>&gt;10 µM</td>
</tr>
<tr>
<td>C-4</td>
<td>![Image]</td>
<td>35 nM</td>
<td>&gt;10 µM</td>
</tr>
<tr>
<td>C-5</td>
<td>![Image]</td>
<td>30 nM</td>
<td>&gt;10 µM</td>
</tr>
<tr>
<td>Compound</td>
<td>Free Base Structure</td>
<td>NR2B IC&lt;sub&gt;50&lt;/sub&gt;</td>
<td>NR2A IC&lt;sub&gt;50&lt;/sub&gt;</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>C-16</td>
<td><img src="image" alt="Structure C-16" /></td>
<td>47 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-18</td>
<td><img src="image" alt="Structure C-18" /></td>
<td>84 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-17</td>
<td><img src="image" alt="Structure C-17" /></td>
<td>44 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-47</td>
<td><img src="image" alt="Structure C-47" /></td>
<td>140 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-230</td>
<td><img src="image" alt="Structure C-230" /></td>
<td>88 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-1</td>
<td><img src="image" alt="Structure C-1" /></td>
<td>159 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-127</td>
<td><img src="image" alt="Structure C-127" /></td>
<td>45 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-128</td>
<td><img src="image" alt="Structure C-128" /></td>
<td>89 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-6</td>
<td><img src="image" alt="Structure C-6" /></td>
<td>31 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>Compound</td>
<td>Free Base Structure</td>
<td>NR2B IC₅₀</td>
<td>NR2A IC₅₀</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>C-7</td>
<td><img src="image1" alt="Free Base Structure" /></td>
<td>14 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-11</td>
<td><img src="image2" alt="Free Base Structure" /></td>
<td>43 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-12</td>
<td><img src="image3" alt="Free Base Structure" /></td>
<td>24 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-178</td>
<td><img src="image4" alt="Free Base Structure" /></td>
<td>64 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-179</td>
<td><img src="image5" alt="Free Base Structure" /></td>
<td>23 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-175</td>
<td><img src="image6" alt="Free Base Structure" /></td>
<td>22 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-176</td>
<td><img src="image7" alt="Free Base Structure" /></td>
<td>26 nM</td>
<td>&gt;10 μM</td>
</tr>
<tr>
<td>C-177</td>
<td><img src="image8" alt="Free Base Structure" /></td>
<td>27 nM</td>
<td>&gt;10 μM</td>
</tr>
</tbody>
</table>

**Example 2.2.** hERG channel inhibition.
The assay was performed on hERG channel stably expressed in HEK293 cells. The cells were cultured at 37°C in a humidified CO₂ incubator in the growth medium consisting of DMEM, 10% fetal bovine serum and antibiotics. Prior to the assay, the cells were seeded onto a 12mm PDL-coated glass coverslip and cultured in a 35mm Petri dish. After 16 to 40 hr culture, the cover slip was transferred into the chamber of OetaFlow perfusion system (ALA Instrument) and under a constant flow of extracellular solution (140 mM NaCl, 4 mM KCl, 1 mM MgCl₂, 2mM CaCl₂, 10 mM HEPES, 10 mM D-glucose, pH 7.35, osmolarity 290). Whole cell patch clamping was performed with a glass micropipette filled with intracellular solution (120 mM KCl, 1.75 mM MgCl₂, 5.4 mM CaCl₂, 10 mM HEPES, 10 mM EGTA, and 4 mM ATP-K₂, pH 7.2, osmolarity 310). Giga-seal was maintained during the test. The voltage control and current measurement were carried out using Axon amplifier 700B, Digidata 1440A and CLAMPLEX10 software (Molecular Devices). Whole-cell hERG currents were recorded following the Petroski protocol; the cell was held at -80 mV, mid the voltage step jumped from -80 to 30 mV and stay for 2 sec with a 20 ms prepulse at -40 mV. After depolarization, the voltage was decreased to -40 mV and stay for 2 sec, and returned back to -80 mV. Test compound was applied by quartz capillary tubes tip (200 µm inner diameter), and the flow rate was controlled at 2-3 mL/min with OetaFlow perfusion system. Different concentrations of the compound were applied to the cells for 5 min and the hERG current was measured three times before, during and after compound treatment. The data were analyzed using Clampfit 30 software (Molecular Devices) to generate IC₅₀ values. Results are shown in the table below.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>hERG IC₅₀</th>
<th>hNR2B IC₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>LX-1</td>
<td><img src="image" alt="Structure of LX-1" /></td>
<td>4.5 µM</td>
<td>24 nM</td>
</tr>
<tr>
<td>C-3</td>
<td><img src="image" alt="Structure of C-3" /></td>
<td>7.0 µM</td>
<td>22 nM</td>
</tr>
</tbody>
</table>
### Inhibitory activities of test compounds on major isoforms of CYP450

