



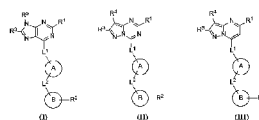
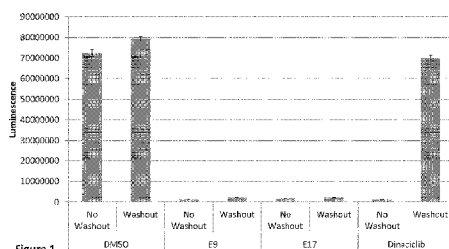
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(54) **Title:** INHIBITORS OF CYCLIN-DEPENDENT KINASES

(57) **Abstract:** The present invention provides novel compounds of Formula (I), (II), or (III), and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof. Also provided are methods and kits involving the inventive compounds or compositions for treating and/or preventing proliferative diseases (e.g., cancers (e.g., leukemia, acute lymphoblastic leukemia, lymphoma, Burkitt's lymphoma, melanoma, multiple myeloma, breast cancer, Ewing's sarcoma, osteosarcoma, brain cancer, ovarian cancer, neuroblastoma, lung cancer, colorectal cancer), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, autoimmune diseases, and autoimmune diseases) in a subject. Treatment of a subject with a proliferative disease using a compound or composition of the invention may inhibit the aberrant activity of a kinase, such as a cyclin-dependent kinase (CDK) (e.g., CDK7, CDK12, or CDK13), and therefore, induce cellular apoptosis and/or inhibit transcription in the subject.

INHIBITORS OF CYCLIN-DEPENDENT KINASES

RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. provisional application, U.S.S.N. 62/139,352, filed March 27, 2015, which is incorporated herein by reference.

GOVERNMENT SUPPORT

[0002] This invention was made with Government support under grant number 1 R01 CA179483-01A1 awarded by the National Institutes of Health (NIH). The Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

[0003] The members of the cyclin-dependent kinase (CDK) family play critical regulatory roles in cell proliferation. There are currently twenty known mammalian CDKs. While CDK7-CDK13 have been linked to transcription, only CDK1, 2, 4, and 6 show demonstrable association with the cell cycle.

[0004] Unique among the mammalian CDKs, CDK7 has consolidated kinase activities, regulating both the cell cycle and transcription. In the cytosol, CDK7 exists as a heterotrimeric complex and is believed to function as a CDK1/2-activating kinase (CAK), whereby phosphorylation of conserved residues in CDK1/2 by CDK7 is required for full catalytic CDK activity and cell cycle progression (Desai *et al.*, "Effects of phosphorylation by CAK on cyclin binding by CDC2 and CDK2." *Mol. Cell Biol.* 15, 345-350 (1995); Kaldis *et al.*, "Analysis of CAK activities from human cells." *Eur. J. Biochem.* 267, 4213-4221 (2000); Larochelle *et al.*, "Requirements for CDK7 in the assembly of CDK1/cyclin B and activation of CDK2 revealed by chemical genetics in human cells." *Mol. Cell* 25, 839-850 (2007)). In the nucleus, CDK7 forms the kinase core of the RNA polymerase (RNAP) II general transcription factor complex and is charged with phosphorylating the C-terminal domain (CTD) of RNAP II, a requisite step in gene transcriptional initiation (Serizawa. *et al.*, "Association of CDK-activating kinase subunits with transcription factor TFIIH." *Nature* 374, 280-282 (1995); Shiekhhattar *et al.*, "CDK-activating kinase complex is a component of human transcription factor TFIIH." *Nature* 374, 283-287 (1995); Drapkin *et al.*, "Human cyclin-dependent kinase-activating kinase exists in three distinct complexes." *Proc. Natl. Acad. Sci. U.S.A.* 93, 6488-6493 (1996); Liu. *et al.*, "Two cyclin-dependent kinases promote

RNA polymerase II transcription and formation of the scaffold complex.” *Mol. Cell Biol.* 24, 1721-1735 (2004); Akhtar *et al.*, “TFIIH kinase places bivalent marks on the carboxy-terminal domain of RNA polymerase II.” *Mol. Cell* 34, 387-393 (2009); Glover-Cutter *et al.*, “TFIIH-associated CDK7 kinase functions in phosphorylation of C-terminal domain Ser7 residues, promoter-proximal pausing, and termination by RNA polymerase II.” *Mol. Cell Biol.* 29, 5455-5464 (2009)). Together, the two functions of CDK7, *i.e.*, CAK and CTD phosphorylation, support critical facets of cellular proliferation, cell cycling, and transcription.

[0005] CDK12 and CDK13 were identified in cDNA screens for cell cycle regulators. Because their cyclin partners were not yet known, they were initially named CRKRS and CDC2L5 (Ko *et al.*, *J. Cell Sci.*, 2001, 114, 2591-2603; Marqués *et al.*, *Biochem Biophys Res Commun.*, 2000, 279(3):832-837), respectively. They were found to be 1490- and 1512-amino acid proteins, respectively, with a conserved central CTD kinase domain and degenerate RS domains identified in their N- and C-terminal regions (Even *et al.*, *J Cell Biochem.*, 2006, 99(3), 890-904).

[0006] Evidence has shown CDK12 and CDK13 play an important role in cancer development. A comprehensive genomic approach identified CDK12 to be one of the most frequently somatically mutated genes in high-grade serous ovarian cancer, the most fatal form of the disease (Erratum, *Nature*, 2011, 474(7353), 609-615). Several identified point mutations in the kinase domain point to the critical importance of the kinase activity of CDK12 for the development/progression of this disease. CDK12 has also been found to contribute to the development of breast cancer. Notably, CDK12 is located on chromosome 17, within the 17q21 locus that contains several candidate genes for breast cancer susceptibility (Kauraniemi *et al.*, *Cancer Res.*, 2001, 61(22), 8235-8240), and it is co-amplified with the tyrosine kinase receptor ERBB2, a protein amplified and overexpressed in about 20% of breast tumors. Gene fusion between CDK12 and ERBB2 was also detected in gastric cancer (Zang *et al.*, *Cancer Res.*, 2011, 71(1), 29-39). CDK12 is also implicated in the modification of tamoxifen sensitivity in estrogen-positive breast cancer *via* the modulation of the mitogen-activated protein kinase pathway (Iorns *et al.*, *Carcinogenesis*, 2009, 30(10):1696-1701).

[0007] Due to the important regulatory functions of kinases, such as CDK7, CDK12, and CDK13, in cell cycle control, cell proliferation, differentiation, and apoptosis, it is important to develop modulators of the activities of these kinases, including selective modulators, for use as research tools as well as therapeutic agents in the treatment of diseases.

SUMMARY OF THE INVENTION

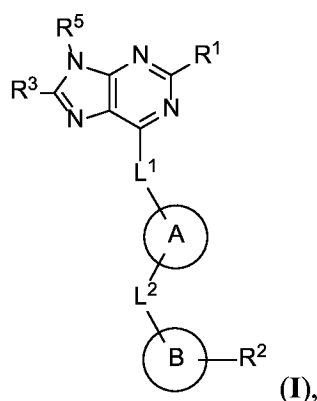
[0008] Cyclin dependent kinases (CDKs), *e.g.*, CDK7, CDK12, and CDK13 are key regulators of the cell cycle. Their successive activation and inactivation drives the cycle forward. The activity of CDKs is regulated by multiple mechanisms such as positive and negative phosphorylation, binding of regulatory proteins like cyclins, and CDK inhibitors. Most CDKs require the phosphorylation of a threonine residue located in the T-loop to achieve full kinase activity. This threonine residue is conserved in all CDKs that function in cell cycle regulation. The enzyme responsible for this phosphorylation is therefore termed CDK-activating-kinase or CAK. CAK complexes have been found to be composed of CDK7, CDK12, CDK13, cyclin H, and MAT1. Besides its CAK function, CDK7, CDK12, and CDK13 also play a role in transcription and possibly in DNA repair. This suggests that the CDK7, CDK12, and CDK13 enzyme complexes are involved in multiple functions in the cell, *e.g.*, cell cycle control, apoptosis, transcription regulation, and DNA repair.

[0009] The present invention provides compounds of Formulae (I)-(III), and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof. The compounds of Formulae (I)-(III), and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, may inhibit the activity of a kinase. The compounds described herein can selectively inhibit specific CDK subtypes, for example, CDK7, CDK12, or CDK13. In certain embodiments, the compounds of Formulae (I)-(III) are selective for CDK7 compared to other kinases. In certain embodiments, the compounds of Formulae (I)-(III) are selective for CDK12 and/or CDK13 compared to other kinases. The present invention also provides methods of using the inventive compounds, and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, to study the inhibition of a kinase (*e.g.*, CDK7, CDK12, and/or CDK13) and as therapeutics for the prevention and/or treatment of diseases associated with the overexpression and/or aberrant activity of a kinase (*e.g.*, CDK7, CDK12, and/or CDK13). In certain embodiments, the inventive compounds are used for the prevention and/or treatment of proliferative diseases (*e.g.*, cancers (*e.g.*, leukemia, acute lymphoblastic leukemia, lymphoma, Burkitt's lymphoma, melanoma, multiple myeloma, breast cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, lung cancer, colorectal cancer), benign neoplasms, diseases associated with

angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases) in a subject.

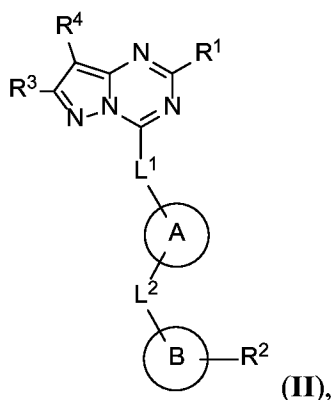
[0010] Since the discovery of selective inhibitors of CDK7, CDK12, and CDK13 has been hampered by the high sequence and structural similarities of the kinase domain of CDK family members, the development of selective inhibitors of the transcriptional cyclin-dependent kinases (tCDKs) will allow dissection of their individual contributions to the regulation of transcription and evaluation of their therapeutic potential. Without wishing to be bound by any particular theory, the inventive compounds' selectivity for CDK7, CDK12, and/or CDK13 may be due to the compounds' ability to covalently modify a specific cysteine residue of these kinases (*e.g.*, Cys312 of CDK7, Cys1039 of CDK12, Cys1017 of CDK13).

[0011] In one aspect, the present invention provides compounds of Formula (I):



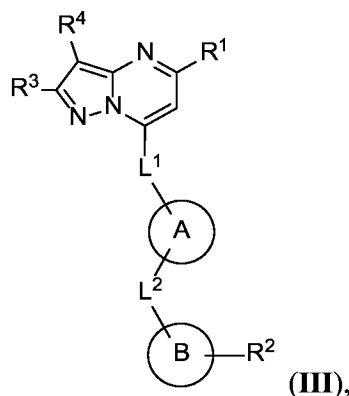
and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, and prodrugs thereof, wherein R^1 , R^2 , R^3 , R^5 , Ring A, Ring B, L^1 , and L^2 are as defined herein.

[0012] In one aspect, the present invention provides compounds of Formula (II):



and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, and prodrugs thereof, wherein R^1 , R^2 , R^3 , R^4 , Ring A, Ring B, L^1 , and L^2 are as defined herein.

[0013] In one aspect, the present invention provides compounds of Formula (III):



and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, and prodrugs thereof, wherein R^1 , R^2 , R^3 , R^4 , Ring A, Ring B, L^1 , and L^2 are as defined herein.

[0014] In another aspect, the present disclosure provides pharmaceutical compositions including a compound described herein, and optionally a pharmaceutically acceptable excipient. In certain embodiments, the pharmaceutical compositions described herein include a therapeutically or prophylactically effective amount of a compound described herein. The pharmaceutical composition may be useful for treating a proliferative disease in a subject in need thereof, preventing a proliferative disease in a subject in need thereof, inhibiting the activity of a protein kinase in a subject, biological sample, tissue, or cell, and/or inducing apoptosis in a cell. In certain embodiments, the proliferative disease is an acute inflammatory disease. In certain embodiments, the acute inflammatory disease is rheumatoid arthritis, Crohn's disease, or fibrosis.

[0015] In another aspect, the present invention provides methods for treating and/or preventing a proliferative disease. Exemplary proliferative diseases which may be treated include cancer, benign neoplasm, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases. In certain embodiments, the cancer is one or more selected from the group consisting of pancreatic cancer, lung cancer (*e.g.* small cell lung cancer (SCLC), and non-small cell lung cancer), prostate cancer, breast cancer, ovarian cancer, kidney cancer, liver cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, and colorectal cancer.

[0016] Another aspect of the invention relates to methods of inhibiting the activity of a kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, CDK13)) in a biological sample or subject. In certain embodiments, the method involves the selective inhibition of CDK7. In certain

embodiments, the method involves the selective inhibition of CDK12. In certain embodiments, the method involves the selective inhibition of CDK13.

[0017] Also provided by the present invention are methods of inhibiting transcription of one or more genes in the cell of a biological sample or subject. The transcription of genes affected by the activity of CDK7 may be inhibited by a compound of the invention. In certain embodiments, these genes are one or more selected from the group consisting of MYC, RUNX1, MYB, TAL1, GATA3, KLF2, HNRPDL, p21, ASCL1, MYCN, INSM1, NEUROD1, NEUROG1, FOXG1, FOXA1, SOX2, SOX4, BCL11A, OTX2, GAT2, PHOX2B, PLK2, TAF1, CTGF, WEE1, SDIM, JUN, PIM1, IL8, FOS1. The transcription of genes affected by the activity of CDK12 may be inhibited by a compound of the invention. In certain embodiments, these genes are one or more selected from the group consisting of BRCA1, FANCI, ATR, FANCD2, APEX1, NEK9, CHEK1, CHEK2, ATM, RAD51C, RAD51D, ORC3L, MDC1, TERF2, ERCC4, FANCF, PARP9, RUNX1, MYB, TAL1, MCL1, MYC, BCL2, ETS1, EWS-FLI. The transcription of genes affected by the activity of CDK13 may be inhibited by a compound of the invention. In certain embodiments, the gene is SNORA38.

[0018] The present invention also provides methods of inhibiting cell growth in a biological sample or subject. In still another aspect, the present invention provides methods of inducing apoptosis of a cell in a biological sample or subject.

[0019] In yet another aspect, the present invention provides compounds of Formulae (I)-(III), and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, for use in the treatment of a disease (*e.g.*, a proliferative disease such as cancer) in a subject.

[0020] Another aspect of the present disclosure relates to kits comprising a container with a compound, or pharmaceutical composition thereof, as described herein. The kits described herein may include a single dose or multiple doses of the compound or pharmaceutical composition. The kits may be useful in a method of the disclosure. In certain embodiments, the kit further includes instructions for using the compound or pharmaceutical composition. A kit described herein may also include information (*e.g.* prescribing information) as required by a regulatory agency such as the U.S. Food and Drug Administration (FDA).

[0021] The present invention provides methods for administering to a subject in need thereof an effective amount of a compound, or pharmaceutical composition thereof, as described herein. Also described are methods for contacting a cell with an effective amount

of a compound, or pharmaceutical composition thereof, as described herein. In certain embodiments, a method described herein further includes administering to the subject an additional pharmaceutical agent. In certain embodiments, a method described herein further includes contacting the cell with an additional pharmaceutical agent. The methods described herein may further include performing radiotherapy, immunotherapy, and/or transplantation on the subject.

[0022] The details of one or more embodiments of the invention are set forth herein. Other features, objects, and advantages of the invention will be apparent from the Detailed Description, the Examples, and the Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention.

[0024] *Figure 1* shows inhibition of Jurkat cell viability by compounds E9, E17, and dinaciclib. Specifically, compounds E9 and E17 irreversibly inhibit Jurkat cell viability. The antiproliferative effects of compounds E9 and E17 are present with and without washout, while dinaciclib's effects are abolished with washout. Cells were treated with each compound for 4 hours and either no washout (no washout) or had compound removed by washing cells with media (washout). Sixty-eight (68) hours after washout, the cells were assayed for antiproliferative effects. Error bars indicate +/-SD.

[0025] *Figure 2* shows binding of compounds E9 and E17 with CDK12 at two concentrations. Compounds E9 and E17 were able to block pulldown of cyclin K at 1 μ M and 200 nM. Specifically, Jurkat cells were treated with DMSO, compounds E9, E17, and dinaciclib at two concentrations for 4 hours. Decreased pulldown of cyclin K with biotin-THZ1 indicated a loss of CDK12 binding. Cyclin H pulldown was not affected, indicating that CDK7 binding is not affected.

[0026] *Figure 3* shows the effect of compounds E9, E17, and Dinaciclib on the downstream protein targets. Specifically, compounds E9 and E17 show an irreversible effect on Polymerase II Serine 2 phosphorylation and MCL1 levels with and without washout. Dinaciclib is only effective when it is present in cells, and its effect is abolished by washout.

[0027] *Figure 4* shows evaluation of the exemplified compounds in neuroblastoma (NB) cells. The IC50 values are shown in nM.

[0028] *Figure 5* shows that Dinaciclib and Compounds E9, E17, and E18 inhibit Jurkat T-cell acute lymphoblastic leukemia (T-ALL) cell proliferation. Compounds E9, E17, and E18 irreversibly inhibit T-ALL cell proliferation while Dinaciclib acts as a reversible inhibitor. Jurkat cells were seeded at a density of 25,000 cells/ well in 96-well plates. Cells were then treated with the indicated compounds in a 10-pt dose escalation format from 1 nM to 10 μ M or DMSO control for 72 hours. After 72 hours, the cells were assayed using CellTiter-Glo Luminescent Cell Viability Assay (Promega) to determine cell viability by measuring the amount of ATP present in each sample cell population, which is an indicator of cell metabolic activity. Results were graphed as fraction of the DMSO control at 72 hours. All data points were performed in biological triplicate. Error bars are +/- SD.

[0029] *Figure 6* shows the effect of Dinaciclib and compounds E9, E17, and E18 on the downstream protein targets. Specifically, reversible inhibitor Dinaciclib and covalent inhibitors Compounds E9, E17, and E18 are likely to downregulate mRNA transcripts of TAL1, RUNX1, and MYB in Jurkat T-cell acute lymphoblastic leukemia (T-ALL) cells. Jurkat cells were seeded at a density of 5 million cells/10 mL. Cells were then treated with 200 nM or 1 μ M of the indicated compounds or with DMSO control for 6 hours. Total RNA was extracted from 5 million cells using the RNeasy Plus Mini Kit (Qiagen) with a gDNA eliminator mini column to remove genomic DNA. mRNA was reverse transcribed into cDNA using the SuperScript III First-Strand Synthesis Kit (Life Technologies) using an oligo-dT primer to capture polyadenylated mRNAs. Quantitative PCR (qPCR) using transcript – specific Taqman probes (Applied Biosystems) was used to assess the effect of compound treatment on the expression of the indicated mRNA transcripts. All experiments shown were performed in biological triplicate. Each individual biological sample was qPCR –amplified in technical duplicate. Error bars are +/- SD. Expression data from drug treatments were normalized to GAPDH probe.

[0030] *Figure 7* shows electrospray ionization mass spectra of CDK12/CCNK complex after treatment with DMSO for 1 hr at room temperature. The zero-charge mass spectra in the upper panel and inset is the result of deconvolution of the raw mass spectrum in the lower panel. A, CCNK. C, phosphorylated CDK12. D, CDK12.

[0031] *Figure 8* shows electrospray ionization mass spectra of CDK12/CCNK complex after treatment with E-9 for 1 hr at room temperature. The zero-charge mass spectra in the upper panel and inset is the result of deconvolution of the raw mass spectrum in the lower panel. A, CCNK. B, phosphorylated and E-9 labeled CDK12. C, E-9 labeled CDK12. Only the masses of CDK12 proteins shift after treatment.

[0032] *Figure 9* shows pull down assay with exemplified compounds. The first and second wells are at the concentrations of 1 μ M and 200 nM respectively.

[0033] *Figure 10* shows KiNativTM kinome profiling of compound E9.

[0034] *Figure 11* shows exemplified downstream genes. Transcription of these downstream genes are affected by the activities of CDK7, CDK12, and CDK13.

[0035] *Figure 12* shows an overview of the CRISPR-mediated strategy to introduce cysteine-to-serine mutations into the genomic loci of CDK12 and CDK13. Shown are gene tracks of RNA polymerase II ChIP-seq signal at CDK12 (left) and CDK13 (left) gene loci in Jurkat cells. Cartoons depict (1) the Cas9/ guide RNA construct used to target Cas9-mediated DNA cutting to particulareither CDK12 or CDK/13 gene loci and (2) a repair construct that contains DNA sequence encoding for a serine mutation in CDK12 (C1039S) and CDK13 (C1017S), which together introduce the desired cysteine-to-serine coding mutations into these loci.

[0036] *Figure 13* shows genotype for wild type (top) CDK12 C1039S/ CDK13 C1017S double mutant (bottom) cells. The sequencing results for CDK12 (left) and CDK13 (right) loci are depicted. Expression of these putatively inhibitor-refractory mutants is expected to rescue compound-induced proliferation defects that result from CDK12 and CDK13 covalent inhibition. For CDK12 WT loci, TGC codes for cysteine; while for CDK12 C1039S loci, TCC codes for serine. For CDK13 WT loci, TGT codes for cysteine; while for CDK13 C1017S loci, TCT codes for serine.

[0037] *Figure 14* shows the 72 hour proliferation results from wild type and CDK12 C1039S/CDK13 C1017S HAP1 cells. Double mutant cells are 4-fold less sensitive to E17 compared to wild type cells indicating rescue of CDK12/13 inhibition –induced proliferation defects. HAP1 cells were seeded at a density of 12,000 cells/ well in 96-well plates. Twenty-four hours later, cells were treated with the indicated compounds in a 10-pt dose escalation format from 1 nM to 10 μ M or DMSO control for 72 hours. After 72 hours, the cells were assayed using CellTiter-Glo Luminescent Cell Viability Assay (Promega) to determine cell viability by measuring the amount of ATP present in each sample cell population, which is an indicator of cell metabolic activity. Results were graphed as fraction of the DMSO control at 72 hours. All data points were performed in biological triplicate. Error bars are +/- SD.

[0038] *Figure 15* shows the profiling of E-9 and E17 in the HAP1 cell proliferation assay. HAP1 cells expressing inhibitor-refractory mutations in CDK12 (C1039S) and CDK13 (C1017S) were 4-fold less sensitive to E17 compared to control wild type HAP1 cells. This result indicates that a significant portion of intracellular E17 activity comes from covalent

inhibition of CDK12 and/or CDK13. Mutation of these targeted cysteines to a less nucleophilic serine is sufficient to rescue a significant portion of anti-proliferative activity at concentrations less than 350 nM.

DEFINITIONS

[0039] Definitions of specific functional groups and chemical terms are described in more detail below. 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's Advanced Organic Chemistry*, 5th Edition, John Wiley & Sons, Inc., New York, 2001; Larock, *Comprehensive Organic Transformations*, VCH Publishers, Inc., New York, 1989; and Carruthers, *Some Modern Methods of Organic Synthesis*, 3rd Edition, Cambridge University Press, Cambridge, 1987. The disclosure is not intended to be limited in any manner by the exemplary listing of substituents described herein.

[0040] Compounds described herein can comprise one or more asymmetric centers, and thus can exist in various isomeric forms, *e.g.*, enantiomers and/or diastereomers. For example, the compounds described herein can be in the form of an individual enantiomer, diastereomer or geometric isomer, or can be in the form of a mixture of stereoisomers, including racemic mixtures and mixtures enriched in one or more stereoisomer. Isomers can be isolated from mixtures by methods known to those skilled in the art, including chiral high pressure liquid chromatography (HPLC) and the formation and crystallization of chiral salts; or preferred isomers can be prepared by asymmetric syntheses. See, for example, Jacques *et al.*, *Enantiomers, Racemates and Resolutions* (Wiley Interscience, New York, 1981); Wilen *et al.*, *Tetrahedron* 33:2725 (1977); Eliel, *Stereochemistry of Carbon Compounds* (McGraw-Hill, NY, 1962); and Wilen, *Tables of Resolving Agents and Optical Resolutions*, p. 268 (E.L. Eliel, Ed., Univ. of Notre Dame Press, Notre Dame, IN 1972). The disclosure additionally encompasses compounds described herein as individual isomers substantially free of other isomers, and alternatively, as mixtures of various isomers.

[0041] In a formula, ~~~ is a single bond where the stereochemistry of the moieties immediately attached thereto is not specified, --- is absent or a single bond, and === or == is a single or double bond.

[0042] Unless otherwise stated, structures depicted herein are also meant to include compounds that differ only in the presence of one or more isotopically enriched atoms. For example, compounds having the present structures except for the replacement of hydrogen by deuterium or tritium, replacement of ^{19}F with ^{18}F , or the replacement of ^{12}C with ^{13}C or ^{14}C are within the scope of the disclosure. Such compounds are useful, for example, as analytical tools or probes in biological assays.

[0043] When a range of values is listed, it is intended to encompass each value and sub-range within the range. For example “C₁₋₆” is intended to encompass, C₁, C₂, C₃, C₄, C₅, C₆, C₁₋₆, C₁₋₅, C₁₋₄, C₁₋₃, C₁₋₂, C₂₋₆, C₂₋₅, C₂₋₄, C₂₋₃, C₃₋₆, C₃₋₅, C₃₋₄, C₄₋₆, C₄₋₅, and C₅₋₆.

[0044] The term “aliphatic” includes both saturated and unsaturated, straight chain (*i.e.*, unbranched), branched, acyclic, cyclic, or polycyclic aliphatic hydrocarbons, which are optionally substituted with one or more functional groups. As will be appreciated by one of ordinary skill in the art, “aliphatic” is intended herein to include, but is not limited to, alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkenyl, and cycloalkynyl moieties. Thus, the term “alkyl” includes straight, branched and cyclic alkyl groups. An analogous convention applies to other generic terms such as “alkenyl”, “alkynyl”, and the like. Furthermore, the terms “alkyl”, “alkenyl”, “alkynyl”, and the like encompass both substituted and unsubstituted groups. In certain embodiments, “lower alkyl” is used to indicate those alkyl groups (cyclic, acyclic, substituted, unsubstituted, branched or unbranched) having 1-6 carbon atoms.

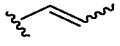
[0045] In certain embodiments, the alkyl, alkenyl, and alkynyl groups employed in the disclosure contain 1-20 aliphatic carbon atoms. In certain other embodiments, the alkyl, alkenyl, and alkynyl groups employed in the disclosure contain 1-10 aliphatic carbon atoms. In yet other embodiments, the alkyl, alkenyl, and alkynyl groups employed in the disclosure contain 1-8 aliphatic carbon atoms. In still other embodiments, the alkyl, alkenyl, and alkynyl groups employed in the disclosure contain 1-6 aliphatic carbon atoms. In yet other embodiments, the alkyl, alkenyl, and alkynyl groups employed in the disclosure contain 1-4 carbon atoms. Illustrative aliphatic groups thus include, but are not limited to, for example, methyl, ethyl, n-propyl, isopropyl, cyclopropyl, -CH₂-cyclopropyl, vinyl, allyl, n-butyl, sec-butyl, isobutyl, tert-butyl, cyclobutyl, -CH₂-cyclobutyl, n-pentyl, sec-pentyl, isopentyl, tert-pentyl, cyclopentyl, -CH₂-cyclopentyl, n-hexyl, sec-hexyl, cyclohexyl, -CH₂-cyclohexyl moieties and the like, which again, may bear one or more substituents. Alkenyl groups include, but are not limited to, for example, ethenyl, propenyl, butenyl, 1-methyl-2-buten-1-yl, and the like. Representative alkynyl groups include, but are not limited to, ethynyl, 2-propynyl (propargyl), 1-propynyl, and the like.

[0046] The term “alkyl” refers to a radical of a straight-chain or branched saturated hydrocarbon group having from 1 to 10 carbon atoms (“C₁₋₁₀ alkyl”). In some embodiments, an alkyl group has 1 to 9 carbon atoms (“C₁₋₉ alkyl”). In some embodiments, an alkyl group has 1 to 8 carbon atoms (“C₁₋₈ alkyl”). In some embodiments, an alkyl group has 1 to 7 carbon atoms (“C₁₋₇ alkyl”). In some embodiments, an alkyl group has 1 to 6 carbon atoms (“C₁₋₆ alkyl”). In some embodiments, an alkyl group has 1 to 5 carbon atoms (“C₁₋₅ alkyl”). In some embodiments, an alkyl group has 1 to 4 carbon atoms (“C₁₋₄ alkyl”). In some embodiments, an alkyl group has 1 to 3 carbon atoms (“C₁₋₃ alkyl”). In some embodiments, an alkyl group has 1 to 2 carbon atoms (“C₁₋₂ alkyl”). In some embodiments, an alkyl group has 1 carbon atom (“C₁ alkyl”). In some embodiments, an alkyl group has 2 to 6 carbon atoms (“C₂₋₆ alkyl”). Examples of C₁₋₆ alkyl groups include methyl (C₁), ethyl (C₂), propyl (C₃) (*e.g.*, n-propyl, isopropyl), butyl (C₄) (*e.g.*, n-butyl, tert-butyl, sec-butyl, iso-butyl), pentyl (C₅) (*e.g.*, n-pentyl, 3-pentanyl, amyl, neopentyl, 3-methyl-2-butanyl, tertiary amyl), and hexyl (C₆) (*e.g.*, n-hexyl). Additional examples of alkyl groups include n-heptyl (C₇), n-octyl (C₈), and the like. Unless otherwise specified, each instance of an alkyl group is independently unsubstituted (an “unsubstituted alkyl”) or substituted (a “substituted alkyl”) with one or more substituents (*e.g.*, halogen, such as F). In certain embodiments, the alkyl group is an unsubstituted C₁₋₁₀ alkyl (such as unsubstituted C₁₋₆ alkyl, *e.g.*, -CH₃). In certain embodiments, the alkyl group is a substituted C₁₋₁₀ alkyl (such as substituted C₁₋₆ alkyl, *e.g.*, -CF₃). In certain embodiments, the alkyl group is unsubstituted C₁₋₁₀ alkyl (such as unsubstituted C₁₋₆ alkyl, *e.g.*, -CH₃ (Me), unsubstituted ethyl (Et), unsubstituted propyl (Pr, *e.g.*, unsubstituted n-propyl (n-Pr), unsubstituted isopropyl (i-Pr)), unsubstituted butyl (Bu, *e.g.*, unsubstituted n-butyl (n-Bu), unsubstituted tert-butyl (tert-Bu or t-Bu), unsubstituted sec-butyl (sec-Bu), unsubstituted isobutyl (i-Bu)). In certain embodiments, the alkyl group is substituted C₁₋₁₀ alkyl (such as substituted C₁₋₆ alkyl, *e.g.*, -CF₃, Bn).

[0047] The term “haloalkyl” is a substituted alkyl group, wherein one or more of the hydrogen atoms are independently replaced by a halogen, *e.g.*, fluoro, bromo, chloro, or iodo. In some embodiments, the haloalkyl moiety has 1 to 8 carbon atoms (“C₁₋₈ haloalkyl”). In some embodiments, the haloalkyl moiety has 1 to 6 carbon atoms (“C₁₋₆ haloalkyl”). In some embodiments, the haloalkyl moiety has 1 to 4 carbon atoms (“C₁₋₄ haloalkyl”). In some embodiments, the haloalkyl moiety has 1 to 3 carbon atoms (“C₁₋₃ haloalkyl”). In some embodiments, the haloalkyl moiety has 1 to 2 carbon atoms (“C₁₋₂ haloalkyl”). Examples of haloalkyl groups include -CHF₂, -CH₂F, -CF₃, -CH₂CF₃, -CF₂CF₃, -CF₂CF₂CF₃, -CCl₃, -CFC₂Cl, -CF₂Cl, and the like.

[0048] The term “heteroalkyl” refers to an alkyl group, which further includes at least one heteroatom (*e.g.*, 1, 2, 3, or 4 heteroatoms) selected from oxygen, nitrogen, or sulfur within (*i.e.*, inserted between adjacent carbon atoms of) and/or placed at one or more terminal position(s) of the parent chain. In certain embodiments, a heteroalkyl group refers to a saturated group having from 1 to 10 carbon atoms and 1 or more heteroatoms within the parent chain (“heteroC₁₋₁₀ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 9 carbon atoms and 1 or more heteroatoms within the parent chain (“heteroC₁₋₉ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 8 carbon atoms and 1 or more heteroatoms within the parent chain (“heteroC₁₋₈ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 7 carbon atoms and 1 or more heteroatoms within the parent chain (“heteroC₁₋₇ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 6 carbon atoms and 1 or more heteroatoms within the parent chain (“heteroC₁₋₆ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 5 carbon atoms and 1 or 2 heteroatoms within the parent chain (“heteroC₁₋₅ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 4 carbon atoms and 1 or 2 heteroatoms within the parent chain (“heteroC₁₋₄ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 3 carbon atoms and 1 heteroatom within the parent chain (“heteroC₁₋₃ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 to 2 carbon atoms and 1 heteroatom within the parent chain (“heteroC₁₋₂ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 1 carbon atom and 1 heteroatom (“heteroC₁ alkyl”). In some embodiments, a heteroalkyl group is a saturated group having 2 to 6 carbon atoms and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₆ alkyl”). Unless otherwise specified, each instance of a heteroalkyl group is independently unsubstituted (an “unsubstituted heteroalkyl”) or substituted (a “substituted heteroalkyl”) with one or more substituents. In certain embodiments, the heteroalkyl group is unsubstituted heteroC₁₋₁₀ alkyl. In certain embodiments, the heteroalkyl group is substituted heteroC₁₋₁₀ alkyl.

[0049] “Alkenyl” refers to a radical of a straight-chain or branched hydrocarbon group having from 2 to 20 carbon atoms, one or more carbon-carbon double bonds, and no triple bonds (“C₂₋₂₀ alkenyl”). In some embodiments, an alkenyl group has 2 to 10 carbon atoms (“C₂₋₁₀ alkenyl”). In some embodiments, an alkenyl group has 2 to 9 carbon atoms (“C₂₋₉ alkenyl”). In some embodiments, an alkenyl group has 2 to 8 carbon atoms (“C₂₋₈ alkenyl”). In some embodiments, an alkenyl group has 2 to 7 carbon atoms (“C₂₋₇ alkenyl”). In some embodiments, an alkenyl group has 2 to 6 carbon atoms (“C₂₋₆ alkenyl”). In some

embodiments, an alkenyl group has 2 to 5 carbon atoms (“C₂₋₅ alkenyl”). In some embodiments, an alkenyl group has 2 to 4 carbon atoms (“C₂₋₄ alkenyl”). In some embodiments, an alkenyl group has 2 to 3 carbon atoms (“C₂₋₃ alkenyl”). In some embodiments, an alkenyl group has 2 carbon atoms (“C₂ alkenyl”). The one or more carbon-carbon double bonds can be internal (such as in 2-butenyl) or terminal (such as in 1-butenyl). Examples of C₂₋₄ alkenyl groups include ethenyl (C₂), 1-propenyl (C₃), 2-propenyl (C₃), 1-butenyl (C₄), 2-butenyl (C₄), butadienyl (C₄), and the like. Examples of C₂₋₆ alkenyl groups include the aforementioned C₂₋₄ alkenyl groups as well as pentenyl (C₅), pentadienyl (C₅), hexenyl (C₆), and the like. Additional examples of alkenyl include heptenyl (C₇), octenyl (C₈), octatrienyl (C₈), and the like. Unless otherwise specified, each instance of an alkenyl group is independently optionally substituted, *i.e.*, unsubstituted (an “unsubstituted alkenyl”) or substituted (a “substituted alkenyl”) with one or more substituents. In certain embodiments, the alkenyl group is unsubstituted C₂₋₁₀ alkenyl. In certain embodiments, the alkenyl group is substituted C₂₋₁₀ alkenyl. In an alkenyl group, a C=C double bond for which the stereochemistry is not specified (*e.g.*, -CH=CHCH₃ or ) may be an (*E*)- or (*Z*)-double bond.

[0050] The term “heteroalkenyl” refers to an alkenyl group, which further includes at least one heteroatom (*e.g.*, 1, 2, 3, or 4 heteroatoms) selected from oxygen, nitrogen, and sulfur within (*i.e.*, inserted between adjacent carbon atoms of) and/or placed at one or more terminal position(s) of the parent chain. In certain embodiments, a heteroalkenyl group refers to a group having from 2 to 10 carbon atoms, at least one double bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₁₀ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 9 carbon atoms at least one double bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₉ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 8 carbon atoms, at least one double bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₈ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 7 carbon atoms, at least one double bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₇ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 6 carbon atoms, at least one double bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₆ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 5 carbon atoms, at least one double bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₅ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 4 carbon atoms, at least one double bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₄ alkenyl”). In some embodiments, a

heteroalkenyl group has 2 to 3 carbon atoms, at least one double bond, and 1 heteroatom within the parent chain (“heteroC₂₋₃ alkenyl”). In some embodiments, a heteroalkenyl group has 2 to 6 carbon atoms, at least one double bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₆ alkenyl”). Unless otherwise specified, each instance of a heteroalkenyl group is independently unsubstituted (“unsubstituted heteroalkenyl”) or substituted (“substituted heteroalkenyl”) with one or more substituents. In certain embodiments, the heteroalkenyl group is unsubstituted heteroC₂₋₁₀ alkenyl. In certain embodiments, the heteroalkenyl group is substituted heteroC₂₋₁₀ alkenyl.

[0051] “Alkynyl” refers to a radical of a straight-chain or branched hydrocarbon group having from 2 to 20 carbon atoms, one or more carbon-carbon triple bonds, and optionally one or more double bonds (“C₂₋₂₀ alkynyl”). In some embodiments, an alkynyl group has 2 to 10 carbon atoms (“C₂₋₁₀ alkynyl”). In some embodiments, an alkynyl group has 2 to 9 carbon atoms (“C₂₋₉ alkynyl”). In some embodiments, an alkynyl group has 2 to 8 carbon atoms (“C₂₋₈ alkynyl”). In some embodiments, an alkynyl group has 2 to 7 carbon atoms (“C₂₋₇ alkynyl”). In some embodiments, an alkynyl group has 2 to 6 carbon atoms (“C₂₋₆ alkynyl”). In some embodiments, an alkynyl group has 2 to 5 carbon atoms (“C₂₋₅ alkynyl”). In some embodiments, an alkynyl group has 2 to 4 carbon atoms (“C₂₋₄ alkynyl”). In some embodiments, an alkynyl group has 2 to 3 carbon atoms (“C₂₋₃ alkynyl”). In some embodiments, an alkynyl group has 2 carbon atoms (“C₂ alkynyl”). The one or more carbon-carbon triple bonds can be internal (such as in 2-butyne) or terminal (such as in 1-butyne). Examples of C₂₋₄ alkynyl groups include, without limitation, ethynyl (C₂), 1-propynyl (C₃), 2-propynyl (C₃), 1-butyne (C₄), 2-butyne (C₄), and the like. Examples of C₂₋₆ alkenyl groups include the aforementioned C₂₋₄ alkynyl groups as well as pentynyl (C₅), hexynyl (C₆), and the like. Additional examples of alkynyl include heptynyl (C₇), octynyl (C₈), and the like. Unless otherwise specified, each instance of an alkynyl group is independently optionally substituted, *i.e.*, unsubstituted (an “unsubstituted alkynyl”) or substituted (a “substituted alkynyl”) with one or more substituents. In certain embodiments, the alkynyl group is unsubstituted C₂₋₁₀ alkynyl. In certain embodiments, the alkynyl group is substituted C₂₋₁₀ alkynyl.

[0052] The term “heteroalkynyl” refers to an alkynyl group that includes at least one heteroatom (*e.g.*, 1, 2, 3, or 4 heteroatoms) selected from oxygen, nitrogen, and sulfur within (*i.e.*, inserted between adjacent carbon atoms of) and/or placed at one or more terminal position(s) of the parent chain. In certain embodiments, a heteroalkynyl group refers to a group having from 2 to 10 carbon atoms, at least one triple bond, and 1 or more heteroatoms

within the parent chain (“heteroC₂₋₁₀ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 9 carbon atoms, at least one triple bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₉ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 8 carbon atoms, at least one triple bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₈ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 7 carbon atoms, at least one triple bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₇ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 6 carbon atoms, at least one triple bond, and 1 or more heteroatoms within the parent chain (“heteroC₂₋₆ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 5 carbon atoms, at least one triple bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₅ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 4 carbon atoms, at least one triple bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₄ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 3 carbon atoms, at least one triple bond, and 1 heteroatom within the parent chain (“heteroC₂₋₃ alkynyl”). In some embodiments, a heteroalkynyl group has 2 to 6 carbon atoms, at least one triple bond, and 1 or 2 heteroatoms within the parent chain (“heteroC₂₋₆ alkynyl”). Unless otherwise specified, each instance of a heteroalkynyl group is independently unsubstituted (“unsubstituted heteroalkynyl”) or substituted (“substituted heteroalkynyl”) with one or more substituents. In certain embodiments, the heteroalkynyl group is unsubstituted heteroC₂₋₁₀ alkynyl. In certain embodiments, the heteroalkynyl group is substituted heteroC₂₋₁₀ alkynyl.

[0053] “Carbocyclyl” or “carbocyclic” refers to a radical of a non-aromatic cyclic hydrocarbon group having from 3 to 10 ring carbon atoms (“C₃₋₁₀ carbocyclyl”) and zero heteroatoms in the non-aromatic ring system. In some embodiments, a carbocyclyl group has 3 to 8 ring carbon atoms (“C₃₋₈ carbocyclyl”). In some embodiments, a carbocyclyl group has 3 to 6 ring carbon atoms (“C₃₋₆ carbocyclyl”). In some embodiments, a carbocyclyl group has 3 to 6 ring carbon atoms (“C₃₋₆ carbocyclyl”). In some embodiments, a carbocyclyl group has 5 to 10 ring carbon atoms (“C₅₋₁₀ carbocyclyl”). Exemplary C₃₋₆ carbocyclyl groups include, without limitation, cyclopropyl (C₃), cyclopropenyl (C₃), cyclobutyl (C₄), cyclobutenyl (C₄), cyclopentyl (C₅), cyclopentenyl (C₅), cyclohexyl (C₆), cyclohexenyl (C₆), cyclohexadienyl (C₆), and the like. Exemplary C₃₋₈ carbocyclyl groups include, without limitation, the aforementioned C₃₋₆ carbocyclyl groups as well as cycloheptyl (C₇), cycloheptenyl (C₇), cycloheptadienyl (C₇), cycloheptatrienyl (C₇), cyclooctyl (C₈), cyclooctenyl (C₈), bicyclo[2.2.1]heptanyl (C₇), bicyclo[2.2.2]octanyl (C₈), and the like. Exemplary C₃₋₁₀ carbocyclyl groups include, without limitation, the aforementioned C₃₋₈ carbocyclyl groups as

well as cyclononyl (C₉), cyclononenyl (C₉), cyclodecyl (C₁₀), cyclodecenyl (C₁₀), octahydro-1*H*-indenyl (C₉), decahydronaphthalenyl (C₁₀), spiro[4.5]decanyl (C₁₀), and the like. As the foregoing examples illustrate, in certain embodiments, the carbocyclyl group is either monocyclic (“monocyclic carbocyclyl”) or contain a fused, bridged or spiro ring system such as a bicyclic system (“bicyclic carbocyclyl”) and can be saturated or can be partially unsaturated. “Carbocyclyl” also includes ring systems wherein the carbocyclic ring, as defined above, is fused with one or more aryl or heteroaryl groups wherein the point of attachment is on the carbocyclic ring, and in such instances, the number of carbons continue to designate the number of carbons in the carbocyclic ring system. Unless otherwise specified, each instance of a carbocyclyl group is independently optionally substituted, *i.e.*, unsubstituted (an “unsubstituted carbocyclyl”) or substituted (a “substituted carbocyclyl”) with one or more substituents. In certain embodiments, the carbocyclyl group is unsubstituted C₃₋₁₀ carbocyclyl. In certain embodiments, the carbocyclyl group is substituted C₃₋₁₀ carbocyclyl.

[0054] In some embodiments, “carbocyclyl” is a monocyclic, saturated carbocyclyl group having from 3 to 10 ring carbon atoms (“C₃₋₁₀ cycloalkyl”). In some embodiments, a cycloalkyl group has 3 to 8 ring carbon atoms (“C₃₋₈ cycloalkyl”). In some embodiments, a cycloalkyl group has 3 to 6 ring carbon atoms (“C₃₋₆ cycloalkyl”). In some embodiments, a cycloalkyl group has 5 to 6 ring carbon atoms (“C₅₋₆ cycloalkyl”). In some embodiments, a cycloalkyl group has 5 to 10 ring carbon atoms (“C₅₋₁₀ cycloalkyl”). Examples of C₅₋₆ cycloalkyl groups include cyclopentyl (C₅) and cyclohexyl (C₆). Examples of C₃₋₆ cycloalkyl groups include the aforementioned C₅₋₆ cycloalkyl groups as well as cyclopropyl (C₃) and cyclobutyl (C₄). Examples of C₃₋₈ cycloalkyl groups include the aforementioned C₃₋₆ cycloalkyl groups as well as cycloheptyl (C₇) and cyclooctyl (C₈). Unless otherwise specified, each instance of a cycloalkyl group is independently unsubstituted (an “unsubstituted cycloalkyl”) or substituted (a “substituted cycloalkyl”) with one or more substituents. In certain embodiments, the cycloalkyl group is unsubstituted C₃₋₁₀ cycloalkyl. In certain embodiments, the cycloalkyl group is substituted C₃₋₁₀ cycloalkyl.

[0055] “Heterocyclyl” or “heterocyclic” refers to a radical of a 3- to 10-membered non-aromatic ring system having ring carbon atoms and 1 to 4 ring heteroatoms, wherein each heteroatom is independently selected from nitrogen, oxygen, sulfur, boron, phosphorus, and silicon (“3-10 membered heterocyclyl”). In heterocyclyl groups that contain one or more nitrogen atoms, the point of attachment can be a carbon or nitrogen atom, as valency permits. A heterocyclyl group can either be monocyclic (“monocyclic heterocyclyl”) or a fused,

bridged, or spiro ring system, such as a bicyclic system (“bicyclic heterocyclyl”), and can be saturated or can be partially unsaturated. Heterocyclyl bicyclic ring systems can include one or more heteroatoms in one or both rings. “Heterocyclyl” also includes ring systems wherein the heterocyclic ring, as defined above, is fused with one or more carbocyclyl groups wherein the point of attachment is either on the carbocyclyl or heterocyclic ring, or ring systems wherein the heterocyclic ring, as defined above, is fused with one or more aryl or heteroaryl groups, wherein the point of attachment is on the heterocyclic ring, and in such instances, the number of ring members continue to designate the number of ring members in the heterocyclic ring system. Unless otherwise specified, each instance of heterocyclyl is independently optionally substituted, *i.e.*, unsubstituted (an “unsubstituted heterocyclyl”) or substituted (a “substituted heterocyclyl”) with one or more substituents. In certain embodiments, the heterocyclyl group is unsubstituted 3-10 membered heterocyclyl. In certain embodiments, the heterocyclyl group is substituted 3-10 membered heterocyclyl.

[0056] In some embodiments, a heterocyclyl group is a 5-10 membered, non-aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms, wherein each heteroatom is independently selected from nitrogen, oxygen, sulfur, boron, phosphorus, and silicon (“5-10 membered heterocyclyl”). In some embodiments, a heterocyclyl group is a 5-8 membered non-aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms, wherein each heteroatom is independently selected from nitrogen, oxygen, and sulfur (“5-8 membered heterocyclyl”). In some embodiments, a heterocyclyl group is a 5-6 membered non-aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms, wherein each heteroatom is independently selected from nitrogen, oxygen, and sulfur (“5-6 membered heterocyclyl”). In some embodiments, the 5-6 membered heterocyclyl has 1-3 ring heteroatoms selected from nitrogen, oxygen, and sulfur. In some embodiments, the 5-6 membered heterocyclyl has 1-2 ring heteroatoms selected from nitrogen, oxygen, and sulfur. In some embodiments, the 5-6 membered heterocyclyl has one ring heteroatom selected from nitrogen, oxygen, and sulfur.