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>hERG IC$_{50}$</th>
<th>hNR2B IC$_{50}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-4</td>
<td><img src="image" alt="Structure C-4" /></td>
<td>11.4 µM</td>
<td>35 nM</td>
</tr>
<tr>
<td>C-5</td>
<td><img src="image" alt="Structure C-5" /></td>
<td>9.5 µM</td>
<td>30 nM</td>
</tr>
<tr>
<td>C-230</td>
<td><img src="image" alt="Structure C-230" /></td>
<td>13.8 µM</td>
<td>88 nM</td>
</tr>
<tr>
<td>C-127</td>
<td><img src="image" alt="Structure C-127" /></td>
<td>6 µM</td>
<td>45 nM</td>
</tr>
<tr>
<td>C-128</td>
<td><img src="image" alt="Structure C-128" /></td>
<td>28 µM</td>
<td>89 nM</td>
</tr>
<tr>
<td>C-175</td>
<td><img src="image" alt="Structure C-175" /></td>
<td>4.5 µM</td>
<td>22 nM</td>
</tr>
</tbody>
</table>

**Example 2.3.** CYP450 enzyme inhibition.

[0407] Inhibitory activities of test compounds on major isoforms of CYP450 were evaluated by using pooled human liver microsome (HLM, purchased from BD Gentest) and selective substrates for those isoforms. Those CYP isoforms and their corresponding probe substrates are as follows: CYP1A2 (phenacetin, 30µM), CYP2C9 (tolbutamide, 100µM), CYP2C19 (S-mephenytoin, 40µM), CYP2D6 (dextromethorphan, 5µM) and CYP3A4 (midazolam, 1µM). All probe substrates were used at concentrations near or below their $K_{i}$.

For experiment, a reaction mixture of test compound at 10 µM or in serial dilution, CYP probe substrate described above and 0.2 mg/mL pooled HLM in phosphate buffer, pH 7.4 in a final volume of 200 µL was pre-incubated at 37°C for 10 minutes in triplicate. The reaction was initiated...
by addition of NADPH at final concentration of 1 mM. The reaction was terminated after 10
minutes (CYPIA.2, CYP2D6 and CYP3A4) or 30 minutes (CYP2C9 and CYP2C19) by
addition of 100 pL ice-cold acetonitrile with internal standard (IS). The samples were then
centrifuged at 13,000 rpm and the supernatants were injected to LC-MS/MS (Agilent
Technologies) to quantify the concentration of the specific metabolites of the probe
substrates formed by individual CYP450 isoforms. The inhibition ratio is calculated as:

\[
\frac{(M_r-M_0)/M_{\text{max}} \times 100\%}
\]

in which \(M_r\) and \(M_0\) represent the concentrations of the specific probe substrate -metabolite,
which was formed by individual CYP450 isoform, at the beginning and end of the reaction in
the presence of test compound; while \(M_{\text{max}}\) also represents the concentration of the specific
metabolite at the end of the reaction in the absence of test compound. Test compound
concentration-dependent response data experiments performed in triplicate. Mean CYP2D6
IC\(_{50}\) values were derived from non-linear, least-squares fitting of dose-dependent response
data to a standard logistic equation (Prism, GraphPad Software, inc) to generate the CYP2D6
IC\(_{50}\) results shown in the table below.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Free Base Structure</th>
<th>CYP2D6 IC(_{50})</th>
<th>NR2B IC(_{50})</th>
</tr>
</thead>
<tbody>
<tr>
<td>LX-1</td>
<td><img src="image" alt="LX-1 Structure" /></td>
<td>1.0 (\mu)M</td>
<td>24 nM</td>
</tr>
<tr>
<td>C-3</td>
<td><img src="image" alt="C-3 Structure" /></td>
<td>12 (\mu)M</td>
<td>22 nM</td>
</tr>
<tr>
<td>C-5</td>
<td><img src="image" alt="C-5 Structure" /></td>
<td>33 (\mu)M</td>
<td>30 nM</td>
</tr>
<tr>
<td>C-127</td>
<td><img src="image" alt="C-127 Structure" /></td>
<td>11 (\mu)M</td>
<td>45 nM</td>
</tr>
</tbody>
</table>
Example 2.4. Forced Swim Test

[0408] The forced swim test was used to evaluate antidepressant activity (Porsoit et al., 1977 Arch. Int. Pharmacol. n. 229: 327-336). Mice that are forced to swim in a situation from which they cannot escape, rapidly become immobile. Drugs with antidepressant activity, such as imipramine, reduce the amount of time spent in the immobile state. Therefore, the amount of immobility time during a test conducted after drug administration represents a useful indicator of antidepressant activity (Lucki et al., 2001, Psychopharmacology 155:315-322).

[0409] Male mice (strain NLMN) weighing 25-35 g were used for testing. All animals were housed in a temperature (22-24 °C) and humidity (50-60%) controlled environment with free access to food and water on a 12-hour light-dark cycle. Test compounds were dissolved in 0.5% dimethylsulfoxide, 4% hydroxypropyl-b-cyclodextrin water to generate the appropriate dosing solution. Drugs were administered by intraperitoneal injection at a dose volume of 10 mL/kg. Testing was initiated 20-60 minutes after dosing. Testing for antidepressant activity was conducted as described by Darci et al. (Darci et al., 2004, Eur. J. Pharmacol. 499:135-146). Mice were placed in a white plastic cylinder 20 cm high with a diameter of 21 cm.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Free Base Structure</th>
<th>CYP2D6 IC₅₀</th>
<th>NR2B IC₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-178</td>
<td><img src="image" alt="structure" /></td>
<td>6.7 µM</td>
<td>64 nM</td>
</tr>
<tr>
<td>C-179</td>
<td><img src="image" alt="structure" /></td>
<td>4.9 µM</td>
<td>23 nM</td>
</tr>
<tr>
<td>C-175</td>
<td><img src="image" alt="structure" /></td>
<td>2.3 µM</td>
<td>22 nM</td>
</tr>
</tbody>
</table>
containing 10 cm of water at 25 ± 2 °C. The mice were videotaped for 6 minutes, and the last 4 minutes of video were analyzed by a blinded observer off-line. The observer judged the animal to be immobile when it ceased all activity (struggling, swimming, jumping etc.) and floated passively atop the water. The amount of time each animal spent in the immobile/state was recorded and used for statistical analysis of compound effect. Group differences were evaluated by student’s t-test or one-way ANOVA followed by post-hoc Dunnett’s test.

[0410] In both Examples 2.4.1 and 2.4.2, the positive control compound, imipramine (32 mg/kg, IP) showed the expected antidepressant activity (see FIGs. 1 and 2). These results indicate that provided compounds exhibit antidepressant activity when tested in a standard model for human depression.

Example 2.4.1. Compound C-178.

[04i3] Results are shown in FIG. 1: Bars represent the mean ± SEM immobility time for each dose group (n = 10, ***/**: different from vehicle group, p < 0.001/0.01 respectively. One-way ANOVA, Dunnett’s post-test). Doses are given as milligram per kilogram (mpk). The dose of imipramine was 32 mpk.

Example 2.4.2. Compound C-179.

[0412] Results are shown in FIG. 2: Bars represent the mean ± SEM immobility time for each study group (n = 10, ***/**: different from vehicle group, p < 0.001/0.01 respectively. One-way ANOVA, Dunnett’s post-test). Doses are given as milligram per kilogram (mpk). The dose of imipramine was 32 mpk.