[0057] Exemplary 3-membered heterocyclyl groups containing one heteroatom include, without limitation, azirdinyl, oxiranyl, thiiranyl. Exemplary 4-membered heterocyclyl groups containing one heteroatom include, without limitation, azetidiny, oxetanyl and thietanyl. Exemplary 5-membered heterocyclyl groups containing one heteroatom include, without limitation, tetrahydrofuranyl, dihydrofuranyl, tetrahydrothiophenyl, dihydrothiophenyl, pyrrolidinyl, dihydropyrrolyl, and pyrrolyl-2,5-dione. Exemplary 5-membered heterocyclyl groups containing two heteroatoms include, without limitation, dioxolanyl, oxasulfuranyl, disulfuranyl, and oxazolidin-2-one. Exemplary 5-membered heterocyclyl groups containing

three heteroatoms include, without limitation, triazoliny, oxadiazoliny, and thiadiazoliny. Exemplary 6-membered heterocyclyl groups containing one heteroatom include, without limitation, piperidiny, tetrahydropyrany, dihydropyridiny, and thianyl. Exemplary 6-membered heterocyclyl groups containing two heteroatoms include, without limitation, piperaziny, morpholiny, dithianyl, and dioxany. Exemplary 6-membered heterocyclyl groups containing three heteroatoms include, without limitation, triazinany. Exemplary 7-membered heterocyclyl groups containing one heteroatom include, without limitation, azepany, oxepany and thiepany. Exemplary 8-membered heterocyclyl groups containing one heteroatom include, without limitation, azocany, oxecany and thiocany. Exemplary 5-membered heterocyclyl groups fused to a C₆ aryl ring (also referred to herein as a 5,6-bicyclic heterocyclic ring) include, without limitation, indoliny, isoindoliny, dihydrobenzofurany, dihydrobenzothienyl, benzoxazolinonyl, and the like. Exemplary 6-membered heterocyclyl groups fused to an aryl ring (also referred to herein as a 6,6-bicyclic heterocyclic ring) include, without limitation, tetrahydroquinoliny, tetrahydroisoquinoliny, and the like. Exemplary bicyclic heterocyclyl groups include, without limitation, indoliny, isoindoliny, dihydrobenzofurany, dihydrobenzothienyl, tetrahydrobenzothienyl, tetrahydrobenzofurany, tetrahydroindolyl, tetrahydroquinoliny, tetrahydroisoquinoliny, decahydroquinoliny, decahydroisoquinoliny, octahydrochromenyl, octahydroisochromenyl, decahydronaphthyridiny, decahydro-1,8-naphthyridiny, octahydropyrrolo[3,2-b]pyrrole, indoliny, phthalimidyl, naphthalimidyl, chromany, chromenyl, 1H-benzo[e][1,4]diazepiny, 1,4,5,7-tetrahydropyrano[3,4-b]pyrroly, 5,6-dihydro-4H-furo[3,2-b]pyrroly, 6,7-dihydro-5H-furo[3,2-b]pyrany, 5,7-dihydro-4H-thieno[2,3-c]pyrany, 2,3-dihydro-1H-pyrrolo[2,3-b]pyridiny, 2,3-dihydrofuro[2,3-b]pyridiny, 4,5,6,7-tetrahydro-1H-pyrrolo[2,3-b]pyridiny, 4,5,6,7-tetrahydrofuro[3,2-c]pyridiny, 4,5,6,7-tetrahydrothieno[3,2-b]pyridiny, 1,2,3,4-tetrahydro-1,6-naphthyridiny, and the like.

[0058] “Aryl” refers to a radical of a monocyclic or polycyclic (*e.g.*, bicyclic or tricyclic) 4n+2 aromatic ring system (*e.g.*, having 6, 10, or 14 pi electrons shared in a cyclic array) having 6-14 ring carbon atoms and zero heteroatoms provided in the aromatic ring system (“C₆₋₁₄ aryl”). In some embodiments, an aryl group has six ring carbon atoms (“C₆ aryl”; *e.g.*, phenyl). In some embodiments, an aryl group has ten ring carbon atoms (“C₁₀ aryl”; *e.g.*, naphthyl such as 1-naphthyl and 2-naphthyl). In some embodiments, an aryl group has fourteen ring carbon atoms (“C₁₄ aryl”; *e.g.*, anthracyl). “Aryl” also includes ring systems wherein the aryl ring, as defined above, is fused with one or more carbocyclyl or heterocyclyl groups, wherein the radical or point of attachment is on the aryl ring, and in such instances,

the number of carbon atoms continue to designate the number of carbon atoms in the aryl ring system. Unless otherwise specified, each instance of an aryl group is independently optionally substituted, *i.e.*, unsubstituted (an “unsubstituted aryl”) or substituted (a “substituted aryl”) with one or more substituents. In certain embodiments, the aryl group is unsubstituted C₆₋₁₄ aryl. In certain embodiments, the aryl group is substituted C₆₋₁₄ aryl.

[0059] “Aralkyl” refers to an optionally substituted alkyl group substituted by an optionally substituted aryl group. “Aralkyl” is a subset of “alkyl” and refers to an alkyl group substituted with an aryl group, wherein the point of attachment is on the alkyl group. In certain embodiments, the aralkyl is optionally substituted benzyl. In certain embodiments, the aralkyl is benzyl. In certain embodiments, the aralkyl is optionally substituted phenethyl. In certain embodiments, the aralkyl is phenethyl.

[0060] “Heteroaryl” refers to a radical of a 5-10 membered, monocyclic or bicyclic 4n+2 aromatic ring system (*e.g.*, having 6 or 10 pi electrons shared in a cyclic array) having ring carbon atoms and 1-4 ring heteroatoms provided in the aromatic ring system, wherein each heteroatom is independently selected from nitrogen, oxygen and sulfur (“5-10 membered heteroaryl”). In heteroaryl groups that contain one or more nitrogen atoms, the point of attachment can be a carbon or nitrogen atom, as valency permits. Heteroaryl bicyclic ring systems can include one or more heteroatoms in one or both rings. “Heteroaryl” includes ring systems wherein the heteroaryl ring, as defined above, is fused with one or more carbocyclyl or heterocyclyl groups wherein the point of attachment is on the heteroaryl ring, and in such instances, the number of ring members continue to designate the number of ring members in the heteroaryl ring system. “Heteroaryl” also includes ring systems wherein the heteroaryl ring, as defined above, is fused with one or more aryl groups wherein the point of attachment is either on the aryl or heteroaryl ring, and in such instances, the number of ring members designates the number of ring members in the fused (aryl/heteroaryl) ring system. Bicyclic heteroaryl groups wherein one ring does not contain a heteroatom (*e.g.*, indolyl, quinolinyl, carbazolyl, and the like) the point of attachment can be on either ring, *i.e.*, either the ring bearing a heteroatom (*e.g.*, 2-indolyl) or the ring that does not contain a heteroatom (*e.g.*, 5-indolyl).

[0061] In some embodiments, a heteroaryl group is a 5-10 membered aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms provided in the aromatic ring system, wherein each heteroatom is independently selected from nitrogen, oxygen, and sulfur (“5-10 membered heteroaryl”). In some embodiments, a heteroaryl group is a 5-8 membered aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms provided in the

aromatic ring system, wherein each heteroatom is independently selected from nitrogen, oxygen, and sulfur ("5-8 membered heteroaryl"). In some embodiments, a heteroaryl group is a 5-6 membered aromatic ring system having ring carbon atoms and 1-4 ring heteroatoms provided in the aromatic ring system, wherein each heteroatom is independently selected from nitrogen, oxygen, and sulfur ("5-6 membered heteroaryl"). In some embodiments, the 5-6 membered heteroaryl has 1-3 ring heteroatoms selected from nitrogen, oxygen, and sulfur. In some embodiments, the 5-6 membered heteroaryl has 1-2 ring heteroatoms selected from nitrogen, oxygen, and sulfur. In some embodiments, the 5-6 membered heteroaryl has 1 ring heteroatom selected from nitrogen, oxygen, and sulfur. Unless otherwise specified, each instance of a heteroaryl group is independently optionally substituted, *i.e.*, unsubstituted (an "unsubstituted heteroaryl") or substituted (a "substituted heteroaryl") with one or more substituents. In certain embodiments, the heteroaryl group is unsubstituted 5-14 membered heteroaryl. In certain embodiments, the heteroaryl group is substituted 5-14 membered heteroaryl.

[0062] Exemplary 5-membered heteroaryl groups containing one heteroatom include, without limitation, pyrrolyl, furanyl, and thiophenyl. Exemplary 5-membered heteroaryl groups containing two heteroatoms include, without limitation, imidazolyl, pyrazolyl, oxazolyl, isoxazolyl, thiazolyl, and isothiazolyl. Exemplary 5-membered heteroaryl groups containing three heteroatoms include, without limitation, triazolyl, oxadiazolyl, and thiadiazolyl. Exemplary 5-membered heteroaryl groups containing four heteroatoms include, without limitation, tetrazolyl. Exemplary 6-membered heteroaryl groups containing one heteroatom include, without limitation, pyridinyl. Exemplary 6-membered heteroaryl groups containing two heteroatoms include, without limitation, pyridazinyl, pyrimidinyl, and pyrazinyl. Exemplary 6-membered heteroaryl groups containing three or four heteroatoms include, without limitation, triazinyl and tetrazinyl, respectively. Exemplary 7-membered heteroaryl groups containing one heteroatom include, without limitation, azepinyl, oxepinyl, and thiepinyl. Exemplary 5,6-bicyclic heteroaryl groups include, without limitation, indolyl, isoindolyl, indazolyl, benzotriazolyl, benzothiophenyl, isobenzothiophenyl, benzofuranyl, benzoisofuranyl, benzimidazolyl, benzoxazolyl, benzisoxazolyl, benzoxadiazolyl, benzthiazolyl, benzisothiazolyl, benzthiadiazolyl, indolizinyl, and purinyl. Exemplary 6,6-bicyclic heteroaryl groups include, without limitation, naphthyridinyl, pteridinyl, quinolinyl, isoquinolinyl, cinnolinyl, quinoxalinyl, phthalazinyl, and quinazolinyl. Exemplary tricyclic heteroaryl groups include, without limitation, phenanthridinyl, dibenzofuranyl, carbazolyl, acridinyl, phenothiazinyl, phenoxazinyl, and phenazinyl.

[0063] “Heteroaralkyl” is a subset of alkyl and heteroaryl and refers to an optionally substituted alkyl group substituted by an optionally substituted heteroaryl group.

[0064] “Unsaturated” or “partially unsaturated” refers to a group that includes at least one double or triple bond. A “partially unsaturated” ring system is further intended to encompass rings having multiple sites of unsaturation, but is not intended to include aromatic groups (*e.g.*, aryl or heteroaryl groups). Likewise, “saturated” refers to a group that does not contain a double or triple bond, *i.e.*, contains all single bonds.

[0065] The term “unsaturated bond” refers to a double or triple bond.

[0066] The term “unsaturated” or “partially unsaturated” refers to a moiety that includes at least one double or triple bond.

[0067] The term “saturated” refers to a moiety that does not contain a double or triple bond, *i.e.*, the moiety only contains single bonds.

[0068] Alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl groups, which are divalent linking groups, are further referred to using the suffix -ene, *e.g.*, alkylene, alkenylene, alkynylene, carbocyclylene, heterocyclylene, arylene, and heteroarylene. Thus, alkylene is the divalent moiety of alkyl, alkenylene is the divalent moiety of alkenyl, alkynylene is the divalent moiety of alkynyl, heteroalkylene is the divalent moiety of heteroalkyl, heteroalkenylene is the divalent moiety of heteroalkenyl, heteroalkynylene is the divalent moiety of heteroalkynyl, carbocyclylene is the divalent moiety of carbocyclyl, heterocyclylene is the divalent moiety of heterocyclyl, arylene is the divalent moiety of aryl, and heteroarylene is the divalent moiety of heteroaryl.

[0069] An atom, moiety, or group described herein may be unsubstituted or substituted, as valency permits, unless otherwise provided expressly. The term “optionally substituted” refers to substituted or unsubstituted.

[0070] A group is optionally substituted unless expressly provided otherwise. The term “optionally substituted” refers to being substituted or unsubstituted. In certain embodiments, alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl groups are optionally substituted (*e.g.*, “substituted” or “unsubstituted” alkyl, “substituted” or “unsubstituted” alkenyl, “substituted” or “unsubstituted” alkynyl, “substituted” or “unsubstituted” carbocyclyl, “substituted” or “unsubstituted” heterocyclyl, “substituted” or “unsubstituted” aryl or “substituted” or “unsubstituted” heteroaryl group). In general, the term “substituted”, whether preceded by the term “optionally” or not, means that at least one hydrogen present on a group (*e.g.*, a carbon or nitrogen atom) is replaced with a permissible substituent, *e.g.*, a substituent which upon substitution results in a stable compound, *e.g.*, a compound which

does not spontaneously undergo transformation such as by rearrangement, cyclization, elimination, or other reaction. Unless otherwise indicated, a “substituted” group has a substituent at one or more substitutable positions of the group, and when more than one position in any given structure is substituted, the substituent is either the same or different at each position. The term “substituted” is contemplated to include substitution with all permissible substituents of organic compounds, any of the substituents described herein that results in the formation of a stable compound. The present disclosure contemplates any and all such combinations in order to arrive at a stable compound. For purposes of this disclosure, heteroatoms such as nitrogen may have hydrogen substituents and/or any suitable substituent as described herein which satisfy the valencies of the heteroatoms and results in the formation of a stable moiety. In certain embodiments, the substituent is a carbon atom substituent. In certain embodiments, the substituent is a nitrogen atom substituent. In certain embodiments, the substituent is an oxygen atom substituent. In certain embodiments, the substituent is a sulfur atom substituent.

[0071] Exemplary carbon atom substituents include, but are not limited to, halogen, -CN, -NO₂, -N₃, -SO₂H, -SO₃H, -OH, -OR^{aa}, -ON(R^{bb})₂, -N(R^{bb})₂, -N(R^{bb})₃⁺X⁻, -N(OR^{cc})R^{bb}, -SH, -SR^{aa}, -SSR^{cc}, -C(=O)R^{aa}, -CO₂H, -CHO, -C(OR^{cc})₂, -CO₂R^{aa}, -OC(=O)R^{aa}, -OCO₂R^{aa}, -C(=O)N(R^{bb})₂, -OC(=O)N(R^{bb})₂, -NR^{bb}C(=O)R^{aa}, -NR^{bb}CO₂R^{aa}, -NR^{bb}C(=O)N(R^{bb})₂, -C(=NR^{bb})R^{aa}, -C(=NR^{bb})OR^{aa}, -OC(=NR^{bb})R^{aa}, -OC(=NR^{bb})OR^{aa}, -C(=NR^{bb})N(R^{bb})₂, -OC(=NR^{bb})N(R^{bb})₂, -NR^{bb}C(=NR^{bb})N(R^{bb})₂, -C(=O)NR^{bb}SO₂R^{aa}, -NR^{bb}SO₂R^{aa}, -SO₂N(R^{bb})₂, -SO₂R^{aa}, -SO₂OR^{aa}, -OSO₂R^{aa}, -S(=O)R^{aa}, -OS(=O)R^{aa}, -Si(R^{aa})₃, -OSi(R^{aa})₃, -C(=S)N(R^{bb})₂, -C(=O)SR^{aa}, -C(=S)SR^{aa}, -SC(=S)SR^{aa}, -SC(=O)SR^{aa}, -OC(=O)SR^{aa}, -SC(=O)OR^{aa}, -SC(=O)R^{aa}, -P(=O)(R^{aa})₂, -P(=O)(OR^{cc})₂, -OP(=O)(R^{aa})₂, -OP(=O)(OR^{cc})₂, -P(=O)(N(R^{bb})₂)₂, -OP(=O)(N(R^{bb})₂)₂, -NR^{bb}P(=O)(R^{aa})₂, -NR^{bb}P(=O)(OR^{cc})₂, -NR^{bb}P(=O)(N(R^{bb})₂)₂, -P(R^{cc})₂, -P(OR^{cc})₂, -P(R^{cc})₃⁺X⁻, -P(OR^{cc})₃⁺X⁻, -P(R^{cc})₄, -P(OR^{cc})₄, -OP(R^{cc})₂, -OP(R^{cc})₃⁺X⁻, -OP(OR^{cc})₂, -OP(OR^{cc})₃⁺X⁻, -OP(R^{cc})₄, -OP(OR^{cc})₄, -B(R^{aa})₂, -B(OR^{cc})₂, -BR^{aa}(OR^{cc}), C₁₋₁₀ alkyl, C₁₋₁₀ perhaloalkyl, C₂₋₁₀ alkenyl, C₂₋₁₀ alkynyl, heteroC₁₋₁₀ alkyl, heteroC₂₋₁₀ alkenyl, heteroC₂₋₁₀ alkynyl, C₃₋₁₀ carbocyclyl, 3-14 membered heterocyclyl, C₆₋₁₄ aryl, and 5-14 membered heteroaryl, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups; or two geminal hydrogens on a carbon atom are replaced with the group =O, =S, =NN(R^{bb})₂, =NNR^{bb}C(=O)R^{aa}, =NNR^{bb}C(=O)OR^{aa}, =NNR^{bb}S(=O)₂R^{aa}, =NR^{bb}, or =NOR^{cc}; wherein X⁻ is a counterion;

each instance of R^{aa} is, independently, selected from C_{1-10} alkyl, C_{1-10} perhaloalkyl, C_{2-10} alkenyl, C_{2-10} alkynyl, C_{3-10} carbocyclyl, 3-14 membered heterocyclyl, C_{6-14} aryl, and 5-14 membered heteroaryl, or two R^{aa} groups are joined to form a 3-14 membered heterocyclyl or 5-14 membered heteroaryl ring, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups;

each instance of R^{bb} is, independently, selected from hydrogen, $-OH$, $-OR^{aa}$, $-N(R^{cc})_2$, $-CN$, $-C(=O)R^{aa}$, $-C(=O)N(R^{cc})_2$, $-CO_2R^{aa}$, $-SO_2R^{aa}$, $-C(=NR^{cc})OR^{aa}$, $-C(=NR^{cc})N(R^{cc})_2$, $-SO_2N(R^{cc})_2$, $-SO_2R^{cc}$, $-SO_2OR^{cc}$, $-SOR^{aa}$, $-C(=S)N(R^{cc})_2$, $-C(=O)SR^{cc}$, $-C(=S)SR^{cc}$, $-P(=O)(R^{aa})_2$, $-P(=O)(OR^{cc})_2$, $-P(=O)(N(R^{cc})_2)_2$, C_{1-10} alkyl, C_{1-10} perhaloalkyl, C_{2-10} alkenyl, C_{2-10} alkynyl, hetero C_{1-10} alkyl, hetero C_{2-10} alkenyl, hetero C_{2-10} alkynyl, C_{3-10} carbocyclyl, 3-14 membered heterocyclyl, C_{6-14} aryl, and 5-14 membered heteroaryl, or two R^{bb} groups are joined to form a 3-14 membered heterocyclyl or 5-14 membered heteroaryl ring, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups; wherein X^- is a counterion;

each instance of R^{cc} is, independently, selected from hydrogen, C_{1-10} alkyl, C_{1-10} perhaloalkyl, C_{2-10} alkenyl, C_{2-10} alkynyl, C_{3-10} carbocyclyl, 3-14 membered heterocyclyl, C_{6-14} aryl, and 5-14 membered heteroaryl, or two R^{cc} groups are joined to form a 3-14 membered heterocyclyl or 5-14 membered heteroaryl ring, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups;

each instance of R^{dd} is, independently, selected from halogen, $-CN$, $-NO_2$, $-N_3$, $-SO_2H$, $-SO_3H$, $-OH$, $-OR^{ee}$, $-ON(R^{ff})_2$, $-N(R^{ff})_2$, $-N(R^{ff})_3^+X^-$, $-N(OR^{ee})R^{ff}$, $-SH$, $-SR^{ee}$, $-SSR^{ee}$, $-C(=O)R^{ee}$, $-CO_2H$, $-CO_2R^{ee}$, $-OC(=O)R^{ee}$, $-OCO_2R^{ee}$, $-C(=O)N(R^{ff})_2$, $-OC(=O)N(R^{ff})_2$, $-NR^{ff}C(=O)R^{ee}$, $-NR^{ff}CO_2R^{ee}$, $-NR^{ff}C(=O)N(R^{ff})_2$, $-C(=NR^{ff})OR^{ee}$, $-OC(=NR^{ff})R^{ee}$, $-OC(=NR^{ff})OR^{ee}$, $-C(=NR^{ff})N(R^{ff})_2$, $-OC(=NR^{ff})N(R^{ff})_2$, $-NR^{ff}C(=NR^{ff})N(R^{ff})_2$, $-NR^{ff}SO_2R^{ee}$, $-SO_2N(R^{ff})_2$, $-SO_2R^{ee}$, $-SO_2OR^{ee}$, $-OSO_2R^{ee}$, $-S(=O)R^{ee}$, $-Si(R^{ee})_3$, $-OSi(R^{ee})_3$, $-C(=S)N(R^{ff})_2$, $-C(=O)SR^{ee}$, $-C(=S)SR^{ee}$, $-SC(=S)SR^{ee}$, $-P(=O)(OR^{ee})_2$, $-P(=O)(R^{ee})_2$, $-OP(=O)(R^{ee})_2$, $-OP(=O)(OR^{ee})_2$, C_{1-6} alkyl, C_{1-6} perhaloalkyl, C_{2-6} alkenyl, C_{2-6} alkynyl, C_{3-10} carbocyclyl, 3-10 membered heterocyclyl, C_{6-10} aryl, 5-10 membered heteroaryl, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{eg} groups, or two geminal R^{dd} substituents can be joined to form $=O$ or $=S$; wherein X^- is a counterion;

each instance of R^{ec} is, independently, selected from C_{1-6} alkyl, C_{1-6} perhaloalkyl, C_{2-6} alkenyl, C_{2-6} alkynyl, C_{3-10} carbocyclyl, C_{6-10} aryl, 3-10 membered heterocyclyl, and 3-10 membered heteroaryl, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{eg} groups;

each instance of R^{ff} is, independently, selected from hydrogen, C_{1-6} alkyl, C_{1-6} perhaloalkyl, C_{2-6} alkenyl, C_{2-6} alkynyl, C_{3-10} carbocyclyl, 3-10 membered heterocyclyl, C_{6-10} aryl and 5-10 membered heteroaryl, or two R^{ff} groups are joined to form a 3-14 membered heterocyclyl or 5-14 membered heteroaryl ring, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{eg} groups; and

each instance of R^{gg} is, independently, halogen, -CN, -NO₂, -N₃, -SO₂H, -SO₃H, -OH, -OC₁₋₆ alkyl, -ON(C₁₋₆ alkyl)₂, -N(C₁₋₆ alkyl)₂, -N(C₁₋₆ alkyl)₃⁺X⁻, -NH(C₁₋₆ alkyl)₂⁺X⁻, -NH₂(C₁₋₆ alkyl)⁺X⁻, -NH₃⁺X⁻, -N(OC₁₋₆ alkyl)(C₁₋₆ alkyl), -N(OH)(C₁₋₆ alkyl), -NH(OH), -SH, -SC₁₋₆ alkyl, -SS(C₁₋₆ alkyl), -C(=O)(C₁₋₆ alkyl), -CO₂H, -CO₂(C₁₋₆ alkyl), -OC(=O)(C₁₋₆ alkyl), -OCO₂(C₁₋₆ alkyl), -C(=O)NH₂, -C(=O)N(C₁₋₆ alkyl)₂, -OC(=O)NH(C₁₋₆ alkyl), -NHC(=O)(C₁₋₆ alkyl), -N(C₁₋₆ alkyl)C(=O)(C₁₋₆ alkyl), -NHCO₂(C₁₋₆ alkyl), -NHC(=O)N(C₁₋₆ alkyl)₂, -NHC(=O)NH(C₁₋₆ alkyl), -NHC(=O)NH₂, -C(=NH)O(C₁₋₆ alkyl), -OC(=NH)(C₁₋₆ alkyl), -OC(=NH)OC₁₋₆ alkyl, -C(=NH)N(C₁₋₆ alkyl)₂, -C(=NH)NH(C₁₋₆ alkyl), -C(=NH)NH₂, -OC(=NH)N(C₁₋₆ alkyl)₂, -OC(NH)NH(C₁₋₆ alkyl), -OC(NH)NH₂, -NHC(NH)N(C₁₋₆ alkyl)₂, -NHC(=NH)NH₂, -NHCO₂(C₁₋₆ alkyl), -SO₂N(C₁₋₆ alkyl)₂, -SO₂NH(C₁₋₆ alkyl), -SO₂NH₂, -SO₂C₁₋₆ alkyl, -SO₂OC₁₋₆ alkyl, -OSO₂C₁₋₆ alkyl, -SOC₁₋₆ alkyl, -Si(C₁₋₆ alkyl)₃, -OSi(C₁₋₆ alkyl)₃, -C(=S)N(C₁₋₆ alkyl)₂, C(=S)NH(C₁₋₆ alkyl), C(=S)NH₂, -C(=O)S(C₁₋₆ alkyl), -C(=S)SC₁₋₆ alkyl, -SC(=S)SC₁₋₆ alkyl, -P(=O)(OC₁₋₆ alkyl)₂, -P(=O)(C₁₋₆ alkyl)₂, -OP(=O)(C₁₋₆ alkyl)₂, -OP(=O)(OC₁₋₆ alkyl)₂, C_{1-6} alkyl, C_{1-6} perhaloalkyl, C_{2-6} alkenyl, C_{2-6} alkynyl, C_{3-10} carbocyclyl, C_{6-10} aryl, 3-10 membered heterocyclyl, 5-10 membered heteroaryl; or two geminal R^{gg} substituents can be joined to form =O or =S; wherein X⁻ is a counterion.

[0072] A “counterion” or “anionic counterion” is a negatively charged group associated with a cationic quaternary amino group in order to maintain electronic neutrality. Exemplary counterions include halide ions (*e.g.*, F⁻, Cl⁻, Br⁻, I⁻), NO₃⁻, ClO₄⁻, OH⁻, H₂PO₄⁻, HSO₄⁻, sulfonate ions (*e.g.*, methanesulfonate, trifluoromethanesulfonate, *p*-toluenesulfonate, benzenesulfonate, 10-camphor sulfonate, naphthalene-2-sulfonate, naphthalene-1-sulfonic acid-5-sulfonate, ethan-1-sulfonic acid-2-sulfonate, and the like), carboxylate ions (*e.g.*, acetate, ethanoate, propanoate, benzoate, glycerate, lactate, tartrate, glycolate, and the like).

Exemplary counterions further include BF_4^- , PF_4^- , PF_6^- , AsF_6^- , SbF_6^- , $\text{B}[3,5-(\text{CF}_3)_2\text{C}_6\text{H}_3]_4^-$, $\text{B}(\text{C}_6\text{F}_5)_4^-$, BPh_4^- , $\text{Al}(\text{OC}(\text{CF}_3)_3)_4^-$, and carborane anions (*e.g.*, $\text{CB}_{11}\text{H}_{12}^-$ or $(\text{HCB}_{11}\text{Me}_5\text{Br}_6)^-$). Exemplary counterions which may be multivalent include CO_3^{2-} , HPO_4^{2-} , PO_4^{3-} , $\text{B}_4\text{O}_7^{2-}$, SO_4^{2-} , $\text{S}_2\text{O}_3^{2-}$, carboxylate anions (*e.g.*, tartrate, citrate, fumarate, maleate, malate, malonate, gluconate, succinate, glutarate, adipate, pimelate, suberate, azelate, sebacate, salicylate, phthalates, aspartate, glutamate, and the like), and carboranes.

[0073] “Halo” or “halogen” refers to fluorine (fluoro, -F), chlorine (chloro, -Cl), bromine (bromo, -Br), or iodine (iodo, -I).

[0074] The term “hydroxyl” or “hydroxy” refers to the group -OH. The term “substituted hydroxyl” or “substituted hydroxyl,” by extension, refers to a hydroxyl group wherein the oxygen atom directly attached to the parent molecule is substituted with a group other than hydrogen, and includes groups selected from $-\text{OR}^{\text{aa}}$, $-\text{ON}(\text{R}^{\text{bb}})_2$, $-\text{OC}(=\text{O})\text{SR}^{\text{aa}}$, $-\text{OC}(=\text{O})\text{R}^{\text{aa}}$, $-\text{OCO}_2\text{R}^{\text{aa}}$, $-\text{OC}(=\text{O})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{R}^{\text{aa}}$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{OR}^{\text{aa}}$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{OS}(=\text{O})\text{R}^{\text{aa}}$, $-\text{OSO}_2\text{R}^{\text{aa}}$, $-\text{OSi}(\text{R}^{\text{aa}})_3$, $-\text{OP}(\text{R}^{\text{cc}})_2$, $-\text{OP}(\text{R}^{\text{cc}})_3^+\text{X}^-$, $-\text{OP}(\text{OR}^{\text{cc}})_2$, $-\text{OP}(\text{OR}^{\text{cc}})_3^+\text{X}^-$, $-\text{OP}(=\text{O})(\text{R}^{\text{aa}})_2$, $-\text{OP}(=\text{O})(\text{OR}^{\text{cc}})_2$, and $-\text{OP}(=\text{O})\text{N}(\text{R}^{\text{bb}})_2$, wherein X^- , R^{aa} , R^{bb} , and R^{cc} are as defined herein.

[0075] The term “amino” refers to the group $-\text{NH}_2$. The term “substituted amino,” by extension, refers to a monosubstituted amino, disubstituted amino, or trisubstituted amino. In certain embodiments, the “substituted amino” is a monosubstituted amino or disubstituted amino group.

[0076] The term “sulfonyl” refers to a group selected from $-\text{SO}_2\text{N}(\text{R}^{\text{bb}})_2$, $-\text{SO}_2\text{R}^{\text{aa}}$, and $-\text{SO}_2\text{OR}^{\text{aa}}$, wherein R^{aa} and R^{bb} are as defined herein.

[0077] The term “sulfinyl” refers to the group $-\text{S}(=\text{O})\text{R}^{\text{aa}}$, wherein R^{aa} is as defined herein.

[0078] “Acyl” refers to a moiety selected from the group consisting of $-\text{C}(=\text{O})\text{R}^{\text{aa}}$, $-\text{CHO}$, $-\text{CO}_2\text{R}^{\text{aa}}$, $-\text{C}(=\text{O})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{C}(=\text{NR}^{\text{bb}})\text{R}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{bb}})\text{OR}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{bb}})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{C}(=\text{O})\text{NR}^{\text{bb}}\text{SO}_2\text{R}^{\text{aa}}$, $-\text{C}(=\text{S})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{C}(=\text{O})\text{SR}^{\text{aa}}$, or $-\text{C}(=\text{S})\text{SR}^{\text{aa}}$, wherein R^{aa} and R^{bb} are as defined herein. In other instances, “acyl” refers to a group having the general formula: $-\text{C}(=\text{O})\text{R}^{\text{X1}}$, $-\text{C}(=\text{O})\text{OR}^{\text{X1}}$, $-\text{C}(=\text{O})-\text{O}-\text{C}(=\text{O})\text{R}^{\text{X1}}$, $-\text{C}(=\text{O})\text{SR}^{\text{X1}}$, $-\text{C}(=\text{O})\text{N}(\text{R}^{\text{X1}})_2$, $-\text{C}(=\text{S})\text{R}^{\text{X1}}$, $-\text{C}(=\text{S})\text{N}(\text{R}^{\text{X1}})_2$, $-\text{C}(=\text{S})\text{S}(\text{R}^{\text{X1}})$, $-\text{C}(=\text{NR}^{\text{X1}})\text{R}^{\text{X1}}$, $-\text{C}(=\text{NR}^{\text{X1}})\text{OR}^{\text{X1}}$, $-\text{C}(=\text{NR}^{\text{X1}})\text{SR}^{\text{X1}}$, or $-\text{C}(=\text{NR}^{\text{X1}})\text{N}(\text{R}^{\text{X1}})_2$, wherein R^{X1} is hydrogen; halogen; substituted or unsubstituted hydroxyl; substituted or unsubstituted thiol; substituted or unsubstituted amino; substituted or unsubstituted acyl, cyclic or acyclic, substituted or unsubstituted, branched or unbranched aliphatic; cyclic or acyclic, substituted or unsubstituted, branched or unbranched heteroaliphatic; cyclic or acyclic, substituted or unsubstituted, branched or unbranched alkyl;

cyclic or acyclic, substituted or unsubstituted, branched or unbranched alkenyl; substituted or unsubstituted alkynyl; substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, aliphaticoxy, heteroaliphaticoxy, alkyloxy, heteroalkyloxy, aryloxy, heteroaryloxy, aliphaticthioxy, heteroaliphaticthioxy, alkylthioxy, heteroalkylthioxy, arylthioxy, heteroarylthioxy, mono- or di- aliphaticamino, mono- or di- heteroaliphaticamino, mono- or di- alkylamino, mono- or di- heteroalkylamino, mono- or di- arylamino, or mono- or di- heteroarylamino; or two R^{X1} groups taken together form a 5- to 6-membered heterocyclic ring. Exemplary acyl groups include aldehydes ($-\text{CHO}$), carboxylic acids ($-\text{CO}_2\text{H}$), ketones, acyl halides, esters, amides, imines, carbonates, carbamates, and ureas. Acyl substituents include, but are not limited to, any of the substituents described herein, that result in the formation of a stable moiety (*e.g.*, aliphatic, alkyl, alkenyl, alkynyl, heteroaliphatic, heterocyclic, aryl, heteroaryl, acyl, oxo, imino, thiooxo, cyano, isocyano, amino, azido, nitro, hydroxyl, thiol, halo, aliphaticamino, heteroaliphaticamino, alkylamino, heteroalkylamino, arylamino, heteroarylamino, alkylaryl, arylalkyl, aliphaticoxy, heteroaliphaticoxy, alkyloxy, heteroalkyloxy, aryloxy, heteroaryloxy, aliphaticthioxy, heteroaliphaticthioxy, alkylthioxy, heteroalkylthioxy, arylthioxy, heteroarylthioxy, acyloxy, and the like, each of which may or may not be further substituted).

[0079] The term “carbonyl” refers a group wherein the carbon directly attached to the parent molecule is sp^2 hybridized, and is substituted with an oxygen, nitrogen, or sulfur atom, *e.g.*, a group selected from ketones ($-\text{C}(=\text{O})\text{R}^{\text{aa}}$), carboxylic acids ($-\text{CO}_2\text{H}$), aldehydes ($-\text{CHO}$), esters ($-\text{CO}_2\text{R}^{\text{aa}}$, $-\text{C}(=\text{O})\text{SR}^{\text{aa}}$, $-\text{C}(=\text{S})\text{SR}^{\text{aa}}$), amides ($-\text{C}(=\text{O})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{C}(=\text{O})\text{NR}^{\text{bb}}\text{SO}_2\text{R}^{\text{aa}}$, $-\text{C}(=\text{S})\text{N}(\text{R}^{\text{bb}})_2$), and imines ($-\text{C}(=\text{NR}^{\text{bb}})\text{R}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{bb}})\text{OR}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{bb}})\text{N}(\text{R}^{\text{bb}})_2$), wherein R^{aa} and R^{bb} are as defined herein.

[0080] The term “silyl” refers to the group $-\text{Si}(\text{R}^{\text{aa}})_3$, wherein R^{aa} is as defined herein.

[0081] The term “oxo” refers to the group $=\text{O}$, and the term “thiooxo” refers to the group $=\text{S}$.

[0082] Nitrogen atoms can be substituted or unsubstituted as valency permits, and include primary, secondary, tertiary, and quaternary nitrogen atoms. Exemplary nitrogen atom substituents include, but are not limited to, hydrogen, $-\text{OH}$, $-\text{OR}^{\text{aa}}$, $-\text{N}(\text{R}^{\text{cc}})_2$, $-\text{CN}$, $-\text{C}(=\text{O})\text{R}^{\text{aa}}$, $-\text{C}(=\text{O})\text{N}(\text{R}^{\text{cc}})_2$, $-\text{CO}_2\text{R}^{\text{aa}}$, $-\text{SO}_2\text{R}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{bb}})\text{R}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{cc}})\text{OR}^{\text{aa}}$, $-\text{C}(=\text{NR}^{\text{cc}})\text{N}(\text{R}^{\text{cc}})_2$, $-\text{SO}_2\text{N}(\text{R}^{\text{cc}})_2$, $-\text{SO}_2\text{R}^{\text{cc}}$, $-\text{SO}_2\text{OR}^{\text{cc}}$, $-\text{SOR}^{\text{aa}}$, $-\text{C}(=\text{S})\text{N}(\text{R}^{\text{cc}})_2$, $-\text{C}(=\text{O})\text{SR}^{\text{cc}}$, $-\text{C}(=\text{S})\text{SR}^{\text{cc}}$, $-\text{P}(=\text{O})(\text{OR}^{\text{cc}})_2$, $-\text{P}(=\text{O})(\text{R}^{\text{aa}})_2$, $-\text{P}(=\text{O})(\text{N}(\text{R}^{\text{cc}})_2)_2$, C_{1-10} alkyl, C_{1-10} perhaloalkyl, C_{2-10} alkenyl, C_{2-10} alkynyl, C_{3-10} carbocyclyl, 3-14 membered heterocyclyl, C_{6-14} aryl, and 5-14 membered heteroaryl, or two R^{cc} groups attached to a nitrogen atom are joined to form a 3-14 membered

heterocyclyl or 5-14 membered heteroaryl ring, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups, and wherein R^{aa} , R^{bb} , R^{cc} , and R^{dd} are as defined above.

[0083] In certain embodiments, the substituent present on a nitrogen atom is a nitrogen protecting group (also referred to as an amino protecting group). Nitrogen protecting groups include, but are not limited to, -OH, -OR^{aa}, -N(R^{cc})₂, -C(=O)R^{aa}, -C(=O)N(R^{cc})₂, -CO₂R^{aa}, -SO₂R^{aa}, -C(=NR^{cc})R^{aa}, -C(=NR^{cc})OR^{aa}, -C(=NR^{cc})N(R^{cc})₂, -SO₂N(R^{cc})₂, -SO₂R^{cc}, -SO₂OR^{cc}, -SOR^{aa}, -C(=S)N(R^{cc})₂, -C(=O)SR^{cc}, -C(=S)SR^{cc}, C₁₋₁₀ alkyl (e.g., aralkyl, heteroaralkyl), C₂₋₁₀ alkenyl, C₂₋₁₀ alkynyl, C₃₋₁₀ carbocyclyl, 3-14 membered heterocyclyl, C₆₋₁₄ aryl, and 5-14 membered heteroaryl groups, wherein each alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, aralkyl, aryl, and heteroaryl is independently substituted with 0, 1, 2, 3, 4, or 5 R^{dd} groups, and wherein R^{aa} , R^{bb} , R^{cc} and R^{dd} are as defined herein. Nitrogen protecting groups are well known in the art and include those described in detail in *Protecting Groups in Organic Synthesis*, T. W. Greene and P. G. M. Wuts, 3rd edition, John Wiley & Sons, 1999, incorporated herein by reference.

[0084] For example, nitrogen protecting groups such as amide groups (e.g., -C(=O)R^{aa}) include, but are not limited to, formamide, acetamide, chloroacetamide, trichloroacetamide, trifluoroacetamide, phenylacetamide, 3-phenylpropanamide, picolinamide, 3-pyridylcarboxamide, *N*-benzoylphenylalanyl derivative, benzamide, *p*-phenylbenzamide, *o*-nitrophenylacetamide, *o*-nitrophenoxycetamide, acetoacetamide, (*N*'-dithiobenzoyloxyacylamino)acetamide, 3-(*p*-hydroxyphenyl)propanamide, 3-(*o*-nitrophenyl)propanamide, 2-methyl-2-(*o*-nitrophenoxy)propanamide, 2-methyl-2-(*o*-phenylazophenoxy)propanamide, 4-chlorobutanamide, 3-methyl-3-nitrobutanamide, *o*-nitrocinnamide, *N*-acetylmethionine derivative, *o*-nitrobenzamide, and *o*-(benzoyloxymethyl)benzamide.

[0085] Nitrogen protecting groups such as carbamate groups (e.g., -C(=O)OR^{aa}) include, but are not limited to, methyl carbamate, ethyl carbamate, 9-fluorenylmethyl carbamate (Fmoc), 9-(2-sulfo)fluorenylmethyl carbamate, 9-(2,7-dibromo)fluorenylmethyl carbamate, 2,7-di-*t*-butyl-[9-(10,10-dioxo-10,10,10-tetrahydrothioxanthyl)]methyl carbamate (DBD-Tmoc), 4-methoxyphenacyl carbamate (Phenoc), 2,2,2-trichloroethyl carbamate (Troc), 2-trimethylsilylethyl carbamate (Teoc), 2-phenylethyl carbamate (hZ), 1-(1-adamantyl)-1-methylethyl carbamate (Adpoc), 1,1-dimethyl-2-haloethyl carbamate, 1,1-dimethyl-2,2-dibromoethyl carbamate (DB-*t*-BOC), 1,1-dimethyl-2,2,2-trichloroethyl carbamate (TCBOC),

1-methyl-1-(4-biphenyl)ethyl carbamate (Bpoc), 1-(3,5-di-*t*-butylphenyl)-1-methylethyl carbamate (*t*-Bumeoc), 2-(2'- and 4'-pyridyl)ethyl carbamate (Pyoc), 2-(*N,N*-dicyclohexylcarboxamido)ethyl carbamate, *t*-butyl carbamate (BOC or Boc), 1-adamantyl carbamate (Adoc), vinyl carbamate (Voc), allyl carbamate (Alloc), 1-isopropylallyl carbamate (Ipaoc), cinnamyl carbamate (Coc), 4-nitrocinnamyl carbamate (Noc), 8-quinolyl carbamate, *N*-hydroxypiperidinyl carbamate, alkylthio carbamate, benzyl carbamate (Cbz), *p*-methoxybenzyl carbamate (Moz), *p*-nitrobenzyl carbamate, *p*-bromobenzyl carbamate, *p*-chlorobenzyl carbamate, 2,4-dichlorobenzyl carbamate, 4-methylsulfinylbenzyl carbamate (MsZ), 9-anthrylmethyl carbamate, diphenylmethyl carbamate, 2-methylthioethyl carbamate, 2-methylsulfonyl ethyl carbamate, 2-(*p*-toluenesulfonyl)ethyl carbamate, [2-(1,3-dithianyl)]methyl carbamate (Dmoc), 4-methylthiophenyl carbamate (Mtpc), 2,4-dimethylthiophenyl carbamate (Bmpc), 2-phosphonioethyl carbamate (Peoc), 2-triphenylphosphonioisopropyl carbamate (Ppoc), 1,1-dimethyl-2-cyanoethyl carbamate, *m*-chloro-*p*-acyloxybenzyl carbamate, *p*-(dihydroxyboryl)benzyl carbamate, 5-benzisoxazolylmethyl carbamate, 2-(trifluoromethyl)-6-chromonylmethyl carbamate (TcroC), *m*-nitrophenyl carbamate, 3,5-dimethoxybenzyl carbamate, *o*-nitrobenzyl carbamate, 3,4-dimethoxy-6-nitrobenzyl carbamate, phenyl(*o*-nitrophenyl)methyl carbamate, *t*-amyl carbamate, *S*-benzyl thiocarbamate, *p*-cyanobenzyl carbamate, cyclobutyl carbamate, cyclohexyl carbamate, cyclopentyl carbamate, cyclopropylmethyl carbamate, *p*-decyloxybenzyl carbamate, 2,2-dimethoxyacylvinyl carbamate, *o*-(*N,N*-dimethylcarboxamido)benzyl carbamate, 1,1-dimethyl-3-(*N,N*-dimethylcarboxamido)propyl carbamate, 1,1-dimethylpropynyl carbamate, di(2-pyridyl)methyl carbamate, 2-furanylmethyl carbamate, 2-iodoethyl carbamate, isoborynl carbamate, isobutyl carbamate, isonicotinyl carbamate, *p*-(*p'*-methoxyphenylazo)benzyl carbamate, 1-methylcyclobutyl carbamate, 1-methylcyclohexyl carbamate, 1-methyl-1-cyclopropylmethyl carbamate, 1-methyl-1-(3,5-dimethoxyphenyl)ethyl carbamate, 1-methyl-1-(*p*-phenylazophenyl)ethyl carbamate, 1-methyl-1-phenylethyl carbamate, 1-methyl-1-(4-pyridyl)ethyl carbamate, phenyl carbamate, *p*-(phenylazo)benzyl carbamate, 2,4,6-tri-*t*-butylphenyl carbamate, 4-(trimethylammonium)benzyl carbamate, and 2,4,6-trimethylbenzyl carbamate.

[0086] Nitrogen protecting groups such as sulfonamide groups (*e.g.*, -S(=O)₂R^{aa}) include, but are not limited to, *p*-toluenesulfonamide (Ts), benzenesulfonamide, 2,3,6-trimethyl-4-methoxybenzenesulfonamide (Mtr), 2,4,6-trimethoxybenzenesulfonamide (Mtb), 2,6-dimethyl-4-methoxybenzenesulfonamide (Pme), 2,3,5,6-tetramethyl-4-

methoxybenzenesulfonamide (Mte), 4-methoxybenzenesulfonamide (Mbs), 2,4,6-trimethylbenzenesulfonamide (Mts), 2,6-dimethoxy-4-methylbenzenesulfonamide (iMds), 2,2,5,7,8-pentamethylchroman-6-sulfonamide (Pmc), methanesulfonamide (Ms), β -trimethylsilylethanesulfonamide (SES), 9-anthracenesulfonamide, 4-(4',8'-dimethoxynaphthylmethyl)benzenesulfonamide (DNMBS), benzylsulfonamide, trifluoromethylsulfonamide, and phenacysulfonamide.

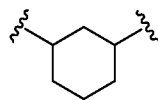
[0087] Other nitrogen protecting groups include, but are not limited to, phenothiazinyl-(10)-acyl derivative, *N'*-*p*-toluenesulfonylaminoacyl derivative, *N'*-phenylaminothioacyl derivative, *N*-benzoylphenylalanyl derivative, *N*-acetylmethionine derivative, 4,5-diphenyl-3-oxazolin-2-one, *N*-phthalimide, *N*-dithiasuccinimide (Dts), *N*-2,3-diphenylmaleimide, *N*-2,5-dimethylpyrrole, *N*-1,1,4,4-tetramethyldisilylazacyclopentane adduct (STABASE), 5-substituted 1,3-dimethyl-1,3,5-triazacyclohexan-2-one, 5-substituted 1,3-dibenzyl-1,3,5-triazacyclohexan-2-one, 1-substituted 3,5-dinitro-4-pyridone, *N*-methylamine, *N*-allylamine, *N*-[2-(trimethylsilyl)ethoxy]methylamine (SEM), *N*-3-acetoxypentylamine, *N*-(1-isopropyl-4-nitro-2-oxo-3-pyrrolin-3-yl)amine, quaternary ammonium salts, *N*-benzylamine, *N*-di(4-methoxyphenyl)methylamine, *N*-5-dibenzosuberylamine, *N*-triphenylmethylamine (Tr), *N*-[(4-methoxyphenyl)diphenylmethyl]amine (MMTr), *N*-9-phenylfluorenylamine (PhF), *N*-2,7-dichloro-9-fluorenylmethyleneamine, *N*-ferrocenylmethylamino (Fcm), *N*-2-picolylamino *N'*-oxide, *N*-1,1-dimethylthiomethyleneamine, *N*-benzylideneamine, *N*-*p*-methoxybenzylideneamine, *N*-diphenylmethyleneamine, *N*-[(2-pyridyl)mesityl]methyleneamine, *N*-(*N'*,*N'*-dimethylaminomethylene)amine, *N*,*N'*-isopropylidenediamine, *N*-*p*-nitrobenzylideneamine, *N*-salicylideneamine, *N*-5-chlorosalicylideneamine, *N*-(5-chloro-2-hydroxyphenyl)phenylmethyleneamine, *N*-cyclohexylideneamine, *N*-(5,5-dimethyl-3-oxo-1-cyclohexenyl)amine, *N*-borane derivative, *N*-diphenylborinic acid derivative, *N*-[phenyl(pentaacylchromium- or tungsten)acyl]amine, *N*-copper chelate, *N*-zinc chelate, *N*-nitroamine, *N*-nitrosoamine, amine *N*-oxide, diphenylphosphinamide (Dpp), dimethylthiophosphinamide (Mpt), diphenylthiophosphinamide (Ppt), dialkyl phosphoramidates, dibenzyl phosphoramidate, diphenyl phosphoramidate, benzenesulfenamide, *o*-nitrobenzenesulfenamide (Nps), 2,4-dinitrobenzenesulfenamide, pentachlorobenzenesulfenamide, 2-nitro-4-methoxybenzenesulfenamide, triphenylmethylsulfenamide, and 3-nitropyridinesulfenamide (Npys).