Example 2.5, Haloperidol-induced Catalepsy (MIC) model.

to induce extrapyramidal side-effects, in particular Parkinsonism. Antagonism of antipsychotic-induced catalepsy can thus serve to detect anti-Parkinson potential.

[0414] Rats were injected with haloperidol (1 mg/kg i.p.) and were examined for catalepsy at 30 minute intervals up to 360 minutes. Presence (+) or absence (-) of catalepsy was assessed by three procedures: 1) imposed crossing of the ipsilateral fore- and hind-limbs; 2) placing the animal in the Buddha position: 3) the tilting hoard, an automatic device that, 5 seconds after positioning the rat, displaces the rat from a horizontal to vertical position and back while it clings to a wire grid with its front paws. Akinesia and catalepsy are assessed depending on whether or not the animal moves before (akinesia) or during operation of the board (catalepsy).

[0415] The 4 scores were cumulated over time to give a global catalepsy score per animal. Six rats were studied per group. The test was performed blind (test substances versus vehicle). Test substances were evaluated at 1 or more doses, administered p.o. 15 minutes before haloperidol (i.e. 45 minutes before the first measurement), and compared with a vehicle control group. Amphetamine (8 mg/kg p.o.), administered 60 minutes before the test (i.e. 90 minutes before the first measurement), was used as reference substance. The experiment therefore included 8 groups. Data with the test substances were analysed by comparing treated groups (7 groups except for the reference substance) with vehicle control using Kruskal-Wallis Test followed by Mann-Whitney U tests at each time and for cumulated score. Data with the reference substance were analysed using Mann-Whitney U tests.

[0416] In examples 2.5.1, 2.5.2 and 2.5.3, the positive control compound amphetamine (8 mg/kg IP) showed the expected robust antica
taleptic activity (FIGs. 3, 4 and 5). These results indicate that provided compounds effectively block NR2B receptors in this rat model.

Example 2.5.1, Compound C-6.

[0417] Results are shown in FIG. 3: Bars represent the mean ± SEM global catalepsy score measured over the entire course of the 4 hour test period (n = 6, **: different from vehicle group, p < 0.01, one-way ANOVA, Dunnett's post test). Doses are given as milligram per kilogram (mpk). The dose of amphetamine was 8 mpk.
Example 2.5.2. Compound C-12.

[0418] Results are shown in FIG. 4: Bars represent the mean ± SEM global catalepsy score measured over the entire course of the 4 hour test period (n = 6, **: different from vehicle group, p < 0.05/0.01 respectively one-way ANOVA, Dunnetts post test). Doses are given as milligram per kilogram (mpk). The dose of amphetamine was 8 mpk.

Example 2.5.3. Compound C-5.

[0419] Results are shown in FIG. 5: Bars represent the mean ± SEM catalepsy score measured at the 3.5 hour test time point (n = 6, **: different from vehicle group, p < 0.05/0.01 respectively, Students t-test). Doses are given as milligram per kilogram (mpk). The dose of amphetamine was 8 mpk.

Example 2.6. Electroconvulsive Threshold (ECT) Test

[0420] The ECT method, which detects proconvulsant or anticonvulsant activity, follows that described by Swinyard et al. (J. Pharmacol Exp. Ther., 106, 319-330, 1952). The electroconvulsive threshold (ECT) test is commonly used in the screening of antiepileptic drugs in rodent models. Use of electrically-induced convulsions is recommended to assess proconvulsant and anticonvulsant activity. The effect of NR2B antagonism on pro- and anti-convulsant activity can, therefore, be measured with the ECT test. (N. O. Dalby et al., Epilepsy Res. 28: 63-72, 1997; E. Bsneanlt et al., J. Pharm. Toxicol. Methods, 72: 59-66, 2015).