[0088] Exemplary oxygen atom substituents include, but are not limited to, $-R^{aa}$, $-C(=O)SR^{aa}$, $-C(=O)R^{aa}$, $-CO_2R^{aa}$, $-C(=O)N(R^{bb})_2$, $-C(=NR^{bb})R^{aa}$, $-C(=NR^{bb})OR^{aa}$, $-C(=NR^{bb})N(R^{bb})_2$, $-S(=O)R^{aa}$, $-SO_2R^{aa}$, $-Si(R^{aa})_3$, $-P(R^{cc})_2$, $-P(R^{cc})_3^+X^-$, $-P(OR^{cc})_2$, $-P(OR^{cc})_3^+X^-$, $-P(=O)(R^{aa})_2$, $-P(=O)(OR^{cc})_2$, and $-P(=O)(N(R^{bb})_2)_2$, wherein X^- , R^{aa} , R^{bb} , and R^{cc} are as defined herein. In certain embodiments, the oxygen atom substituent present on an oxygen atom is an oxygen protecting group (also referred to as a hydroxyl protecting group). Oxygen protecting groups are well known in the art and include those described in detail in *Protecting Groups in Organic Synthesis*, T. W. Greene and P. G. M. Wuts, 3rd edition, John Wiley & Sons, 1999, incorporated herein by reference. Exemplary oxygen protecting groups include, but are not limited to, methyl, *t*-butyloxycarbonyl (BOC or Boc), methoxymethyl (MOM), methylthiomethyl (MTM), *t*-butylthiomethyl, (phenyldimethylsilyl)methoxymethyl (SMOM), benzyloxymethyl (BOM), *p*-methoxybenzyloxymethyl (PMBM), (4-methoxyphenoxy)methyl (*p*-AOM), guaiacolmethyl (GUM), *t*-butoxymethyl, 4-pentenylloxymethyl (POM), siloxymethyl, 2-methoxyethoxymethyl (MEM), 2,2,2-trichloroethoxymethyl, bis(2-chloroethoxy)methyl, 2-(trimethylsilyl)ethoxymethyl (SEMOR), tetrahydropyranyl (THP), 3-bromotetrahydropyranyl, tetrahydrothiopyranyl, 1-methoxycyclohexyl, 4-methoxytetrahydropyranyl (MTHP), 4-methoxytetrahydrothiopyranyl, 4-methoxytetrahydrothiopyranyl S,S-dioxide, 1-[(2-chloro-4-methyl)phenyl]-4-methoxypiperidin-4-yl (CTMP), 1,4-dioxan-2-yl, tetrahydrofuranyl, tetrahydrothiofuranyl, 2,3,3a,4,5,6,7,7a-octahydro-7,8,8-trimethyl-4,7-methanobenzofuran-2-yl, 1-ethoxyethyl, 1-(2-chloroethoxy)ethyl, 1-methyl-1-methoxyethyl, 1-methyl-1-benzyloxyethyl, 1-methyl-1-benzyloxy-2-fluoroethyl, 2,2,2-trichloroethyl, 2-trimethylsilylethyl, 2-(phenylselenyl)ethyl, *t*-butyl, allyl, *p*-chlorophenyl, *p*-methoxyphenyl, 2,4-dinitrophenyl, benzyl (Bn), *p*-methoxybenzyl, 3,4-dimethoxybenzyl, *o*-nitrobenzyl, *p*-nitrobenzyl, *p*-halobenzyl, 2,6-dichlorobenzyl, *p*-cyanobenzyl, *p*-phenylbenzyl, 2-picolyl, 4-picolyl, 3-methyl-2-picolyl *N*-oxido, diphenylmethyl, *p,p'*-dinitrobenzhydryl, 5-dibenzosuberyl, triphenylmethyl, α -naphthylmethyl, *p*-methoxyphenyldiphenylmethyl, di(*p*-methoxyphenyl)phenylmethyl, tri(*p*-methoxyphenyl)methyl, 4-(4'-bromophenacyloxyphenyl)diphenylmethyl, 4,4',4''-tris(4,5-dichlorophthalimidophenyl)methyl, 4,4',4''-tris(levulinoyloxyphenyl)methyl, 4,4',4''-tris(benzoyloxyphenyl)methyl, 3-(imidazol-1-yl)bis(4',4''-dimethoxyphenyl)methyl, 1,1-bis(4-methoxyphenyl)-1'-pyrenylmethyl, 9-anthryl, 9-(9-phenyl)xanthenyl, 9-(9-phenyl-10-oxo)anthryl, 1,3-benzodisulfuran-2-yl, benzisothiazolyl S,S-dioxido, trimethylsilyl (TMS),

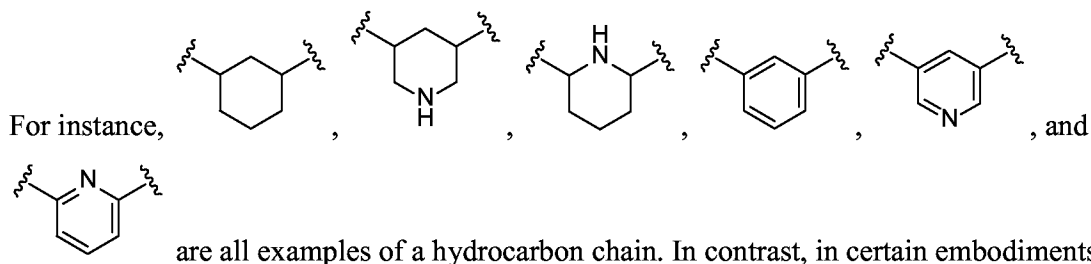
triethylsilyl (TES), triisopropylsilyl (TIPS), dimethylisopropylsilyl (IPDMS), diethylisopropylsilyl (DEIPS), dimethylhexylsilyl, *t*-butyldimethylsilyl (TBDMS), *t*-butyldiphenylsilyl (TBDPS), tribenzylsilyl, tri-*p*-xylylsilyl, triphenylsilyl, diphenylmethylsilyl (DPMS), *t*-butylmethoxyphenylsilyl (TBMPS), formate, benzoylformate, acetate, chloroacetate, dichloroacetate, trichloroacetate, trifluoroacetate, methoxyacetate, triphenylmethoxyacetate, phenoxyacetate, *p*-chlorophenoxyacetate, 3-phenylpropionate, 4-oxopentanoate (levulinate), 4,4-(ethylenedithio)pentanoate (levulinoyldithioacetal), pivaloate, adamantoate, crotonate, 4-methoxycrotonate, benzoate, *p*-phenylbenzoate, 2,4,6-trimethylbenzoate (mesitoate), alkyl methyl carbonate, 9-fluorenylmethyl carbonate (Fmoc), alkyl ethyl carbonate, alkyl 2,2,2-trichloroethyl carbonate (Troc), 2-(trimethylsilyl)ethyl carbonate (TMSEC), 2-(phenylsulfonyl) ethyl carbonate (Psec), 2-(triphenylphosphonio) ethyl carbonate (Peoc), alkyl isobutyl carbonate, alkyl vinyl carbonate alkyl allyl carbonate, alkyl *p*-nitrophenyl carbonate, alkyl benzyl carbonate, alkyl *p*-methoxybenzyl carbonate, alkyl 3,4-dimethoxybenzyl carbonate, alkyl *o*-nitrobenzyl carbonate, alkyl *p*-nitrobenzyl carbonate, alkyl *S*-benzyl thiocarbonate, 4-ethoxy-1-naphthyl carbonate, methyl dithiocarbonate, 2-iodobenzoate, 4-azidobutyrate, 4-nitro-4-methylpentanoate, *o*-(dibromomethyl)benzoate, 2-formylbenzenesulfonate, 2-(methylthiomethoxy)ethyl, 4-(methylthiomethoxy)butyrate, 2-(methylthiomethoxymethyl)benzoate, 2,6-dichloro-4-methylphenoxyacetate, 2,6-dichloro-4-(1,1,3,3-tetramethylbutyl)phenoxyacetate, 2,4-bis(1,1-dimethylpropyl)phenoxyacetate, chlorodiphenylacetate, isobutyrate, monosuccinoate, (*E*)-2-methyl-2-butenate, *o*-(methoxyacyl)benzoate, α -naphthoate, nitrate, alkyl *N,N,N',N'*-tetramethylphosphorodiamidate, alkyl *N*-phenylcarbamate, borate, dimethylphosphinothioyl, alkyl 2,4-dinitrophenylsulfenate, sulfate, methanesulfonate (mesylate), benzylsulfonate, and tosylate (Ts).

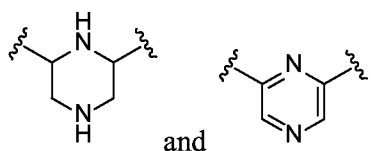
[0089] Exemplary sulfur atom substituents include, but are not limited to, $-R^{aa}$, $-C(=O)SR^{aa}$, $-C(=O)R^{aa}$, $-CO_2R^{aa}$, $-C(=O)N(R^{bb})_2$, $-C(=NR^{bb})R^{aa}$, $-C(=NR^{bb})OR^{aa}$, $-C(=NR^{bb})N(R^{bb})_2$, $-S(=O)R^{aa}$, $-SO_2R^{aa}$, $-Si(R^{aa})_3$, $-P(R^{cc})_2$, $-P(R^{cc})_3$, $-P(R^{cc})_3^+X^-$, $-P(OR^{cc})_2$, $-P(OR^{cc})_3^+X^-$, $-P(=O)(R^{aa})_2$, $-P(=O)(OR^{cc})_2$, and $-P(=O)(N(R^{bb})_2)_2$, wherein R^{aa} , R^{bb} , and R^{cc} are as defined herein. In certain embodiments, the sulfur atom substituent present on a sulfur atom is a sulfur protecting group (also referred to as a thiol protecting group). Sulfur protecting groups are well known in the art and include those described in detail in *Protecting Groups in Organic Synthesis*, T. W. Greene and P. G. M. Wuts, 3rd edition, John Wiley & Sons, 1999, incorporated herein by reference.

[0090] A “hydrocarbon chain” refers to a substituted or unsubstituted divalent alkyl, alkenyl, or alkynyl group. A hydrocarbon chain includes (1) one or more chains of carbon atoms immediately between the two radicals of the hydrocarbon chain; (2) optionally one or more hydrogen atoms on the chain(s) of carbon atoms; and (3) optionally one or more substituents (“non-chain substituents,” which are not hydrogen) on the chain(s) of carbon atoms. A chain of carbon atoms consists of consecutively connected carbon atoms (“chain atoms” or “carbon units”) and does not include hydrogen atoms or heteroatoms. However, a non-chain substituent of a hydrocarbon chain may include any atoms, including hydrogen atoms, carbon atoms, and heteroatoms. For example, hydrocarbon chain $-C^A H(C^B H_2 C^C H_3)-$ includes one chain atom C^A , one hydrogen atom on C^A , and non-chain substituent $-(C^B H_2 C^C H_3)$. The term “ C_x hydrocarbon chain,” wherein x is a positive integer, refers to a hydrocarbon chain that includes x number of chain atom(s) between the two radicals of the hydrocarbon chain. If there is more than one possible value of x , the smallest possible value of x is used for the definition of the hydrocarbon chain. For example, $-\text{CH}(\text{C}_2\text{H}_5)-$ is a C_1



hydrocarbon chain, and is a C_3 hydrocarbon chain. When a range of values is used, the meaning of the range is as described herein. For example, a C_{3-10} hydrocarbon chain refers to a hydrocarbon chain where the number of chain atoms of the shortest chain of carbon atoms immediately between the two radicals of the hydrocarbon chain is 3, 4, 5, 6, 7, 8, 9, or 10. A hydrocarbon chain may be saturated (*e.g.*, $-(\text{CH}_2)_4-$). A hydrocarbon chain may also be unsaturated and include one or more $\text{C}=\text{C}$ and/or $\text{C}\equiv\text{C}$ bonds anywhere in the hydrocarbon chain. For instance, $-\text{CH}=\text{CH}-(\text{CH}_2)_2-$, $-\text{CH}_2-\text{C}\equiv\text{C}-\text{CH}_2-$, and $-\text{C}\equiv\text{C}-\text{CH}=\text{CH}-$ are all examples of a unsubstituted and unsaturated hydrocarbon chain. In certain embodiments, the hydrocarbon chain is unsubstituted (*e.g.*, $-\text{C}\equiv\text{C}-$ or $-(\text{CH}_2)_4-$). In certain embodiments, the hydrocarbon chain is substituted (*e.g.*, $-\text{CH}(\text{C}_2\text{H}_5)-$ and $-\text{CF}_2-$). Any two substituents on the hydrocarbon chain may be joined to form an optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl ring.





are not within the scope of the hydrocarbon chains described

herein. When a chain atom of a C_x hydrocarbon chain is replaced with a heteroatom, the resulting group is referred to as a C_x hydrocarbon chain wherein a chain atom is replaced with a heteroatom, as opposed to a C_{x-1} hydrocarbon chain. For example, is a C_3 hydrocarbon chain wherein one chain atom is replaced with an oxygen atom.

[0091] The term “leaving group” is given its ordinary meaning in the art of synthetic organic chemistry and refers to an atom or a group capable of being displaced by a nucleophile. Examples of suitable leaving groups include, but are not limited to, halogen (such as F, Cl, Br, or I (iodine)), alkoxy-carbonyloxy, aryloxy-carbonyloxy, alkanesulfonyloxy, arenesulfonyloxy, alkyl-carbonyloxy (*e.g.*, acetoxy), arylcarbonyloxy, aryloxy, methoxy, *N,O*-dimethylhydroxylamino, pixyl, and haloformates. In some cases, the leaving group is a sulfonic acid ester, such as toluenesulfonate (tosylate, -OTs), methanesulfonate (mesylate, -OMs), *p*-bromobenzenesulfonyloxy (brosylate, -OBs), $-\text{OS}(=\text{O})_2(\text{CF}_2)_3\text{CF}_3$ (nonaflate, -ONf), or trifluoromethanesulfonate (triflate, -OTf). In some cases, the leaving group is a brosylate, such as *p*-bromobenzenesulfonyloxy. In some cases, the leaving group is a nosylate, such as 2-nitrobenzenesulfonyloxy. The leaving group may also be a phosphineoxide (*e.g.*, formed during a Mitsunobu reaction) or an internal leaving group such as an epoxide or cyclic sulfate. Other non-limiting examples of leaving groups are water, ammonia, alcohols, ether moieties, thioether moieties, zinc halides, magnesium moieties, diazonium salts, and copper moieties. Other exemplary leaving groups include, but are not limited to, activated substituted hydroxyl groups (*e.g.*, $-\text{OC}(=\text{O})\text{SR}^{\text{aa}}$, $-\text{OC}(=\text{O})\text{R}^{\text{aa}}$, $-\text{OCO}_2\text{R}^{\text{aa}}$, $-\text{OC}(=\text{O})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{R}^{\text{aa}}$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{OR}^{\text{aa}}$, $-\text{OC}(=\text{NR}^{\text{bb}})\text{N}(\text{R}^{\text{bb}})_2$, $-\text{OS}(=\text{O})\text{R}^{\text{aa}}$, $-\text{OSO}_2\text{R}^{\text{aa}}$, $-\text{OP}(\text{R}^{\text{cc}})_2$, $-\text{OP}(\text{R}^{\text{cc}})_3$, $-\text{OP}(=\text{O})_2\text{R}^{\text{aa}}$, $-\text{OP}(=\text{O})(\text{R}^{\text{aa}})_2$, $-\text{OP}(=\text{O})(\text{OR}^{\text{cc}})_2$, $-\text{OP}(=\text{O})_2\text{N}(\text{R}^{\text{bb}})_2$, and $-\text{OP}(=\text{O})(\text{NR}^{\text{bb}})_2$, wherein R^{aa} , R^{bb} , and R^{cc} are as defined herein).

[0092] The term “heteroatom” refers to an atom that is not hydrogen or carbon. In certain embodiments, the heteroatom is nitrogen. In certain embodiments, the heteroatom is oxygen. In certain embodiments, the heteroatom is sulfur.

[0093] As used herein, the term “salt” refers to any and all salts, and encompasses pharmaceutically acceptable salts. The term “salt” refers to ionic compounds that result from the neutralization reaction of an acid and a base. A salt is composed of one or more cations (positively charged ions) and one or more anions (negative ions) so that the salt is electrically

neutral (without a net charge). Salts of the compounds of this invention include those derived from inorganic and organic acids and bases. Examples of 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 known in the art such as ion exchange. Other salts include adipate, alginate, ascorbate, aspartate, benzenesulfonate, benzoate, bisulfate, borate, butyrate, camphorate, camphorsulfonate, citrate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, formate, fumarate, glucoheptonate, glycerophosphate, gluconate, hemisulfate, heptanoate, hexanoate, hydroiodide, 2-hydroxy-ethanesulfonate, lactobionate, lactate, laurate, lauryl sulfate, malate, maleate, malonate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, oleate, oxalate, palmitate, pamoate, pectinate, persulfate, 3-phenylpropionate, phosphate, picrate, pivalate, propionate, stearate, succinate, sulfate, tartrate, thiocyanate, *p*-toluenesulfonate, undecanoate, valerate, hippurate, and the like. 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 salts include ammonium, quaternary ammonium, and amine cations formed using counterions such as halide, hydroxide, carboxylate, sulfate, phosphate, nitrate, lower alkyl sulfonate, and aryl sulfonate.

[0094] 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, 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 described herein include those derived from suitable inorganic and organic acids and bases. Examples of pharmaceutically acceptable, nontoxic 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 known in the art such as ion exchange. Other pharmaceutically acceptable salts include adipate, alginate, ascorbate, aspartate, benzenesulfonate, benzoate, bisulfate, borate, butyrate, camphorate,

camphorsulfonate, citrate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, formate, fumarate, glucoheptonate, glycerophosphate, gluconate, hemisulfate, heptanoate, hexanoate, hydroiodide, 2-hydroxy-ethanesulfonate, lactobionate, lactate, laurate, lauryl sulfate, malate, maleate, malonate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, oleate, oxalate, palmitate, pamoate, pectinate, persulfate, 3-phenylpropionate, phosphate, picrate, pivalate, propionate, stearate, succinate, sulfate, tartrate, thiocyanate, p-toluenesulfonate, undecanoate, valerate salts, and the like. 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, carboxylate, sulfate, phosphate, nitrate, lower alkyl sulfonate, and aryl sulfonate.

[0095] The term “solvate” refers to forms of the compound that are associated with a solvent, usually by a solvolysis reaction. This physical association may include hydrogen bonding. Conventional solvents include water, methanol, ethanol, acetic acid, DMSO, THF, diethyl ether, and the like. The compounds described herein may be prepared, *e.g.*, in crystalline form, and may be solvated. Suitable solvates include pharmaceutically acceptable solvates and further include both stoichiometric solvates and non-stoichiometric solvates. In certain instances, the solvate will be capable of isolation, for example, when one or more solvent molecules are incorporated in the crystal lattice of a crystalline solid. “Solvate” encompasses both solution-phase and isolatable solvates. Representative solvates include hydrates, ethanolates, and methanolates.

[0096] The term “hydrate” refers to a compound that is associated with water. Typically, the number of the water molecules contained in a hydrate of a compound is in a definite ratio to the number of the compound molecules in the hydrate. Therefore, a hydrate of a compound may be represented, for example, by the general formula $R \cdot x \text{ H}_2\text{O}$, wherein R is the compound, and x is a number greater than 0. A given compound may form more than one type of hydrate, including, *e.g.*, monohydrates (x is 1), lower hydrates (x is a number greater than 0 and smaller than 1, *e.g.*, hemihydrates ($R \cdot 0.5 \text{ H}_2\text{O}$)), and polyhydrates (x is a number greater than 1, *e.g.*, dihydrates ($R \cdot 2 \text{ H}_2\text{O}$) and hexahydrates ($R \cdot 6 \text{ H}_2\text{O}$)).

[0097] The term “tautomers” or “tautomeric” refers to two or more interconvertible compounds resulting from at least one formal migration of a hydrogen atom and at least one

change in valency (*e.g.*, a single bond to a double bond, a triple bond to a single bond, or *vice versa*). The exact ratio of the tautomers depends on several factors, including temperature, solvent, and pH. Tautomerizations (*i.e.*, the reaction providing a tautomeric pair) may be catalyzed by acid or base. Exemplary tautomerizations include keto-to-enol, amide-to-imide, lactam-to-lactim, enamine-to-imine, and enamine-to-(a different enamine) tautomerizations.

[0098] It is also to be understood that compounds that have the same molecular formula but differ in the nature or sequence of bonding of their atoms or the arrangement of their atoms in space are termed “isomers”. Isomers that differ in the arrangement of their atoms in space are termed “stereoisomers”.

[0099] Stereoisomers that are not mirror images of one another are termed “diastereomers” and those that are non-superimposable mirror images of each other are termed “enantiomers”. When a compound has an asymmetric center, for example, it is bonded to four different groups, a pair of enantiomers is possible. An enantiomer can be characterized by the absolute configuration of its asymmetric center and is described by the R- and S-sequencing rules of Cahn and Prelog, or by the manner in which the molecule rotates the plane of polarized light and designated as dextrorotatory or levorotatory (*i.e.*, as (+) or (-)-isomers respectively). A chiral compound can exist as either individual enantiomer or as a mixture thereof. A mixture containing equal proportions of the enantiomers is called a “racemic mixture”.

[00100] The term “polymorphs” refers to a crystalline form of a compound (or a salt, hydrate, or solvate thereof) in a particular crystal packing arrangement. All polymorphs have the same elemental composition. Different crystalline forms usually have different X-ray diffraction patterns, infrared spectra, melting points, density, hardness, crystal shape, optical and electrical properties, stability, and solubility. Recrystallization solvent, rate of crystallization, storage temperature, and other factors may cause one crystal form to dominate. Various polymorphs of a compound can be prepared by crystallization under different conditions.

[00101] The term “co-crystal” refers to a crystalline structure composed of at least two components. In certain embodiments, a co-crystal may contain a compound of the present invention and one or more other component, including but not limited to, atoms, ions, molecules, or solvent molecules. In certain embodiments, a co-crystal may contain a compound of the present invention and one or more components related to said compound, including not limited to, an isomer, tautomer, salt, solvate, hydrate, synthetic precursor, synthetic derivative, fragment or impurity of said compound. Co-crystals may be useful to

improve the properties (*e.g.*, solubility, stability, and ease of formulation) of a compound of the present invention.

[00102] The term “isotopes” refers to variants of a particular chemical element such that, while all isotopes of a given element share the same number of protons in each atom of the element, those isotopes differ in the number of neutrons. The term “radioactivity” or “radioactive decay” refers to the process by which a nucleus of an unstable isotope (*e.g.*, ^{18}F) loses energy by emitting particles or rays (*e.g.*, alpha particles, beta particles, and gamma rays) of electromagnetic radiation. Such an unstable isotope or a material including the unstable isotope is referred to as “radioactive.” The Curie (Ci) is a non-SI (non-International System of Units) unit of radioactivity and is defined as $1\text{ Ci} = 3.7 \times 10^{10}$ decays per second. The term “specific activity” refers to the unit radioactivity of a material (*e.g.*, any compound disclosed herein, or a salt, tautomer, stereoisomer, or isotopically labeled derivative (*e.g.*, ^{18}F -labeled derivative) thereof). In certain embodiments, the term “specific activity” refers to the radioactivity of a material per micromole (μmol) of the material.

[00103] The term “isotopically labeled derivative” or “isotopically labeled” refers to a compound wherein one or more atoms in the compound (or in an associated ion or molecule of a salt, hydrate, or solvate) has been replaced with an isotope of the same element. For the given element or position in the molecule the isotope will be enriched, or present in a higher percentage of all atoms of the element or of all atoms at the position in the molecule in a sample, relative to an unlabeled variant. In certain embodiments, the enriched isotope will be a stable isotope. In certain embodiments, the enriched isotope will be an unstable or radioactive isotope (*e.g.*, a radionuclide). In certain embodiments, the enriched isotope may be detected by a measurement technique, including but not limited to nuclear magnetic resonance, mass spectrometry, infrared spectroscopy, or a technique that measures radioactive decay.

[00104] The term “prodrugs” refers to compounds that have cleavable groups and become by solvolysis or under physiological conditions the compounds described herein, which are pharmaceutically active *in vivo*. Such examples include, but are not limited to, choline ester derivatives and the like, N-alkylmorpholine esters and the like. Other derivatives of the compounds described herein have activity in both their acid and acid derivative forms, but in the acid sensitive form often offer advantages of solubility, tissue compatibility, or delayed release in the mammalian organism (see, Bundgard, H., *Design of Prodrugs*, pp. 7-9, 21-24, Elsevier, Amsterdam 1985). Prodrugs include acid derivatives well known to practitioners of

the art, such as, for example, esters prepared by reaction of the parent acid with a suitable alcohol, or amides prepared by reaction of the parent acid compound with a substituted or unsubstituted amine, or acid anhydrides, or mixed anhydrides. Simple aliphatic or aromatic esters, amides, and anhydrides derived from acidic groups pendant on the compounds described herein are particular prodrugs. In some cases it is desirable to prepare double ester type prodrugs such as (acyloxy)alkyl esters or ((alkoxycarbonyl)oxy)alkylesters. C₁-C₈ alkyl, C₂-C₈ alkenyl, C₂-C₈ alkynyl, aryl, C₇-C₁₂ substituted aryl, and C₇-C₁₂ arylalkyl esters of the compounds described herein may be preferred.

[00105] The term “inhibition”, “inhibiting”, “inhibit,” or “inhibitor” refer to the ability of a compound to reduce, slow, halt or prevent activity of a particular biological process (*e.g.*, activity of a bromodomain and/or a bromodomain-containing protein) in a cell relative to vehicle.

[00106] As used herein the term “inhibit” or “inhibition” in the context of enzymes, for example, in the context of CDK (*e.g.*, CDK7, CDK12, CDK13), refers to a reduction in the activity of the enzyme. In some embodiments, the term refers to a reduction in the level of enzyme activity, *e.g.*, CDK (*e.g.*, CDK7, CDK12, CDK13) activity, to a level that is statistically significantly lower than an initial level, which may, for example, be a baseline level of enzyme activity. In some embodiments, the term refers to a reduction in the level of enzyme activity, *e.g.*, CDK (*e.g.*, CDK7, CDK12, CDK13) activity, to a level that is less than 75%, less than 50%, less than 40%, less than 30%, less than 25%, less than 20%, less than 10%, less than 9%, less than 8%, less than 7%, less than 6%, less than 5%, less than 4%, less than 3%, less than 2%, less than 1%, less than 0.5%, less than 0.1%, less than 0.01%, less than 0.001%, or less than 0.0001% of an initial level, which may, for example, be a baseline level of enzyme activity.

[00107] When a compound, pharmaceutical composition, method, use, or kit is referred to as “selectively,” “specifically,” or “competitively” binding a first protein or a first chromatin, the compound, pharmaceutical composition, method, use, or kit binds the first protein or the first chromatin with a higher binding affinity (*e.g.*, not less than about 2-fold, not less than about 5-fold, not less than about 10-fold, not less than about 30-fold, not less than about 100-fold, not less than about 1,000-fold, or not less than about 10,000-fold) than binding a second protein or second chromatin that is different from the first protein and the first chromatin. When a compound, pharmaceutical composition, method, use, or kit is referred to as “selectively,” “specifically,” or “competitively” modulating (*e.g.*, increasing or inhibiting) the activity of a bromodomain-containing protein, the compound, pharmaceutical composition,

method, use, or kit modulates the activity of the bromodomain-containing protein to a greater extent (*e.g.*, not less than about 2-fold, not less than about 5-fold, not less than about 10-fold, not less than about 30-fold, not less than about 100-fold, not less than about 1,000-fold, or not less than about 10,000-fold) than the activity of at least one protein that is different from the bromodomain-containing protein.

[00108] The term “aberrant activity” refers to activity deviating from normal activity, that is, abnormal activity. The term “increased activity” refers to activity higher than normal activity.

[00109] The terms “composition” and “formulation” are used interchangeably.

[00110] A “subject” to which administration is contemplated refers to a human (*i.e.*, male or female of any age group, *e.g.*, pediatric subject (*e.g.*, infant, child, or adolescent) or adult subject (*e.g.*, young adult, middle-aged adult, or senior adult)) or non-human animal. In certain embodiments, the non-human animal is a mammal (*e.g.*, primate (*e.g.*, cynomolgus monkey or rhesus monkey), commercially relevant mammal (*e.g.*, cattle, pig, horse, sheep, goat, cat, or dog), or bird (*e.g.*, commercially relevant bird, such as chicken, duck, goose, or turkey)). In certain embodiments, the non-human animal is a fish, reptile, or amphibian. The non-human animal may be a male or female at any stage of development. The non-human animal may be a transgenic animal or genetically engineered animal. A “patient” refers to a human subject in need of treatment of a disease.

[00111] The term “biological sample” refers to any sample including tissue samples (such as tissue sections and needle biopsies of a tissue); cell samples (*e.g.*, cytological smears (such as Pap or blood smears) or samples of cells obtained by microdissection); samples of whole organisms (such as samples of yeasts or bacteria); or cell fractions, fragments or organelles (such as obtained by lysing cells and separating the components thereof by centrifugation or otherwise). Other examples of biological samples include blood, serum, urine, semen, fecal matter, cerebrospinal fluid, interstitial fluid, mucous, tears, sweat, pus, biopsied tissue (*e.g.*, obtained by a surgical biopsy or needle biopsy), nipple aspirates, milk, vaginal fluid, saliva, swabs (such as buccal swabs), or any material containing biomolecules that is derived from another biological sample.

[00112] The terms “administer,” “administering,” or “administration” refers to implanting, absorbing, ingesting, injecting, inhaling, or otherwise introducing a compound described herein, or a composition thereof, into, in, or on a subject.

[00113] The terms “treatment,” “treat,” and “treating” refer to reversing, alleviating, delaying the onset of, or inhibiting the progress of a disease described herein. In some

embodiments, treatment may be administered after one or more signs or symptoms of the disease have developed or have been observed. In other embodiments, treatment may be administered in the absence of signs or symptoms of the disease. For example, treatment may be administered to a susceptible subject prior to the onset of symptoms (*e.g.*, in light of a history of symptoms and/or in light of exposure to a pathogen). Treatment may also be continued after symptoms have resolved, for example, to delay or prevent recurrence.

[00114] The term “prevent,” “preventing,” or “prevention” refers to a prophylactic treatment of a subject who has not and had not been diagnosed with a disease but is at risk of developing the disease. The term “prevent,” “preventing,” or “prevention” also refers to a prophylactic treatment of a subject who was suffering from a disease or has not been diagnosed with the disease, but is at risk of regression or recurrence of the disease. In certain embodiments, the subject is at a higher risk of developing the disease or at a higher risk of regression of the disease than an average healthy member of a population.

[00115] The terms “condition,” “disease,” and “disorder” are used interchangeably.

[00116] An “effective amount” of a compound described herein refers to an amount sufficient to elicit the desired biological response, *i.e.*, treating the condition. As will be appreciated by those of ordinary skill in this art, the effective amount of a compound described herein may vary depending on such factors as the desired biological endpoint, the pharmacokinetics of the compound, the condition being treated, the mode of administration, and the age and health of the subject. In certain embodiments, an effective amount is a therapeutically effective amount. In certain embodiments, an effective amount is a prophylactic treatment. In certain embodiments, an effective amount is the amount of a compound described herein in a single dose. In certain embodiments, an effective amount is the combined amounts of a compound described herein in multiple doses.

[00117] A “therapeutically effective amount” of a compound described herein is an amount sufficient to provide a therapeutic benefit in the treatment of a condition or to delay or minimize one or more symptoms associated with the condition. A therapeutically effective amount of a compound means an amount of therapeutic agent, alone or in combination with other therapies, which provides a therapeutic benefit in the treatment of the condition. The term “therapeutically effective amount” can encompass an amount that improves overall therapy, reduces or avoids symptoms, signs, or causes of the condition, and/or enhances the therapeutic efficacy of another therapeutic agent. In certain embodiments, a therapeutically effective amount is an amount sufficient for inhibiting CDK (*e.g.*, CDK7, CDK12, CDK13). In certain embodiments, a therapeutically effective amount is an amount sufficient for

treating an acute inflammatory disease (*e.g.*, rheumatoid arthritis, Crohn's disease, or fibrosis) and/or a proliferative disease (*e.g.*, cancer, benign neoplasm, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, autoimmune diseases, pancreatic cancer, lung cancer (*e.g.* small cell lung cancer (SCLC), non-small cell lung cancer), prostate cancer, breast cancer, ovarian cancer, kidney cancer, liver cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, and colorectal cancer). In certain embodiments, a therapeutically effective amount is an amount sufficient for inhibiting CDK (*e.g.*, CDK7, CDK12, CDK13) and for treating an acute inflammatory disease (*e.g.*, rheumatoid arthritis, Crohn's disease, or fibrosis) and/or a proliferative disease (*e.g.*, cancer, benign neoplasm, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, autoimmune diseases, pancreatic cancer, lung cancer (*e.g.* small cell lung cancer (SCLC), and non-small cell lung cancer), prostate cancer, breast cancer, ovarian cancer, kidney cancer, liver cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, and colorectal cancer).

[00118] A “prophylactically effective amount” of a compound described herein is an amount sufficient to prevent a condition, or one or more symptoms associated with the condition or prevent its recurrence. A prophylactically effective amount of a compound means an amount of a therapeutic agent, alone or in combination with other agents, which provides a prophylactic benefit in the prevention of the condition. The term “prophylactically effective amount” can encompass an amount that improves overall prophylaxis or enhances the prophylactic efficacy of another prophylactic agent. In certain embodiments, a prophylactically effective amount is an amount sufficient for inhibiting CDK (*e.g.*, CDK7, CDK12, CDK13). In certain embodiments, a prophylactically effective amount is an amount sufficient for treating an acute inflammatory disease (*e.g.*, rheumatoid arthritis, Crohn's disease, or fibrosis) and/or a proliferative disease (*e.g.*, cancer, benign neoplasm, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, autoimmune diseases, pancreatic cancer, lung cancer (*e.g.* small cell lung cancer (SCLC), and non-small cell lung cancer), prostate cancer, breast cancer, ovarian cancer, kidney cancer, liver cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, and colorectal cancer). In certain embodiments, a prophylactically effective amount is an amount sufficient for inhibiting CDK (*e.g.*, CDK7, CDK12, CDK13) and for treating acute inflammatory disease (*e.g.*, rheumatoid arthritis, Crohn's disease, or fibrosis) and/or a proliferative disease (*e.g.*, cancer, benign neoplasm, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, autoimmune diseases, pancreatic cancer, lung cancer (*e.g.* small

cell lung cancer (SCLC), and non-small cell lung cancer), prostate cancer, breast cancer, ovarian cancer, kidney cancer, liver cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, and colorectal cancer).

[00119] A “proliferative disease” refers to a disease that occurs due to abnormal growth or extension by the multiplication of cells (Walker, *Cambridge Dictionary of Biology*; Cambridge University Press: Cambridge, UK, 1990). A proliferative disease may be associated with: 1) the pathological proliferation of normally quiescent cells; 2) the pathological migration of cells from their normal location (*e.g.*, metastasis of neoplastic cells); 3) the pathological expression of proteolytic enzymes such as the matrix metalloproteinases (*e.g.*, collagenases, gelatinases, and elastases); or 4) the pathological angiogenesis as in proliferative retinopathy and tumor metastasis. Exemplary proliferative diseases include cancers (*i.e.*, “malignant neoplasms”), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, and autoimmune diseases.

[00120] The term “angiogenesis” refers to the physiological process through which new blood vessels form from pre-existing vessels. Angiogenesis is distinct from vasculogenesis, which is the *de novo* formation of endothelial cells from mesoderm cell precursors. The first vessels in a developing embryo form through vasculogenesis, after which angiogenesis is responsible for most blood vessel growth during normal or abnormal development. Angiogenesis is a vital process in growth and development, as well as in wound healing and in the formation of granulation tissue. However, angiogenesis is also a fundamental step in the transition of tumors from a benign state to a malignant one, leading to the use of angiogenesis inhibitors in the treatment of cancer. Angiogenesis may be chemically stimulated by angiogenic proteins, such as growth factors (*e.g.*, VEGF). “Pathological angiogenesis” refers to abnormal (*e.g.*, excessive or insufficient) angiogenesis that amounts to and/or is associated with a disease.

[00121] The terms “neoplasm” and “tumor” are used herein interchangeably and refer to an abnormal mass of tissue wherein the growth of the mass surpasses and is not coordinated as in the growth of normal tissue. A neoplasm or tumor may be “benign” or “malignant,” depending on the following characteristics: degree of cellular differentiation (including morphology and functionality), rate of growth, local invasion, and metastasis. A “benign neoplasm” is generally well differentiated, has characteristically slower growth than a malignant neoplasm, and remains localized to the site of origin. In addition, a benign neoplasm does not have the capacity to infiltrate, invade, or metastasize to distant sites. Exemplary benign neoplasms include, but are not limited to, lipoma, chondroma, adenomas,

acrochordon, senile angiomas, seborrheic keratoses, lentigos, and sebaceous hyperplasias. In some cases, certain “benign” tumors may later give rise to malignant neoplasms, which may result from additional genetic changes in a subpopulation of the tumor’s neoplastic cells, and these tumors are referred to as “pre-malignant neoplasms.” An exemplary pre-malignant neoplasm is a teratoma. In contrast, a “malignant neoplasm” is generally poorly differentiated (anaplasia) and has characteristically rapid growth accompanied by progressive infiltration, invasion, and destruction of the surrounding tissue. Furthermore, a malignant neoplasm generally has the capacity to metastasize to distant sites. The term “metastasis,” “metastatic,” or “metastasize” refers to the spread or migration of cancerous cells from a primary or original tumor to another organ or tissue and is typically identifiable by the presence of a “secondary tumor” or “secondary cell mass” of the tissue type of the primary or original tumor and not of that of the organ or tissue in which the secondary (metastatic) tumor is located. For example, a prostate cancer that has migrated to bone is said to be metastasized prostate cancer and includes cancerous prostate cancer cells growing in bone tissue.

[00122] The term “cancer” refers to a class of diseases characterized by the development of abnormal cells that proliferate uncontrollably and have the ability to infiltrate and destroy normal body tissues. See, *e.g.*, *Stedman’s Medical Dictionary*, 25th ed.; Hensyl ed.; Williams & Wilkins: Philadelphia, 1990. Exemplary cancers include, but are not limited to, hematological malignancies. Additional exemplary cancers include, but are not limited to, acoustic neuroma; adenocarcinoma; adrenal gland cancer; anal cancer; angiosarcoma (*e.g.*, lymphangiosarcoma, lymphangioendotheliosarcoma, hemangiosarcoma); appendix cancer; benign monoclonal gammopathy; biliary cancer (*e.g.*, cholangiocarcinoma); bladder cancer; breast cancer (*e.g.*, adenocarcinoma of the breast, papillary carcinoma of the breast, mammary cancer, medullary carcinoma of the breast, triple negative breast cancer (TNBC)); brain cancer (*e.g.*, meningioma, glioblastomas, glioma (*e.g.*, astrocytoma, oligodendroglioma), medulloblastoma); bronchus cancer; carcinoid tumor; cervical cancer (*e.g.*, cervical adenocarcinoma); choriocarcinoma; chordoma; craniopharyngioma; colorectal cancer (*e.g.*, colon cancer, rectal cancer, colorectal adenocarcinoma); connective tissue cancer; epithelial carcinoma; ependymoma; endotheliosarcoma (*e.g.*, Kaposi’s sarcoma, multiple idiopathic hemorrhagic sarcoma); endometrial cancer (*e.g.*, uterine cancer, uterine sarcoma); esophageal cancer (*e.g.*, adenocarcinoma of the esophagus, Barrett’s adenocarcinoma); Ewing’s sarcoma; ocular cancer (*e.g.*, intraocular melanoma, retinoblastoma); familial hypereosinophilia; gall bladder cancer; gastric cancer (*e.g.*, stomach adenocarcinoma); gastrointestinal stromal tumor (GIST); germ cell cancer; head and neck

cancer (*e.g.*, head and neck squamous cell carcinoma, oral cancer (*e.g.*, oral squamous cell carcinoma), throat cancer (*e.g.*, laryngeal cancer, pharyngeal cancer, nasopharyngeal cancer, oropharyngeal cancer)); heavy chain disease (*e.g.*, alpha chain disease, gamma chain disease, mu chain disease; hemangioblastoma; hypopharynx cancer; inflammatory myofibroblastic tumors; immunocytic amyloidosis; kidney cancer (*e.g.*, nephroblastoma *a.k.a.* Wilms' tumor, renal cell carcinoma); liver cancer (*e.g.*, hepatocellular cancer (HCC), malignant hepatoma); lung cancer (*e.g.*, bronchogenic carcinoma, small cell lung cancer (SCLC), non-small cell lung cancer (NSCLC), adenocarcinoma of the lung); leiomyosarcoma (LMS); mastocytosis (*e.g.*, systemic mastocytosis); muscle cancer; myelodysplastic syndrome (MDS); mesothelioma; myeloproliferative disorder (MPD) (*e.g.*, polycythemia vera (PV), essential thrombocythosis (ET), agnogenic myeloid metaplasia (AMM) *a.k.a.* myelofibrosis (MF), chronic idiopathic myelofibrosis, chronic myelocytic leukemia (CML), chronic neutrophilic leukemia (CNL), hypereosinophilic syndrome (HES)); neuroblastoma; neurofibroma (*e.g.*, neurofibromatosis (NF) type 1 or type 2, schwannomatosis); neuroendocrine cancer (*e.g.*, gastroenteropancreatic neuroendocrine tumor (GEP-NET), carcinoid tumor); osteosarcoma (*e.g.*, bone cancer); ovarian cancer (*e.g.*, cystadenocarcinoma, ovarian embryonal carcinoma, ovarian adenocarcinoma); papillary adenocarcinoma; pancreatic cancer (*e.g.*, pancreatic adenocarcinoma, intraductal papillary mucinous neoplasm (IPMN), Islet cell tumors); penile cancer (*e.g.*, Paget's disease of the penis and scrotum); pinealoma; primitive neuroectodermal tumor (PNT); plasma cell neoplasia; paraneoplastic syndromes; intraepithelial neoplasms; prostate cancer (*e.g.*, prostate adenocarcinoma); rectal cancer; rhabdomyosarcoma; salivary gland cancer; skin cancer (*e.g.*, squamous cell carcinoma (SCC), keratoacanthoma (KA), melanoma, basal cell carcinoma (BCC)); small bowel cancer (*e.g.*, appendix cancer); soft tissue sarcoma (*e.g.*, malignant fibrous histiocytoma (MFH), liposarcoma, malignant peripheral nerve sheath tumor (MPNST), chondrosarcoma, fibrosarcoma, myxosarcoma); sebaceous gland carcinoma; small intestine cancer; sweat gland carcinoma; synovium; testicular cancer (*e.g.*, seminoma, testicular embryonal carcinoma); thyroid cancer (*e.g.*, papillary carcinoma of the thyroid, papillary thyroid carcinoma (PTC), medullary thyroid cancer); urethral cancer; vaginal cancer; and vulvar cancer (*e.g.*, Paget's disease of the vulva).

[00123] The term "hematological malignancy" refers to tumors that affect blood, bone marrow, and/or lymph nodes. Exemplary hematological malignancies include, but are not limited to, leukemia, such as acute lymphoblastic leukemia (ALL) (*e.g.*, B-cell ALL, T-cell ALL), acute myelocytic leukemia (AML) (*e.g.*, B-cell AML, T-cell AML), chronic

myelocytic leukemia (CML) (*e.g.*, B-cell CML, T-cell CML), and chronic lymphocytic leukemia (CLL) (*e.g.*, B-cell CLL, T-cell CLL)); lymphoma, such as Hodgkin lymphoma (HL) (*e.g.*, B-cell HL, T-cell HL) and non-Hodgkin lymphoma (NHL) (*e.g.*, B-cell NHL, such as diffuse large cell lymphoma (DLCL) (*e.g.*, diffuse large B-cell lymphoma (DLBCL, *e.g.*, activated B-cell (ABC) DLBCL (ABC-DLBCL))), follicular lymphoma, chronic lymphocytic leukemia/small lymphocytic lymphoma (CLL/SLL), mantle cell lymphoma (MCL), marginal zone B-cell lymphoma (*e.g.*, mucosa-associated lymphoid tissue (MALT) lymphoma, nodal marginal zone B-cell lymphoma, splenic marginal zone B-cell lymphoma), primary mediastinal B-cell lymphoma, Burkitt's lymphoma, Waldenström's macroglobulinemia (WM, lymphoplasmacytic lymphoma), hairy cell leukemia (HCL), immunoblastic large cell lymphoma, precursor B-lymphoblastic lymphoma, central nervous system (CNS) lymphoma (*e.g.*, primary CNS lymphoma and secondary CNS lymphoma); and T-cell NHL, such as precursor T-lymphoblastic lymphoma/leukemia, peripheral T-cell lymphoma (PTCL) (*e.g.*, cutaneous T-cell lymphoma (CTCL) (*e.g.*, mycosis fungoides, Sezary syndrome), angioimmunoblastic T-cell lymphoma, extranodal natural killer T-cell lymphoma, enteropathy type T-cell lymphoma, subcutaneous panniculitis-like T-cell lymphoma, and anaplastic large cell lymphoma); lymphoma of an immune privileged site (*e.g.*, cerebral lymphoma, ocular lymphoma, lymphoma of the placenta, lymphoma of the fetus, testicular lymphoma); a mixture of one or more leukemia/lymphoma as described above; myelodysplasia; and multiple myeloma (MM).

[00124] The term “inflammatory disease” refers to a disease caused by, resulting from, or resulting in inflammation. The term “inflammatory disease” may also refer to a dysregulated inflammatory reaction that causes an exaggerated response by macrophages, granulocytes, and/or T-lymphocytes leading to abnormal tissue damage and/or cell death. An inflammatory disease can be either an acute or chronic inflammatory condition and can result from infections or non-infectious causes. Inflammatory diseases include, without limitation, atherosclerosis, arteriosclerosis, autoimmune disorders, multiple sclerosis, systemic lupus erythematosus, polymyalgia rheumatica (PMR), gouty arthritis, degenerative arthritis, tendonitis, bursitis, psoriasis, cystic fibrosis, arthrosteitis, rheumatoid arthritis, inflammatory arthritis, Sjogren's syndrome, giant cell arteritis, progressive systemic sclerosis (scleroderma), ankylosing spondylitis, polymyositis, dermatomyositis, pemphigus, pemphigoid, diabetes (*e.g.*, Type I), myasthenia gravis, Hashimoto's thyroiditis, Graves' disease, Goodpasture's disease, mixed connective tissue disease, sclerosing cholangitis, inflammatory bowel disease, Crohn's disease, ulcerative colitis, pernicious anemia,

inflammatory dermatoses, usual interstitial pneumonitis (UIP), asbestosis, silicosis, bronchiectasis, berylliosis, talcosis, pneumoconiosis, sarcoidosis, desquamative interstitial pneumonia, lymphoid interstitial pneumonia, giant cell interstitial pneumonia, cellular interstitial pneumonia, extrinsic allergic alveolitis, Wegener's granulomatosis and related forms of angiitis (temporal arteritis and polyarteritis nodosa), inflammatory dermatoses, hepatitis, delayed-type hypersensitivity reactions (*e.g.*, poison ivy dermatitis), pneumonia, respiratory tract inflammation, Adult Respiratory Distress Syndrome (ARDS), encephalitis, immediate hypersensitivity reactions, asthma, hay fever, allergies, acute anaphylaxis, rheumatic fever, glomerulonephritis, pyelonephritis, cellulitis, cystitis, chronic cholecystitis, ischemia (ischemic injury), reperfusion injury, allograft rejection, host-versus-graft rejection, appendicitis, arteritis, blepharitis, bronchiolitis, bronchitis, cervicitis, cholangitis, chorioamnionitis, conjunctivitis, dacryoadenitis, dermatomyositis, endocarditis, endometritis, enteritis, enterocolitis, epicondylitis, epididymitis, fasciitis, fibrositis, gastritis, gastroenteritis, gingivitis, ileitis, iritis, laryngitis, myelitis, myocarditis, nephritis, omphalitis, oophoritis, orchitis, osteitis, otitis, pancreatitis, parotitis, pericarditis, pharyngitis, pleuritis, phlebitis, pneumonitis, proctitis, prostatitis, rhinitis, salpingitis, sinusitis, stomatitis, synovitis, testitis, tonsillitis, urethritis, urocystitis, uveitis, vaginitis, vasculitis, vulvitis, vulvovaginitis, angitis, chronic bronchitis, osteomyelitis, optic neuritis, temporal arteritis, transverse myelitis, necrotizing fasciitis, and necrotizing enterocolitis.

[00125] An "autoimmune disease" refers to a disease arising from an inappropriate immune response of the body of a subject against substances and tissues normally present in the body. In other words, the immune system mistakes some part of the body as a pathogen and attacks its own cells. This may be restricted to certain organs (*e.g.*, in autoimmune thyroiditis) or involve a particular tissue in different places (*e.g.*, Goodpasture's disease which may affect the basement membrane in both the lung and kidney). The treatment of autoimmune diseases is typically with immunosuppression, *e.g.*, medications which decrease the immune response. Exemplary autoimmune diseases include, but are not limited to, glomerulonephritis, Goodpasture's syndrome, necrotizing vasculitis, lymphadenitis, peri-arteritis nodosa, systemic lupus erythematosus, rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus, psoriasis, ulcerative colitis, systemic sclerosis, dermatomyositis/polymyositis, anti-phospholipid antibody syndrome, scleroderma, pemphigus vulgaris, ANCA-associated vasculitis (*e.g.*, Wegener's granulomatosis, microscopic polyangiitis), uveitis, Sjogren's syndrome, Crohn's disease, Reiter's syndrome, ankylosing spondylitis, Lyme disease, Guillain-Barré syndrome, Hashimoto's thyroiditis, and cardiomyopathy.