[0421] Rats were administered ECS (rectangular current: 0.6 ms pulse width, 15 s duration, 200 Hz) via earclip electrodes connected to a constant current shock generator (Ugo Basile: type 780 1). Treatment groups of 20 rats were exposed to ECS as follows; Animal #1 was exposed to 30 mA of ECS. If animal #1 did not show convulsions (tonic convulsions) within 5 seconds maximum, animal #2 was exposed to 3.5 mA, etc. (increases of 5 mA.) until the first tonic convolution was observed. Once the first tonic convolution was observed, the intensity of ECS was decreased by 2 mA for the next animal and then decreased or increased by 2 mA front animal to animal depending on whether the previous animal convulsed or not. If the
first animal did convulse (tonic convulsions) within 5 seconds, animal #2 was exposed to 25 mA, etc. (decreases of 5 mA) until the absence of tonic convulsions was observed. At this point, the intensity of ECS was increased by 2 mA for the next animal and then decreased or increased by 2 mA from animal to animal depending on whether the previous animal convulsed or not. The minimum current intensity applied is 5 mA and the maximum 95 mA. The first 5 animals serve to approach threshold current and were not included in the analysis.

The results are presented as the mean current intensity administered to the final 15 animals of a group. The test was performed blind to treatment. A positive percent change indicates an anticonvulsant effect. A negative percent change indicates a proconvulsant effect. The test substance was evaluated at 3 doses, administered p.o. 60 minutes before ECS, and compared with a vehicle control group. All statistical analyses were conducted using Microsoft Excel.

[0422] Theophylline (128 mg/kg p.o.) and diazepam (16 mg/kg p.o.), administered under the same experimental conditions, were used as reference substances. Test compounds, C-11, C-127 and C-179 were administered orally 1 hour before the beginning of the test.

[0423] In each of Examples 2.6.1, 2.6.2 and 2.6.3 the positive control compounds, theophylline (128 mg/kg, p.o.) and diazepam (16 mg/kg p.o.) showed the expected pro- and anticonvulsant activities (see FIGs. 6, 7 & 8). These results indicate that provided compounds exhibit anticonvulsant activity when tested in a standard model for human convulsions.

Example 2.6.1, Compound C-11 in the ECT test

[0424] Results are shown in FIG. 6. Bars represent the mean ± SEM electroconvulsive threshold for each study group (n = 15, ***: different from vehicle group, p < 0.05/0.01/0.001 respectively. One-way ANOVA, Dunnert's post-test). Doses are given as milligram per kilogram (mpk). The dose of theophylline was 128 mpk (p.o.) and the dose of diazepam was 16 mpk (p.o.).

Example 2.6.2, Compound C-127 in the ECT test

10425] Results are shown in FIG. 7. Bars represent the mean ± SEM electroconvulsive threshold in mA for each dose group (n = 15, ***: different from vehicle group, p < 0.001,
One-way ANOVA, Dunnett’s post-test). Doses are given as milligram per kilogram (mpk). The dose of theophylline was 128 mpk (p.o.) and the dose of diazepam was 16 mpk (p.o.).

Example 2.6.3, Compound C-179 in the ECT test

Results are shown in FIG. 8. Bars represent the mean ± SEM electroconvulsive threshold for each study group (a ≥ 15, ***/***: different from vehicle group, p < 0.05/0.01/0.001 respectively. One-way ANOVA, Dunnett’s post-test). Doses are given as milligram per kilogram (mpk). The dose of theophylline was 128 mpk (p.o.) and the dose of diazepam was 16 mpk ip.o.).

Example 2.7. 6 Hz Seizure Test

The 6 Hz seizure test, which detects anticonvulsant activity of test compounds, was conducted according to methods described by Brown et al. (J. Pharmacol. Exp. Ther. 107, 273-283, 1953) and Barton et al. (Epilepsy Res. 47, 217-227, 2001). Mice, were administered a rectangular current (44 mA, rectangular pulse: 0.2 ms pulse width, 3 s duration. 6 Hz) via corneal electrodes connected to a constant current shock generator (Ugo Basile: type 7801).

The results for the number of seizures as reflected by forelimb clonus and Straub-tail were recorded during the first minute following current administration. Forelimb clonus was scored as absent (0), mild (1) and strong (2) whereas Straub tail was rated as absent (0) or present (1). 15 mice were studied per group. The test was performed partially blind (test substance vs vehicle). Test substance (Compound C-179) was evaluated at 3 doses, administered p.o. 30 minutes before the test and compared with a vehicle control group. Diazepam (8 mg/kg p.o.), administered 60 minutes before the test, was used as reference substance. Quantitative data (scores) with the test substance was analyzed by comparing treated groups with vehicle control using Kaiiskall-Wallis test followed by Mann-Whitney U tests.

Example 2.7.1 Compound C-139 in the 6 Hz Seizure Test

Results are shown in FIG. 9. Bars represent the mean ± SEM forelimb clonus score (arbitrary units) for each dose group (n = 15, ***/***: different from vehicle group, p <
0.05/0.001, One-way ANOVA, Dutnatt’s post-test). Doses are given as milligram per kilogram (mpk). The dose of diazepam was 8 mpk (p.o.).
WHAT IS CLAIMED IS:

1. A chemical entity, which is a compound of formula 1:

   ![Chemical Structure](image)

   or a pharmaceutically acceptable salt thereof.

   wherein:

   Y and Z are independently N or C(R²);

   X is -H; halo; C₁-C₆ alkyl optionally substituted with 1 to 6 fluoro; C₅-C₆ cycloalkyl;
   C₁-C₄ alkoxy optionally substituted with 1 to 6 fluoro; -CN; -N⁰⁴; -N(R⁷)(R⁸); -SR⁷;
   -S(0)₂R⁹; or -C(0)OR⁷;

   R¹ is -H; halo; C₁-C₄ alkyl optionally substituted with 1 to 3 fluoro; C₇-C₈ cycloalkyl;
   CrC₄ alkoxy optionally substituted with 1 to 3 fluoro: -CM; -N⁰₂; -N(R⁷)(R⁸);
   -C(())OR⁷; or -C(0)N(R⁷)(R⁸);

   R² is -H; halo; C₁-C₄ alkyl optionally substituted with 1 to 3 fluoro; cyclopropyl; or
   C₁-C₄ alkoxy optionally substituted with 1 to 3 fluoro;

   R³ is -H, -F, -Cl, -C⁺₄, -CF₃ or -GC₄⁺;

   R⁴ is -H, -F, -Cl; C₁-C₃ alkyl optionally substituted with 1 to 3 fluoro; or cyclopropyl;

   R⁵ is -H or -C₁⁺₄

   R⁶ is -E, -F or -CH₃;

   each instance of R⁷ independently is C₁-C₄ alkyl;

   each instance of R⁸ independently is -H or C₁-C₄ alkyl; and
R\(^9\) is C\(_1\)-C\(_4\) alkyl optionally substituted with 1 to 3 fluoro.

2. The chemical entity of claim 1, wherein:

X is -H, -F, -Cl, -CH\(_3\), -CH\(_2\)CH\(_3\), -CH(C\(_3\)H\(_5\)) \_ cyclopropyl, -CF\(_3\), -CHF\(_2\), -CH\(_2\)F, -CF\(_2\)CF\(_3\),

-CH\(_2\)CF\(_2\)CF\(_3\) \_ cyclopropyl, -CF\(_3\), -CHF\(_2\), -CF\(_2\)CF\(_3\),

-NH(CH\(_3\))\(_2\), -N(CH\(_3\))\(_2\), -N(CH\(_3\))\(_2\)(C\(_3\)H\(_5\)), -SCH\(_3\), -SCH\(_2\)CH\(_3\), -S\(_0\)\(_2\)CH\(_3\), -S\(_0\)\(_2\)CH\(_2\)CH\(_3\) or -S\(_0\)\(_2\)CF\(_3\);

R\(^1\) is -H, -F, -Cl, -CH\(_3\), -CH\(_2\)CH\(_3\), -CH(C\(_3\)H\(_5\)) \_ cyclopropyl, -CF\(_3\), -CHF\(_2\), -CF\(_2\)CF\(_3\),