[00126] The term “kinase” is a type of enzyme that transfers phosphate groups from high energy donor molecules, such as ATP, to specific substrates, referred to as phosphorylation. Kinases are part of the larger family of phosphotransferases. One of the largest groups of kinases are protein kinases, which act on and modify the activity of specific proteins. Kinases are used extensively to transmit signals and control complex processes in cells. Various other kinases act on small molecules such as lipids, carbohydrates, amino acids, and nucleotides, either for signaling or to prime them for metabolic pathways. Kinases are often named after their substrates. More than 500 different protein kinases have been identified in humans. Exemplary human protein kinases include, but are not limited to, AAK1, ABL, ACK, ACTR2, ACTR2B, AKT1, AKT2, AKT3, ALK, ALK1, ALK2, ALK4, ALK7, AMPKa1, AMPKa2, ANKRD3, ANPa, ANPb, ARAF, ARAFps, ARG, AurA, AurAps1, AurAps2, AurB, AurBps1, AurC, AXL, BARK1, BARK2, BIKE, BLK, BMPR1A, BMPR1Aps1, BMPR1Aps2, BMPR1B, BMPR2, BMX, BRAF, BRAFps, BRK, BRSK1, BRSK2, BTK, BUB1, BUBR1, CaMK1a, CaMK1b, CaMK1d, CaMK1g, CaMK2a, CaMK2b, CaMK2d, CaMK2g, CaMK4, CaMKK1, CaMKK2, caMLCK, CASK, CCK4, CCRK, CDC2, CDC7, CDK10, CDK11, CDK2, CDK3, CDK4, CDK4ps, CDK5, CDK5ps, CDK6, CDK7, CDK7ps, CDK8, CDK8ps, CDK9, CDKL1, CDKL2, CDKL3, CDKL4, CDKL5, CGDps, CHED, CHK1, CHK2, CHK2ps1, CHK2ps2, CK1a, CK1a2, CK1aps1, CK1aps2, CK1aps3, CK1d, CK1e, CK1g1, CK1g2, CK1g2ps, CK1g3, CK2a1, CK2a1-rs, CK2a2, CLIK1, CLIK1L, CLK1, CLK2, CLK2ps, CLK3, CLK3ps, CLK4, COT, CRIK, CRK7, CSK, CTK, CYGD, CYGF, DAPK1, DAPK2, DAPK3, DCAMKL1, DCAMKL2, DCAMKL3, DDR1, DDR2, DLK, DMPK1, DMPK2, DRAK1, DRAK2, DYRK1A, DYRK1B, DYRK2, DYRK3, DYRK4, EGFR, EphA1, EphA10, EphA2, EphA3, EphA4, EphA5, EphA6, EphA7, EphA8, EphB1, EphB2, EphB3, EphB4, EphB6, Erk1, Erk2, Erk3, Erk3ps1, Erk3ps2, Erk3ps3, Erk3ps4, Erk4, Erk5, Erk7, FAK, FER, FERps, FES, FGFR1, FGFR2, FGFR3, FGFR4, FGR, FLT1, FLT1ps, FLT3, FLT4, FMS, FRK, Fused, FYN, GAK, GCK, GCN2, GCN22, GPRK4, GPRK5, GPRK6, GPRK6ps, GPRK7, GSK3A, GSK3B, Haspin, HCK, HER2/ErbB2, HER3/ErbB3, HER4/ErbB4, HH498, HIPK1, HIPK2, HIPK3, HIPK4, HPK1, HRI, HRIps, HSER, HUNK, ICK, IGF1R, IKKa, IKKb, IKKe, ILK, INSR, IRAK1, IRAK2, IRAK3, IRAK4, IRE1, IRE2, IRR, ITK, JAK1, JAK2, JAK3, JNK1, JNK2, JNK3, KDR, KHS1, KHS2, KIS, KIT, KSGCps, KSR1, KSR2, LATS1, LATS2, LCK, LIMK1, LIMK2, LIMK2ps, LKB1, LMR1, LMR2, LMR3, LOK, LRRK1, LRRK2, LTK, LYN, LZK, MAK, MAP2K1, MAP2K1ps, MAP2K2, MAP2K2ps, MAP2K3, MAP2K4, MAP2K5, MAP2K6, MAP2K7, MAP3K1, MAP3K2, MAP3K3, MAP3K4, MAP3K5, MAP3K6, MAP3K7,

MAP3K8, MAPKAPK2, MAPKAPK3, MAPKAPK5, MAPKAPKps1, MARK1, MARK2, MARK3, MARK4, MARKps01, MARKps02, MARKps03, MARKps04, MARKps05, MARKps07, MARKps08, MARKps09, MARKps10, MARKps11, MARKps12, MARKps13, MARKps15, MARKps16, MARKps17, MARKps18, MARKps19, MARKps20, MARKps21, MARKps22, MARKps23, MARKps24, MARKps25, MARKps26, MARKps27, MARKps28, MARKps29, MARKps30, MAST1, MAST2, MAST3, MAST4, MASTL, MELK, MER, MET, MISR2, MLK1, MLK2, MLK3, MLK4, MLKL, MNK1, MNK1ps, MNK2, MOK, MOS, MPSK1, MPSK1ps, MRCKa, MRCKb, MRCKps, MSK1, MSK12, MSK2, MSK22, MSSK1, MST1, MST2, MST3, MST3ps, MST4, MUSK, MYO3A, MYO3B, MYT1, NDR1, NDR2, NEK1, NEK10, NEK11, NEK2, NEK2ps1, NEK2ps2, NEK2ps3, NEK3, NEK4, NEK4ps, NEK5, NEK6, NEK7, NEK8, NEK9, NIK, NIM1, NLK, NRBP1, NRBP2, NuaK1, NuaK2, Obscn, Obscn2, OSR1, p38a, p38b, p38d, p38g, p70S6K, p70S6Kb, p70S6Kps1, p70S6Kps2, PAK1, PAK2, PAK2ps, PAK3, PAK4, PAK5, PAK6, PASK, PBK, PCTAIRE1, PCTAIRE2, PCTAIRE3, PDGFRa, PDGFRb, PDK1, PEK, PFTAIRE1, PFTAIRE2, PHKg1, PHKg1ps1, PHKg1ps2, PHKg1ps3, PHKg2, PIK3R4, PIM1, PIM2, PIM3, PINK1, PITSLRE, PKACa, PKACb, PKACg, PKCa, PKCb, PKCd, PKCe, PKCg, PKCh, PKCi, PKCips, PKCt, PKCz, PKD1, PKD2, PKD3, PKG1, PKG2, PKN1, PKN2, PKN3, PKR, PLK1, PLK1ps1, PLK1ps2, PLK2, PLK3, PLK4, PRKX, PRKXps, PRKY, PRP4, PRP4ps, PRPK, PSKH1, PSKH1ps, PSKH2, PYK2, QIK, QSK, RAF1, RAF1ps, RET, RHOK, RIPK1, RIPK2, RIPK3, RNaseL, ROCK1, ROCK2, RON, ROR1, ROR2, ROS, RSK1, RSK12, RSK2, RSK22, RSK3, RSK32, RSK4, RSK42, RSKL1, RSKL2, RYK, RYKps, SAKps, SBK, SCYL1, SCYL2, SCYL2ps, SCYL3, SGK, SgK050ps, SgK069, SgK071, SgK085, SgK110, SgK196, SGK2, SgK223, SgK269, SgK288, SGK3, SgK307, SgK384ps, SgK396, SgK424, SgK493, SgK494, SgK495, SgK496, SIK(*e.g.*, SIK1, SIK2), skMLCK, SLK, Slob, smMLCK, SNRK, SPEG, SPEG2, SRC, SRM, SRPK1, SRPK2, SRPK2ps, SSTK, STK33, STK33ps, STLK3, STLK5, STLK6, STLK6ps1, STLK6-rs, SuRTK106, SYK, TAK1, TAO1, TAO2, TAO3, TBCK, TBK1, TEC, TESK1, TESK2, TGFbR1, TGFbR2, TIE1, TIE2, TLK1, TLK1ps, TLK2, TLK2ps1, TLK2ps2, TNK1, Trad, Trb1, Trb2, Trb3, Trio, TRKA, TRKB, TRKC, TSSK1, TSSK2, TSSK3, TSSK4, TSSKps1, TSSKps2, TTBK1, TTBK2, TTK, TTN, TXK, TYK2, TYK22, TYRO3, TYRO3ps, ULK1, ULK2, ULK3, ULK4, VACAMKL, VRK1, VRK2, VRK3, VRK3ps, Wee1, Wee1B, Wee1Bps, Wee1ps1, Wee1ps2, Wnk1, Wnk2, Wnk3, Wnk4, YANK1, YANK2, YANK3, YES, YESps, YSK1, ZAK, ZAP70, ZC1/HGK, ZC2/TNIK, ZC3/MINK, and ZC4/NRK.

[00127] The term “SRC family kinase” refers to a family of non-receptor tyrosine protein kinases that includes nine members: SRCA subfamily that includes c-SRC (proto-oncogene tyrosine-protein kinase SRC), YES (proto-oncogene tyrosine-protein kinase Yes), FYN (proto-oncogene tyrosine-protein kinase FYN), and FGR (Gardner-Rasheed feline sarcoma viral (v-FGR) oncogene homolog); SRCB subfamily that includes LCK (lymphocyte-specific protein tyrosine kinase), HCK (tyrosine-protein kinase HCK, hemopoietic cell kinase), BLK (tyrosine-protein kinase BLK), and LYN (tyrosine-protein kinase LYN); and FRK (Fyn-related kinase).

[00128] The term “CDK” refers to a cyclin-dependent kinase. A CDK binds a cyclin (*e.g.*, Cyclin H), which is a regulatory protein. CDKs phosphorylate their substrates at serines and threonines. The consensus sequence for the phosphorylation site in the amino acid sequence of a CDK substrate is [S/T*]PX[K/R], where S/T* is the phosphorylated serine or threonine, P is proline, X is any amino acid, K is lysine, and R is arginine. CDKs include CDK1, CDK2, CDK3, CDK4, CDK5, CDK6, CDK7, CDK8, CDK9, CDK10, CDK11, CDK12, CDK13, CDK14, CDK15, CDK16, CDK17, CDK18, CDK19 and CDK20.

[00129] CDK7, cyclin-dependent kinase 7, is a CDK, wherein the substrate is Cyclin H, MAT1 (*e.g.*, MNAT1), or Cyclin H and MAT1. CDK7 is alternatively referred to as CAK1, HCAK, MO15, STK1, CDKN7, and p39MO15. Non-limiting examples of the nucleotide and protein sequences for human CDK7 are described in GenBank Accession Number NP_001790, incorporated herein by reference. The amino acid sequence of this CDK7 is as follows:

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MALDVKSRAKRYEKLDFLGEGQFATVYKARDKNTNQIVAIAKKIKLGHRSEAKDGINRTAL
REIKLLQELSHPNIIIGLLDAFGHKSNIISLVDFMETDLEVIKDNSLVLTTPSHIKAYMLM
TLQGLEYLHQHWILHRDLKPNNLLLDENGVLKLADFGGLAKSFGSPNRAYTHQVVTRWYRA
PELLFGARMYGVGVDMWAVGCILAELLRLVPFLPGDSDDLQDLTRIFETLGTPTTEEQWPDM
CSLPDYVTFKSFPGIPLHHIFSAAGDLDLLIQLGLFLFNPCARITATQALKMKYFSNRPG
PTPGCQLPRNCPVETLKEQSNPALAIKRKRTEALEQGGLPKKLIF
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[00130] CDK12, cyclin-dependent kinase 12, is a CDK, wherein the substrate is Cyclin K or Flavopiridol. CDK12 is alternatively referred to as Cdc2-related kinase, CDC2-related protein kinase 7, Cell division cycle 2-related protein kinase 7, Cell division protein kinase 12, CRK7, CRKR, CRKRS, cyclin-dependent kinase 12, or KIAA0904. Non-limiting examples of the nucleotide and protein sequences for human CDK12 are described in Uniprot Number Q9NYV4, which is incorporated herein by reference. The amino acid sequence of this CDK12 is as follows:

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MPNSERHGGKKDGGSGASGTLQPSSGGGSSNSRERHRLVSKHKRHKSKHSDMGLVTPEA
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ASLGTVIKPLVEYDDISSDSTFSDDMAFKLDRRENDERRGSDRSDDLHKHRHHQHRRSR
 DLLKAKQTEKEKSQEVSSKSGSMKDRISSGSSKRSNEETDDYGKAQVAKSSSSKESRSSKLH
 KEKTRKERELKSGHKDRSKSHRKRETPKSYKTVDSPKRRSRSPHRKWSDDSSKQDDSPSGA
 SYGQDYDLSPSRSHSSNYDSYKKSPGSTSRRQSVSPPYKEPSAYQSSTRSPSPYSRRQR
 SVSPYSRRRSSSYERSGSGRSPSPYGRRRSSSPFLSKRSLRSPLPSRKSMKSRSRSP
 AYSRHSSSHSKKKRSSSRSRHSSISPVRLPLNSSLGAELSRKKKRAAAAAAAKMDGKES
 KGSPVFLPRKENS SVEAKDSGLESKKLPRSVKLEKSAPDTELNVNTHLNTTEVKNSSDTGK
 VKLDENSEKHLVKDLKAQGTRDSKPIALKEEIVTPKETETSEKETPPPLPTIASPPPPPLP
 TTTPPPQTPPLPPLPPIPALPQQPPLPPSQPAFSQVPASSTSTLPPSTHSTSAVSSQAN
 SQPPVQVSVKTQVSVTAAI PHLKTSTLPPPLPPLLPGLDDMDSPKETLPSKPVKKEKEQ
 RTRHLLTDLPLPPELPGGDLSPDSEPKAITPPQQPYKKRPKICCPRYGERRQTESDWG
 KRCVDKFDIIGIIGEGTYGQVYKAKDKDTGELVALKKVRLDNEKEGFPITAIKILRQ
 LIHRSVVMKEIVTDKQDALDFKKDKGAFYLVFEYMDHDLMLGLLESGLVHFSEDHIKFSM
 KQLMEGLEYCHKKNFLHRDIKCSNILLNNSGQIKLADFGRLARLYNSEESRPYTNKVITLW
 YRPELLELLGEERYTPAIDVWSCGICLGELEFTKKPIFQANLELAQLELISRLCGSPCPAVW
 PDVIKLPYFNTMKPKKQYRRRLREEFSFIPSAALDLDHMLTLDPSKRCTAEQTLQSDFL
 KDVELSKMAPDLPWHQDCHELWSKKRRRQRQSGVVVEEPPPSKTSRKETTSGTSTEPVK
 NSSPAPPQPAPGKVESGAGDAIGLADITQQLNQSELAVLLNLLQSQTDL SIPQMAQLLNI
 HSNPEMQQLEALNQSISALTEATSQQQDSETMAPEESLKEAPSAPVILPSAEQTTLEAS
 STPADMQNILAVLLSQLMKTQEPAGSLEENNSDKNSGPQGPRRTPTMPQEEAAACPPHIL
 PPEKRPPPEPPGPPPPPPPPPLVEGDLSSAPQELNPAVTAALLQLLSQPEAEPPGHLPHHEH
 QALRPMEYSTRPRPNRTYGN TDGPETGFS AIDTDERN SGPALTESLVQTLVKNRTFSGSL
 SHLGESSSYQGTGSVQFPGDQDLRFARVPLALHPVVGQPFLKAEGSSNSVVAETKLQNY
 GELGPGTTGASSSGAGLHWGGPTQSSAYGKLYRGPTRVPPRGGRGRGVY

[00131] CDK13, cyclin-dependent kinase 13, is a CDK, wherein the relevant cyclin is cyclin K and a reference inhibitor is the pan-CDK inhibitor Flavopiridol and the c-terminal domain (CTD) of RNA-polymerase II is a physiological substrate. CDK13 is alternatively referred to as CHED; CDC2L; CDC2L5; or hCDK13. Non-limiting examples of the nucleotide and protein sequences for human CDK12 are described in GenBank Accession Number M80629, which is incorporated herein by reference. The amino acid sequence of this CDK13 is as follows:

MPSSSDTALGGGGGLSWAEKKLEERRKRRRFLSPQQPPLLLPLLQPQLLQPPPPPPPLLF
 LAAPGTAAAAAAAASSSCFSPGPPLEVKRLARGKRRAGGRQKRRRGPRAGQEA EKRRV
 FSLPQPQQDGGGGASSGGVTPLEVEDVSSQSEQGLLLGGASAATAATAAGGTGGSGGS
 PASSSGTQRRGEGSERPRRRDRSSSGRSKERHREHRRRDGQRGGSEASKSRSRHSHSGE
 ERAEVAKSGSSSSSGRRKSASATSSSSSSRKDRDSKAHRSRTKSSKEPPSAYKEPPKAY
 REDKTEPKAYRRRRSLSP LGGRDDSPVSHRASQSLRSRKSPSPAGGGSSPYSRRLPRSPS
 PYSRRRSPSYSRHSSYERGGDVSPSPYSSSSWRRSRSPYSPVLRSGKSRSRSPYSSRHS

RSRSRHRLSRSRSRHSSISPSTLTLLKSSLAELNKNKKARAAEAARAAEAAKAAEATKAA
 EAAAKAASNTSTPTKNTETSASASQTNHVKDVKKIKIEHAPSPSSGGTLKNDKAKTK
 PPLQVTKVENNLIVDKATKKAVIVGKESKSAATKEESVSLKEKTKPLTPSIGAKEKEQHV
 ALVTSTLPLPLPLPMLPEDKEADSLRGNISVKAVKKEVEKKLRCLLADLPLPPELPGGDD
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DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS OF THE INVENTION

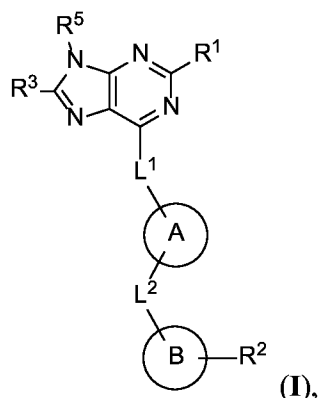
[00132] Cyclin dependent kinases (CDKs) are key regulators of the cell cycle. Their successive activation and inactivation drives the cycle forward. The activity of CDKs is regulated by multiple mechanisms such as positive and negative phosphorylation, binding of regulatory proteins like cyclins, and CDK inhibitors. CDK7 plays a critical role in the regulation of RNA polymerase II-mediated transcription of protein-encoding genes. Disruption of CDK7, CDK12, and/or CDK13 signaling cause defects in transcription. However, a complete understanding of how these disruptions affect global transcription is lacking. Furthermore, the absence of selective inhibitors of CDK7, CDK12, and CDK13 has hindered investigation of the transcriptional and functional consequences of acute and long-term inhibition of these kinases under normal and pathological conditions. The present invention provides selective CDK7, CDK12, and/or CDK13 inhibitors and analogs, which have the ability to covalently modify a cysteine residue located outside of the canonical kinase domain (*i.e.*, Cys312 of CDK7, Cys1039 of CDK12, and Cys1017 of CDK13). Selective covalent inhibitors of these kinases may be useful in the treatment of various proliferative diseases including cancer.

[00133] The present invention provides compounds, which inhibit the activity of a kinase, for the prevention and/or treatment of a subject with a proliferative disease. In certain embodiments, the inventive compounds inhibit the activity of cyclin-dependent kinase (CDK). In certain embodiments, the inventive compounds inhibit the activity of a cyclin-dependent kinase 7 (CDK7). In certain embodiments, the inventive compounds inhibit the activity of a cyclin-dependent kinase 12 (CDK12). In certain embodiments, the inventive compounds inhibit the activity of a cyclin-dependent kinase 13 (CDK13). The present invention also provides methods of using the compounds described herein, *e.g.*, as biological probes to study the inhibition of the activity of a kinase (*e.g.*, CDK (*e.g.* CDK7, CDK12, and/or CDK13)), and as therapeutics, *e.g.*, in the prevention and/or treatment of diseases associated with the overexpression and/or aberrant activity of a kinase (*e.g.*, CDK (*e.g.* CDK7, CDK12, and/or CDK13)). In certain embodiments, the diseases are proliferative diseases. The proliferative diseases that may be treated and/or prevented include, but are not limited to, cancers (*e.g.*, breast cancer, leukemia, melanoma, multiple myeloma), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases. Also provided by the present disclosure are pharmaceutical compositions, kits, methods, and uses including a compound of Formula (I) as described herein.

Compounds

[00134] Aspects of the present disclosure relate to the compounds described herein. The compounds described herein are purine, pyrazolo-triazine, and pyrazolo-pyrimidine containing compounds that are useful in treating and/or preventing proliferative diseases in a subject, inhibiting the activity of a protein kinase (*e.g.*, CDK) in a subject or biological sample, and inducing apoptosis of a cell. In certain embodiments, a compound described herein is a compound of any one of Formulae (I)-(III), or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof. In certain embodiments, a compound described herein is a compound of Formula (I), or a pharmaceutically acceptable salt thereof. In certain embodiments, a compound described herein is a compound of Formula (II), or a pharmaceutically acceptable salt thereof. In certain embodiments, a compound described herein is a compound of Formula (III), or a pharmaceutically acceptable salt thereof.

[00135] In certain embodiments, a compound described herein is of Formula (I):



or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-NR^aR^b$, $-OR^b$, $-SR^b$, $-C(=O)R^b$, $-C(=O)OR^b$, or $-C(=O)NR^aR^b$, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

R^3 is hydrogen, halogen, or optionally substituted C_1 - C_6 alkyl;

R^5 is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

L^1 is a bond, $-NR^{L1}-(CH_2)_t-$, $-O-$, or $-S-$;

R^{L1} is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

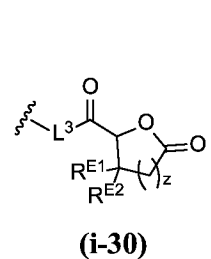
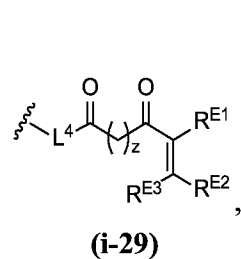
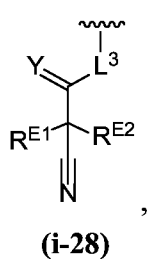
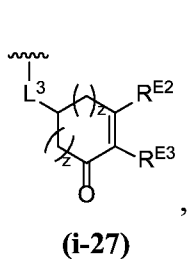
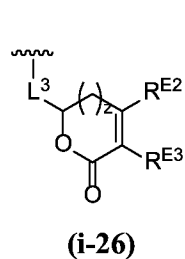
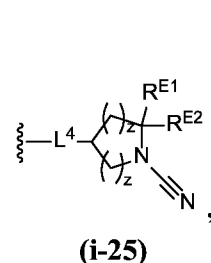
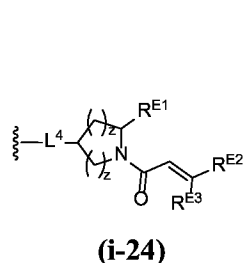
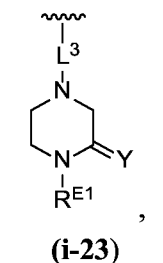
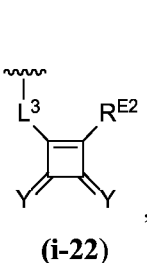
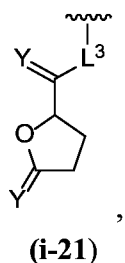
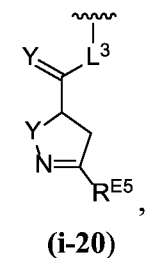
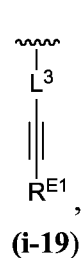
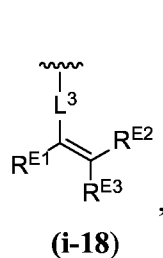
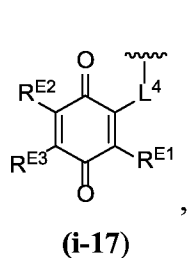
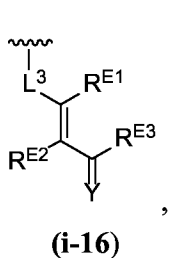
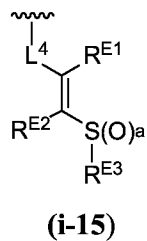
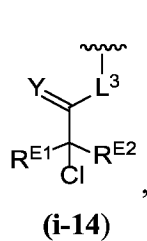
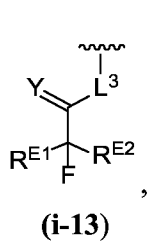
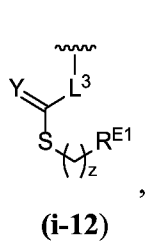
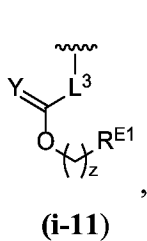
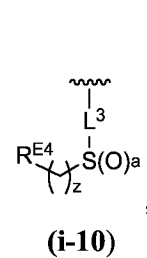
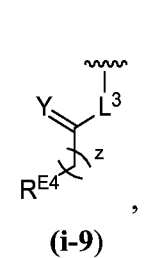
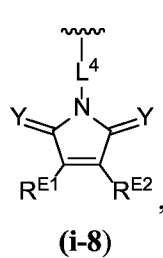
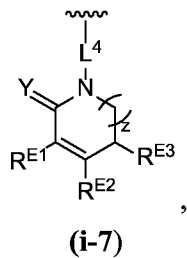
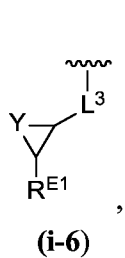
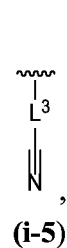
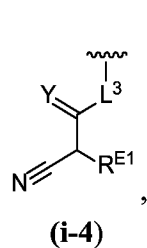
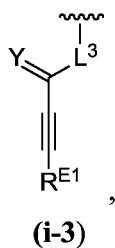
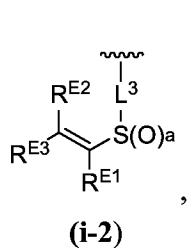
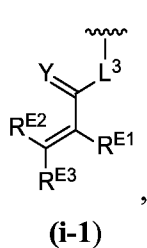
t is 0 or an integer between 1 and 5, inclusive;

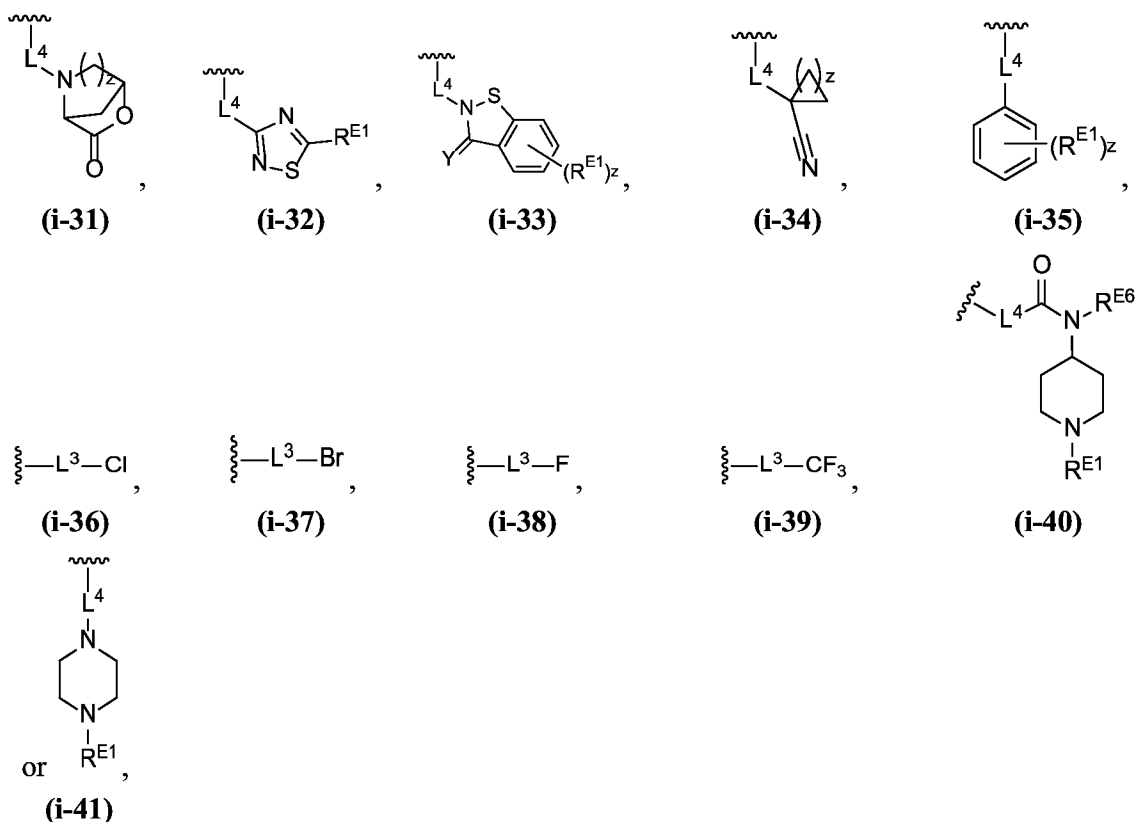
Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl;

L^2 is a bond, optionally substituted C_{1-4} alkylene, $-C(=O)-$, $-NR^{L2}-$, $-C(=O)NR^{L2}-$, $-NR^{L2}C(=O)-$, $-O-$, or $-S-$, wherein R^{L2} is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protection group;

Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and

R^2 is any of Formulae (i-1)-(i-41):





wherein:

L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C(=O)-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain;

each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, $-CN$, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$,

and $-SR^{EE}$, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring; or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

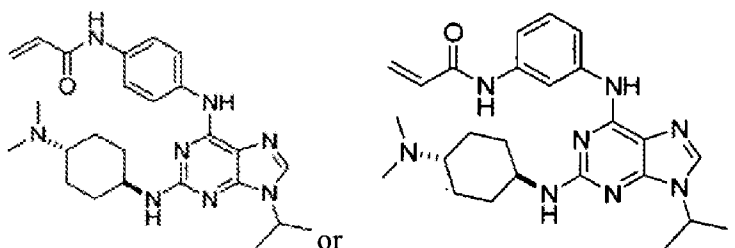
R^{E5} is halogen;

R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

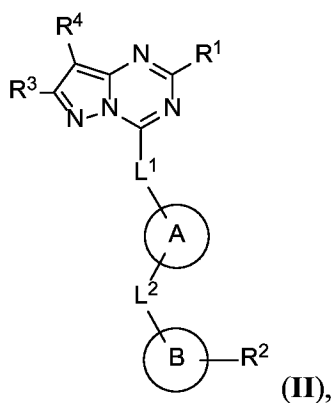
each instance of Y is independently O, S, or NR^{E7} , wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits; and provided that the compound is not



[00136] In certain embodiments, a compound described herein is of Formula (II):



or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted

heterocyclyl, optionally substituted heteroaryl, $-\text{NR}^a\text{R}^b$, $-\text{OR}^b$, $-\text{SR}^b$, $-\text{C}(=\text{O})\text{R}^b$, $-\text{C}(=\text{O})\text{OR}^b$, or $-\text{C}(=\text{O})\text{NR}^a\text{R}^b$, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

each of R^3 and R^4 is independently hydrogen, halogen, or optionally substituted $\text{C}_1\text{-C}_6$ alkyl;

L^1 is a bond, $-\text{NR}^{\text{L}1}(\text{CH}_2)_t-$, $-\text{O}-$, or $-\text{S}-$;

$\text{R}^{\text{L}1}$ is hydrogen, optionally substituted $\text{C}_1\text{-C}_6$ alkyl, or a nitrogen protecting group;

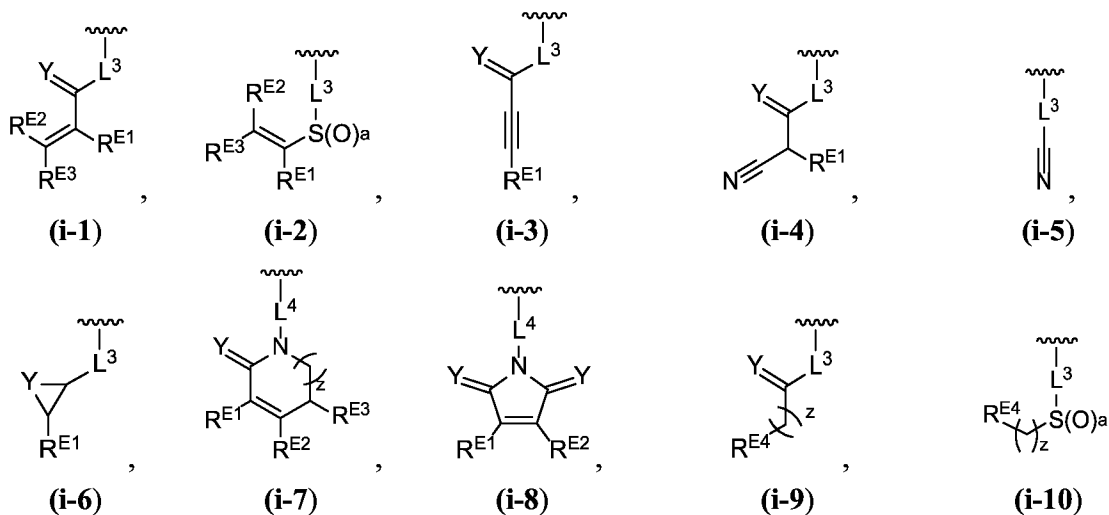
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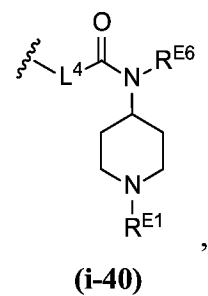
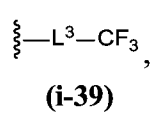
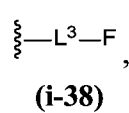
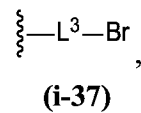
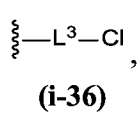
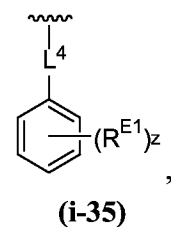
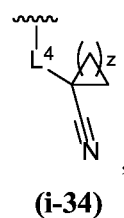
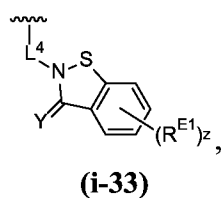
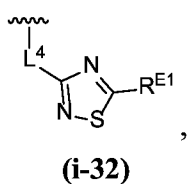
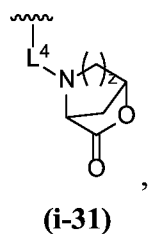
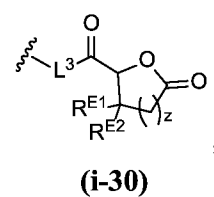
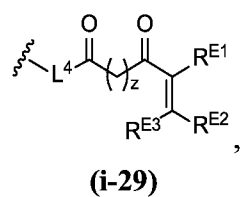
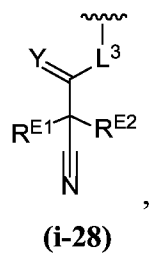
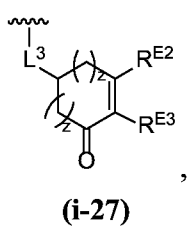
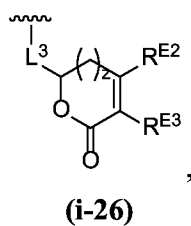
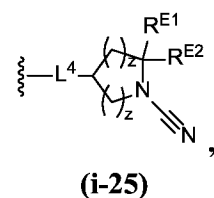
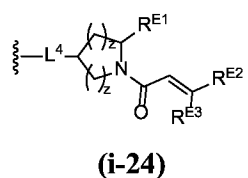
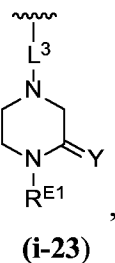
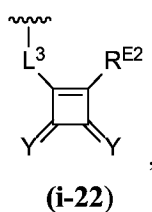
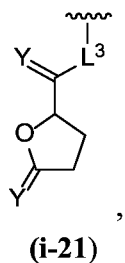
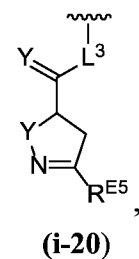
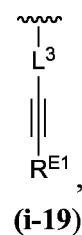
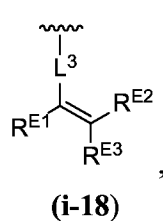
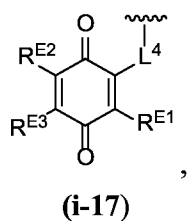
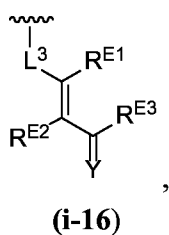
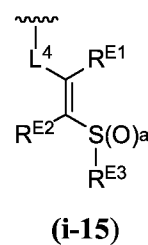
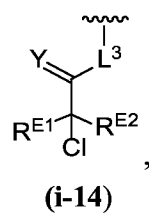
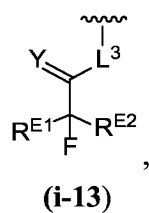
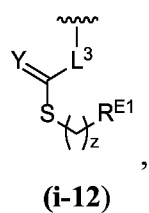
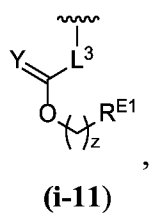
Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl;

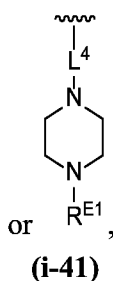
L^2 is a bond, optionally substituted C_{1-4} alkylene, $-\text{C}(=\text{O})-$, $-\text{NR}^{\text{L}2}-$, $-\text{C}(=\text{O})\text{NR}^{\text{L}2}-$, $-\text{NR}^{\text{L}2}\text{C}(=\text{O})-$, $-\text{O}-$, or $-\text{S}-$, wherein $\text{R}^{\text{L}2}$ is hydrogen, optionally substituted $\text{C}_1\text{-C}_6$ alkyl, or a nitrogen protection group;

Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and

R^2 is any of Formulae (i-1)-(i-41):







wherein:

L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C=O-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain;

each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, $-CN$, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, and $-SR^{EE}$, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring;

or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

R^{E5} is halogen;

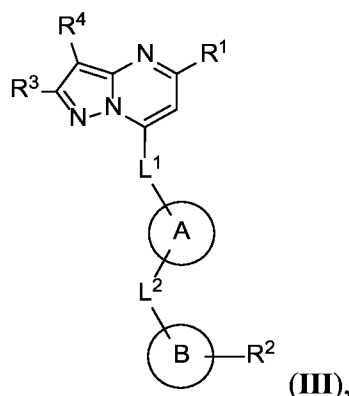
R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

each instance of Y is independently O, S, or NR^{E7} , wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits.

[00137] In certain embodiments, a compound described herein is of Formula (III):



or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-NR^aR^b$, $-OR^b$, $-SR^b$, $-C(=O)R^b$, $-C(=O)OR^b$, or $-C(=O)NR^aR^b$, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

each of R^3 and R^4 is independently hydrogen, halogen, or optionally substituted C_1-C_6 alkyl;

L^1 is a bond, $-NR^{L1}-(CH_2)_t-$, $-O-$, or $-S-$;

R^{L1} is hydrogen, optionally substituted C_1-C_6 alkyl, or a nitrogen protecting group;

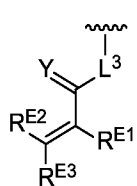
t is 0 or an integer between 1 and 5, inclusive;

Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl;

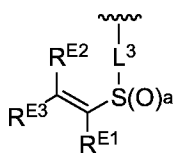
L^2 is a bond, optionally substituted C_{1-4} alkylene, $-C(=O)-$, $-NR^{L^2}-$, $-C(=O)NR^{L^2}-$, $-NR^{L^2}C(=O)-$, $-O-$, or $-S-$, wherein R^{L^2} is hydrogen, optionally substituted C_1-C_6 alkyl, or a nitrogen protection group;

Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and

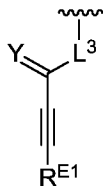
R^2 is any of Formulae (i-1)-(i-41):



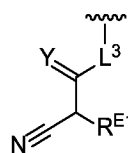
(i-1)



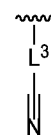
(i-2)



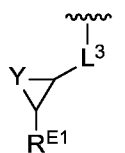
(i-3)



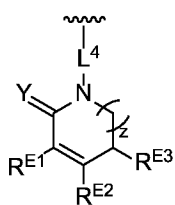
(i-4)



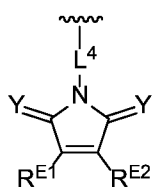
(i-5)



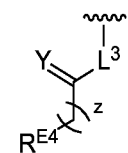
(i-6)



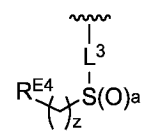
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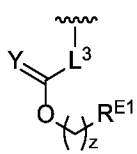
(i-8)



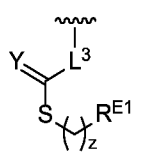
(i-9)



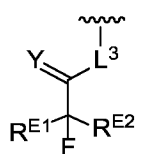
(i-10)



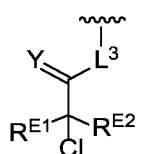
(i-11)



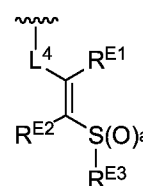
(i-12)



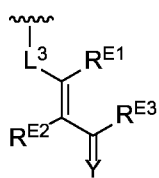
(i-13)



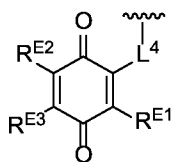
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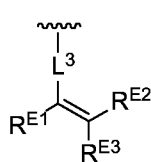
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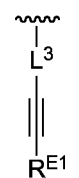
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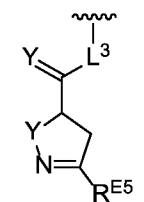
(i-17)



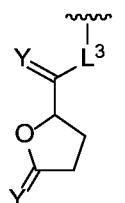
(i-18)



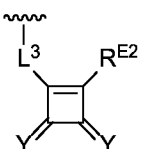
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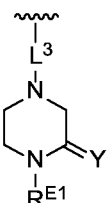
(i-20)



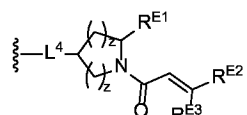
(i-21)



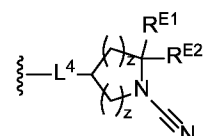
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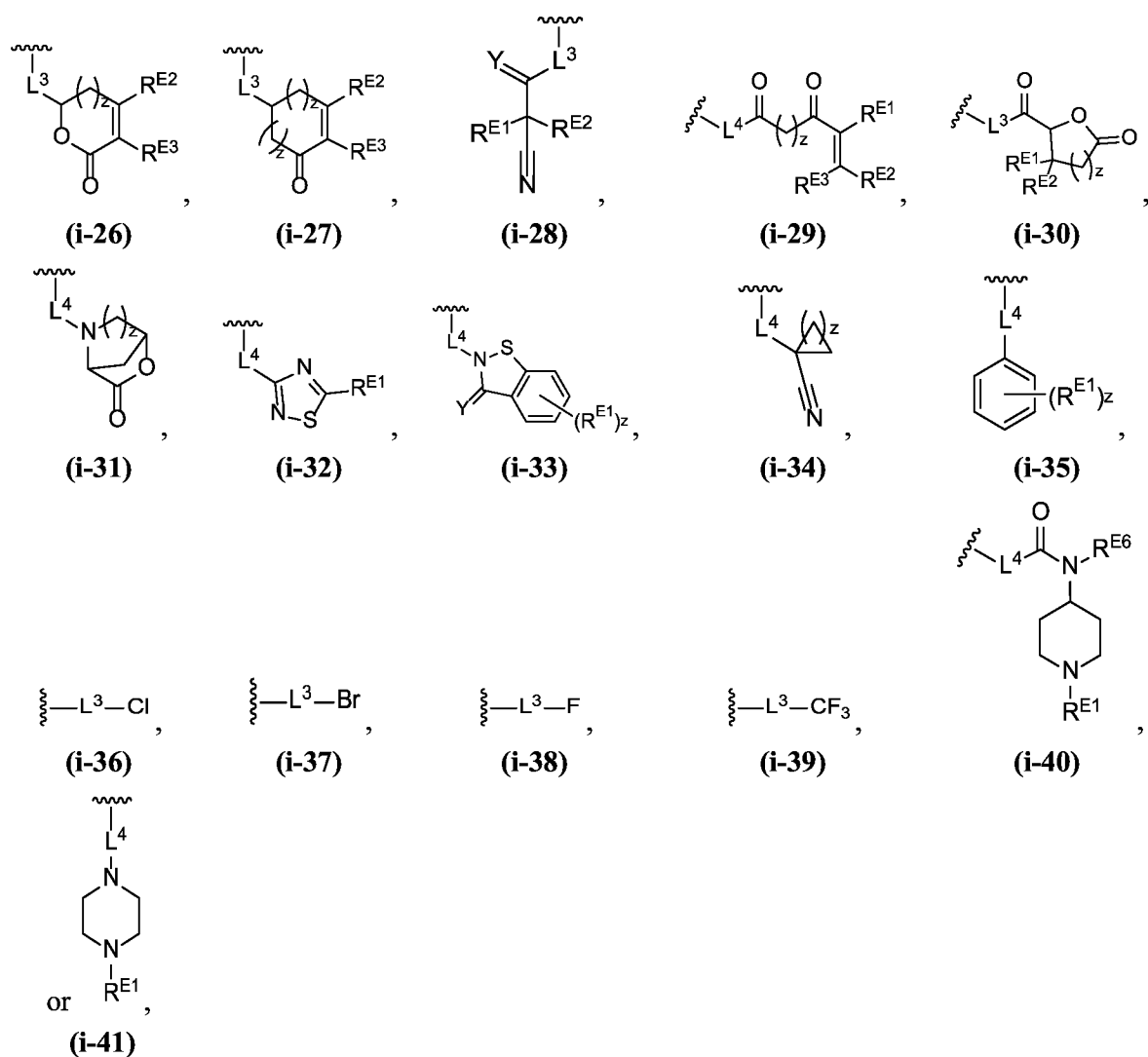
(i-23)



(i-24)



(i-25)



L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C(=O)-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain;

each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, -CN, -CH₂OR^{EE}, -CH₂N(R^{EE})₂, -CH₂SR^{EE}, -OR^{EE}, -N(R^{EE})₂, -Si(R^{EE})₃, and -SR^{EE}, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring;

or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

R^{E5} is halogen;

R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

each instance of Y is independently O, S, or NR^{E7}, wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits.

[00138] As generally defined herein in Formulae (I)-(III), R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, -NR^aR^b, -OR^b, -SR^b, -C(=O)R^b, -C(=O)OR^b, or -C(=O)NR^aR^b, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring.

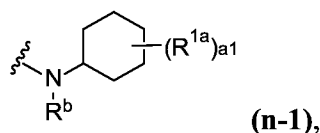
[00139] In certain embodiments, R^1 is optionally substituted alkyl. In certain embodiments, R^1 is unsubstituted alkyl. In certain embodiments, R^1 is substituted alkyl. In certain

embodiments, R^1 is substituted alkyl. In certain embodiments, R^1 is optionally substituted carbocyclalkyl, optionally substituted arylalkyl, optionally substituted heterocyclalkyl, or optionally substituted heteroarylalkyl. In certain embodiments, R^1 is optionally substituted heteroaryl. In certain embodiments, R^1 is optionally substituted monocyclic heteroaryl. In certain embodiments, R^1 is optionally substituted 5-membered heteroaryl. In certain embodiments, R^1 is optionally substituted 6-membered heteroaryl. In certain embodiments, R^1 is optionally substituted heterocycl. In certain embodiments, R^1 is optionally substituted monocyclic heterocycl. In certain embodiments, R^1 is optionally substituted 5-membered heterocycl. In certain embodiments, R^1 is optionally substituted 6-membered heterocycl. In certain embodiments, R^1 is $-OR^b$, wherein R^b is as defined herein. In certain embodiments, R^1 is $-OR^b$, wherein R^b is optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted heteroaryl, or an oxygen protecting group. In certain embodiments, R^1 is $-SR^b$, wherein R^b is as defined herein. In certain embodiments, R^1 is $-SR^b$, wherein R^b is optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted heteroaryl, or a sulfur protecting group. In certain embodiments, R^1 is $-C(=O)R^b$, wherein R^b is as defined herein. In certain embodiments, R^1 is $-C(=O)R^b$, wherein R^b is optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted heteroaryl. In certain embodiments, R^1 is $-C(=O)OR^b$, wherein R^b is as defined herein. In certain embodiments, R^1 is $-C(=O)OR^b$, wherein R^b is optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted heteroaryl, or an oxygen protecting group. In certain embodiments, R^1 is $C(=O)NR^aR^b$, wherein R^a and R^b are as defined herein. In certain embodiments, R^1 is $C(=O)NR^aR^b$, wherein each instance of R^a and R^b is independently optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group, or R^a and R^b are taken together with the nitrogen to form an optionally substituted heterocycl ring. In certain embodiments, R^1 is $C(=O)NR^aR^b$, wherein R^a is hydrogen or optionally substituted alkyl, and R^b is independently optionally substituted alkyl, optionally substituted carbocycl, optionally substituted aryl, optionally substituted heterocycl, optionally substituted aryl, optionally substituted

heteroaryl, or a nitrogen protecting group, or R^a and R^b are taken together with the nitrogen to form an optionally substituted heterocyclyl ring.

[00140] In certain embodiments, R^1 is $-NR^aR^b$, wherein R^a and R^b are as defined herein. In certain embodiments, R^1 is $-NR^aR^b$, wherein each of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted carbocyclyl, or a nitrogen protecting group. In certain embodiments, R^1 is $-NR^aR^b$, wherein R^a is hydrogen, optionally substituted alkyl, or optionally substituted carbocyclyl; and R^b is independently hydrogen, optionally substituted alkyl, or a nitrogen protecting group.

[00141] In certain embodiments of Formulae (I)-(III), R^1 is of Formula (n-1):



wherein:

each instance of R^{1a} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

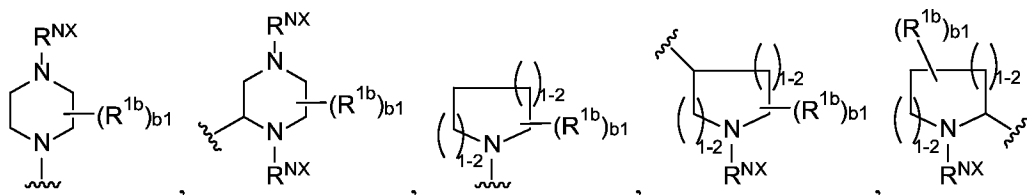
$a1$ is 0 or an integer between 1 and 6, inclusive.