-OCF\(_3\), -CN, -N\(_0\)\(_2\), -CO\(_2\)CH\(_3\), -CO\(_2\)CH\(_2\)CH\(_3\), -C(0)N(CH\(_3\))\(_2\), -C(0)N(CH\(_3\))\(_2\), -C(0)N(CH\(_3\))\(_2\);

R\(^2\) is -H, -F, -Cl, -C\(_3\)H\(_7\) or cyclopropyl, -OCF\(_3\), -GCF\(_3\), -OCF\(_2\) or -OCF\(_2\)H;

R\(^3\) is -H, -F, -Cl, -CH\(_3\), -CF\(_3\) or -OCH\(_3\);

R\(^4\) is -H, -F, -Cl, -CH\(_3\) or cyclopropyl;

R\(^5\) is -H or -CH\(_2\); sad

R\(^6\) is -il -F or -t\(_\Phi\).

3. The chemical entity of claim 1, wherein:

X is -P\(_i\) -F, -Cl, -CH\(_3\), -C\(_3\)H\(_7\) or cyclopropyl, -OCF\(_3\), -CHF\(_2\), -CF\(_3\), -CH\(_2\)F, cyclopropyl, -OC\(_3\)H\(_5\) or -CF\(_3\);

R\(^1\) is -H, -F, -CF -C\(_3\) or -CF\(_3\);

R\(^2\) is -H, -F, -Cl, -C\(_3\)H\(_7\) or -CF\(_3\);

R\(^3\) is -H, -F, -Cl, -CH\(_3\) or -CF\(_3\);

R\(^4\) is -B, -Cl or -CH\(_3\);

R\(^5\) is -H or -CH\(_3\); and
R is -H, -F or -CH₃.

4. The chemical entity of any of claims 1-3, which is a chemical entity of formula (Ia):

5. The chemical entity of any of claims 1-3, which is a chemical entity of formula (II):

6. The chemical entity of any of claims 1-3, which is a chemical entity of formula (IIa):

7. The chemical entity of any of claims 1-3, which is a chemical entity of formula (III):

8. The chemical entity of any of claims 1-3, which is a chemical entity of formula (IV).
9. The chemical entity of any of claims 1-3, which is a chemical entity of formula (V):

10. The chemical entity of any of claims 1-3, which is a chemical entity of formula (Va):

11. The chemical entity of any of claims 1-3, which is a chemical entity of formula (VI):

12. The chemical entity of any of claims 1-3, which is a chemical entity of formula (VII):
13. The chemical entity of any of claims 1-3, which is a chemical entity of formula (Villi): 

(VIII).

14. The chemical entity of any of claims 1-3, which is a chemical entity of formula (Villa): 

(VIIia).

15. The chemical entity of any of claims 1-3, which is a chemical entity of formula (IX): 

(IX).

16. A pharmaceutical composition comprising the chemical entity of any one of claims 1-15 and a pharmaceutically acceptable carrier.

17. The pharmaceutical composition of claim 16, which is suitable for oral administration.

18. A method of treating a disease or disorder responsive to NR2B antagonism in a subject in need of such treatment comprising administering an effective amount of the chemical entity of any one of claims 1-15.

19. The method of claim 18, wherein the disease or disorder is depression, a seizure disorder, pain, a movement disorder, Huntington's disease, cognitive dysfunction, cerebral ischaemia, traumatic brain-injury, or a substance abuse disorder.
20. The method of claim 19, wherein the disease or disorder is depression.
FIG. 1
FIG. 3
FIG. 5
FIG. 6
FIG. 7
FIG. 8
FIG. 9
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. C07D487/04 A61K31/519 A61P25/00

**ADD.**

According to International Patent Classification (IPC) into both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, CHEM ABS Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>A</td>
<td>wo 2006/113471 A2 (MERCK &amp; CO INC [US]; LAYTON MARK E [US]; RODZINAK KEVIN J [US]; KELLY) 26 October 2006 (2006-10-26) page 1 lines 5-10, claims 5, 8 and 11</td>
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☐ Further documents are listed in the continuation of Box C. ❏ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "Z" document member of the same patent family

Date of the actual completion of the international search

27 November 2015

Date of mailing of the international search report

09/12/2015

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Gregoire, Ariane
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