[00142] In certain embodiments, $a1$ is 1. In certain embodiments, $a1$ is 2. In certain embodiments, $a1$ is 3.

[00143] In certain embodiments, R^{1a} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is methyl or ethyl. In certain embodiments, R^{1a} is substituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is hydroxy C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-CH_2OH$. In certain embodiments, R^{1a} is $-CH_2CH_2OH$. In certain embodiments, R^{1a} is $-N(R^{N1})_2$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is hydrogen or optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-NH_2$. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1a} is $-NHCH_3$. In certain embodiments, R^{1a} is $-NHR^{N1}$, wherein R^{N1} is a nitrogen protecting group. In certain embodiments, R^{1a} is $-N(CH_3)R^{N1}$,

wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-N(CH_3)R^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1a} is $-N(CH_3)R^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1a} is $-N(CH_3)_2$. In certain embodiments, R^{1a} is $-N(CH_3)R^{N1}$, wherein R^{N1} is a nitrogen protecting group.

[00144] In certain embodiments of Formulae (I)-(III), R^1 is $-NR^aR^b$, wherein R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring. In certain embodiments, R^1 is of one of the following formulae:



wherein:

each instance of R^{NX} is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, or a nitrogen protecting group;

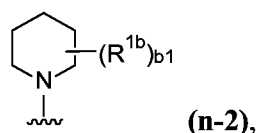
each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

$b1$ is 0 or an integer between 1 and 6, inclusive, as valency permits.

[00145] In certain embodiments, R^1 is of Formula (n-2):



wherein:

each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

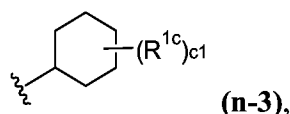
b1 is 0 or an integer between 1 and 6, inclusive.

[00146] In certain embodiments, b1 is 1. In certain embodiments, b1 is 2. In certain embodiments, b1 is 3.

[00147] In certain embodiments, R^{1b} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is methyl or ethyl. In certain embodiments, R^{1b} is substituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is hydroxy C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-CH_2OH$. In certain embodiments, R^{1b} is $-CH_2CH_2OH$. In certain embodiments, R^{1b} is $-N(R^{N1})_2$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is hydrogen or optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-NH_2$. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1b} is $-NHCH_3$. In certain embodiments, R^{1b} is $-NHR^{N1}$, wherein R^{N1} is a nitrogen protecting group. In certain embodiments, R^{1b} is $-N(CH_3)R^{N1}$, wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-N(CH_3)R^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1b} is $-N(CH_3)R^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1b} is $-N(CH_3)_2$. In certain embodiments, R^{1b} is $-N(CH_3)R^{N1}$, wherein R^{N1} is a nitrogen protecting group.

[00148] In certain embodiments, R^{NX} is hydrogen. In certain embodiments, R^{NX} is optionally substituted alkyl. In certain embodiments, R^{NX} is unsubstituted C_1 - C_6 alkyl (*e.g.* methyl or ethyl). In certain embodiments, R^{NX} is substituted C_1 - C_6 alkyl. In certain embodiments, R^{NX} is a nitrogen protecting group.

[00149] In certain embodiments of Formulae (I)-(III), R^1 is optionally substituted carbocyclyl. In certain embodiments, R^1 is optionally substituted monocyclic carbocyclyl. In certain embodiments, R^1 is optionally substituted cyclopentyl. In certain embodiments, R^1 is optionally substituted cyclohexyl of Formula (n-3)



wherein:

each instance of R^{1c} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

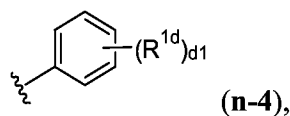
R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

c1 is 0 or an integer between 1 and 6, inclusive.

[00150] In certain embodiments, c1 is 1. In certain embodiments, c1 is 2. In certain embodiments, c1 is 3.

[00151] In certain embodiments, R^{1c} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is methyl or ethyl. In certain embodiments, R^{1c} is substituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is hydroxy C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-CH_2OH$. In certain embodiments, R^{1c} is $-CH_2CH_2OH$. In certain embodiments, R^{1c} is $-N(R^{N1})_2$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is as defined herein. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is hydrogen or optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-NH_2$. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1c} is $-NHCH_3$. In certain embodiments, R^{1c} is $-NHR^{N1}$, wherein R^{N1} is a nitrogen protecting group. In certain embodiments, R^{1c} is $-N(CH_3)R^{N1}$, wherein R^{N1} is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-N(CH_3)R^{N1}$, wherein R^{N1} is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^{1c} is $-N(CH_3)R^{N1}$, wherein R^{N1} is methyl or ethyl. In certain embodiments, R^{1c} is $-N(CH_3)_2$. In certain embodiments, R^{1c} is $-N(CH_3)R^{N1}$, wherein R^{N1} is a nitrogen protecting group.

[00152] In certain embodiments of Formulae (I)-(III), R^1 is optionally substituted aryl. In certain embodiments, R^1 is optionally substituted monocyclic aryl. In certain embodiments, R^1 is optionally substituted phenyl of Formula (n-4)



wherein:

each instance of R^{1d} is independently hydrogen, halogen, $-CN$, $-NO_2$, $-N_3$, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-OR^A$, $-N(R^B)_2$, $-SR^A$, $-C(=O)R^C$, $-C(=O)OR^A$, $-OC(=O)R^C$,

$-C(=O)N(R^B)_2$, $-NR^B C(=O)R^C$, $-OC(=O)N(R^B)_2$, $-NR^B C(=O)OR^A$, $-NR^B C(=O)N(R^B)_2$, $S(=O)R^C$, $-SO_2R^C$, $-NR^B SO_2R^C$, or $-SO_2N(R^B)_2$;

each instance of R^A is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur;

each instance of R^B is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted acyl, or a nitrogen protecting group, or two R^B groups are taken together with their intervening atoms to form an optionally substituted heterocyclic ring; and

$d1$ is 0 or an integer between 1 and 5, inclusive.

[00153] In certain embodiments, $d1$ is 0. In certain embodiments, $d1$ is 1. In certain embodiments, $d1$ is 2. In certain embodiments, $d1$ is 3.

[00154] In certain embodiments, R^{1d} is hydrogen. In certain embodiments, R^{1d} is halogen (*e.g.* F, Cl, Br, or I). In certain embodiments, R^{1d} is optionally substituted alkyl. In certain embodiments, R^{1d} is unsubstituted alkyl. In certain embodiments, R^{1d} is methyl or ethyl.

[00155] As generally defined herein in Formulae (I)-(III), R^3 is hydrogen, halogen, or optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^3 is hydrogen. In certain embodiments, R^3 is halogen (*e.g.* F, Cl, Br, or I). In certain embodiments, R^3 is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^3 is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^3 is methyl, ethyl, *n*-propyl, or isopropyl. In certain embodiments, R^3 is substituted C_1 - C_6 alkyl.

[00156] As generally defined herein in Formulae (II)-(III), R^4 is hydrogen, halogen, or optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^4 is hydrogen. In certain embodiments, R^4 is halogen (*e.g.* F, Cl, Br, or I). In certain embodiments, R^4 is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^4 is unsubstituted C_1 - C_6 alkyl. In certain embodiments, R^4 is methyl, ethyl, *n*-propyl, or isopropyl. In certain embodiments, R^4 is substituted C_1 - C_6 alkyl.

[00157] As generally defined herein in Formula (I), R^5 is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group. In certain embodiments, R^5 is hydrogen. In certain embodiments, R^5 is optionally substituted C_1 - C_6 alkyl. In certain embodiments, R^5 is

unsubstituted C₁-C₆ alkyl. In certain embodiments, R⁵ is methyl, ethyl, *n*-propyl, or isopropyl. In certain embodiments, R⁵ is substituted C₁-C₆ alkyl. In certain embodiments, R⁵ is nitrogen protecting group. In certain embodiments, R⁵ is nitrogen protecting group.

[00158] As generally defined herein in Formulae (I)-(III), L¹ is a bond, -NR^{L1}-(CH₂)_t-, -O-, or -S-, wherein R^{L1} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group, wherein t is 0 or an integer between 1 and 5, inclusive. In certain embodiments, L¹ is a bond. In certain embodiments, L¹ is -O-. In certain embodiments, L¹ is -S-. In certain embodiments, L¹ is -NR^{L1}-(CH₂)_t-, wherein R^{L1} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group. In certain embodiments, t is 0. In certain embodiments, t is 1. In certain embodiments, t is 2. In certain embodiments, t is 3. In certain embodiments, t is 4. In certain embodiments, t is 5. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group. In certain embodiments, L¹ is -NH-. In certain embodiments, L¹ is -NH-. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is optionally substituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is unsubstituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is methyl or ethyl. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is substituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-, wherein R^{L1} is a nitrogen protecting group (*e.g.* Boc). In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group. In certain embodiments, L¹ is -NHCH₂-. In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is optionally substituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is unsubstituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is methyl or ethyl. In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is substituted C₁-C₆ alkyl. In certain embodiments, L¹ is -NR^{L1}-CH₂-, wherein R^{L1} is a nitrogen protecting group (*e.g.* Boc).

[00159] As generally defined herein in Formulae (I)-(III), L² is a bond, optionally substituted C₁₋₄ alkylene, -C(=O)-, -NR^{L2}-, -C(=O)NR^{L2}-, -NR^{L2}C(=O)-, -O-, or -S-, wherein R^{L2} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protection group. In certain embodiments, L² is a bond. In certain embodiments, L² is -O-. In certain embodiments, L² is -S-. In certain embodiments, L² is optionally substituted C₁₋₄ alkylene. In certain embodiments, L² is unsubstituted C₁₋₄ alkylene. In certain embodiments, L² is -CH₂-. In certain embodiments, L² is -(CH₂)₂-. In certain embodiments, L² is -(CH₂)₃-. In certain embodiments, L² is -(CH₂)₄-. In certain embodiments, L² is -C(=O)-. In certain embodiments, L² is -NR^{L2}-, wherein R^{L2} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen

protecting group. In certain embodiments, L^2 is -NH-. In certain embodiments, L^2 is -NH-. In certain embodiments, L^2 is -NR^{L2}-, wherein R^{L2} is optionally substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}-, wherein R^{L2} is unsubstituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}-, wherein R^{L2} is methyl or ethyl. In certain embodiments, L^2 is -NR^{L2}-, wherein R^{L2} is substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}-, wherein R^{L2} is a nitrogen protecting group (*e.g.* Boc). In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group. In certain embodiments, L^2 is -C(=O)NH-. In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is optionally substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is unsubstituted C₁-C₆ alkyl. In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is methyl or ethyl. In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -C(=O)NR^{L2}-, wherein R^{L2} is a nitrogen protecting group (*e.g.* Boc). In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group. In certain embodiments, L^2 is -NHC(=O)-. In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is optionally substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is unsubstituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is methyl or ethyl. In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is substituted C₁-C₆ alkyl. In certain embodiments, L^2 is -NR^{L2}C(=O)-, wherein R^{L2} is a nitrogen protecting group (*e.g.* Boc).

[00160] In certain embodiments of Formula (I), R³ is hydrogen and R⁵ is optionally substituted C₁-C₆ alkyl or a nitrogen protecting group. In certain embodiments of Formula (I), R³ is hydrogen and R⁵ is optionally substituted C₁-C₆ alkyl. In certain embodiments of Formula (I), R³ is hydrogen and R⁵ is unsubstituted C₁-C₆ alkyl. In certain embodiments of Formula (I), R³ is hydrogen and R⁵ is methyl, ethyl, n-propyl, or isopropyl.

[00161] In certain embodiments of Formula (II) or (III), R³ is hydrogen and R⁴ is optionally substituted C₁-C₆ alkyl or a nitrogen protecting group. In certain embodiments of Formula (II) or (III), R³ is hydrogen and R⁴ is optionally substituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R³ is hydrogen and R⁴ is unsubstituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R³ is hydrogen and R⁴ is methyl, ethyl, n-propyl, or isopropyl.

[00162] In certain embodiments of Formula (I), R¹ is optionally substituted carbocyclyl; R³ is hydrogen; and R⁵ is optionally substituted C₁-C₆ alkyl or a nitrogen protecting group. In certain embodiments of Formula (I), R¹ is optionally substituted cyclohexyl; R³ is hydrogen;

and R^5 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is mono-substituted cyclohexyl; R^3 is hydrogen; and R^5 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is optionally substituted aryl; R^3 is hydrogen; and R^5 is optionally substituted C_1 - C_6 alkyl or a nitrogen protecting group. In certain embodiments of Formula (I), R^1 is optionally substituted phenyl; R^3 is hydrogen; and R^5 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is mono-substituted phenyl; R^3 is hydrogen; and R^5 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a and R^b are as defined herein; R^3 is hydrogen; and R^5 is optionally substituted C_1 - C_6 alkyl or a nitrogen protecting group. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a is optionally substituted carbocyclyl and R^b is hydrogen or optionally substituted alkyl; R^3 is hydrogen; and R^5 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a is optionally substituted cyclohexyl and R^b is hydrogen; R^3 is hydrogen; and R^5 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a and R^b are joined to form an optionally substituted heterocyclic ring; R^3 is hydrogen; and R^5 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a and R^b are joined to form an optionally substituted piperidine ring; R^3 is hydrogen; and R^5 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (I), R^1 is $-NR^aR^b$, wherein R^a and R^b are joined to form a mono-substituted piperidine ring; R^3 is hydrogen; and R^5 is unsubstituted C_1 - C_6 alkyl.

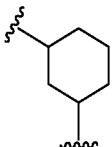
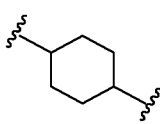
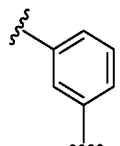
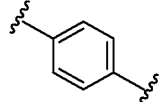
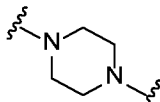
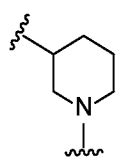
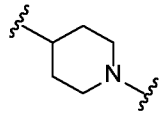
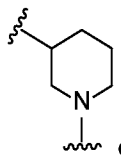
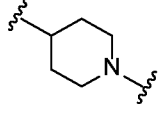
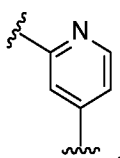
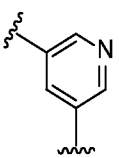
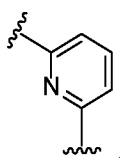
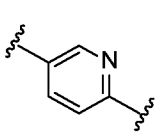
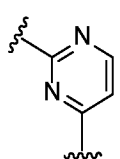
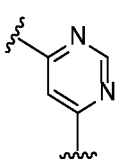
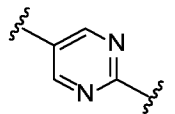
[00163] In certain embodiments of Formula (II) or (III), R^3 is hydrogen and R^4 is optionally substituted C_1 - C_6 alkyl or a nitrogen protecting group. In certain embodiments of Formula (II) or (III), R^3 is hydrogen and R^4 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (II) or (III), R^3 is hydrogen and R^4 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (II) or (III), R^3 is hydrogen and R^4 is methyl, ethyl, n-propyl, or isopropyl.

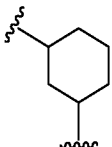
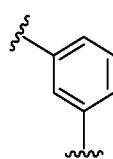
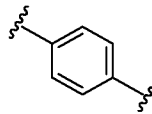
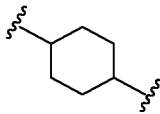
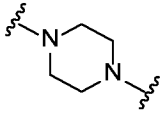
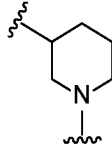
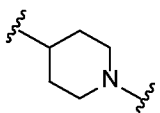
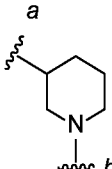
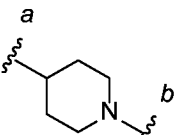
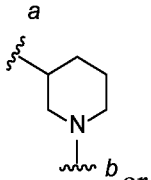
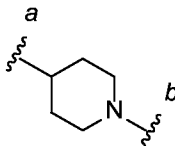
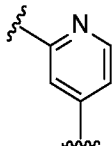
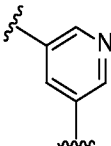
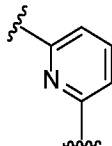
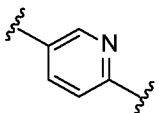
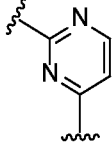
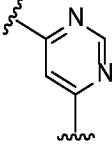
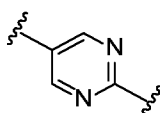
[00164] In certain embodiments of Formula (II) or (III), R^1 is optionally substituted carbocyclyl; R^3 is hydrogen; and R^4 is optionally substituted C_1 - C_6 alkyl or a nitrogen protecting group. In certain embodiments of Formula (II) or (III), R^1 is optionally substituted cyclohexyl; R^3 is hydrogen; and R^4 is optionally substituted C_1 - C_6 alkyl. In certain embodiments of Formula (II) or (III), R^1 is mono-substituted cyclohexyl; R^3 is hydrogen and R^4 is unsubstituted C_1 - C_6 alkyl. In certain embodiments of Formula (II) or (III), R^1 is optionally substituted aryl; R^3 is hydrogen and R^4 is optionally substituted C_1 - C_6 alkyl or a nitrogen protecting group. In certain embodiments of Formula (II) or (III), R^1 is optionally

substituted phenyl; R³ is hydrogen; and R⁴ is optionally substituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is mono-substituted phenyl; R³ is hydrogen; and R⁴ is unsubstituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a and R^b are as defined herein; R³ is hydrogen; and R⁴ is optionally substituted C₁-C₆ alkyl or a nitrogen protecting group. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a is optionally substituted carbocyclyl and R^b is hydrogen or optionally substituted alkyl; R³ is hydrogen and R⁴ is optionally substituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a is optionally substituted cyclohexyl and R^b is hydrogen; R³ is hydrogen; and R⁴ is unsubstituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a and R^b are joined to form an optionally substituted heterocyclic ring; R³ is hydrogen; and R⁴ is optionally substituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a and R^b are joined to form an optionally substituted piperidine ring; R³ is hydrogen; and R⁴ is unsubstituted C₁-C₆ alkyl. In certain embodiments of Formula (II) or (III), R¹ is -NR^aR^b, wherein R^a and R^b are joined to form a mono-substituted piperidine ring; R³ is hydrogen; and R⁴ is methyl, ethyl, n-propyl, or isopropyl.

[00165] Compounds of any one of Formulae (I)-(III) include Ring A between linker L¹ and linker L². Ring A may be optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl. In certain embodiments, Ring A is optionally substituted carbocyclyl. In certain embodiments, Ring A is optionally substituted heterocyclyl. In certain embodiments, Ring A is optionally substituted aryl. In certain embodiments, Ring A is optionally substituted heteroaryl. In certain embodiments, Ring A is optionally substituted phenyl. In certain embodiments, Ring A is phenyl substituted with only L¹ and L². In certain embodiments, Ring A is optionally substituted cyclohexyl. In certain embodiments, Ring A is optionally substituted piperidinyl. In certain embodiments, Ring A is optionally substituted piperizinyl. In certain embodiments, Ring A is optionally substituted pyridinyl. In certain embodiments, Ring A is optionally substituted pyrimidinyl.

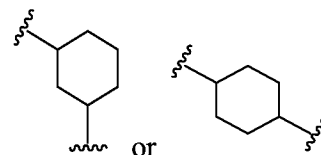
[00166] In certain embodiments of Formulae (I)-(III), linkers L¹ and L² are attached "ortho" or 1,2 to Ring A. In certain embodiments, linkers L¹ and L² are attached "meta" or 1,3 to Ring A. In certain embodiments, linkers L¹ and L² are attached "para" or 1,4 to ring A.

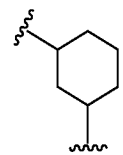
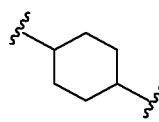
[00167] In certain embodiments of Formulae (I)-(III), Ring A is  or , wherein each ring atom is optionally substituted. In certain embodiments, Ring A is  or , wherein each ring atom is optionally substituted. In certain embodiments, Ring A is , wherein each ring atom is optionally substituted. In certain embodiments, Ring A is  or , wherein each ring atom is optionally substituted, and L^1 and L^2 may attach to ring A at either indicated position. In certain embodiments, Ring A is  or , wherein each ring atom is optionally substituted, and L^1 and L^2 may attach to ring A at either indicated position. In certain embodiments, Ring A is , , , or , wherein each ring atom is optionally substituted, and L^1 and L^2 may attach to ring A at either indicated position. In certain embodiments, Ring A is , , or , wherein each ring atom is optionally substituted, and L^1 and L^2 may attach to ring A at either indicated position.

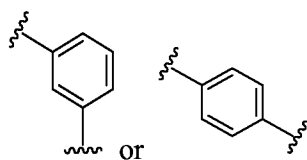
[00168] In certain embodiments of Formulae (I)-(III), Ring A is  or  or . In certain embodiments, Ring A is . In certain embodiments, Ring A is . In certain embodiments, Ring A is  or . L^1 and L^2 may attach to ring A at either indicated position. In certain embodiments, Ring A is  or  , wherein L^1 is attached to position a and L^2 is attached to position b . In certain embodiments, Ring A is  and L^2 is attached to position b . In certain embodiments, Ring A is  , wherein L^2 is attached to position a and L^1 is attached to position b . In certain embodiments, Ring A is  ,  ,  , or  , wherein L^1 and L^2 may attach to ring A at either indicated position. In certain embodiments, Ring A is  ,  ,  , wherein L^1 and L^2 may attach to ring A at either indicated position.

[00169] Compounds of Formulae (I)-(III) include Ring B between linker L^2 and group R^2 . In certain embodiments, linker L^2 is a bond, such that Ring B is directly attached to Ring A. Ring B may absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl. In certain embodiments, Ring B is absent, such that L^2 is directly attached to R^2 . In certain embodiments, Ring B is absent and linker L^2 is a bond, such that Ring A is directly attached to R^2 . In certain embodiments, Ring B is optionally substituted carbocyclyl. In certain embodiments, Ring B is optionally substituted heterocyclyl. In certain embodiments, Ring B is optionally substituted aryl. In certain embodiments, Ring B is optionally substituted heteroaryl. In certain embodiments, Ring B is optionally substituted phenyl. In certain embodiments, Ring B is optionally substituted cyclohexyl. In certain embodiments, Ring B is optionally substituted piperidinyl. In certain embodiments, Ring B is optionally substituted piperizinyl. In certain embodiments, Ring B is optionally substituted pyridinyl. In certain embodiments, Ring B is optionally substituted pyrimidinyl.

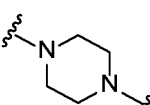
[00170] In certain embodiments of Formulae (I)-(III), linker L^2 and group R^2 are attached “ortho” or 1,2 to each other on Ring B. In certain embodiments, linkers L^2 and group R^2 are attached “meta” or 1,3 to each other on Ring B. In certain embodiments, linkers L^2 and R^2 are attached “para” or 1,4 to each other on Ring B.

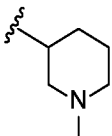
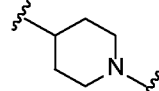


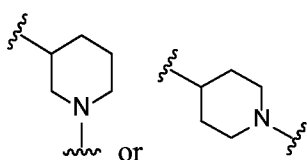
[00171] In certain embodiments of Formulae (I)-(III), Ring B is  or , wherein each ring atom is optionally substituted. In certain embodiments, Ring B is



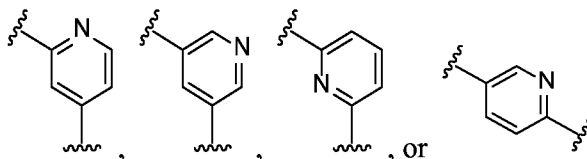
, wherein each ring atom is optionally substituted. In certain

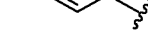
embodiments, Ring B is , wherein each ring atom is optionally substituted. In

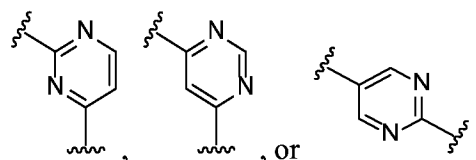
certain embodiments, Ring B is  or , wherein each ring atom is optionally substituted, and L^2 and R^2 may attach to Ring B at either indicated position. In

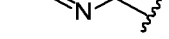


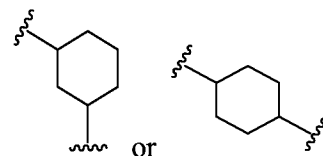
certain embodiments, Ring B is  or , wherein each ring atom is optionally substituted, and L^2 and R^2 may attach to Ring B at either indicated position. In



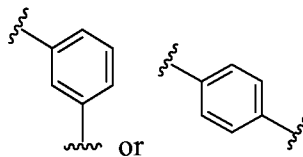
certain embodiments, Ring B is , , , or , wherein each ring atom is optionally substituted, and L^2 and R^2 may attach to Ring B at either

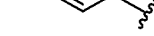


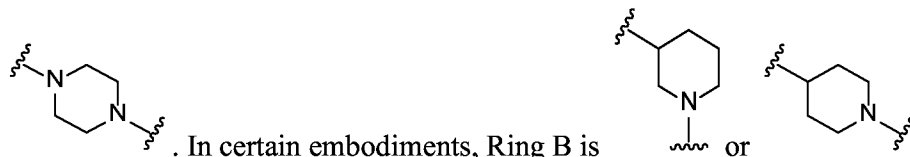
indicated position. In certain embodiments, Ring B is , , or , wherein each ring atom is optionally substituted, and L^2 and R^2 may attach to Ring B at either indicated position.

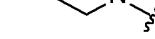
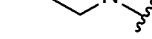


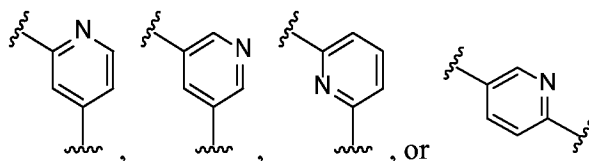
[00172] In certain embodiments of Formulae (I)-(III), Ring B is

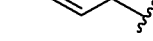


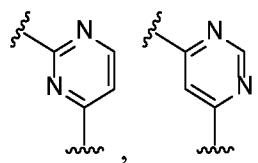
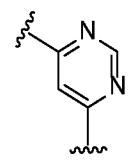
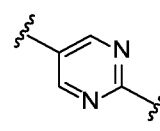
. In certain embodiments, Ring B is  or . In certain embodiments, Ring



B is . In certain embodiments, Ring B is  or , L^2 and R^2 may attach to Ring B at either indicated position. In certain embodiments, Ring B is

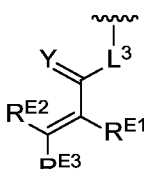


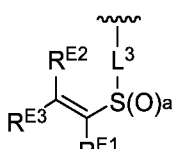
, , , or , wherein L^2 and R^2 may attach to Ring B at

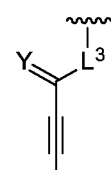
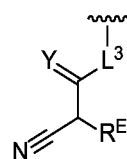
either indicated position. In certain embodiments, Ring B is  ,  ,  , wherein L^2 and R^2 may attach to Ring B at either indicated position.

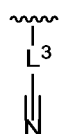
[00173] Compounds of Formulae (I)-(III) include R^2 attached to Ring B. In certain embodiments, Ring B is absent, such that R^2 is directly attached to linker L^2 . In certain embodiments, Ring B is absent and L^2 is a bond, such that R^2 is directly attached to Ring A. In certain embodiments, R^2 comprises an electrophilic moiety. In certain embodiments, R^2 comprises a Michael acceptor moiety. The electrophilic moiety (*e.g.*, Michael acceptor moiety) may react with a cysteine residue of a kinase (*e.g.*, CDK (*e.g.*, CDK7)) to allow for covalent attachment of the compound to the kinase. In certain embodiments, the electrophilic moiety (*e.g.*, Michael acceptor moiety) may react with a cysteine residue of a kinase (*e.g.*, CDK (*e.g.*, CDK7)). In certain embodiments, the electrophilic moiety (*e.g.*, Michael acceptor moiety) may react with the Cys312 residue of CDK7. In certain embodiments, the covalent attachment is irreversible. In certain embodiments, the covalent attachment is reversible.

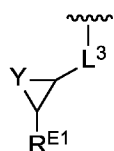
[00174] As generally defined herein in Formulae (I)-(III), R^2 may be any one of Formulae

(i-1)-(i-41). In certain embodiments, R^2 is of Formula (i-1):  (i-1). In certain

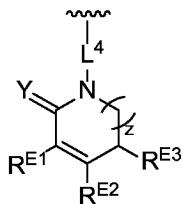
embodiments, R^2 is of Formula (i-2):  (i-2). In certain embodiments, R^2 is of

Formula (i-3):  (i-3). In certain embodiments, R^2 is of Formula (i-4):  (i-

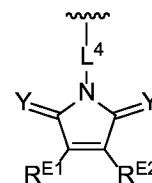
4). In certain embodiments, R^2 is of Formula (i-5):  (i-5). In certain embodiments, R^2 is



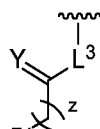
of Formula (i-6): (i-6). In certain embodiments, R^2 is of Formula (i-7):



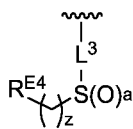
(i-7). In certain embodiments, R^2 is of Formula (i-8):



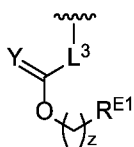
(i-8). In



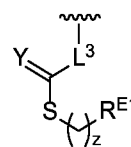
certain embodiments, R^2 is of Formula (i-9): (i-9). In certain embodiments, R^2 is of



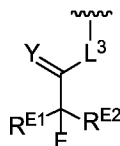
Formula (i-10): (i-10). In certain embodiments, R^2 is of Formula (i-11):



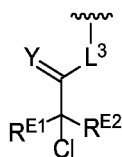
(i-11). In certain embodiments, R^2 is of Formula (i-12):



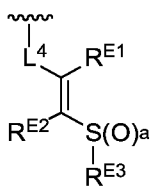
(i-12). In



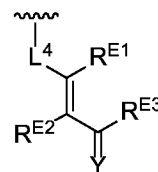
certain embodiments, R^2 is of Formula (i-13): (i-13). In certain embodiments, R^2 is



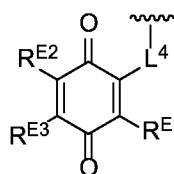
of Formula (i-14): (i-14). In certain embodiments, R^2 is of Formula (i-15):



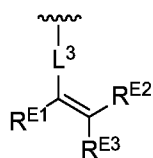
(i-15). In certain embodiments, R^2 is of Formula (i-16):



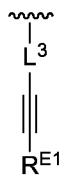
(i-16). In



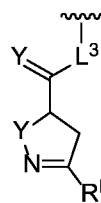
certain embodiments, R^2 is of Formula (i-17): (i-17). In certain embodiments,



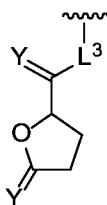
R^2 is of Formula (i-18): (i-18). In certain embodiments, R^2 is of Formula (i-19):



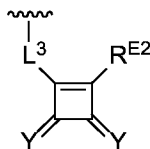
(i-19). In certain embodiments, R^2 is of Formula (i-20):



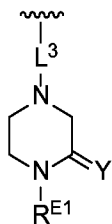
(i-20). In certain



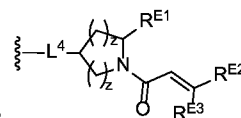
embodiments, R^2 is of Formula (i-21): (i-21). In certain embodiments, R^2 is of



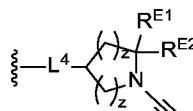
Formula (i-22): (i-22). In certain embodiments, R^2 is of Formula (i-23):



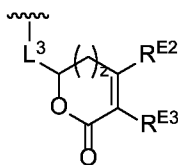
(i-23). In certain embodiments, R^2 is of Formula (i-24):



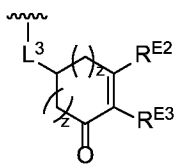
(i-24).



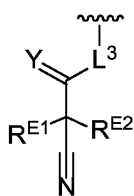
In certain embodiments, R^2 is of Formula (i-25): (i-25). In certain



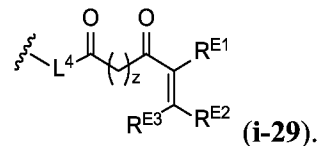
embodiments, R^2 is of Formula (i-26): (i-26). In certain embodiments, R^2 is of



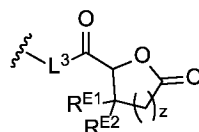
Formula (i-27): (i-27). In certain embodiments, R^2 is of Formula (i-28):



(i-28). In certain embodiments, R^2 is of Formula (i-29):

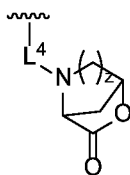


In certain embodiments, R^2 is of Formula (i-30):



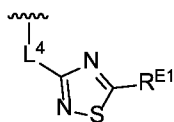
(i-30). In certain

embodiments, R^2 is of Formula (i-31):

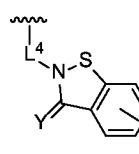


(i-31). In certain embodiments, R^2 is of

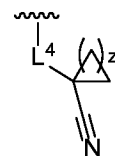
Formula (i-32):



(i-32). In certain embodiments, R^2 is of Formula (i-33):

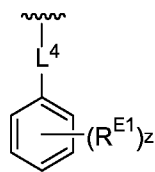


(i-33). In certain embodiments, R^2 is of Formula (i-34):



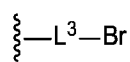
(i-34). In

certain embodiments, R^2 is of Formula (i-35):



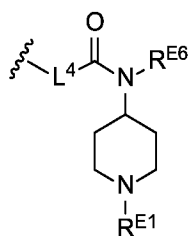
(i-35). In certain embodiments, R^2

is of Formula (i-36): $\text{---L}^3\text{---Cl}$ (i-36). In certain embodiments, R^2 is of Formula (i-37):

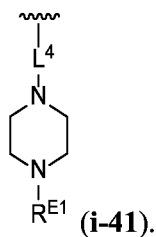


(i-37). In certain embodiments, R^2 is of Formula (i-38): $\text{---L}^3\text{---F}$ (i-38). In certain

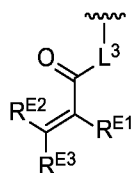
embodiments, R^2 is of Formula (i-39): $\text{---L}^3\text{---CF}_3$ (i-39). In certain embodiments, R^2 is of



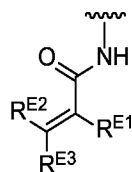
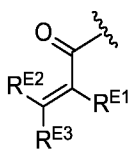
Formula (i-40):

(i-40). In certain embodiments, R^2 is of Formula (i-41):

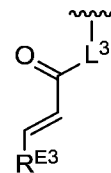
(i-41).

[00175] In certain embodiments, R^2 is of Formula (i-1a):

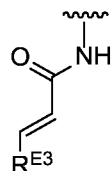
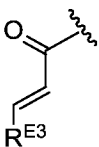
(i-1a). In certain

embodiments, R^2 is of Formula (i-1b):(i-1b). In certain embodiments, R^2 is of

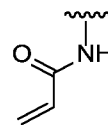
Formula (i-1c):

(i-1c). In certain embodiments, R^2 is of Formula (i-1d):(i-1d). In certain embodiments, R^2 is of Formula (i-1e):

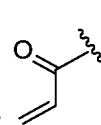
(i-1e). In certain

embodiments, R^2 is of Formula (i-1f):(i-1f). In certain embodiments, R^2 is of

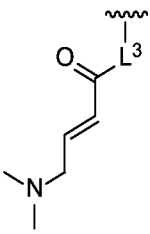
Formula (i-1g):

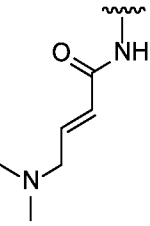
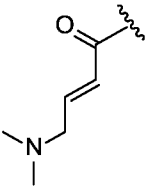
(i-1g). In certain embodiments, R^2 is

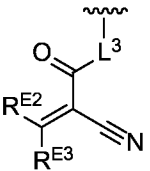
or

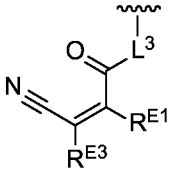


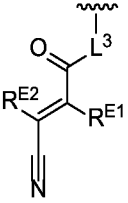
. In

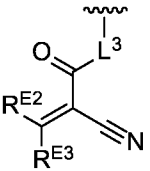
certain embodiments, R^2 is of Formula (i-1h):  (i-1h). In certain embodiments,

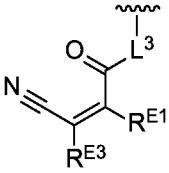
R^2 is  or .

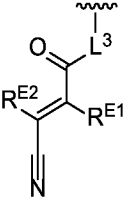
[00176] In certain embodiments, R^2 is of Formula (i-1a):  (i-1a). In certain

embodiments, R^2 is of Formula (i-1b):  (i-1b). In certain embodiments, R^2 is of

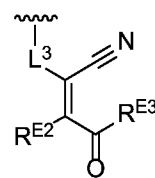
Formula (i-1c):  (i-1c).

[00177] In certain embodiments, R^2 is of Formula (i-18a):  (i-18a). In certain

embodiments, R^2 is of Formula (i-18b):  (i-18b). In certain embodiments, R^2 is

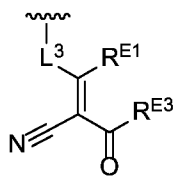
of Formula (i-18c):  (i-18c).

[00178] In certain embodiments, R^2 is of Formula (i-15a):



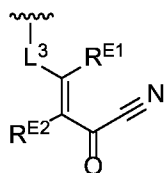
(i-15a). In certain

embodiments, R^2 is of Formula (i-15b):



(i-15b). In certain embodiments, R^2 is

of Formula (i-15c):



(i-15c).

[00179] R^2 may contain linker L^3 or L^4 . In certain embodiments, L^3 is a bond. L^3 is an optionally substituted C_{1-4} hydrocarbon chain. In certain embodiments, L^3 is an optionally substituted C_{1-4} hydrocarbon chain, wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C(=O)-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, $trans-CR^{L3b}=CR^{L3b}-$, $cis-CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$. In certain embodiments, L^3 is an optionally substituted C_{1-4} hydrocarbon chain, wherein one carbon unit of the hydrocarbon chain is replaced with $-NR^{L3a}-$ (e.g., $-NH-$). In certain embodiments, L^3 is of the formula: $-(CH_2)_{1-4}-NR^{L3a}-$ (e.g., $-(CH_2)_{1-4}-NH-$) or $-NR^{L3a}-(CH_2)_{1-4}-$ (e.g., $-NH-(CH_2)_{1-4}-$). In certain embodiments, L^3 is $-NR^{L3a}-$. In certain embodiments, L^3 is $-NR^{L3a}C(=O)-$. In certain embodiments, L^3 is $-C(=O)NR^{L3a}-$. In certain embodiments, L^3 is $-NH-$. In certain embodiments, L^3 is $-C(=O)-$. In certain embodiments, L^3 is $-NH(C=O)-$. In certain embodiments, L^3 is $-(C=O)NH-$. In certain embodiments, L^3 is $-O-$. In certain embodiments, L^3 is $-S-$. In certain embodiments, L^4 is a bond. In certain embodiments, L^4 is an optionally substituted C_{1-4} hydrocarbon chain.

[00180] Linker L^3 may contain groups R^{L3a} or R^{L3b} . In certain embodiments, R^{L3a} is hydrogen. In certain embodiments, at least one instance of R^{L3b} is hydrogen. In certain embodiments, each instance of R^{L3b} is hydrogen. In certain embodiments, at least one instance of R^{L3b} is $-Cl$, $-Br$, or $-I$. In certain embodiments, each instance of R^{L3b} is $-Cl$, $-Br$, or $-I$. In certain embodiments, at least one instance of R^{L3b} is $-F$. In certain embodiments, each instance of R^{L3b} is $-F$. In certain embodiments, at least one instance of R^{L3b} is optionally

substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl. In certain embodiments, two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring.

[00181] R^2 may contain groups R^{E1} , R^{E2} , and/or R^{E3} . In certain embodiments, R^{E1} is hydrogen. In certain embodiments, R^{E2} is hydrogen. In certain embodiments, R^{E3} is hydrogen. In certain embodiments, R^{E1} is -Cl, -Br, or -I. In certain embodiments, R^{E2} is -Cl, -Br, or -I. In certain embodiments, R^{E3} is -Cl, -Br, or -I. In certain embodiments, R^{E1} is -F. In certain embodiments, R^{E2} is -F. In certain embodiments, R^{E3} is -F. In certain embodiments, R^{E1} is optionally substituted alkyl (*e.g.*, substituted or unsubstituted C_{1-6} alkyl). In certain embodiments, R^{E2} is optionally substituted alkyl (*e.g.*, substituted or unsubstituted C_{1-6} alkyl). In certain embodiments, R^{E3} is optionally substituted alkyl (*e.g.*, substituted or unsubstituted C_{1-6} alkyl). In certain embodiments, R^{E1} is optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, -CN, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, or $-SR^{EE}$. In certain embodiments, R^{E2} is optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, -CN, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, or $-SR^{EE}$. In certain embodiments, R^{E3} is optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, -CN, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, or $-SR^{EE}$. In certain embodiments, R^{E1} is $-N(R^{EE})_2$. In certain embodiments, R^{E2} is $-N(R^{EE})_2$. In certain embodiments, R^{E3} is $-N(R^{EE})_2$. In certain embodiments, R^{E1} is $-N(CH_3)_2$. In certain embodiments, R^{E2} is $-N(CH_3)_2$. In certain embodiments, R^{E3} is $-N(CH_3)_2$. In certain embodiments, R^{E1} is $-CH_2N(R^{EE})_2$. In certain embodiments, R^{E2} is $-CH_2N(R^{EE})_2$. In certain embodiments, R^{E3} is $-CH_2N(R^{EE})_2$. In certain embodiments, R^{E1} is $-CH_2N(CH_3)_2$. In certain embodiments, R^{E2} is $-CH_2N(CH_3)_2$. In certain embodiments, R^{E3} is $-CH_2N(CH_3)_2$. In certain embodiments, R^{E1} is -CN. In certain embodiments, R^{E2} is -CN. In certain embodiments, R^{E3} is -CN.

[00182] In certain embodiments, R^{E1} and R^{E3} are joined to form an optionally substituted carbocyclic ring. In certain embodiments, R^{E1} and R^{E3} are joined to form an optionally substituted heterocyclic ring. In certain embodiments, R^{E2} and R^{E3} are joined to form an optionally substituted carbocyclic ring. In certain embodiments, R^{E2} and R^{E3} are joined to

form an optionally substituted heterocyclic ring. In certain embodiments, R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic ring. In certain embodiments, R^{E1} and R^{E2} are joined to form an optionally substituted heterocyclic ring.

[00183] R^2 may contain group R^{E4} , where R^{E4} is a leaving group. In certain embodiments, R^{E4} is -Cl, -Br, or -I. In certain embodiments, R^{E4} is -F. In certain embodiments, R^{E4} is -OS(=O) R^{E4a} or -OS(=O) $_2R^{E4a}$, wherein R^{E4a} is substituted or unsubstituted alkyl, substituted or unsubstituted alkenyl, substituted or unsubstituted alkynyl, substituted or unsubstituted carbocyclyl, substituted or unsubstituted heterocyclyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In certain embodiments, R^{E4} is -OR E4a . In certain embodiments, R^{E4} is -OMs, -OTf, -OTs, -OBs, or 2-nitrobenzenesulfonyloxy. In certain embodiments, R^{E4} is -OR E4a . In certain embodiments, R^{E4} is -OMe, -OCF $_3$, or -OPh. In certain embodiments, R^{E4} is -OC(=O) R^{E4a} . In certain embodiments, R^{E4} is -OC(=O)Me, -OC(=O)CF $_3$, -OC(=O)Ph, or -OC(=O)Cl. In certain embodiments, R^{E4} is -OC(=O)OR E4a . In certain embodiments, R^{E4} is -OC(=O)OMe or -OC(=O)O(*t*-Bu).

[00184] R^2 may contain group R^{E5} , where R^{E5} is a halogen. In certain embodiments, R^{E5} is -Cl, -Br, or -I. In certain embodiments, R^{E5} is -F.

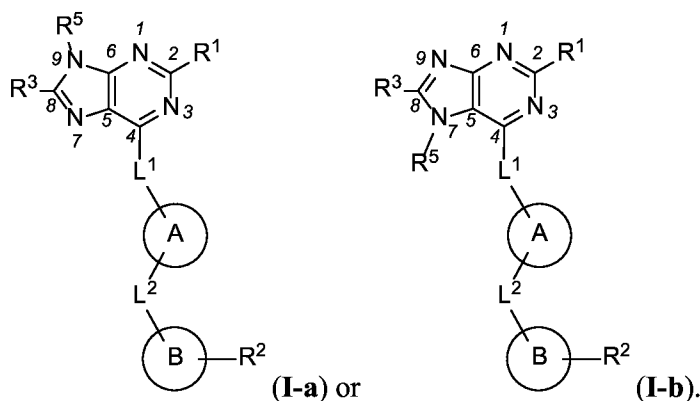
[00185] R^2 may contain group R^{E6} . In certain embodiments, R^{E6} is hydrogen. In certain embodiments, R^{E6} is substituted or unsubstituted C $_1$ -C $_6$ alkyl. In certain embodiments, R^{E6} is a nitrogen protecting group.

[00186] In certain embodiments, *a* is 1. In certain embodiments, *a* is 2.

[00187] In certain embodiments, *z* is 0. In certain embodiments, *z* is 1. In certain embodiments, *z* is 2. In certain embodiments, *z* is 3, 4, 5, or 6.

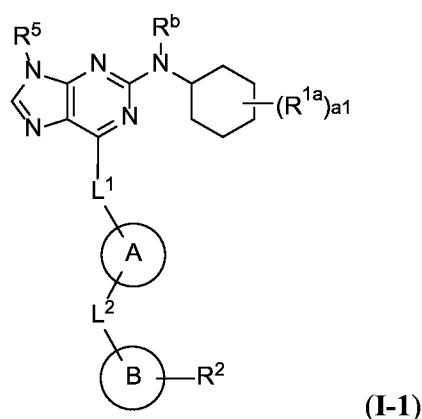
[00188] R^2 may contain group *Y*. In certain embodiments, *Y* is O. In certain embodiments, *Y* is S. In certain embodiments, *Y* is NR E7 . In certain embodiments, *Y* is NH.

[00189] Compounds of Formula (I) may exist as tautomers or mixtures thereof of Formulae (I-a) and (I-b):



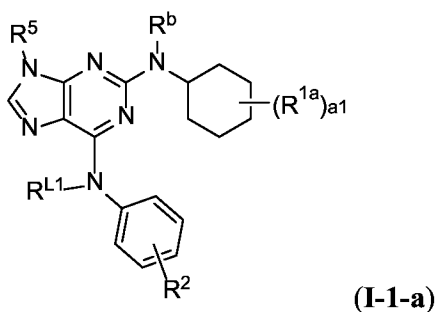
[00190] In each tautomer, R^5 is attached to different imidazole nitrogens in compounds of each formula. In certain embodiments, R^5 is attached to the nitrogen at the position labeled 9, as in Formula (I-a). In certain embodiments, R^5 is attached to the nitrogen at the position labeled 7, as in Formula (I-b). In certain embodiments, compounds of Formula (I) may exist as a mixture of compounds of Formulae (I-a) and (I-b), in which case R^5 is attached to the nitrogen at the position labeled 9 for components of the mixture corresponding to Formula (I-a), and R^5 is attached to the nitrogen at the position labeled 7 for components of the mixture corresponding to Formula (I-b).

[00191] In certain embodiments, a compound of Formula (I) is of Formula (I-1):



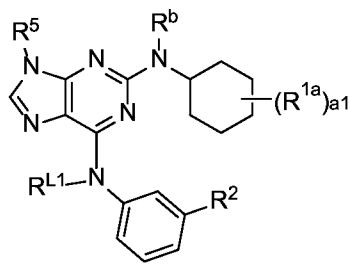
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein L^1 , L^2 , Ring A, Ring B, R^2 , R^5 , R^b , R^{1a} , and $a1$ are as defined herein.

[00192] In certain embodiments, a compound of Formula (I) is of Formula (I-1-a):



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

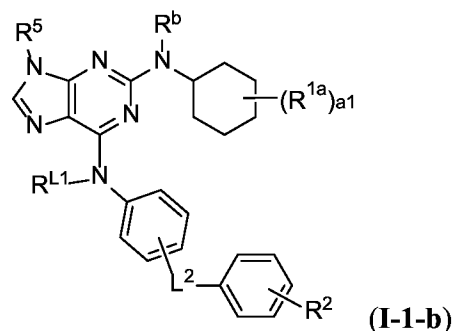
[00193] In certain embodiments, a compound of Formula (I) is of Formula (I-1-a-i):



(I-1-a-i)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

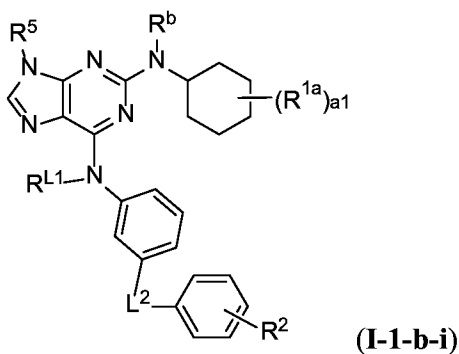
[00194] In certain embodiments, a compound of Formula (I) is of Formula (I-1-b):



(I-1-b)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

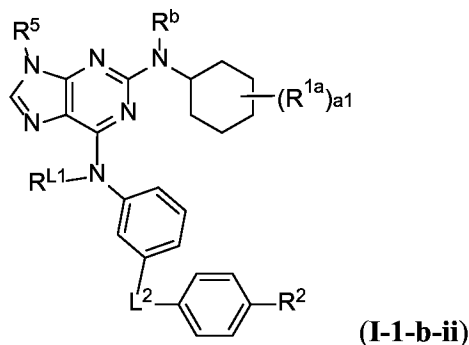
[00195] In certain embodiments, a compound of Formula (I) is of Formula (I-1-b-i):



(I-1-b-i)

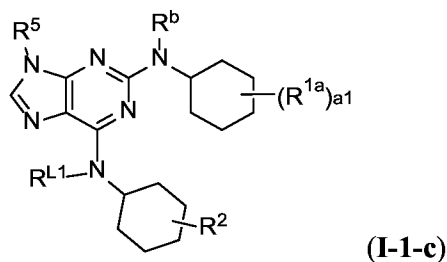
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

[00196] In certain embodiments, a compound of Formula (I) is of Formula (I-1-b-ii):



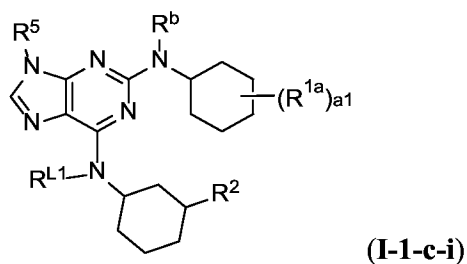
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

[00197] In certain embodiments, a compound of Formula (I) is of Formula (I-1-c):



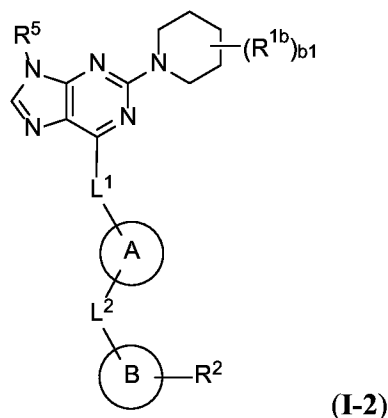
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

[00198] In certain embodiments, a compound of Formula (I) is of Formula (I-1-c-i):



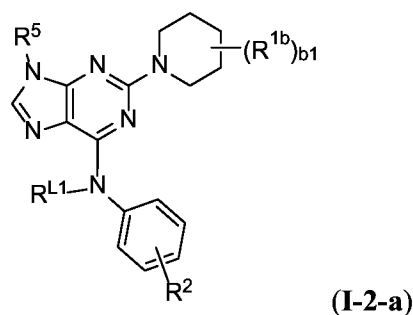
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^5 , R^{L1} , R^b , R^{1a} , and $a1$ are as defined herein.

[00199] In certain embodiments, a compound of Formula (I) is of Formula (I-2):



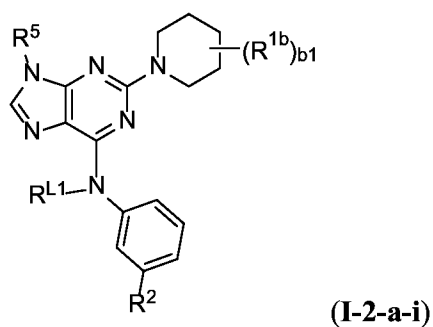
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , L^1 , Ring A, Ring B, R^5 , R^{1b} , and $b1$ are as defined herein

[00200] In certain embodiments, a compound of Formula (I) is of Formula (I-2-a):



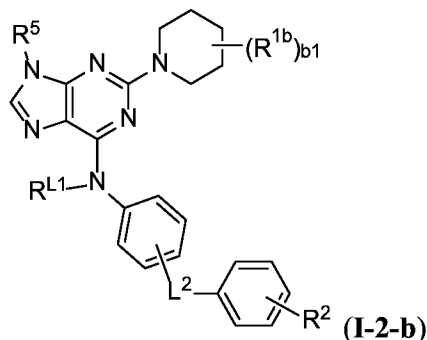
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^5 , R^{1b} , and $b1$ are as defined herein.

[00201] In certain embodiments, a compound of Formula (I) is of Formula (I-2-a-i):



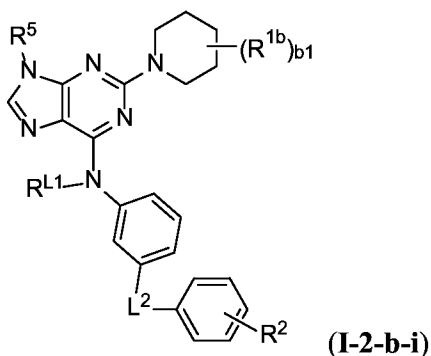
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^5 , R^{1b} , and $b1$ are as defined herein.

[00202] In certain embodiments, a compound of Formula (I) is of Formula (I-2-b):



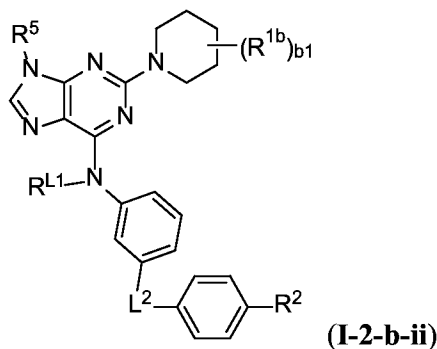
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁵, R^{1b}, and b1 are as defined herein.

[00203] In certain embodiments, a compound of Formula (I) is of Formula (I-2-b-i):



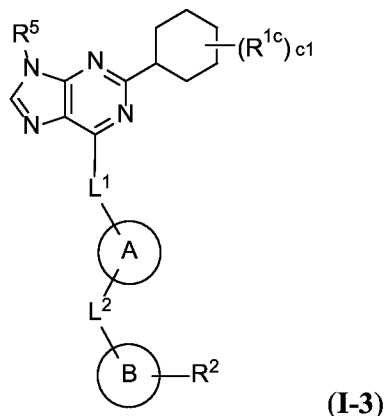
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁵, R^{1b}, and b1 are as defined herein.

[00204] In certain embodiments, a compound of Formula (I) is of Formula (I-2-b-ii):



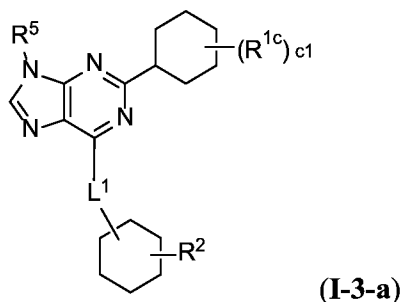
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁵, R^{1b}, and b1 are as defined herein.

[00205] In certain embodiments, a compound of Formula (I) is of Formula (I-3):



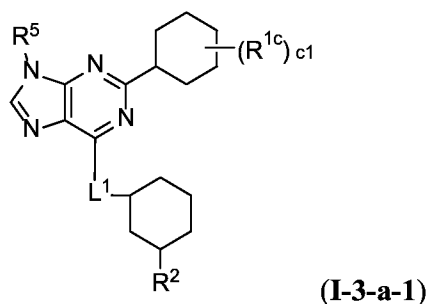
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , L^1 , Ring A, Ring B, R^5 , R^{1c} , and $c1$ are as defined herein.

[00206] In certain embodiments, a compound of Formula (I) is of Formula (I-3-a):



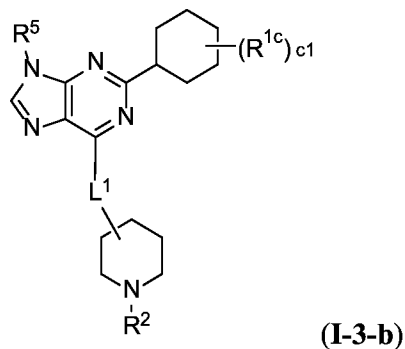
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , R^5 , R^{1c} , and $c1$ are as defined herein.

[00207] In certain embodiments, a compound of Formula (I) is of Formula (I-3-a-1):



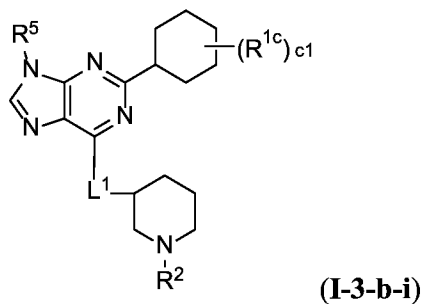
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , R^5 , R^{1c} , and $c1$ are as defined herein.

[00208] In certain embodiments, a compound of Formula (I) is of Formula (I-3-b):



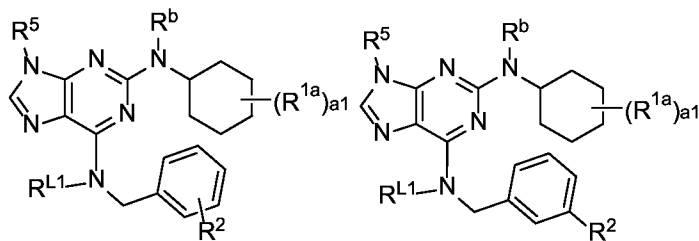
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , R^5 , R^{1c} , and $c1$ are as defined herein.

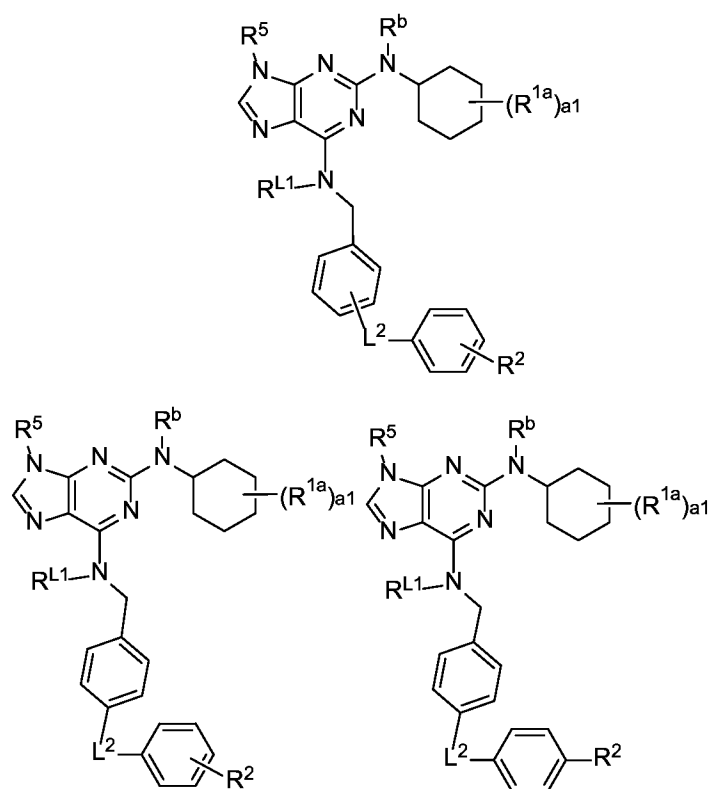
[00209] In certain embodiments, a compound of Formula (II) is of Formula (I-3-b-i):



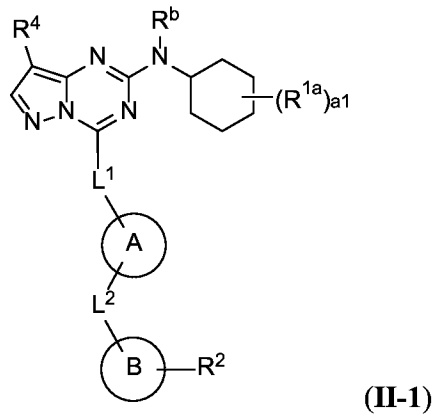
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , R^5 , R^{1c} , and $c1$ are as defined herein.

[00210] In certain embodiments, a compound of Formula (I) is one of the following formulae:



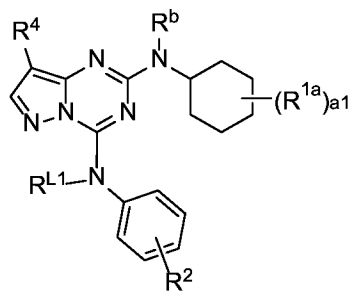


[00211] In certain embodiments, a compound of Formula (II) is of Formula (II-1):



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , L^2 , Ring A, Ring B, R^4 , R^b , R^{1a} , and a_1 are as defined herein.

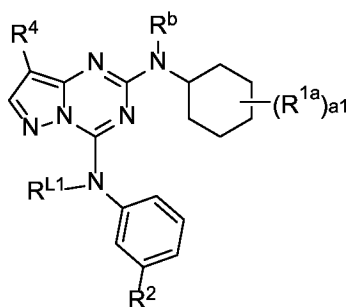
[00212] In certain embodiments, a compound of Formula (II) is of Formula (II-1-a):



(II-1-a)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

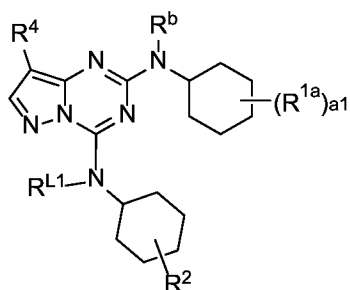
[00213] In certain embodiments, a compound of Formula (II) is of Formula (II-1-a-i):



(II-1-a-i)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

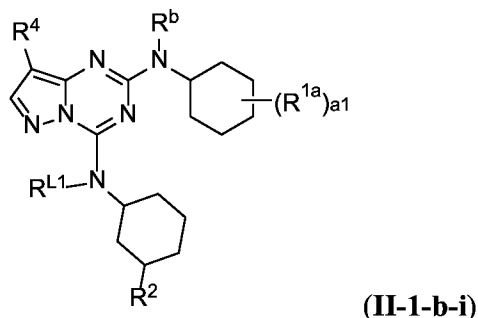
[00214] In certain embodiments, a compound of Formula (II) is of Formula (II-1-b):



(II-1-b)

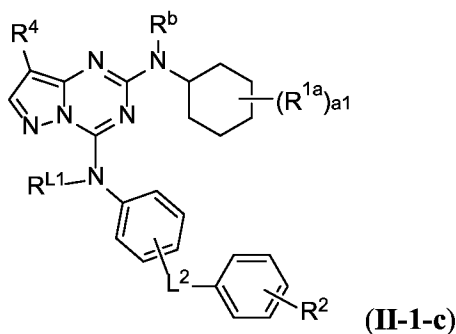
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00215] In certain embodiments, a compound of Formula (II) is of Formula (II-1-b-i):



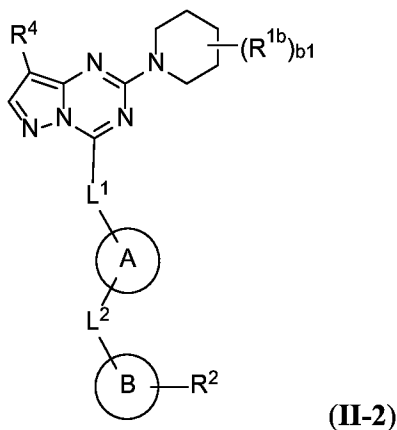
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00216] In certain embodiments, a compound of Formula (II) is of Formula (II-1-c):



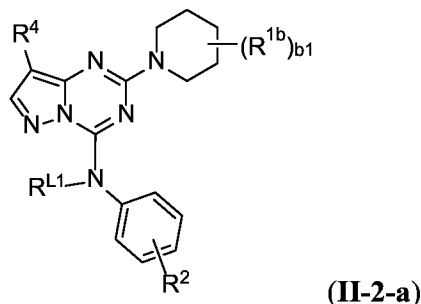
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00217] In certain embodiments, a compound of Formula (II) is of Formula (II-2):



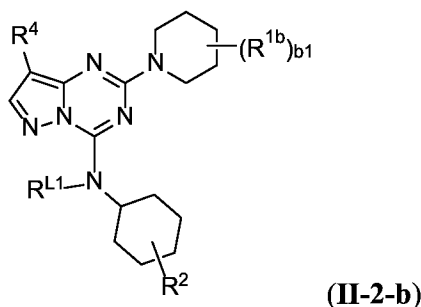
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , L^2 , Ring A, Ring B, R^4 , R^{1b} , and $b1$ are as defined herein.

[00218] In certain embodiments, a compound of Formula (II) is of Formula (II-2-a):



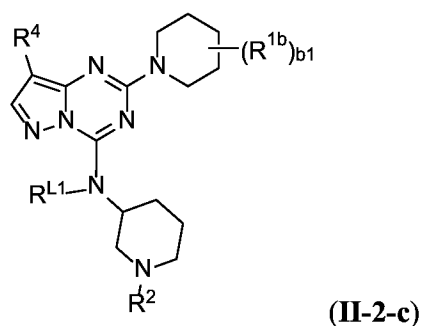
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00219] In certain embodiments, a compound of Formula (II) is of Formula (II-2-b):



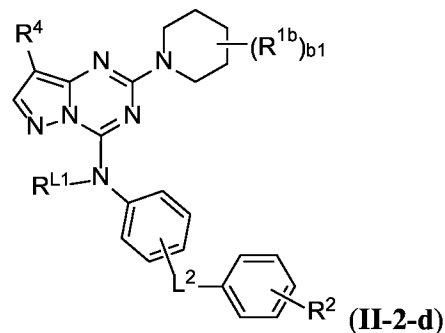
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00220] In certain embodiments, a compound of Formula (II) is of Formula (II-2-c):



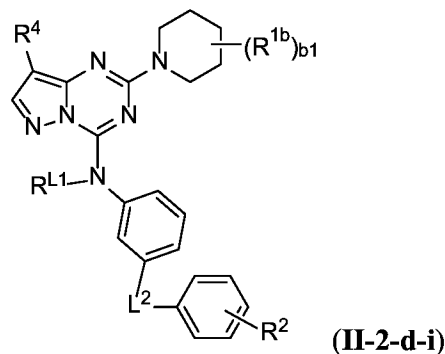
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00221] In certain embodiments, a compound of Formula (II) is of Formula (II-2-d):



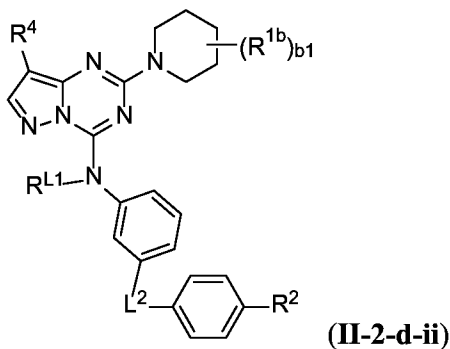
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00222] In certain embodiments, a compound of Formula (II) is of Formula (II-2-d-i):



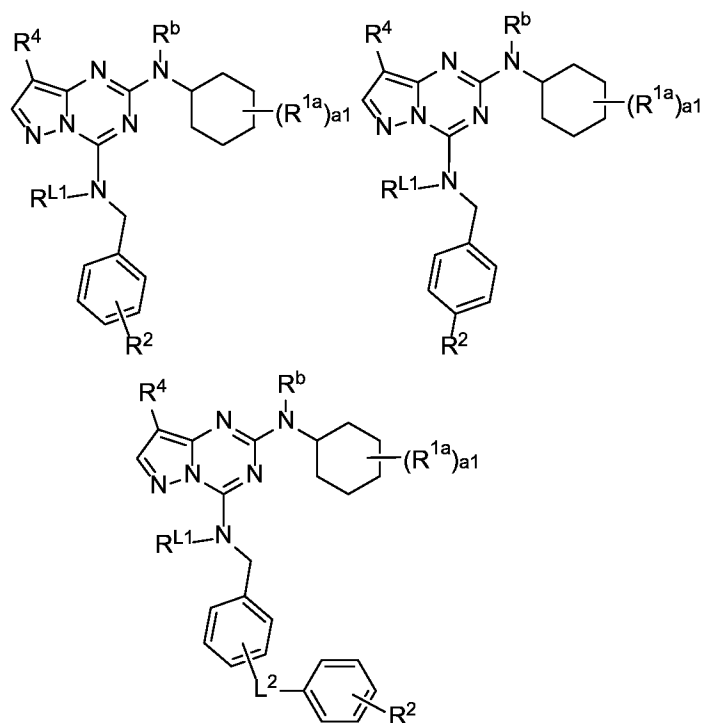
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00223] In certain embodiments, a compound of Formula (II) is of Formula (II-2-d-ii):

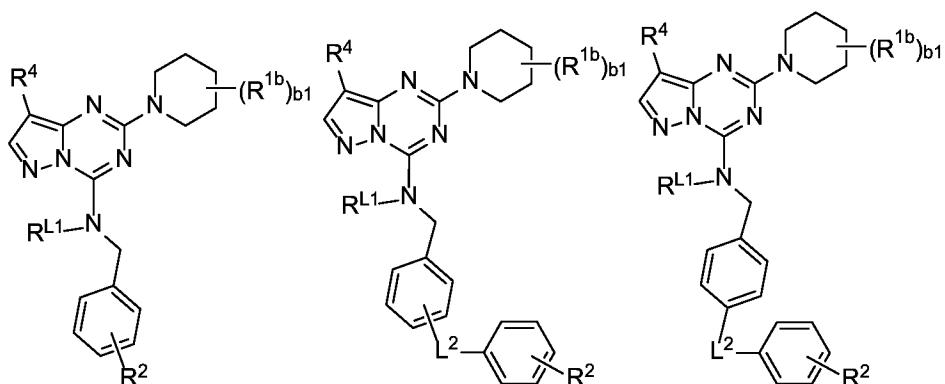


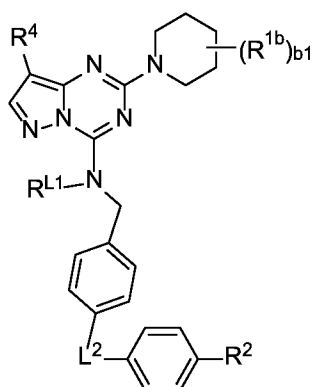
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00224] In certain embodiments, a compound of Formula (II) is of one of the following formulae:

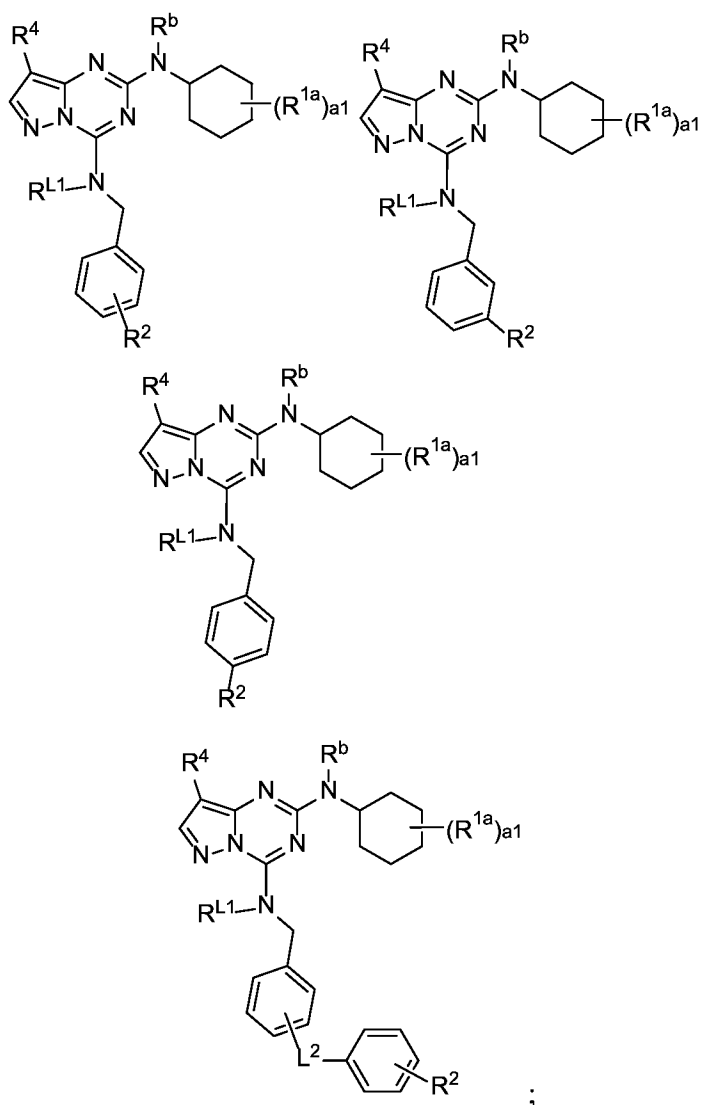


[00225] In certain embodiments, a compound of Formula (II) is of one of the following formulae:



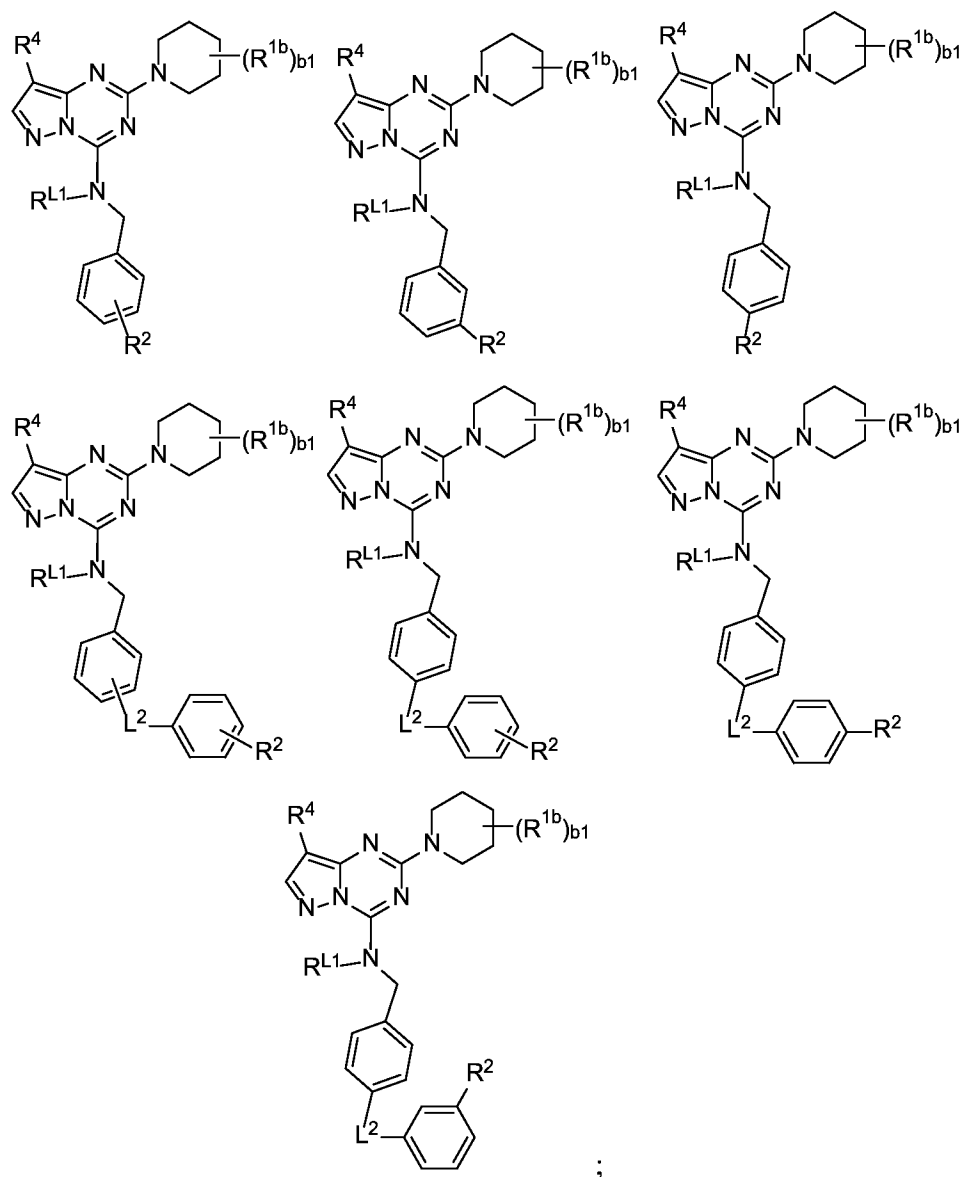


[00226] In certain embodiments, a compound of Formula (II) is of the formula:



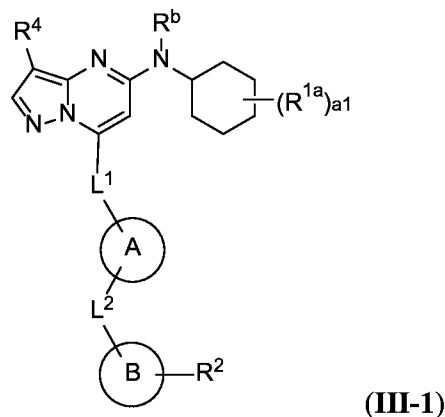
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00227] In certain embodiments, a compound of Formula (II) is of the formula:



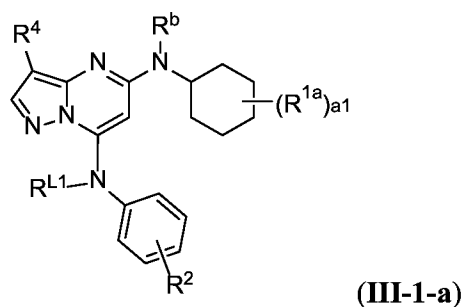
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00228] In certain embodiments, a compound of Formula (III) is of Formula (III-1):



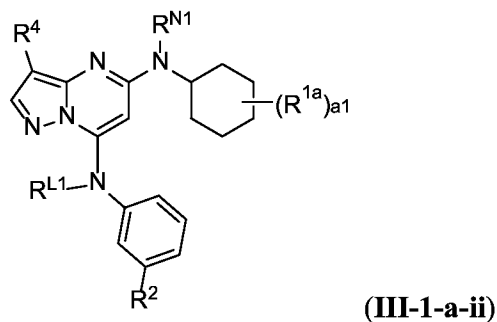
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , L^1 , Ring A, Ring B, R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00229] In certain embodiments, a compound of Formula (III) is of Formula (III-1-a):



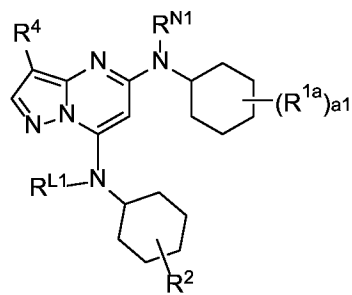
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00230] In certain embodiments, a compound of Formula (III) is of Formula (III-1-a-ii):



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

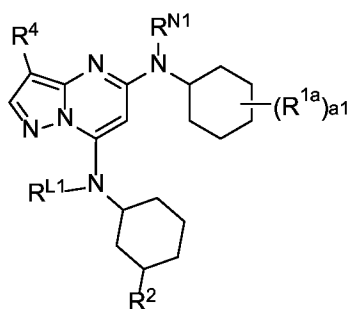
[00231] In certain embodiments, a compound of Formula (III) is of Formula (III-1-b):



(III-1-b)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

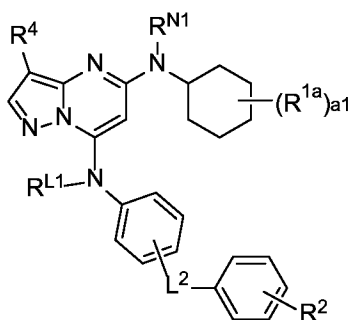
[00232] In certain embodiments, a compound of Formula (III) is of Formula (III-1-b-i):



(III-1-b-i)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

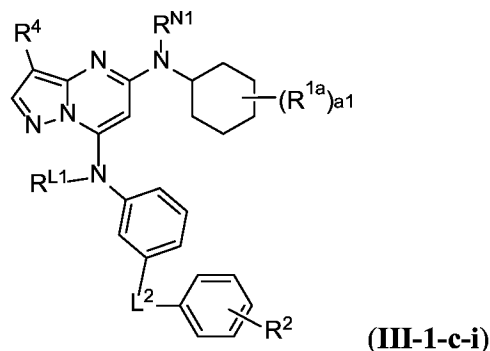
[00233] In certain embodiments, a compound of Formula (III) is of Formula (III-1-c):



(III-1-c)

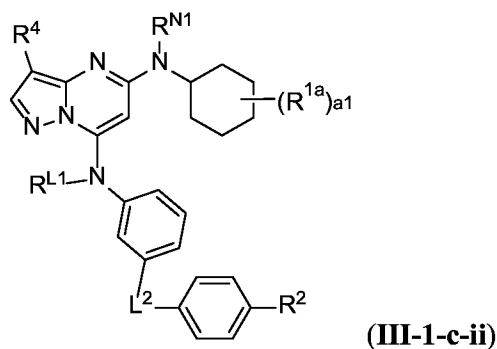
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00234] In certain embodiments, a compound of Formula (III) is of Formula (III-1-c-i):



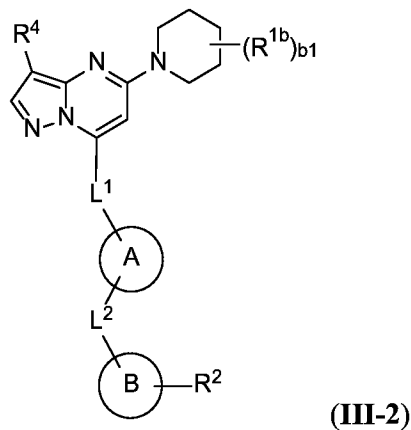
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00235] In certain embodiments, a compound of Formula (III) is of Formula (III-1-c-ii):



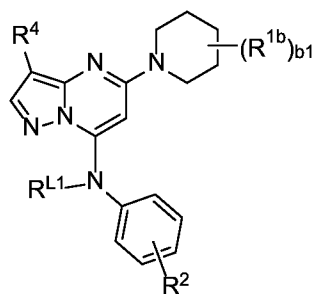
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^2 , R^{L1} , R^4 , R^b , R^{1a} , and $a1$ are as defined herein.

[00236] In certain embodiments, a compound of Formula (III) is of Formula (III-2):



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , L^1 , L^2 , Ring A, Ring B, R^4 , R^{1b} , and $b1$ are as defined herein.

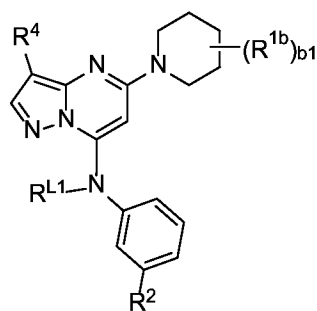
[00237] In certain embodiments, a compound of Formula (III) is of Formula (III-2-a):



(III-2-a)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

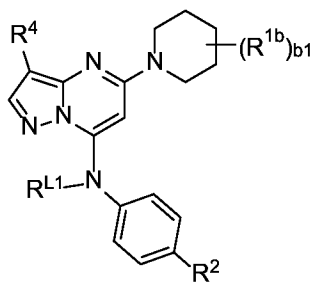
[00238] In certain embodiments, a compound of Formula (III) is of Formula (III-2-a-i):



(III-2-a-i)

or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

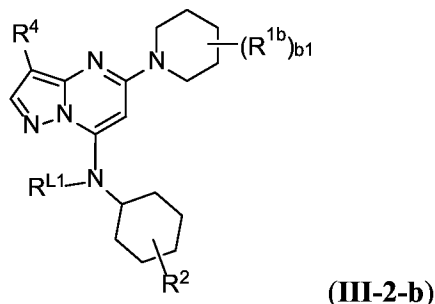
[00239] In certain embodiments, a compound of Formula (III) is of Formula (III-2-a-ii):



(III-2-a-ii)

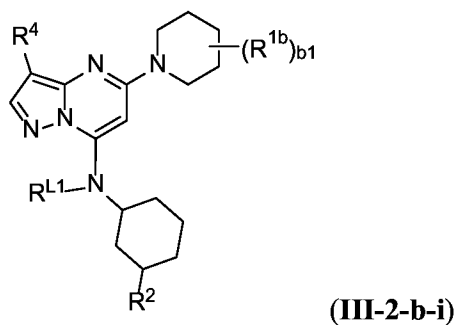
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00240] In certain embodiments, a compound of Formula (III) is of Formula (III-2-b):



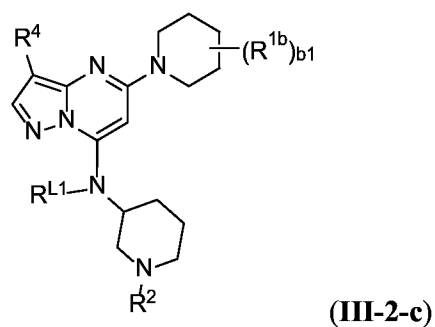
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00241] In certain embodiments, a compound of Formula (III) is of Formula (III-2-b-i):



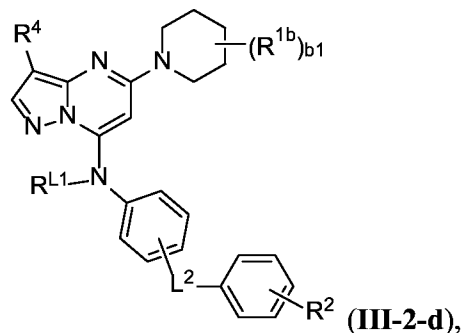
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00242] In certain embodiments, a compound of Formula (III) is of Formula (III-2-c):



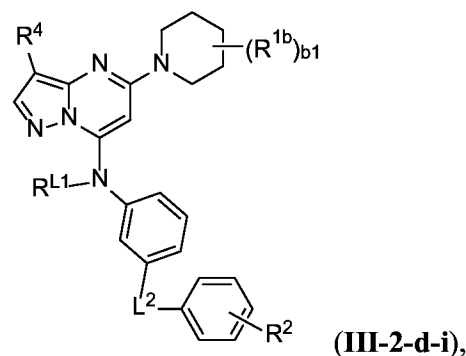
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R^2 , R^{L1} , R^4 , R^{1b} , and $b1$ are as defined herein.

[00243] In certain embodiments, a compound of Formula (III) is of Formula (III-2-d):



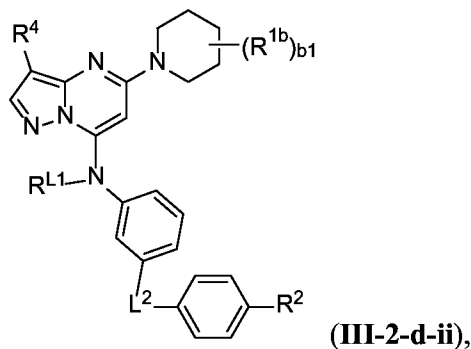
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00244] In certain embodiments, a compound of Formula (III) is of Formula (III-2-d-i):



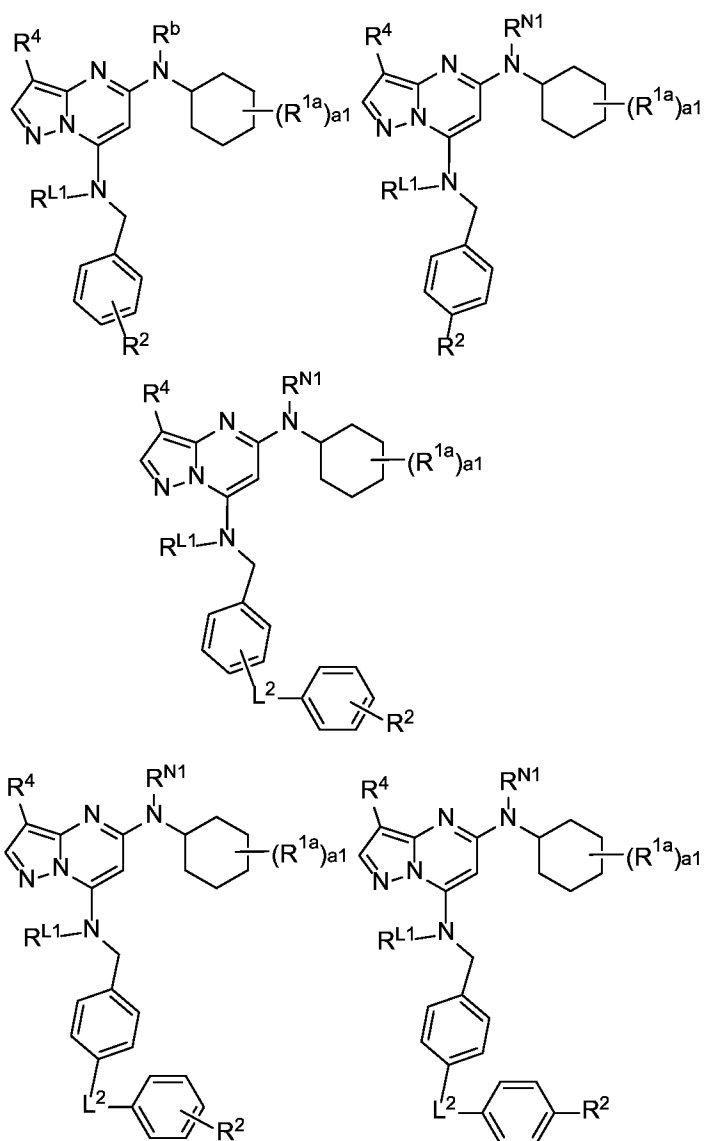
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00245] In certain embodiments, a compound of Formula (III) is of Formula (III-2-d-ii):

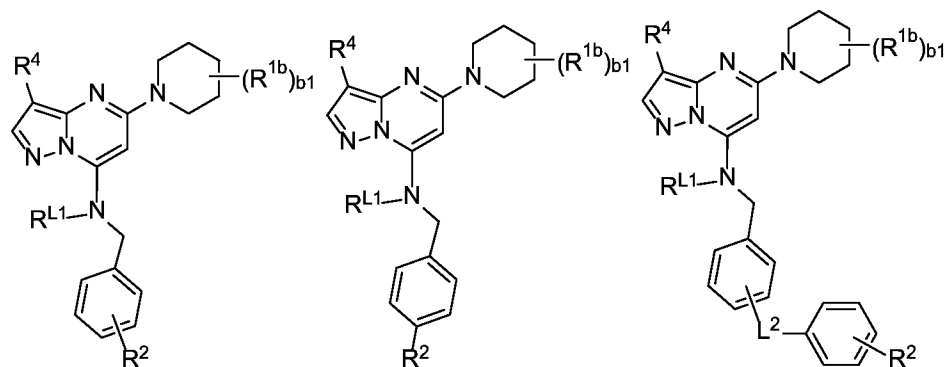


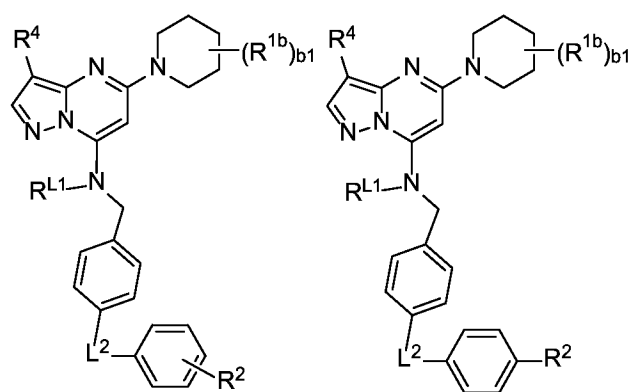
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, wherein R², L², R^{L1}, R⁴, R^{1b}, and b1 are as defined herein.

[00246] In certain embodiments, a compound of Formula (III) is of one of the following formulae:

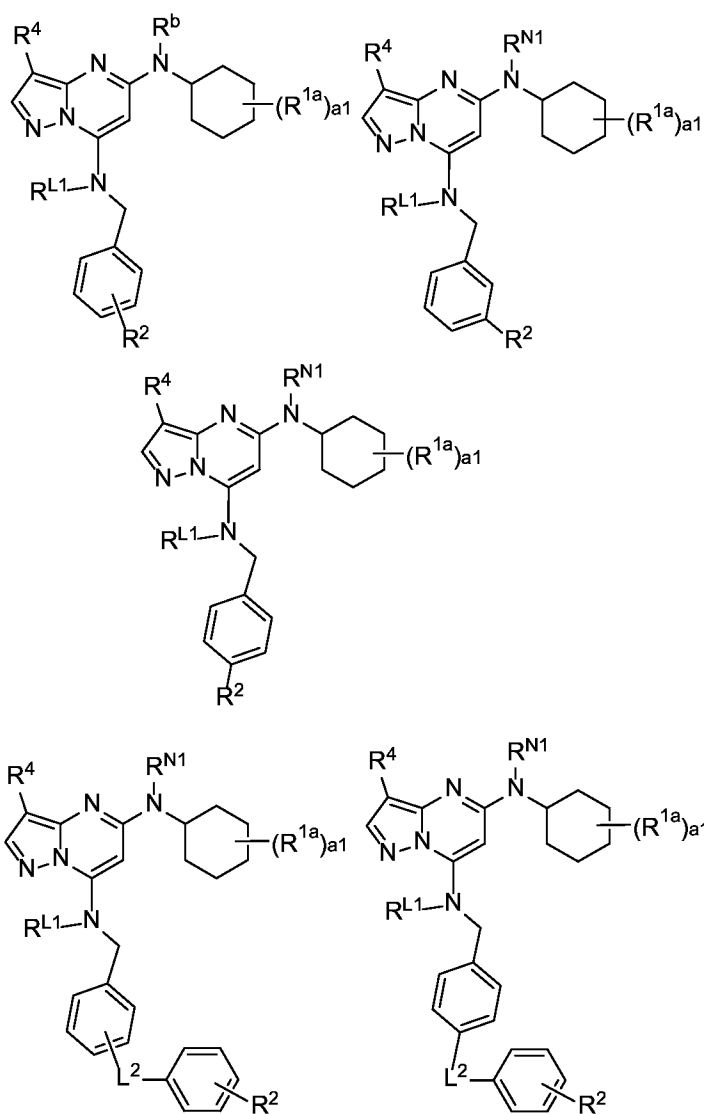


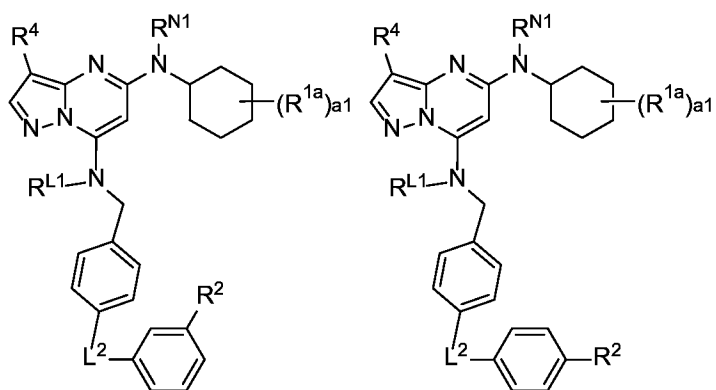
[00247] In certain embodiments, a compound of Formula (III) is of one of the following formulae:



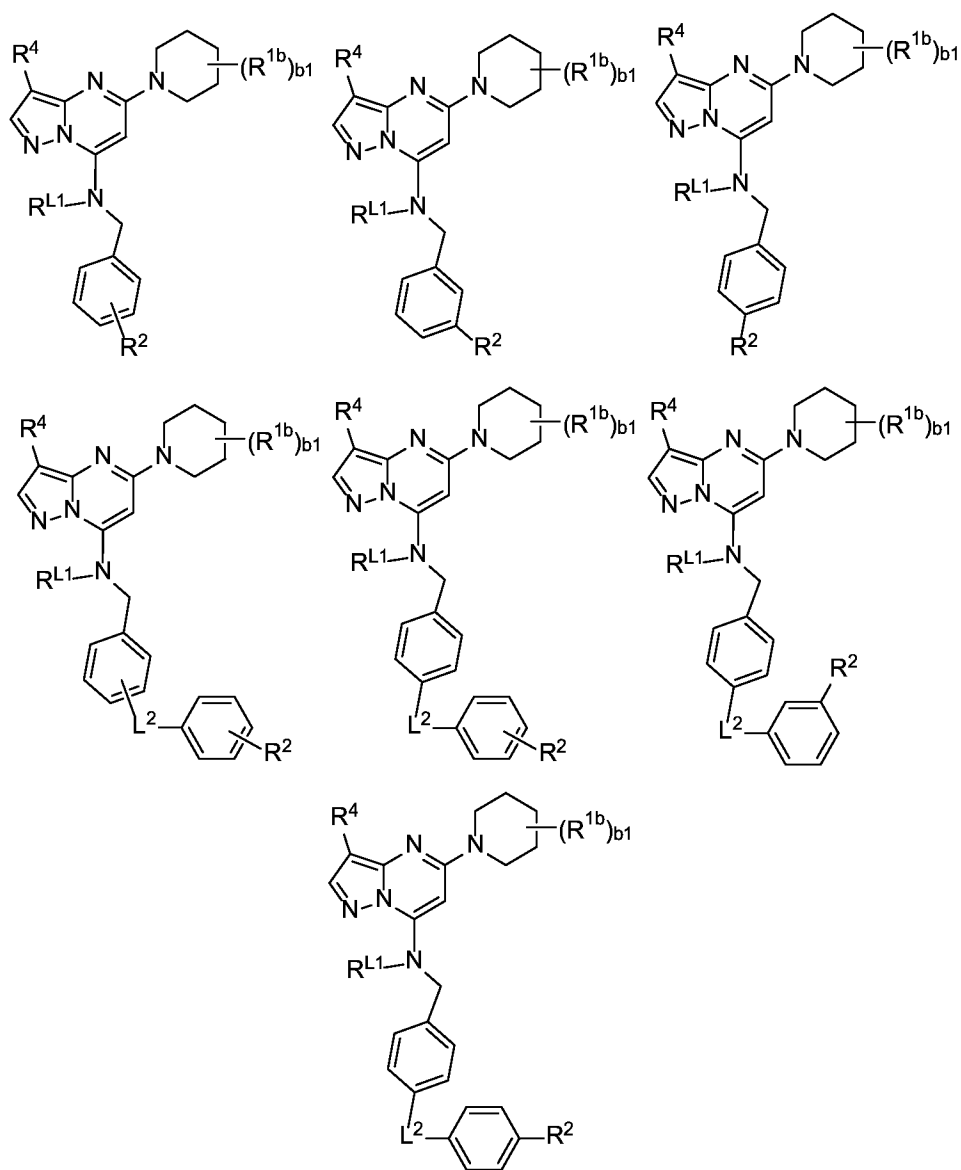


[00248] In certain embodiments, a compound of Formula (III) is of the formula:



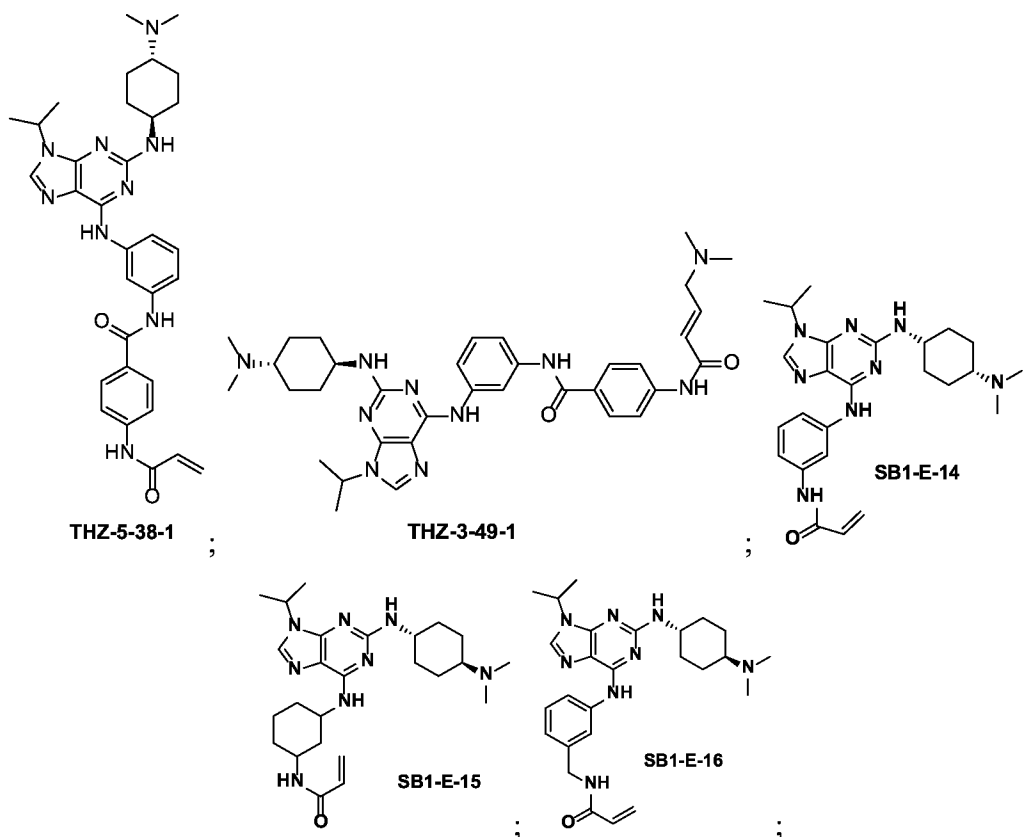


[00249] In certain embodiments, a compound of Formula (III) is of the formula:



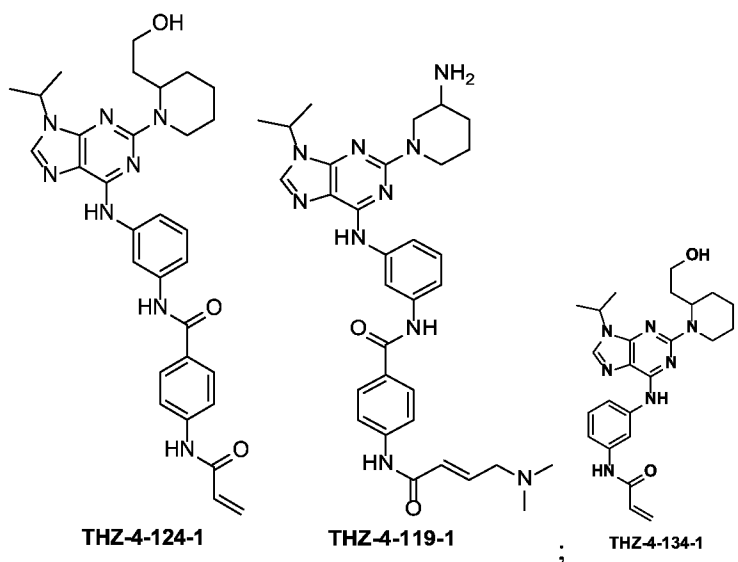
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00250] In some embodiments, a compound of Formula (I) is of the formula:



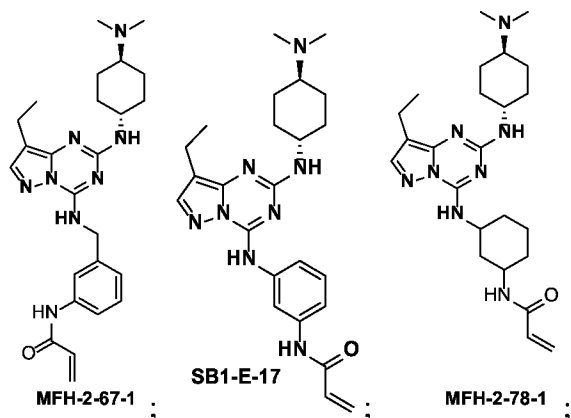
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00251] In some embodiments, a compound of Formula (I) is of the formula:



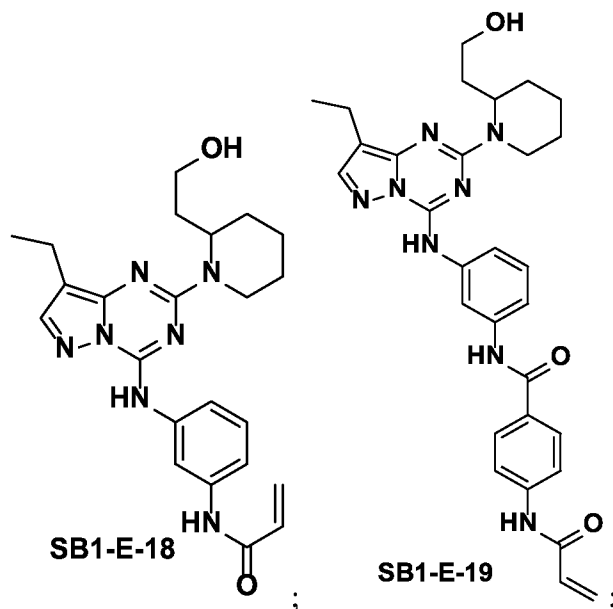
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00252] In some embodiments, a compound of Formula (II) is of the formula:



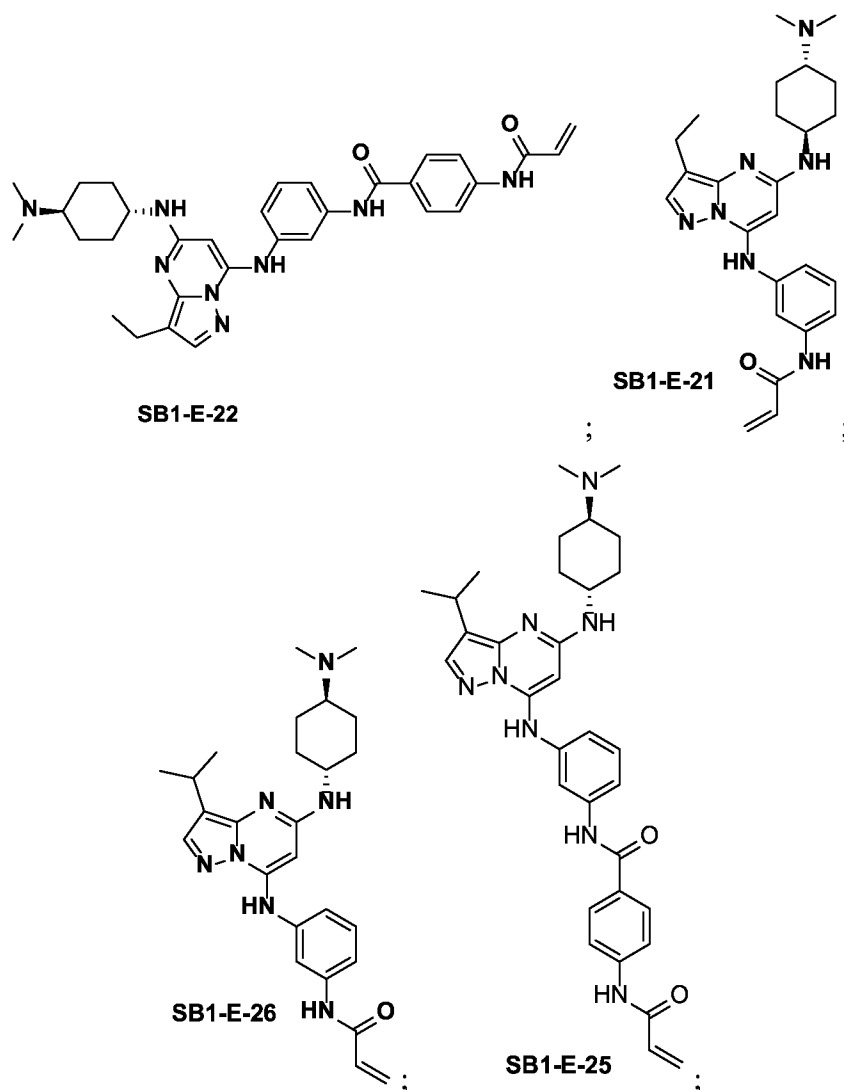
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00253] In some embodiments, a compound of Formula (II) is of the formula:



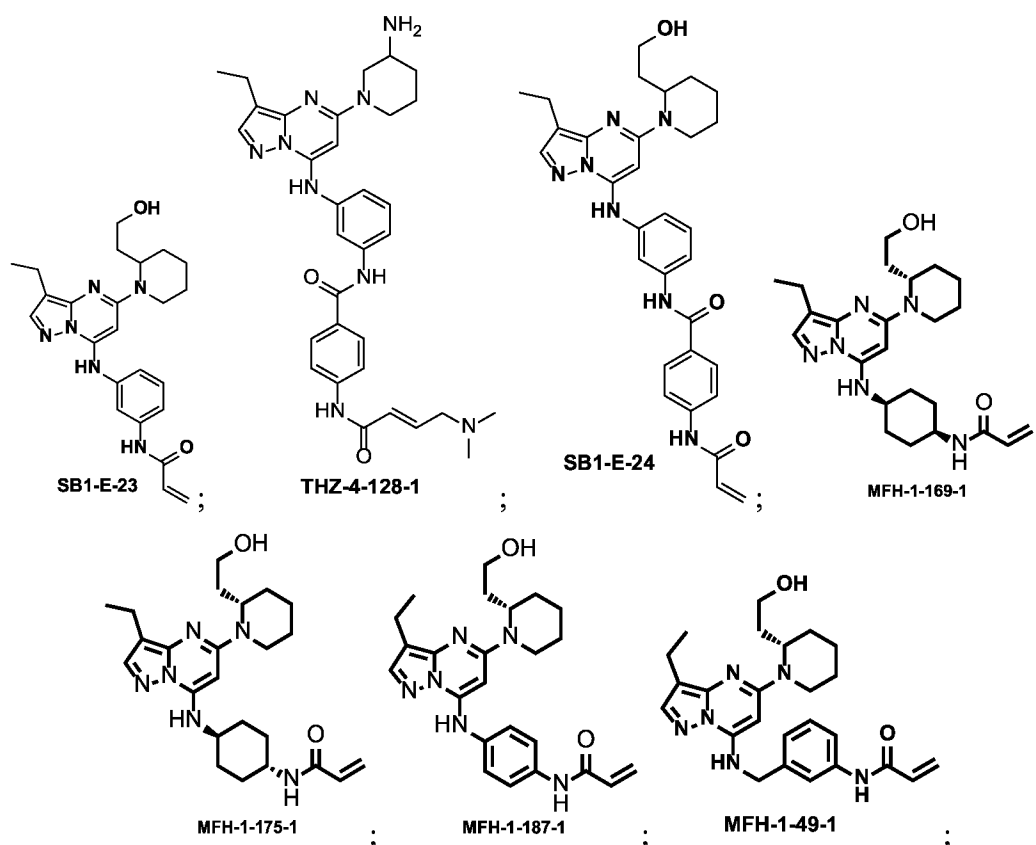
or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00254] In some embodiments, a compound of Formula (III) is of the formula:



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

[00255] In some embodiments, a compound of Formula (III) is of the formula:



or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof.

Pharmaceutical Compositions, Kits, and Administration

[00256] The pharmaceutical compositions described herein are useful in treating and/or preventing proliferative diseases (*e.g.*, cancers (*e.g.*, leukemia, acute lymphoblastic leukemia, lymphoma, Burkitt's lymphoma, melanoma, multiple myeloma, breast cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, lung cancer, colorectal cancer), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases) in a subject. The compositions described herein are also useful for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) in a subject, biological sample, tissue, or cell. The compositions described herein are also useful for inducing apoptosis in a cell.

[00257] The present disclosure provides pharmaceutical compositions comprising a compound described herein (*e.g.*, a compound of any one of Formulae (I)-(III)), or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer,

stereoisomer, isotopically labeled derivative, or prodrug thereof, and optionally a pharmaceutically acceptable excipient. In certain embodiments, the pharmaceutical composition of the invention comprises a compound described herein, or a pharmaceutically acceptable salt thereof, and optionally a pharmaceutically acceptable excipient. In certain embodiments, a pharmaceutical composition described herein comprises a compound described herein, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable excipient. In certain embodiments, the compound described herein, or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, is provided in an effective amount in the pharmaceutical composition.

[00258] In certain embodiments, the effective amount is a therapeutically effective amount (*e.g.*, amount effective for treating a proliferative disease in a subject in need thereof). In certain embodiments, the effective amount is an amount effective for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) in a subject in need thereof. In certain embodiments, the effective amount is an amount effective for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) in a cell. In certain embodiments, the effective amount is an amount effective for inducing apoptosis in a cell. In certain embodiments, the effective amount is a prophylactically effective amount (*e.g.*, amount effective for preventing a proliferative disease in a subject in need thereof and/or for keeping a subject in need thereof in remission of a proliferative disease).

[00259] In certain embodiments, a protein kinase described herein is a CDK. In certain embodiments, a protein kinase described herein is CDK1, CDK2, CDK3, CDK4, CDK5, CDK6, CDK7, CDK8, CDK9, CDK10, CDK11, CDK12, CDK13, CDK14, CDK15, CDK16, CDK17, CDK18, CDK19, or CDK20. In certain embodiments, a protein kinase described herein is CDK7. In certain embodiments, a protein kinase described herein is CDK12. In certain embodiments, a protein kinase described herein is CDK13. In certain embodiments, a protein kinase described herein is a Src family kinase. In certain embodiments, a protein kinase described herein is SRC. In certain embodiments, a protein kinase described herein is FGR. In certain embodiments, a protein kinase described herein is BUB1B. In certain embodiments, a protein kinase described herein is CHEK2. In certain embodiments, a protein kinase described herein is HIPK4. In certain embodiments, a protein kinase described herein is PRKCQ. In certain embodiments, a protein kinase described herein is RET. In certain embodiments, a protein kinase described herein is MELK. In certain embodiments, a protein kinase described herein is IRAK1, IRAK4, BMX, or PI3K. In certain embodiments, a protein

kinase described herein is ABL, ARG, BLK, CSK, EphB1, EphB2, FGR, FRK, FYN, SRC, YES, LCK, LYN, MAP2K5, NLK, p38a, SNRK, or TEC. In certain embodiments, a protein kinase described herein is ABL1(H396P)-phosphorylated, ABL1-phosphorylated, BLK, EPHA4, EPHB2, EPHB3, EPHB4, FGR, JAK3(JH1 domain-catalytic), KIT, KIT(L576P), KIT(V559D), PDGFRB, SRC, YES, ABL1(H396P)-nonphosphorylated, ABL1(Y253F)-phosphorylated, ABL1-nonphosphorylated, FRK, LYN, ABL1(Q252H)-nonphosphorylated, DDR1, EPHB1, ERBB4, p38-alpha, ABL2, ABL1(Q252H)-phosphorylated, SIK, EPHA8, MEK5, ABL1(E255K)-phosphorylated, ABL1(F317L)-nonphosphorylated, FYN, LCK, EPHA2, ABL1(M351T)-phosphorylated, TXK, EGFR(L858R), EGFR(L861Q), ERBB2, ERBB3, EPHA5, ABL1(F317I)-nonphosphorylated, EGFR(L747-E749del, A750P), CSK, EPHA1, ABL1(F317L)-phosphorylated, BRAF(V600E), EGFR, KIT-autoinhibited, or EGFR(E746-A750del). In certain embodiments, a protein kinase described herein is ABL1(F317L)-nonphosphorylated, ABL1(H396P)-nonphosphorylated, ABL1(H396P)-phosphorylated, ABL1-phosphorylated, BLK, EPHA4, EPHB2, EPHB3, EPHB4, JAK3(JH1 domain-catalytic), KIT, KIT(L576P), KIT(V559D), LYN, PDGFRB, SRC, YES, ABL1-nonphosphorylated, ABL1(Y253F)-phosphorylated, ERBB3, FGR, FRK, p38-alpha, ABL1(F317I)-nonphosphorylated, DDR1, EPHA2, ABL1(Q252H)-phosphorylated, MEK5, ABL1(Q252H)-nonphosphorylated, ABL2, FYN, EPHB1, ABL1(E255K)-phosphorylated, ABL1(F317L)-phosphorylated, EPHA1, ABL1(M351T)-phosphorylated, ERBB4, TXK, LCK, EPHA8, SIK, EPHA5, EGFR(L861Q), CSF1R-autoinhibited, BRAF(V600E), BRK, CSK, KIT(D816V), KIT-autoinhibited, EGFR(L747-T751del,Sins), EGFR(L858R), EGFR(L747-E749del, A750P), or CSF1R.

[00260] In certain embodiments, the effective amount is an amount effective for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) by at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 95%, or at least about 98%. In certain embodiments, the effective amount is an amount effective for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) by not more than 10%, not more than 20%, not more than 30%, not more than 40%, not more than 50%, not more than 60%, not more than 70%, not more than 80%, not more than 90%, not more than 95%, or not more than 98%. In certain embodiments, the effective amount is an amount effective for inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) by a range between a percentage described in this paragraph and another percentage described in this paragraph, inclusive.

[00261] Pharmaceutical compositions described herein can be prepared by any method known in the art of pharmacology. In general, such preparatory methods include bringing the compound described herein (*i.e.*, the “active ingredient”) into association with a carrier or excipient, and/or one or more other accessory ingredients, and then, if necessary and/or desirable, shaping, and/or packaging the product into a desired single- or multi-dose unit.

[00262] Pharmaceutical compositions can be prepared, packaged, and/or sold in bulk, as a single unit dose, and/or as a plurality of single unit doses. A “unit dose” is a discrete amount of the pharmaceutical composition comprising a predetermined amount of the active ingredient. The amount of the active ingredient is generally equal to the dosage of the active ingredient which would be administered to a subject and/or a convenient fraction of such a dosage, such as one-half or one-third of such a dosage.

[00263] Relative amounts of the active ingredient, the pharmaceutically acceptable excipient, and/or any additional ingredients in a pharmaceutical composition described herein will vary, depending upon the identity, size, and/or condition of the subject treated and further depending upon the route by which the composition is to be administered. The composition may comprise between 0.1% and 100% (w/w) active ingredient.

[00264] Pharmaceutically acceptable excipients used in the manufacture of provided pharmaceutical compositions include inert diluents, dispersing and/or granulating agents, surface active agents and/or emulsifiers, disintegrating agents, binding agents, preservatives, buffering agents, lubricating agents, and/or oils. Excipients such as cocoa butter and suppository waxes, coloring agents, coating agents, sweetening, flavoring, and perfuming agents may also be present in the composition.

[00265] Exemplary diluents include calcium carbonate, sodium carbonate, calcium phosphate, dicalcium phosphate, calcium sulfate, calcium hydrogen phosphate, sodium phosphate lactose, sucrose, cellulose, microcrystalline cellulose, kaolin, mannitol, sorbitol, inositol, sodium chloride, dry starch, cornstarch, powdered sugar, and mixtures thereof.

[00266] Exemplary granulating and/or dispersing agents include potato starch, corn starch, tapioca starch, sodium starch glycolate, clays, alginic acid, guar gum, citrus pulp, agar, bentonite, cellulose, and wood products, natural sponge, cation-exchange resins, calcium carbonate, silicates, sodium carbonate, cross-linked poly(vinyl-pyrrolidone) (crospovidone), sodium carboxymethyl starch (sodium starch glycolate), carboxymethyl cellulose, cross-linked sodium carboxymethyl cellulose (croscarmellose), methylcellulose, pregelatinized starch (starch 1500), microcrystalline starch, water insoluble starch, calcium carboxymethyl

cellulose, magnesium aluminum silicate (Veegum), sodium lauryl sulfate, quaternary ammonium compounds, and mixtures thereof.

[00267] Exemplary surface active agents and/or emulsifiers include natural emulsifiers (*e.g.*, acacia, agar, alginic acid, sodium alginate, tragacanth, chondrux, cholesterol, xanthan, pectin, gelatin, egg yolk, casein, wool fat, cholesterol, wax, and lecithin), colloidal clays (*e.g.*, bentonite (aluminum silicate) and Veegum (magnesium aluminum silicate)), long chain amino acid derivatives, high molecular weight alcohols (*e.g.*, stearyl alcohol, cetyl alcohol, oleyl alcohol, triacetin monostearate, ethylene glycol distearate, glyceryl monostearate, and propylene glycol monostearate, polyvinyl alcohol), carbomers (*e.g.*, carboxy polymethylene, polyacrylic acid, acrylic acid polymer, and carboxyvinyl polymer), carrageenan, cellulosic derivatives (*e.g.*, carboxymethylcellulose sodium, powdered cellulose, hydroxymethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, methylcellulose), sorbitan fatty acid esters (*e.g.*, polyoxyethylene sorbitan monolaurate (Tween[®] 20), polyoxyethylene sorbitan (Tween[®] 60), polyoxyethylene sorbitan monooleate (Tween[®] 80), sorbitan monopalmitate (Span[®] 40), sorbitan monostearate (Span[®] 60), sorbitan tristearate (Span[®] 65), glyceryl monooleate, sorbitan monooleate (Span[®] 80), polyoxyethylene esters (*e.g.*, polyoxyethylene monostearate (Myrj[®] 45), polyoxyethylene hydrogenated castor oil, polyethoxylated castor oil, polyoxymethylene stearate, and Solutol[®]), sucrose fatty acid esters, polyethylene glycol fatty acid esters (*e.g.*, Cremophor[®]), polyoxyethylene ethers, (*e.g.*, polyoxyethylene lauryl ether (Brij[®] 30)), poly(vinyl-pyrrolidone), diethylene glycol monolaurate, triethanolamine oleate, sodium oleate, potassium oleate, ethyl oleate, oleic acid, ethyl laurate, sodium lauryl sulfate, Pluronic[®] F-68, poloxamer P-188, cetrimonium bromide, cetylpyridinium chloride, benzalkonium chloride, docusate sodium, and/or mixtures thereof.

[00268] Exemplary binding agents include starch (*e.g.*, cornstarch and starch paste), gelatin, sugars (*e.g.*, sucrose, glucose, dextrose, dextrin, molasses, lactose, lactitol, mannitol, *etc.*), natural and synthetic gums (*e.g.*, acacia, sodium alginate, extract of Irish moss, panwar gum, ghatti gum, mucilage of isapol husks, carboxymethylcellulose, methylcellulose, ethylcellulose, hydroxyethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, microcrystalline cellulose, cellulose acetate, poly(vinyl-pyrrolidone), magnesium aluminum silicate (Veegum[®]), and larch arabogalactan), alginates, polyethylene oxide, polyethylene glycol, inorganic calcium salts, silicic acid, polymethacrylates, waxes, water, alcohol, and/or mixtures thereof.

[00269] Exemplary preservatives include antioxidants, chelating agents, antimicrobial preservatives, antifungal preservatives, antiprotozoan preservatives, alcohol preservatives,

acidic preservatives, and other preservatives. In certain embodiments, the preservative is an antioxidant. In other embodiments, the preservative is a chelating agent.

[00270] Exemplary antioxidants include alpha tocopherol, ascorbic acid, ascorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, monothioglycerol, potassium metabisulfite, propionic acid, propyl gallate, sodium ascorbate, sodium bisulfite, sodium metabisulfite, and sodium sulfite.

[00271] Exemplary chelating agents include ethylenediaminetetraacetic acid (EDTA) and salts and hydrates thereof (*e.g.*, sodium edetate, disodium edetate, trisodium edetate, calcium disodium edetate, dipotassium edetate, and the like), citric acid and salts and hydrates thereof (*e.g.*, citric acid monohydrate), fumaric acid and salts and hydrates thereof, malic acid and salts and hydrates thereof, phosphoric acid and salts and hydrates thereof, and tartaric acid and salts and hydrates thereof. Exemplary antimicrobial preservatives include benzalkonium chloride, benzethonium chloride, benzyl alcohol, bronopol, cetrimide, cetylpyridinium chloride, chlorhexidine, chlorobutanol, chlorocresol, chloroxylonol, cresol, ethyl alcohol, glycerin, hexetidine, imidurea, phenol, phenoxyethanol, phenylethyl alcohol, phenylmercuric nitrate, propylene glycol, and thimerosal.

[00272] Exemplary antifungal preservatives include butyl paraben, methyl paraben, ethyl paraben, propyl paraben, benzoic acid, hydroxybenzoic acid, potassium benzoate, potassium sorbate, sodium benzoate, sodium propionate, and sorbic acid.

[00273] Exemplary alcohol preservatives include ethanol, polyethylene glycol, phenol, phenolic compounds, bisphenol, chlorobutanol, hydroxybenzoate, and phenylethyl alcohol.

[00274] Exemplary acidic preservatives include vitamin A, vitamin C, vitamin E, beta-carotene, citric acid, acetic acid, dehydroacetic acid, ascorbic acid, sorbic acid, and phytic acid.

[00275] Other preservatives include tocopherol, tocopherol acetate, deteroxime mesylate, cetrimide, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), ethylenediamine, sodium lauryl sulfate (SLS), sodium lauryl ether sulfate (SLES), sodium bisulfite, sodium metabisulfite, potassium sulfite, potassium metabisulfite, Glydant[®] Plus, Phenonip[®], methylparaben, Germall[®] 115, Germaben[®] II, Neolone[®], Kathon[®], and Euxyl[®].

[00276] Exemplary buffering agents include citrate buffer solutions, acetate buffer solutions, phosphate buffer solutions, ammonium chloride, calcium carbonate, calcium chloride, calcium citrate, calcium gluconate, calcium gluceptate, calcium gluconate, D-gluconic acid, calcium glycerophosphate, calcium lactate, propanoic acid, calcium levulinate, pentanoic acid, dibasic calcium phosphate, phosphoric acid, tribasic calcium phosphate,

calcium hydroxide phosphate, potassium acetate, potassium chloride, potassium gluconate, potassium mixtures, dibasic potassium phosphate, monobasic potassium phosphate, potassium phosphate mixtures, sodium acetate, sodium bicarbonate, sodium chloride, sodium citrate, sodium lactate, dibasic sodium phosphate, monobasic sodium phosphate, sodium phosphate mixtures, tromethamine, magnesium hydroxide, aluminum hydroxide, alginic acid, pyrogen-free water, isotonic saline, Ringer's solution, ethyl alcohol, and mixtures thereof.

[00277] Exemplary lubricating agents include magnesium stearate, calcium stearate, stearic acid, silica, talc, malt, glyceryl behanate, hydrogenated vegetable oils, polyethylene glycol, sodium benzoate, sodium acetate, sodium chloride, leucine, magnesium lauryl sulfate, sodium lauryl sulfate, and mixtures thereof.

[00278] Exemplary natural oils include almond, apricot kernel, avocado, babassu, bergamot, black current seed, borage, cade, camomile, canola, caraway, carnauba, castor, cinnamon, cocoa butter, coconut, cod liver, coffee, corn, cotton seed, emu, eucalyptus, evening primrose, fish, flaxseed, geraniol, gourd, grape seed, hazel nut, hyssop, isopropyl myristate, jojoba, kukui nut, lavandin, lavender, lemon, litsea cubeba, macademia nut, mallow, mango seed, meadowfoam seed, mink, nutmeg, olive, orange, orange roughy, palm, palm kernel, peach kernel, peanut, poppy seed, pumpkin seed, rapeseed, rice bran, rosemary, safflower, sandalwood, sasquana, savoury, sea buckthorn, sesame, shea butter, silicone, soybean, sunflower, tea tree, thistle, tsubaki, vetiver, walnut, and wheat germ oils. Exemplary synthetic oils include, but are not limited to, butyl stearate, caprylic triglyceride, capric triglyceride, cyclomethicone, diethyl sebacate, dimethicone 360, isopropyl myristate, mineral oil, octyldodecanol, oleyl alcohol, silicone oil, and mixtures thereof.

[00279] Liquid dosage forms for oral and parenteral administration include pharmaceutically acceptable emulsions, microemulsions, solutions, suspensions, syrups and elixirs. In addition to the active ingredients, the liquid dosage forms may comprise inert diluents commonly used in the art such as, for example, 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, dimethylformamide, oils (*e.g.*, cottonseed, groundnut, corn, germ, olive, castor, and sesame oils), glycerol, tetrahydrofurfuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof. Besides inert diluents, the oral compositions can include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, and perfuming agents. In certain embodiments for parenteral administration, the conjugates described herein

are mixed with solubilizing agents such as Cremophor[®], alcohols, oils, modified oils, glycols, polysorbates, cyclodextrins, polymers, and mixtures thereof.

[00280] Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions can be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation can be a sterile injectable solution, suspension, or emulsion in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that can 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 di-glycerides. In addition, fatty acids such as oleic acid are used in the preparation of injectables.

[00281] 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.

[00282] In order to prolong the effect of a drug, it is often desirable to slow the absorption of the drug from subcutaneous or intramuscular injection. This can be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution, which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered drug form may be accomplished by dissolving or suspending the drug in an oil vehicle.

[00283] Compositions for rectal or vaginal administration are typically suppositories which can be prepared by mixing the conjugates described herein 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 ingredient.

[00284] Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active ingredient is mixed with at least one inert, pharmaceutically acceptable excipient or 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, for example, carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidone, sucrose, and acacia, (c) humectants such as glycerol, (d)

disintegrating agents such as agar, calcium carbonate, potato or tapioca starch, alginic 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, for example, 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 include a buffering agent.

[00285] Solid compositions of a similar type can 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 art of pharmacology. They may optionally comprise opacifying agents and can be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of encapsulating compositions which can be used include polymeric substances and waxes. Solid compositions of a similar type can 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.

[00286] The active ingredient can be in a 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 ingredient can be admixed with at least one inert diluent such as sucrose, lactose, or starch. Such dosage forms may 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 comprise buffering agents. They may optionally comprise opacifying agents and can be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of encapsulating agents which can be used include polymeric substances and waxes.

[00287] Dosage forms for topical and/or transdermal administration of a compound described herein may include ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants, and/or patches. Generally, the active ingredient is admixed under sterile

conditions with a pharmaceutically acceptable carrier or excipient and/or any needed preservatives and/or buffers as can be required. Additionally, the present disclosure contemplates the use of transdermal patches, which often have the added advantage of providing controlled delivery of an active ingredient to the body. Such dosage forms can be prepared, for example, by dissolving and/or dispensing the active ingredient in the proper medium. Alternatively or additionally, the rate can be controlled by either providing a rate controlling membrane and/or by dispersing the active ingredient in a polymer matrix and/or gel.

[00288] Suitable devices for use in delivering intradermal pharmaceutical compositions described herein include short needle devices. Intradermal compositions can be administered by devices which limit the effective penetration length of a needle into the skin. Alternatively or additionally, conventional syringes can be used in the classical mantoux method of intradermal administration. Jet injection devices which deliver liquid formulations to the dermis *via* a liquid jet injector and/or *via* a needle which pierces the stratum corneum and produces a jet which reaches the dermis are suitable. Ballistic powder/particle delivery devices which use compressed gas to accelerate the compound in powder form through the outer layers of the skin to the dermis are suitable.

[00289] Formulations suitable for topical administration include, but are not limited to, liquid and/or semi-liquid preparations such as liniments, lotions, oil-in-water and/or water-in-oil emulsions such as creams, ointments, and/or pastes, and/or solutions and/or suspensions. Topically administrable formulations may, for example, comprise from about 1% to about 10% (w/w) active ingredient, although the concentration of the active ingredient can be as high as the solubility limit of the active ingredient in the solvent. Formulations for topical administration may further comprise one or more of the additional ingredients described herein.

[00290] A pharmaceutical composition described herein can be prepared, packaged, and/or sold in a formulation suitable for pulmonary administration *via* the buccal cavity. Such a formulation may comprise dry particles which comprise the active ingredient and which have a diameter in the range from about 0.5 to about 7 nanometers, or from about 1 to about 6 nanometers. Such compositions are conveniently in the form of dry powders for administration using a device comprising a dry powder reservoir to which a stream of propellant can be directed to disperse the powder and/or using a self-propelling solvent/powder dispensing container such as a device comprising the active ingredient dissolved and/or suspended in a low-boiling propellant in a sealed container. Such powders

comprise particles wherein at least 98% of the particles by weight have a diameter greater than 0.5 nanometers and at least 95% of the particles by number have a diameter less than 7 nanometers. Alternatively, at least 95% of the particles by weight have a diameter greater than 1 nanometer and at least 90% of the particles by number have a diameter less than 6 nanometers. Dry powder compositions may include a solid fine powder diluent such as sugar and are conveniently provided in a unit dose form.

[00291] Low boiling propellants generally include liquid propellants having a boiling point of below 65 °F at atmospheric pressure. Generally the propellant may constitute 50 to 99.9% (w/w) of the composition, and the active ingredient may constitute 0.1 to 20% (w/w) of the composition. The propellant may further comprise additional ingredients such as a liquid non-ionic and/or solid anionic surfactant and/or a solid diluent (which may have a particle size of the same order as particles comprising the active ingredient).

[00292] Pharmaceutical compositions described herein formulated for pulmonary delivery may provide the active ingredient in the form of droplets of a solution and/or suspension. Such formulations can be prepared, packaged, and/or sold as aqueous and/or dilute alcoholic solutions and/or suspensions, optionally sterile, comprising the active ingredient, and may conveniently be administered using any nebulization and/or atomization device. Such formulations may further comprise one or more additional ingredients including, but not limited to, a flavoring agent such as saccharin sodium, a volatile oil, a buffering agent, a surface active agent, and/or a preservative such as methylhydroxybenzoate. The droplets provided by this route of administration may have an average diameter in the range from about 0.1 to about 200 nanometers.

[00293] Formulations described herein as being useful for pulmonary delivery are useful for intranasal delivery of a pharmaceutical composition described herein. Another formulation suitable for intranasal administration is a coarse powder comprising the active ingredient and having an average particle from about 0.2 to 500 micrometers. Such a formulation is administered by rapid inhalation through the nasal passage from a container of the powder held close to the nares.

[00294] Formulations for nasal administration may, for example, comprise from about as little as 0.1% (w/w) to as much as 100% (w/w) of the active ingredient, and may comprise one or more of the additional ingredients described herein. A pharmaceutical composition described herein can be prepared, packaged, and/or sold in a formulation for buccal administration. Such formulations may, for example, be in the form of tablets and/or lozenges made using conventional methods, and may contain, for example, 0.1 to 20% (w/w) active

ingredient, the balance comprising an orally dissolvable and/or degradable composition and, optionally, one or more of the additional ingredients described herein. Alternately, formulations for buccal administration may comprise a powder and/or an aerosolized and/or atomized solution and/or suspension comprising the active ingredient. Such powdered, aerosolized, and/or aerosolized formulations, when dispersed, may have an average particle and/or droplet size in the range from about 0.1 to about 200 nanometers, and may further comprise one or more of the additional ingredients described herein.

[00295] A pharmaceutical composition described herein can be prepared, packaged, and/or sold in a formulation for ophthalmic administration. Such formulations may, for example, be in the form of eye drops including, for example, a 0.1-1.0% (w/w) solution and/or suspension of the active ingredient in an aqueous or oily liquid carrier or excipient. Such drops may further comprise buffering agents, salts, and/or one or more other of the additional ingredients described herein. Other ophthalmically-administrable formulations which are useful include those which comprise the active ingredient in microcrystalline form and/or in a liposomal preparation. Ear drops and/or eye drops are also contemplated as being within the scope of this disclosure.

[00296] Although the descriptions of pharmaceutical compositions provided herein are principally directed to pharmaceutical compositions which are suitable for administration to humans, such compositions are generally suitable for administration to animals of all sorts. Modification of pharmaceutical compositions suitable for administration to humans in order to render the compositions suitable for administration to various animals is well understood, and the ordinarily skilled veterinary pharmacologist can design and/or perform such modification with ordinary experimentation.

[00297] The compounds provided herein are typically formulated in dosage unit form for ease of administration and uniformity of dosage. It will be understood, however, that the total daily usage of the compositions described herein will be decided by a physician within the scope of sound medical judgment. The specific therapeutically effective dose level for any particular subject or organism will depend upon a variety of factors including the disease being treated and the severity of the disorder; the activity of the specific active ingredient employed; the specific composition employed; the age, body weight, general health, sex, and diet of the subject; the time of administration, route of administration, and rate of excretion of the specific active ingredient employed; the duration of the treatment; drugs used in combination or coincidental with the specific active ingredient employed; and like factors well known in the medical arts.

[00298] The compounds and compositions provided herein can be administered by any route, including enteral (*e.g.*, oral), parenteral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, subcutaneous, intraventricular, transdermal, interdermal, rectal, intravaginal, intraperitoneal, topical (as by powders, ointments, creams, and/or drops), mucosal, nasal, bucal, sublingual; by intratracheal instillation, bronchial instillation, and/or inhalation; and/or as an oral spray, nasal spray, and/or aerosol. Specifically contemplated routes are oral administration, intravenous administration (*e.g.*, systemic intravenous injection), regional administration *via* blood and/or lymph supply, and/or direct administration to an affected site. In general, the most appropriate route of administration will depend upon a variety of factors including the nature of the agent (*e.g.*, its stability in the environment of the gastrointestinal tract), and/or the condition of the subject (*e.g.*, whether the subject is able to tolerate oral administration). In certain embodiments, the compound or pharmaceutical composition described herein is suitable for topical administration to the eye of a subject.

[00299] The exact amount of a compound required to achieve an effective amount will vary from subject to subject, depending, for example, on species, age, and general condition of a subject, severity of the side effects or disorder, identity of the particular compound, mode of administration, and the like. An effective amount may be included in a single dose (*e.g.*, single oral dose) or multiple doses (*e.g.*, multiple oral doses). In certain embodiments, when multiple doses are administered to a subject or applied to a biological sample, tissue, or cell, any two doses of the multiple doses include different or substantially the same amounts of a compound described herein. In certain embodiments, when multiple doses are administered to a subject or applied to a biological sample, tissue, or cell, the frequency of administering the multiple doses to the subject or applying the multiple doses to the tissue or cell is three doses a day, two doses a day, one dose a day, one dose every other day, one dose every third day, one dose every week, one dose every two weeks, one dose every three weeks, or one dose every four weeks. In certain embodiments, the frequency of administering the multiple doses to the subject or applying the multiple doses to the tissue or cell is one dose per day. In certain embodiments, the frequency of administering the multiple doses to the subject or applying the multiple doses to the tissue or cell is two doses per day. In certain embodiments, the frequency of administering the multiple doses to the subject or applying the multiple doses to the tissue or cell is three doses per day. In certain embodiments, when multiple doses are administered to a subject or applied to a biological sample, tissue, or cell, the duration between the first dose and last dose of the multiple doses is one day, two days, four days, one

week, two weeks, three weeks, one month, two months, three months, four months, six months, nine months, one year, two years, three years, four years, five years, seven years, ten years, fifteen years, twenty years, or the lifetime of the subject, biological sample, tissue, or cell. In certain embodiments, the duration between the first dose and last dose of the multiple doses is three months, six months, or one year. In certain embodiments, the duration between the first dose and last dose of the multiple doses is the lifetime of the subject, biological sample, tissue, or cell. In certain embodiments, a dose (*e.g.*, a single dose, or any dose of multiple doses) described herein includes independently between 0.1 μg and 1 μg , between 0.001 mg and 0.01 mg, between 0.01 mg and 0.1 mg, between 0.1 mg and 1 mg, between 1 mg and 3 mg, between 3 mg and 10 mg, between 10 mg and 30 mg, between 30 mg and 100 mg, between 100 mg and 300 mg, between 300 mg and 1,000 mg, or between 1 g and 10 g, inclusive, of a compound described herein. In certain embodiments, a dose described herein includes independently between 1 mg and 3 mg, inclusive, of a compound described herein. In certain embodiments, a dose described herein includes independently between 3 mg and 10 mg, inclusive, of a compound described herein. In certain embodiments, a dose described herein includes independently between 10 mg and 30 mg, inclusive, of a compound described herein. In certain embodiments, a dose described herein includes independently between 30 mg and 100 mg, inclusive, of a compound described herein.

[00300] In certain embodiments, an effective amount of a compound for administration one or more times a day to a 70 kg adult human comprises about 0.0001 mg to about 3000 mg, about 0.0001 mg to about 2000 mg, about 0.0001 mg to about 1000 mg, about 0.001 mg to about 1000 mg, about 0.01 mg to about 1000 mg, about 0.1 mg to about 1000 mg, about 1 mg to about 1000 mg, about 1 mg to about 100 mg, about 10 mg to about 1000 mg, or about 100 mg to about 1000 mg, of a compound per unit dosage form.

[00301] In certain embodiments, the compound of the invention is administered orally or parenterally at dosage levels sufficient to deliver from about 0.001 mg/kg to about 100 mg/kg, from about 0.01 mg/kg to about 50 mg/kg, preferably from about 0.1 mg/kg to about 40 mg/kg, preferably from about 0.5 mg/kg to about 30 mg/kg, from about 0.01 mg/kg to about 10 mg/kg, from about 0.1 mg/kg to about 10 mg/kg, and more preferably from about 1 mg/kg to about 25 mg/kg, of subject body weight per day, one or more times a day, to obtain the desired therapeutic effect.

[00302] Dose ranges as described herein provide guidance for the administration of provided pharmaceutical compositions to an adult. The amount to be administered to, for

example, a child or an adolescent can be determined by a medical practitioner or person skilled in the art and can be lower or the same as that administered to an adult.

[00303] A compound or composition, as described herein, can be administered in combination with one or more additional pharmaceutical agents (*e.g.*, therapeutically and/or prophylactically active agents) useful in treating and/or preventing a proliferative disease. The compounds or compositions can be administered in combination with additional pharmaceutical agents that improve their activity (*e.g.*, activity (*e.g.*, potency and/or efficacy) in treating a proliferative disease in a subject in need thereof, in preventing a proliferative disease in a subject in need thereof, and/or in inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) in a subject, biological sample, tissue, or cell), improve bioavailability, improve safety, reduce drug resistance, reduce and/or modify metabolism, inhibit excretion, and/or modify distribution in a subject, biological sample, tissue, or cell. It will also be appreciated that the therapy employed may achieve a desired effect for the same disorder, and/or it may achieve different effects. In certain embodiments, a pharmaceutical composition described herein including a compound described herein and an additional pharmaceutical agent shows a synergistic effect that is absent in a pharmaceutical composition including one of the compound and the additional pharmaceutical agent, but not both.

[00304] The compound or composition can be administered concurrently with, prior to, or subsequent to one or more additional pharmaceutical agents, which may be useful as, *e.g.*, combination therapies in treating and/or preventing a proliferative disease. Pharmaceutical agents include therapeutically active agents. Pharmaceutical agents also include prophylactically active agents. Pharmaceutical agents include small organic molecules such as drug compounds (*e.g.*, compounds approved for human or veterinary use by the U.S. Food and Drug Administration as provided in the Code of Federal Regulations (CFR)), peptides, proteins, carbohydrates, monosaccharides, oligosaccharides, polysaccharides, nucleoproteins, mucoproteins, lipoproteins, synthetic polypeptides or proteins, small molecules linked to proteins, glycoproteins, steroids, nucleic acids, DNAs, RNAs, nucleotides, nucleosides, oligonucleotides, antisense oligonucleotides, lipids, hormones, vitamins, and cells. In certain embodiments, the additional pharmaceutical agent is a pharmaceutical agent useful in treating a proliferative disease. In certain embodiments, the additional pharmaceutical agent is a pharmaceutical agent useful in preventing a proliferative disease. In certain embodiments, the additional pharmaceutical agent is a pharmaceutical agent useful in inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, and/or CDK13)) in a subject, biological

sample, tissue, or cell. In certain embodiments, the additional pharmaceutical agent is a pharmaceutical agent useful in inducing apoptosis in a cell. In certain embodiments, the additional pharmaceutical agent is a pharmaceutical agent approved by a regulatory agency (*e.g.*, the US FDA) for treating and/or preventing a proliferative disease. Each additional pharmaceutical agent may be administered at a dose and/or on a time schedule determined for that pharmaceutical agent. The additional pharmaceutical agent(s) may also be administered together with each other and/or with the compound or composition described herein in a single dose or administered separately in different doses. The particular combination to employ in a regimen will take into account compatibility of the compound described herein with the additional pharmaceutical agent(s) and/or the desired therapeutic and/or prophylactic effect to be achieved. In general, it is expected that the additional pharmaceutical agent(s) in combination be utilized at levels that do not exceed the levels at which they are utilized individually. In some embodiments, the levels utilized in combination will be lower than those utilized individually.

[00305] In certain embodiments, the additional pharmaceutical agent is an anti-proliferative agent (*e.g.*, anti-cancer agent). In certain embodiments, the additional pharmaceutical agent is an anti-leukemia agent. In certain embodiments, the additional pharmaceutical agent is ABITREXATE (methotrexate), ADE, Adriamycin RDF (doxorubicin hydrochloride), Ambochlorin (chlorambucil), ARRANON (nelarabine), ARZERRA (ofatumumab), BOSULIF (bosutinib), BUSULFEX (busulfan), CAMPATH (alemtuzumab), CERUBIDINE (daunorubicin hydrochloride), CLAFEN (cyclophosphamide), CLOFAREX (clofarabine), CLOLAR (clofarabine), CVP, CYTOSAR-U (cytarabine), CYTOXAN (cyclophosphamide), ERWINAZE (Asparaginase *Erwinia Chrysanthemi*), FLUDARA (fludarabine phosphate), FOLEX (methotrexate), FOLEX PFS (methotrexate), GAZYVA (obinutuzumab), GLEEVEC (imatinib mesylate), Hyper-CVAD, ICLUSIG (ponatinib hydrochloride), IMBRUVICA (ibrutinib), LEUKERAN (chlorambucil), LINFOLIZIN (chlorambucil), MARQIBO (vincristine sulfate liposome), METHOTREXATE LPF (methotrexate), MEXATE (methotrexate), MEXATE-AQ (methotrexate), mitoxantrone hydrochloride, MUSTARGEN (mechlorethamine hydrochloride), MYLERAN (busulfan), NEOSAR (cyclophosphamide), ONCASPAR (Pegaspargase), PURINETHOL (mercaptopurine), PURIXAN (mercaptopurine), Rubidomycin (daunorubicin hydrochloride), SPRYCEL (dasatinib), SYNRIBO (omacetaxine mepesuccinate), TARABINE PFS (cytarabine), TASIGNA (nilotinib), TREANDA (bendamustine hydrochloride), TRISENOX (arsenic trioxide), VINCASAR PFS (vincristine sulfate), ZYDELIG (idelalisib), or a combination thereof. In

certain embodiments, the additional pharmaceutical agent is an anti-lymphoma agent. In certain embodiments, the additional pharmaceutical agent is ABITREXATE (methotrexate), ABVD, ABVE, ABVE-PC, ADCETRIS (brentuximab vedotin), ADRIAMYCIN PFS (doxorubicin hydrochloride), ADRIAMYCIN RDF (doxorubicin hydrochloride), AMBOCHLORIN (chlorambucil), AMBOCLORIN (chlorambucil), ARRANON (nelarabine), BEACOPP, BECENUM (carmustine), BELEODAQ (belinostat), BEXXAR (tositumomab and iodine I 131 tositumomab), BICNU (carmustine), BLENOXANE (bleomycin), CARMUBRIS (carmustine), CHOP, CLAFEN (cyclophosphamide), COPP, COPP-ABV, CVP, CYTOXAN (cyclophosphamide), DEPOCYT (liposomal cytarabine), DTIC-DOME (dacarbazine), EPOCH, FOLEX (methotrexate), FOLEX PFS (methotrexate), FOLOTYN (pralatrexate), HYPER-CVAD, ICE, IMBRUVICA (ibrutinib), INTRON A (recombinant interferon alfa-2b), ISTODAX (romidepsin), LEUKERAN (chlorambucil), LINFOLIZIN (chlorambucil), Lomustine, MATULANE (procarbazine hydrochloride), METHOTREXATE LPF (methotrexate), MEXATE (methotrexate), MEXATE-AQ (methotrexate), MOPP, MOZOBIL (plerixafor), MUSTARGEN (mechlorethamine hydrochloride), NEOSAR (cyclophosphamide), OEPA, ONTAK (denileukin diftitox), OPPA, R-CHOP, REVLIMID (lenalidomide), RITUXAN (rituximab), STANFORD V, TREANDA (bendamustine hydrochloride), VAMP, VELBAN (vinblastine sulfate), VELCADE (bortezomib), VELSAR (vinblastine sulfate), VINCASAR PFS (vincristine sulfate), ZEVALIN (ibritumomab tiuxetan), ZOLINZA (vorinostat), ZYDELIG (idelalisib), or a combination thereof. In certain embodiments, the additional pharmaceutical agent is an anti-myelodysplasia agent. In certain embodiments, the additional pharmaceutical agent is REVLIMID (lenalidomide), DACOGEN (decitabine), VIDAZA (azacitidine), CYTOSAR-U (cytarabine), IDAMYCIN (idarubicin), CERUBIDINE (daunorubicin), or a combination thereof.

[00306] In certain embodiments, the additional pharmaceutical agent is an anti-macroglobulinemia agent. In certain embodiments, the additional pharmaceutical agent is LEUKERAN (chlorambucil), NEOSAR (cyclophosphamide), FLUDARA (fludarabine), LEUSTATIN (cladribine), or a combination thereof. In certain embodiments, the additional pharmaceutical agent is ABITREXATE (methotrexate), ABRAXANE (paclitaxel albumin-stabilized nanoparticle formulation), AC, AC-T, ADE, ADRIAMYCIN PFS (doxorubicin hydrochloride), ADRUCIL (fluorouracil), AFINITOR (everolimus), AFINITOR DISPERZ (everolimus), ALDARA (imiquimod), ALIMTA (pemetrexed disodium), AREDIA (pamidronate disodium), ARIMIDEX (anastrozole), AROMASIN (exemestane), AVASTIN

(bevacizumab), BECENUM (carmustine), BEP, BICNU (carmustine), BLENOXANE (bleomycin), CAF, CAMPTOSAR (irinotecan hydrochloride), CAPOX, CAPRELSA (vandetanib), CARBOPLATIN-TAXOL, CARMUBRIS (carmustine), CASODEX (bicalutamide), CEENU (lomustine), CERUBIDINE (daunorubicin hydrochloride), CERVARIX (recombinant HPV bivalent vaccine), CLAFEN (cyclophosphamide), CMF, COMETRIQ (cabozantinib-s-malate), COSMEGEN (dactinomycin), CYFOS (ifosfamide), CYRAMZA (ramucirumab), CYTOSAR-U (cytarabine), CYTOXAN (cyclophosphamide), DACOGEN (decitabine), DEGARELIX, DOXIL (doxorubicin hydrochloride liposome), DOXORUBICIN HYDROCHLORIDE, DOX-SL (doxorubicin hydrochloride liposome), DTIC-DOME (dacarbazine), EFUDEX (fluorouracil), ELLENCE (epirubicin hydrochloride), ELOXATIN (oxaliplatin), ERBITUX (cetuximab), ERIVEDGE (vismodegib), ETOPOPHOS (etoposide phosphate), EVACET (doxorubicin hydrochloride liposome), FARESTON (toremifene), FASLODEX (fulvestrant), FEC, FEMARA (letrozole), FLUOROPLEX (fluorouracil), FOLEX (methotrexate), FOLEX PFS (methotrexate), FOLFIRI, FOLFIRI-BEVACIZUMAB, FOLFIRI-CETUXIMAB, FOLFIRINOX, FOLFOX, FU-LV, GARDASIL (recombinant human papillomavirus (HPV) quadrivalent vaccine), GEMCITABINE-CISPLATIN, GEMCITABINE-OXALIPLATIN, GEMZAR (gemcitabine hydrochloride), GILOTRIF (afatinib dimaleate), GLEEVEC (imatinib mesylate), GLIADEL (carmustine implant), GLIADEL WAFER (carmustine implant), HERCEPTIN (trastuzumab), HYCAMTIN (topotecan hydrochloride), IFEX (ifosfamide), IFOSFAMIDUM (ifosfamide), INLYTA (axitinib), INTRON A (recombinant interferon alfa-2b), IRESSA (gefitinib), IXEMPRA (ixabepilone), JAKAFI (ruxolitinib phosphate), JEVTANA (cabazitaxel), KADCYLA (ado-trastuzumab emtansine), KEYTRUDA (pembrolizumab), KYPROLIS (carfilzomib), LIPODOX (doxorubicin hydrochloride liposome), LUPRON (leuprolide acetate), LUPRON DEPOT (leuprolide acetate), LUPRON DEPOT-3 MONTH (leuprolide acetate), LUPRON DEPOT-4 MONTH (leuprolide acetate), LUPRON DEPOT-PED (leuprolide acetate), MEGACE (megestrol acetate), MEKINIST (trametinib), METHAZOLASTONE (temozolomide), METHOTREXATE LPF (methotrexate), MEXATE (methotrexate), MEXATE-AQ (methotrexate), MITOXANTRONE HYDROCHLORIDE, MITOZYTREX (mitomycin c), MOZOBIL (plerixafor), MUSTARGEN (mechlorethamine hydrochloride), MUTAMYCIN (mitomycin c), MYLOSAR (azacitidine), NAVELBINE (vinorelbine tartrate), NEOSAR (cyclophosphamide), NEXAVAR (sorafenib tosylate), NOLVADEX (tamoxifen citrate), NOVALDEX (tamoxifen citrate), OFF, PAD, PARAPLAT (carboplatin), PARAPLATIN (carboplatin), PEG-INTRON (peginterferon alfa-2b),

PEMETREXED DISODIUM, PERJETA (pertuzumab), PLATINOL (cisplatin), PLATINOL-AQ (cisplatin), POMALYST (pomalidomide), prednisone, PROLEUKIN (aldesleukin), PROLIA (denosumab), PROVENGE (sipuleucel-t), REVLIMID (lenalidomide), RUBIDOMYCIN (daunorubicin hydrochloride), SPRYCEL (dasatinib), STIVARGA (regorafenib), SUTENT (sunitinib malate), SYLATRON (peginterferon alfa-2b), SYLVANT (siltuximab), SYNOVIR (thalidomide), TAC, TAFINLAR (dabrafenib), TARABINE PFS (cytarabine), TARCEVA (erlotinib hydrochloride), TASIGNA (nilotinib), TAXOL (paclitaxel), TAXOTERE (docetaxel), TEMODAR (temozolomide), THALOMID (thalidomide), TOPOSAR (etoposide), TORISEL (temsirolimus), TPF, TRISENOX (arsenic trioxide), TYKERB (lapatinib ditosylate), VECTIBIX (panitumumab), VEIP, VELBAN (vinblastine sulfate), VELCADE (bortezomib), VELSAR (vinblastine sulfate), VEPESID (etoposide), VIADUR (leuprolide acetate), VIDAZA (azacitidine), VINCASAR PFS (vincristine sulfate), VOTRIENT (pazopanib hydrochloride), WELLCOVORIN (leucovorin calcium), XALKORI (crizotinib), XELODA (capecitabine), XELOX, XGEVA (denosumab), XOFIGO (radium 223 dichloride), XTANDI (enzalutamide), YERVOY (ipilimumab), ZALTRAP (ziv-aflibercept), ZELBORAF (vemurafenib), ZOLADEX (goserelin acetate), ZOMETA (zoledronic acid), ZYKADIA (ceritinib), ZYTIGA (abiraterone acetate), or a combination thereof. In certain embodiments, the additional pharmaceutical agent is a protein kinase inhibitor (*e.g.*, tyrosine protein kinase inhibitor). In certain embodiments, the additional pharmaceutical agent is an inhibitor of a Src family kinase. In certain embodiments, the additional pharmaceutical agent is a CDK inhibitor. In certain embodiments, the additional pharmaceutical agent is a CDK7 inhibitor. In certain embodiments, the additional pharmaceutical agent is a CDK12 inhibitor. In certain embodiments, the additional pharmaceutical agent is a CDK13 inhibitor. In certain embodiments, the additional pharmaceutical agent is an inhibitor of one or more protein kinases selected from the group consisting of IRAK1, IRAK4, BMX, and PI3K. In certain embodiments, the additional pharmaceutical agent is an inhibitor of one or more protein kinases selected from the group consisting of BUB1B, CDK2, CDK9, CHEK2, FGR, HIPK4, PRKCQ, RET, SRC, or MELK. In certain embodiments, the additional pharmaceutical agent is an inhibitor of one or more protein kinases selected from the group consisting of ABL, ARG, BLK, CSK, EphB1, EphB2, FGR, FRK, FYN, SRC, YES, LCK, LYN, MAP2K5, NLK, p38a, SNRK, and TEC. In certain embodiments, the additional pharmaceutical agent is an inhibitor of one or more protein kinases selected from the group consisting of ABL1(H396P)-phosphorylated, ABL1-phosphorylated, BLK, EPHA4, EPHB2, EPHB3,

EPHB4, FGR, JAK3(JH1domain-catalytic), KIT, KIT(L576P), KIT(V559D), PDGFRB, SRC, YES, ABL1(H396P)-nonphosphorylated, ABL1(Y253F)-phosphorylated, ABL1-nonphosphorylated, FRK, LYN, ABL1(Q252H)-nonphosphorylated, DDR1, EPHB1, ERBB4, p38-alpha, ABL2, ABL1(Q252H)-phosphorylated, SIK, EPHA8, MEK5, ABL1(E255K)-phosphorylated, ABL1(F317L)-nonphosphorylated, FYN, LCK, EPHA2, ABL1(M351T)-phosphorylated, TXK, EGFR(L858R), EGFR(L861Q), ERBB2, ERBB3, EPHA5, ABL1(F317I)-nonphosphorylated, EGFR(L747-E749del, A750P), CSK, EPHA1, ABL1(F317L)-phosphorylated, BRAF(V600E), EGFR, KIT-autoinhibited, and EGFR(E746-A750del). In certain embodiments, the additional pharmaceutical agent is an inhibitor of one or more protein kinases selected from the group consisting of ABL1(F317L)-nonphosphorylated, ABL1(H396P)-nonphosphorylated, ABL1(H396P)-phosphorylated, ABL1-phosphorylated, BLK, EPHA4, EPHB2, EPHB3, EPHB4, JAK3(JH1domain-catalytic), KIT, KIT(L576P), KIT(V559D), LYN, PDGFRB, SRC, YES, ABL1-nonphosphorylated, ABL1(Y253F)-phosphorylated, ERBB3, FGR, FRK, p38-alpha, ABL1(F317I)-nonphosphorylated, DDR1, EPHA2, ABL1(Q252H)-phosphorylated, MEK5, ABL1(Q252H)-nonphosphorylated, ABL2, FYN, EPHB1, ABL1(E255K)-phosphorylated, ABL1(F317L)-phosphorylated, EPHA1, ABL1(M351T)-phosphorylated, ERBB4, TXK, LCK, EPHA8, SIK, EPHA5, EGFR(L861Q), CSF1R-autoinhibited, BRAF(V600E), BRK, CSK, KIT(D816V), KIT-autoinhibited, EGFR(L747-T751del,Sins), EGFR(L858R), EGFR(L747-E749del, A750P), and CSF1R. In certain embodiments, the additional pharmaceutical agent is an anti-angiogenesis agent, anti-inflammatory agent, immunosuppressant, anti-bacterial agent, anti-viral agent, cardiovascular agent, cholesterol-lowering agent, anti-diabetic agent, anti-allergic agent, pain-relieving agent, or a combination thereof. In certain embodiments, the compounds described herein or pharmaceutical compositions can be administered in combination with an anti-cancer therapy including, but not limited to, transplantation (*e.g.*, bone marrow transplantation, stem cell transplantation), surgery, radiation therapy, immunotherapy, and chemotherapy.

[00307] Also encompassed by the disclosure are kits (*e.g.*, pharmaceutical packs). The kits provided may comprise a pharmaceutical composition or compound described herein and a container (*e.g.*, a vial, ampule, bottle, syringe, and/or dispenser package, or other suitable container). In some embodiments, provided kits may optionally further include a second container comprising a pharmaceutical excipient for dilution or suspension of a pharmaceutical composition or compound described herein. In some embodiments, the

pharmaceutical composition or compound described herein provided in the first container and the second container are combined to form one unit dosage form.

[00308] In certain embodiments, a kit described herein includes a first container comprising a compound or pharmaceutical composition described herein. In certain embodiments, a kit described herein is useful in treating a proliferative disease (*e.g.*, cancers (*e.g.*, leukemia, acute lymphoblastic leukemia, lymphoma, Burkitt's lymphoma, melanoma, multiple myeloma, breast cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, lung cancer, colorectal cancer), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases) in a subject in need thereof, preventing a proliferative disease in a subject in need thereof, inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, or CDK13)) in a subject, biological sample, tissue, or cell, and/or inducing apoptosis in a cell.

[00309] In certain embodiments, a kit described herein further includes instructions for using the compound or pharmaceutical composition included in the kit. A kit described herein may also include information as required by a regulatory agency such as the U.S. Food and Drug Administration (FDA). In certain embodiments, the information included in the kits is prescribing information. In certain embodiments, the kits and instructions provide for treating a proliferative disease in a subject in need thereof, preventing a proliferative disease in a subject in need thereof, inhibiting the activity of a protein kinase (*e.g.*, CDK (*e.g.*, CDK7, CDK12, or CDK13)) in a subject, biological sample, tissue, or cell, and/or inducing apoptosis in a cell. A kit described herein may include one or more additional pharmaceutical agents described herein as a separate composition.

Methods of Treatment and Uses

[00310] The present invention also provides methods for the treatment or prevention of a proliferative disease (*e.g.*, cancers (*e.g.*, leukemia, acute lymphoblastic leukemia, lymphoma, Burkitt's lymphoma, melanoma, multiple myeloma, breast cancer, Ewing's sarcoma, osteosarcoma, brain cancer, neuroblastoma, lung cancer, colorectal cancer), benign neoplasms, diseases associated with angiogenesis, inflammatory diseases, autoinflammatory diseases, and autoimmune diseases).

[00311] The compounds described herein may exhibit kinase inhibitory activity; the ability to inhibit cyclin-dependent kinase (CDK); the ability to inhibit cyclin-dependent kinase 7 (CDK7); the ability to inhibit cyclin-dependent kinase 7 (CDK7), without inhibiting another cyclin-dependent kinase (CDK); the ability to inhibit cyclin-dependent kinase 12 (CDK12);

the ability to inhibit cyclin-dependent kinase 12 (CDK12), without inhibiting another cyclin-dependent kinase (CDK); the ability to inhibit cyclin-dependent kinase 13 (CDK13); the ability to inhibit cyclin-dependent kinase 13 (CDK13), without inhibiting another cyclin-dependent kinase (CDK); the ability to inhibit cyclin-dependent kinases 12 and 13 (CDK12 and CDK13); the ability to inhibit cyclin-dependent kinases 12 and 13 (CDK12 and CDK13), without inhibiting another cyclin-dependent kinase (CDK); a therapeutic effect and/or preventative effect in the treatment of cancers; a therapeutic effect and/or preventative effect in the treatment of Myc-dependent cancers; and/or a therapeutic profile (*e.g.*, optimum safety and curative effect) that is superior to existing chemotherapeutic agents.

[00312] Without wishing to be bound by any particular theory, the compounds described herein are able to bind (*e.g.*, covalently modify) a protein kinase described herein. In certain embodiments, the R² group of a compound described herein is able to bind (*e.g.*, covalently modify) to the protein kinase. In certain embodiments, the R² group of a compound described herein is able to covalently bind a cysteine residue of the protein kinase. In certain embodiments, the R² group of a compound described herein is able to covalently bind Cys312 residue of CDK7. In certain embodiments, the R² group of a compound described herein is able to covalently bind Cys Cys1039 residue of CDK12. In certain embodiments, the R² group of a compound described herein is able to covalently bind Cys1017 residue of CDK13.

[00313] In another aspect, the present disclosure provides methods of inhibiting the activity of a protein kinase in a subject, the methods comprising administering to the subject an effective amount (*e.g.*, therapeutically effective amount) of a compound, or pharmaceutical composition thereof, as described herein.

[00314] In another aspect, the present disclosure provides methods of inhibiting the activity of a protein kinase in a biological sample, the methods comprising contacting the biological sample with an effective amount of a compound, or pharmaceutical composition thereof, as described herein.

[00315] In another aspect, the present disclosure provides methods of inhibiting the activity of a protein kinase in a tissue, the methods comprising contacting the tissue with an effective amount of a compound, or pharmaceutical composition thereof, as described herein.

[00316] In another aspect, the present disclosure provides methods of inhibiting the activity of a protein kinase in a cell, the methods comprising contacting the cell with an effective amount of a compound, or pharmaceutical composition thereof, as described herein.

[00317] In certain embodiments, the subject being treated is a mammal. In certain embodiments, the subject is a human. In certain embodiments, the subject is a domesticated animal, such as a dog, cat, cow, pig, horse, sheep, or goat. In certain embodiments, the subject is a companion animal such as a dog or cat. In certain embodiments, the subject is a livestock animal such as a cow, pig, horse, sheep, or goat. In certain embodiments, the subject is a zoo animal. In another embodiment, the subject is a research animal such as a rodent, dog, or non-human primate. In certain embodiments, the subject is a non-human transgenic animal such as a transgenic mouse or transgenic pig.

[00318] In certain embodiments, a biological sample described herein is a breast tissue, bone marrow, lymph node, spleen, or blood.

[00319] In certain embodiments, a cell described herein is *in vitro*. In certain embodiments, a cell described herein is *ex vivo*. In certain embodiments, a cell described herein is *in vivo*. In certain embodiments, a cell described herein is a malignant cell (*e.g.*, malignant blood cell). In certain embodiments, a cell described herein is a malignant hematopoietic stem cell (*e.g.*, malignant myeloid cell or malignant lymphoid cell). In certain embodiments, a cell described herein is a malignant lymphocyte (*e.g.*, malignant T-cell or malignant B-cell). In certain embodiments, a cell described herein is a malignant red blood cell, malignant white blood cell, or malignant platelet. In certain embodiments, a cell described herein is a malignant neutrophil, malignant macrophage, or malignant plasma cell. In certain embodiments, a cell described herein is a carcinoma cell. In certain embodiments, a cell described herein is a carcinoma breast cell. In certain embodiments, a cell described herein is a sarcomas cell. In certain embodiments, a cell described herein is a sarcomas breast cell.

[00320] The proliferative disease to be treated or prevented using the compounds described herein may be associated with overexpression of a kinase, such as cyclin-dependent kinase (CDK). The process of eukaryotic cell division may be broadly divided into a series of sequential phases termed G1, S, G2, and M. Correct progression through the various phases of the cell cycle has been shown to be critically dependent upon the spatial and temporal regulation of a family of proteins known as cyclin dependent kinases (CDKs) and a diverse set of their cognate protein partners termed cyclins. CDKs are CDC2 (also known as CDK1) homologous serine-threonine kinase proteins that are able to utilize ATP as a substrate in the phosphorylation of diverse polypeptides in a sequence-dependent context. Cyclins are a family of proteins characterized by a homology region, containing approximately 100 amino acids, termed the “cyclin box” which is used in binding to, and defining selectivity for, specific CDK partner proteins.

[00321] Modulation of the expression levels, degradation rates, protein levels, and activity levels of various CDKs and cyclins throughout the cell cycle leads to the cyclical formation of a series of CDK/cyclin complexes, in which the CDKs are enzymatically active. The formation of these complexes controls passage through discrete cell cycle checkpoints and thereby enables the process of cell division to continue. Failure to satisfy the prerequisite biochemical criteria at a given cell cycle checkpoint, *i.e.*, failure to form a required CDK/cyclin complex, can lead to cell cycle arrest and/or cellular apoptosis. Aberrant cellular proliferation can often be attributed to loss of correct cell cycle control. Inhibition of CDK enzymatic activity therefore provides a means by which abnormally dividing cells can have their division arrested and/or be killed. The diversity of CDKs, and CDK complexes, and their critical roles in mediating the cell cycle, provides a broad spectrum of potential therapeutic targets selected on the basis of a defined biochemical rationale.

[00322] CDK7, a member of the CDK family, was originally isolated as the catalytic subunit of the trimeric CDK-activating kinase (CAK) complex. This complex, consisting of CDK7, cyclin H, and MAT1, is responsible for activation of the mitotic promoting factor *in vitro*. The discovery that CDK7 was also a component of the basal transcription repair factor IIIH (TFIIH) implicated a dual role for CDK7 in transcription as part of TFIIH and in the control of the cell cycle as the trimeric CAK complex. TFIIH is a multi-subunit protein complex identified as a factor required for RNA polymerase II (RNAP II)-catalyzed transcription, and subsequently this complex was found to play a key role in nucleotide excision repair. CDK7 is a component of at least three complexes, *i.e.*, the trimeric CAK complex, the quaternary complex with the XPD (or ERCC2, a protein involved in transcription-coupled nucleotide excision repair), and the nine-subunit TFIIH complex. The two functions of CDK7 in CAK and CTD phosphorylation support critical facets of cellular proliferation, cell cycling, and transcription. Overexpression of CDK7 may inhibit apoptosis, promote transcription and cell proliferation, and/or disrupt DNA repair, and therefore, cause proliferative diseases. In certain embodiments, the proliferative disease to be treated or prevented using the compounds described herein may be associated with overexpression of a CDK (*e.g.*, CDK7).

[00323] Cdk12 and Cdk13 are Cdc2-related proteins that share 92% identity in their kinase domains (Chen *et al.*, *Exp. Neurol.*, 2014, 261, 10-21). CDK12 plays a critical role in cell processes, for example, regulating transcription and splicing machinery by stabilizing the RNAPII and DNA interaction, and regulating DNA damage response (DDR) and maintenance of genomic stability by modulating the expression of DDR genes.

Overexpression of CDK12 has been found to correlate, both at the transcriptional and protein level, with pathological parameters of breast cancer disease.

[00324] A proliferative disease may be associated with aberrant activity of a CDK (*e.g.*, CDK7, CDK12, and/or CDK13). Aberrant activity of a CDK (*e.g.*, CDK7, CDK12, and/or CDK13) may be an elevated and/or an inappropriate activity of the CDK. Deregulation of cell cycle progression is a characteristic of a proliferative disease, and a majority of proliferative diseases have abnormalities in some component of CDK (*e.g.*, CDK7, CDK12, and/or CDK13) activity, frequently through elevated and/or inappropriate CDK activation. Inhibition of the catalytic activity of CDK7, CDK12, and/or CDK13 would be expected to inhibit cell cycle progression by blocking the phosphorylation of cell cycle CDKs, and would additionally inhibit transcription of effectors of cell division. In certain embodiments, CDK7 is not overexpressed, and the activity of CDK7 is elevated and/or inappropriate. In certain other embodiments, CDK7 is overexpressed, and the activity of CDK7 is elevated and/or inappropriate. In certain embodiments, CDK12 is not overexpressed, and the activity of CDK12 is elevated and/or inappropriate. In certain embodiments, CDK12 is overexpressed, and the activity of CDK12 is elevated and/or inappropriate. In certain other embodiments, CDK13 is not overexpressed, and the activity of CDK13 is elevated and/or inappropriate. In certain other embodiments, CDK13 is overexpressed, and the activity of CDK13 is elevated and/or inappropriate. The compounds described herein, and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, may inhibit the activity of CDK7 and be useful in treating and/or preventing proliferative diseases. The compounds described herein, and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, may inhibit the activity of CDK12 and/or CDK13 and be useful in treating and/or preventing proliferative diseases.

[00325] A proliferative disease may also be associated with inhibition of apoptosis of a cell in a biological sample or subject. All types of biological samples described herein or known in the art are contemplated as being within the scope of the invention. Apoptosis is the process of programmed cell death. Inhibition of apoptosis may result in uncontrolled cell proliferation and, therefore, may cause proliferative diseases. The cell cycle CDKs (CDK1, 2, 4, and 6) are activated by phosphorylation by CDK7/cyclin H (also called CAK). Inhibition of CDK7 would therefore result in cell-cycle arrest at multiple points in the cell cycle due to failure to activate the cell cycle CDKs. CDK 7 activates transcription by phosphorylating the

CTD of RNAP II. Inhibition of CTD phosphorylation has been shown to inhibit transcription and reduce expression of short lived proteins, including those involved in apoptosis regulation. It is appreciated in the art that stalling of RNA polymerase may activate p53 (also known as protein 53 or tumor protein 53, a tumor suppressor protein that is encoded in humans by the TP53 gene), leading to apoptosis. Thus, inhibition of the activity of CDK7 are expected to cause cytotoxicity by inducing apoptosis. The compounds described herein, and pharmaceutically acceptable salts, solvates, hydrates, polymorphs, co-crystals, tautomers, stereoisomers, isotopically labeled derivatives, prodrugs, and compositions thereof, may induce apoptosis, and therefore, be useful in treating and/or preventing proliferative diseases.

[00326] The CycK/Cdk12 complex regulates phosphorylation of Ser2 in the C-terminal domain of RNA polymerase II and expression of a small subset of human genes, as revealed in expression microarrays. Through regulation of expression of DNA damage response genes (*i.e.* oncogenes), CycK/Cdk12 protects cells from genomic instability. In certain embodiments, the DNA damage response genes are BRCA1, BRCA2, HER1, HER2, ATR, FANCI, or FANCD2. In certain embodiments, the DNA damage response genes are BRCA1, HER2, ATR, FANCI, and FANCD2. In certain embodiments, the DNA damage response genes are BRCA1. In certain embodiments, the DNA damage response genes are HER2.

[00327] In certain embodiments, the proliferative disease to be treated or prevented using the compounds described herein is cancer. All types of cancers disclosed herein or known in the art are contemplated as being within the scope of the invention. In certain embodiments, the proliferative disease is a cancer associated with dependence on BCL-2 anti-apoptotic proteins (*e.g.*, MCL-1 and/or XIAP). In certain embodiments, the proliferative disease is a cancer associated with dependence on BCL-2 anti-apoptotic proteins (*e.g.*, MCL-1 and/or XIAP). In certain embodiments, the proliferative disease is a cancer associated with overexpression of MYC (a gene that codes for a transcription factor). In certain embodiments, the cancer is a MYC-dependent cancer. In certain embodiments, the proliferative disease is a cancer associated with amplification of BRCA1. In certain embodiments, the proliferative disease is a cancer associated with amplification of HER2. In certain embodiments, the proliferative disease is a hematological malignancy. In certain embodiments, the proliferative disease is a blood cancer. In certain embodiments, the proliferative disease is a hematological malignancy. In certain embodiments, the proliferative disease is leukemia. In certain embodiments, the proliferative disease is chronic lymphocytic leukemia (CLL). In certain embodiments, the proliferative disease is acute lymphoblastic leukemia (ALL). In certain embodiments, the proliferative disease is T-cell acute

lymphoblastic leukemia (T-ALL). In certain embodiments, the proliferative disease is chronic myelogenous leukemia (CML). In certain embodiments, the proliferative disease is acute myelogenous leukemia (AML). In certain embodiments, the proliferative disease is acute monocytic leukemia (AMoL). In certain embodiments, the proliferative disease is lymphoma. In some embodiments, the proliferative disease is Burkitt's lymphoma. In certain embodiments, the proliferative disease is a Hodgkin's lymphoma. In certain embodiments, the proliferative disease is a non-Hodgkin's lymphoma. In certain embodiments, the proliferative disease is multiple myeloma. In certain embodiments, the proliferative disease is melanoma. In certain embodiments, the proliferative disease is colorectal cancer. In certain embodiments, the proliferative disease is breast cancer. In certain embodiments, the proliferative disease is recurring breast cancer. In certain embodiments, the proliferative disease is mutant breast cancer. In certain embodiments, the proliferative disease is HER2+ breast cancer. In certain embodiments, the proliferative disease is HER2- breast cancer. In certain embodiments, the proliferative disease is triple-negative breast cancer (TNBC). In certain embodiments, the proliferative disease is a bone cancer. In certain embodiments, the proliferative disease is osteosarcoma. In certain embodiments, the proliferative disease is Ewing's sarcoma. In some embodiments, the proliferative disease is a brain cancer. In some embodiments, the proliferative disease is neuroblastoma. In some embodiments, the proliferative disease is a lung cancer. In some embodiments, the proliferative disease is small cell lung cancer (SCLC). In some embodiments, the proliferative disease is non-small cell lung cancer. In some embodiments, the proliferative disease is a benign neoplasm. All types of benign neoplasms disclosed herein or known in the art are contemplated as being within the scope of the invention. In some embodiments, the proliferative disease is associated with angiogenesis. All types of angiogenesis disclosed herein or known in the art are contemplated as being within the scope of the invention. In certain embodiments, the proliferative disease is an inflammatory disease. All types of inflammatory diseases disclosed herein or known in the art are contemplated as being within the scope of the invention. In certain embodiments, the inflammatory disease is rheumatoid arthritis.

In certain embodiments, the proliferative disease is an acute inflammatory disease. In certain embodiments, the acute inflammatory disease is rheumatoid arthritis, Crohn's disease, or fibrosis. In some embodiments, the proliferative disease is an autoinflammatory disease. All types of autoinflammatory diseases disclosed herein or known in the art are contemplated as being within the scope of the invention. In some embodiments, the proliferative disease is an

autoimmune disease. All types of autoimmune diseases disclosed herein or known in the art are contemplated as being within the scope of the invention.

[00328] Another aspect of the invention relates to methods of inhibiting the activity of a kinase in a biological sample or subject. In certain embodiments, the kinase is CDK. In certain embodiments, the kinase is CDK7. In certain embodiments, the kinase is CDK12. In certain embodiments, the kinase is CDK13. In certain embodiments, the activity of the kinase is aberrant activity of the kinase. In certain embodiments, the inhibition of the activity of the kinase is irreversible. In other embodiments, the inhibition of the activity of the kinase is reversible. In certain embodiments, the methods of inhibiting the activity of the kinase include attaching a compound described herein to the kinase.

[00329] Also provided in the present invention are methods of inhibiting transcription of genes in a biological sample or subject. In certain embodiments, the genes which may have their transcription inhibited by the activity of CDK7, CDK12, and/or CDK13 are listed in Figure 11. In certain embodiments, the transcription of genes affected by the activity of CDK7 may be inhibited by a compound of the invention. In certain embodiments, the genes which may have their transcription inhibited by the activity of CDK7 are one or more selected from the group consisting of MYC, RUNX1, MYB, TAL1, GATA3, KLF2, HNRPDL, p21, ASCL1, MYCN, INSM1, NEUROD1, NEUROG1, FOXG1, FOXA1, SOX2, SOX4, BCL11A, OTX2, GAT2, PHOX2B, PLK2, TAF1, CTGF, WEE1, SDIM, JUN, PIM1, IL8, and FOS1. In certain embodiments, the genes which may have their transcription inhibited by the activity of CDK7 include MYC, KLF2, E2F2, CDK6, CCND3, E2F3, HNRPDL, TET1, IL7R, BRCA1, BRCA2, HER1, and HER2. In certain embodiments, the transcription of genes affected by the activity of CDK12 may be inhibited by a compound of the invention. In certain embodiments, the genes which may have their transcription inhibited by the activity of CDK12 are one or more selected from the group consisting of BRCA1, FANCI, ATR, FANCD2, APEX1, NEK9, CHEK1, CHEK2, ATM, RAD51C, RAD51D, ORC3L, MDC1, TERF2, ERCC4, FANCF, PARP9, RUNX1, MYB, TAL1, MCL1, MYC, BCL2, ETS1, and EWS-FLI. In certain embodiments, the transcription of genes affected by the activity of CDK13 may be inhibited by a compound of the invention. In certain embodiments, the genes which may have their transcription inhibited by the compounds herein are SNORA38.

[00330] The present invention also provides methods of inhibiting cell growth in a biological sample or subject.

[00331] In still another aspect, the present invention provides methods of inducing apoptosis of a cell in a biological sample or a subject.

[00332] In certain embodiments, the methods described herein include administering to a subject or contacting a biological sample with an effective amount of a compound described herein, or a pharmaceutically acceptable salt, solvate, hydrate, polymorph, co-crystal, tautomer, stereoisomer, isotopically labeled derivative, or prodrug thereof, or a pharmaceutical composition thereof. In certain embodiments, the methods described herein include administering to a subject or contacting a biological sample with an effective amount of a compound described herein, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition thereof. In certain embodiments, the compound is contacted with a biological sample. In certain embodiments, the compound is administered to a subject. In certain embodiments, the compound is administered in combination with one or more additional pharmaceutical agents described herein. The additional pharmaceutical agent may be an anti-proliferative agent. In certain embodiments, the additional pharmaceutical agent is an anti-cancer agent. The additional pharmaceutical agent may also be a kinase inhibitor. In certain embodiments, the additional pharmaceutical agent is an inhibitor of a CDK. In certain embodiments, the additional pharmaceutical agent is an inhibitor of CDK7. In certain embodiments, the additional pharmaceutical agent is a selective inhibitor of CDK7. In certain embodiments, the additional pharmaceutical agent is a nonselective inhibitor of CDK7. In certain embodiments, the additional pharmaceutical agent is an inhibitor of CDK12. In certain embodiments, the additional pharmaceutical agent is a selective inhibitor of CDK12. In certain embodiments, the additional pharmaceutical agent is a nonselective inhibitor of CDK12. In certain embodiments, the additional pharmaceutical agent is an inhibitor of CDK13. In certain embodiments, the additional pharmaceutical agent is a selective inhibitor of CDK13. In certain embodiments, the additional pharmaceutical agent is a nonselective inhibitor of CDK13. In certain embodiments, the additional pharmaceutical agent is an inhibitor of another CDK. In certain embodiments, the additional pharmaceutical agent is a selective inhibitor of another CDK. In certain embodiments, the additional pharmaceutical agent is a nonselective inhibitor of another CDK. In certain embodiments, the additional pharmaceutical agent is flavopiridol, triptolide, SNS-032 (BMS-387032), PHA-767491, PHA-793887, BS-181, (*S*)-CR8, (*R*)-CR8, or NU6140. In certain embodiments, the additional pharmaceutical agent is an inhibitor of a mitogen-activated protein kinase (MAPK). In certain embodiments, the additional pharmaceutical agent is an inhibitor of a glycogen synthase kinase 3 (GSK3). In certain embodiments, the additional pharmaceutical agent is an inhibitor

of an AGC kinase. In certain embodiments, the additional pharmaceutical agent is an inhibitor of a calmodulin-dependent kinase (CaM Kinase). In certain embodiments, the additional pharmaceutical agent is an inhibitor of a casein kinase 1. In certain embodiments, the additional pharmaceutical agent is an inhibitor of a STE kinase. In certain embodiments, the additional pharmaceutical agent is an inhibitor of a tyrosine kinase.

[00333] In some embodiments, the additional pharmaceutical agent is a topoisomerase inhibitor, a MCL1 inhibitor, a BCL-2 inhibitor, a BCL-xL inhibitor, a BRD4 inhibitor, a BRCA1 inhibitor, BRCA2 inhibitor, HER1 inhibitor, HER2 inhibitor, a CDK9 inhibitor, a Jumonji histone demethylase inhibitor, or a DNA damage inducer. In some embodiments, the additional pharmaceutical agent is etoposide, obatoclax, navitoclax, JQ1, 4-(((5'-chloro-2'-(((1*R*,4*R*)-4-(((*R*)-1-methoxypropan-2-yl)amino)cyclohexyl)amino)-[2,4'-bipyridin]-6-yl)amino)methyl)tetrahydro-2H-pyran-4-carbonitrile, JIB04, or cisplatin. In some embodiments, the additional pharmaceutical agent is etoposide, obatoclax, or navitoclax, and the disease to be treated is breast cancer, *e.g.*, triple-negative breast cancer, HER2 positive breast cancer, HER2 negative breast cancer, ER-positive breast cancer, ER-negative breast cancer, or ER/PR-positive breast cancer. In some embodiments, the additional pharmaceutical agent is etoposide, JIB04, or cisplatin, and the disease to be treated is Ewing's sarcoma. In some embodiments, the additional pharmaceutical agent is JQ1 or NVP2, and the disease to be treated is leukemia, *e.g.*, acute myelogenous leukemia, myeloblastic leukemia, promyelocytic leukemia, myelomonocytic leukemia, monocytic leukemia, monoblastic leukemia, or megakaryoblastic leukemia. In certain embodiments, a pharmaceutical composition described herein further comprises a combination of the additional pharmaceutical agents described herein.

[00334] The inventive compounds or compositions may synergistically augment inhibition of CDK7 induced by the additional pharmaceutical agent(s) in the biological sample or subject. The inventive compounds or compositions may synergistically augment inhibition of CDK12 and/or CDK13 induced by the additional pharmaceutical agent(s) in the biological sample or subject. Thus, the combination of the inventive compounds or compositions and the additional pharmaceutical agent(s) may be useful in treating proliferative diseases resistant to a treatment using the additional pharmaceutical agent(s) without the inventive compounds or compositions.

[00335] In some embodiments, the activity of a protein kinase is non-selectively inhibited by the compounds or pharmaceutical compositions described herein. In some embodiments, the activity of a protein kinase described herein is selectively inhibited by the compounds or

pharmaceutical compositions described herein, compared to the activity of a different protein (*e.g.*, a different protein kinase). In certain embodiments, the activity of CDK (*e.g.*, CDK7, CDK12, or CDK13) is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of a different protein. In certain embodiments, the activity of CDK7 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of a different CDK protein. In certain embodiments, the activity of CDK7 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK12. In certain embodiments, the activity of CDK7 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK13. In certain embodiments, the activity of CDK7 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK12 and the activity of CDK13. In certain embodiments, the activity of CDK12 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK7. In certain embodiments, the activity of CDK13 is selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK7. In certain embodiments, the activity of CDK12 and the activity of CDK13 are selectively inhibited by a compound or pharmaceutical composition described herein, compared to the activity of CDK7.

[00336] The selectivity of a compound or pharmaceutical composition described herein in inhibiting the activity of a protein kinase over a different protein (*e.g.*, a different protein kinase) may be measured by the quotient of the IC_{50} value of the compound or pharmaceutical composition in inhibiting the activity of the different protein over the IC_{50} value of the compound or pharmaceutical composition in inhibiting the activity of the protein kinase. The selectivity of a compound or pharmaceutical composition described herein for a protein kinase over a different protein may also be measured by the quotient of the K_d value of an adduct of the compound or pharmaceutical composition and the different protein over the K_d value of an adduct of the compound or pharmaceutical composition and the protein kinase. In certain embodiments, the selectivity is at least 2-fold, at least 3-fold, at least 5-fold, at least 10-fold, at least 30-fold, at least 100-fold, at least 300-fold, at least 1,000-fold, at least 3,000-fold, at least 10,000-fold, at least 30,000-fold, or at least 100,000-fold. In certain embodiments, the selectivity is not more than 100,000-fold, not more than 10,000-fold, not more than 1,000-fold, not more than 100-fold, not more than 10-fold, or not more than 2-fold.

Combinations of the above-referenced ranges (*e.g.*, at least 2-fold and not more than 10,000-fold) are also within the scope of the disclosure.

[00337]

EXAMPLES

[00338] In order that the invention described herein may be more fully understood, the following examples are set forth. The synthetic and biological examples described in this application are offered to illustrate the compounds, pharmaceutical compositions, and methods provided herein and are not to be construed in any way as limiting their scope.

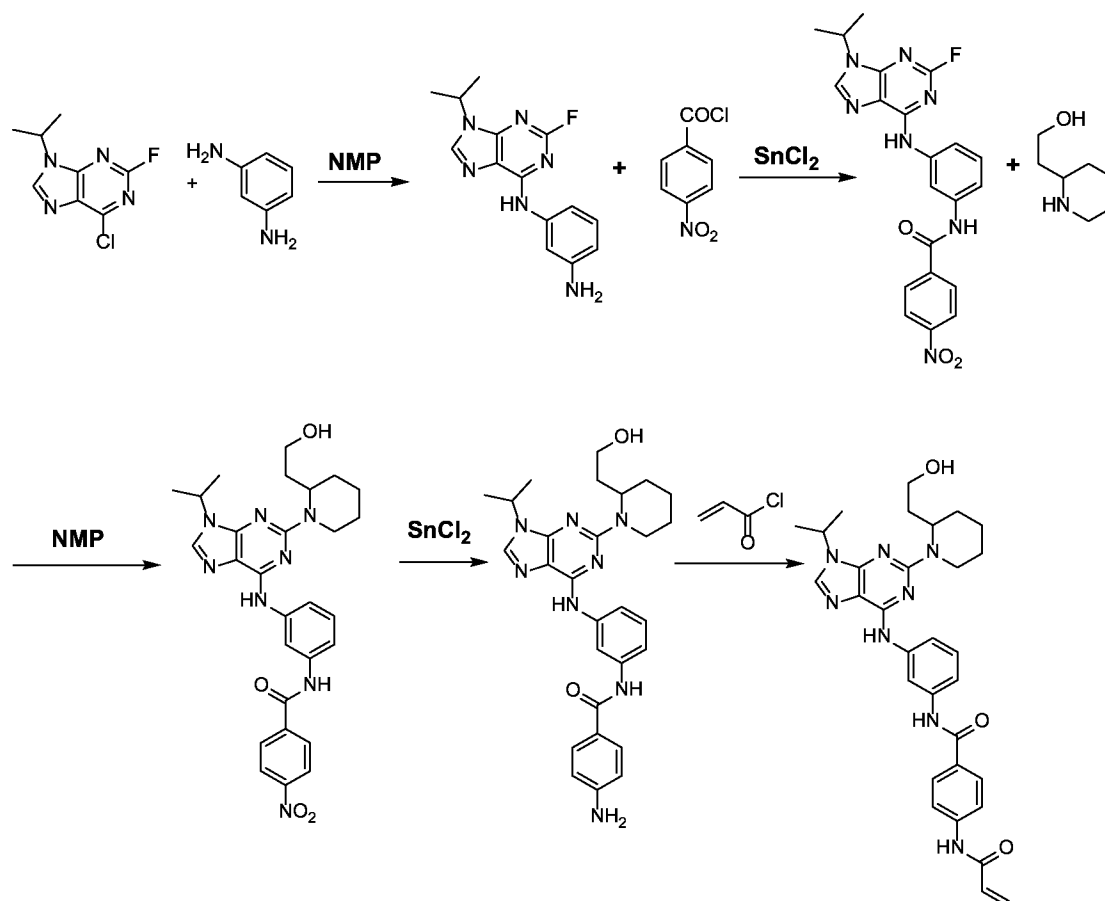
Synthesis of the Compounds

[00339] The compounds provided herein can be prepared from readily available starting materials using the following general methods and procedures. Reactions were monitored by thin layer chromatography (TLC) with 0.25 mm E. Merck pre-coated silica gel plates (60 F₂₅₄) and Waters LCMS system (Waters 2489 UV/Visible Detector, Waters 3100 Mass, Waters 515 HPLC pump, Waters 2545 Binary Gradient Module, Waters Reagent Manager, Waters 2767 Sample Manager) using SunFire™ C18 column (4.6 x 50 mm, 5 µm particle size): solvent gradient = 95% A at 0 min, 0% A at 5 min; solvent A = 0.5% TFA in Water; solvent B = Methanol; flow rate: 1.5 mL/min. Purification of reaction products was carried out by flash chromatography using CombiFlash®Rf with Teledyne Isco RediSep®Rf High Performance Gold or Silicycle SiliaSep™ High Performance columns (4 g, 12 g, 24 g, 40 g, 80 g or 120 g) or by Waters preparative HPLC system with a C18 column: solvent gradient = 100% A at 0 min, 0% A at 15 min; solvent A = 0.5% TFA in Water; solvent B = Methanol; flow rate: 20 mL/min. The purity of all compounds was over 95% and was analyzed with Waters LCMS system. ¹H NMR and ¹³C NMR spectra were obtained using a Varian Inova-600 or 400 MHz spectrometer. Chemical shifts are reported relative to chloroform ($\delta = 7.24$) for ¹H NMR or dimethyl sulfoxide ($\delta = 2.50$) for ¹H NMR and dimethyl sulfoxide ($\delta = 39.51$) for ¹³C NMR. Data are reported as (*br* = broad, *s* = singlet, *d* = doublet, *t* = triplet, *q* = quartet, *m* = multiplet).

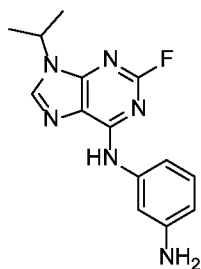
Example 1. 4-Acrylamido-N-(3-((2-(2-(2-hydroxyethyl)piperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide (THZ-4-124-1)

[00340] The synthesis of THZ-4-124-1 follows *Synthetic Scheme 1*. The reagents and conditions used for the synthesis are: (1) NMP, DIPEA, 100 °C (2) pyridine, 80 °C (3) NMP, 135°C (4) SnCl₂, Ethyl acetate and Methanol (5) acryl chloride, acetonitrile, 0 °C.

Synthetic Scheme 1.



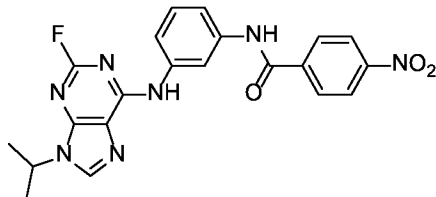
N1-(2-Fluoro-9-isopropyl-9H-purin-6-yl)benzene-1,3-diamine



[00341] To a solution of 6-chloro-2-fluoro-9-isopropyl-9H-purine (214mg) in NMP (N-Methyl-2-pyrrolidone) was added benzene-1,3-diamine (130 mg, 1.2 equiv) and

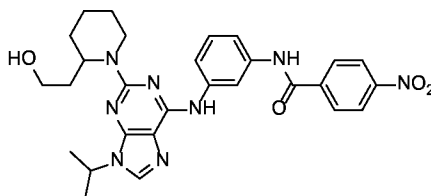
diisopropylethylamine (129 mg, 1.0 equiv). The solution was heated for 2 h at 100 °C. The cooled solution was diluted with 100 mL of ethyl acetate and then washed with water. The separation by silica gel with CH₂Cl₂/methanol (10/1) to give of the product (225 mg, 79%).

N-(3-((2-Fluoro-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-nitrobenzamide



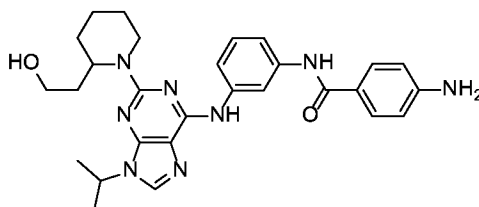
[00342] To a stirred solution of the above product (225 mg, 0.80 mmol) in 10 mL of pyridine was added 4-nitrobenzoyl chloride (219 mg, 1.5 equiv) and resulting solution was heated to 80 °C. The reaction mixture was stirred for 2 h and concentrated under reduced pressure. The crude was purified by silica gel with CH₂Cl₂/methanol (10/1) to give of the product (285 mg, 82%).

N-(3-((2-(2-(2-Hydroxyethyl)piperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-nitrobenzamide



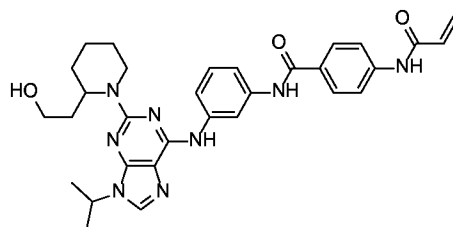
[00343] The nitro compound (285 mg, 0.65 mmol) obtained from above reaction was dissolved in 3 mL of NMP and then was added with 2-(piperidin-2-yl)ethanol (170 mg, 2.0 equiv). The solution was heated to 135 °C for 2h and then cooled down to RT. The product was purified by HPLC to give the product (105 mg, 30%).

4-Amino-N-(3-((2-(2-(2-hydroxyethyl)piperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide



[00344] The nitro compound from step 3 (105 mg, 0.19 mmol) was suspended in 5 mL of ethyl acetate/methanol (5:1) and treated with SnCl_2 (91 mg, 2.5 equiv). After stirring for 2 h at 80 °C, the reaction mixture was cooled to room temperature and poured into saturated aqueous NaHCO_3 . The mixture was stirred for 10 min and the aqueous phase was then extracted with 30 mL of chloroform and 2-propanol (4:1). The combined organic layer was washed with water and brine, dried over MgSO_4 , filtered through a pad of celite and concentrated under reduced pressure. The resulting crude product was purified by flash column chromatography with CH_2Cl_2 /methanol (10/1) to provide the title compound (68 mg, 70%).

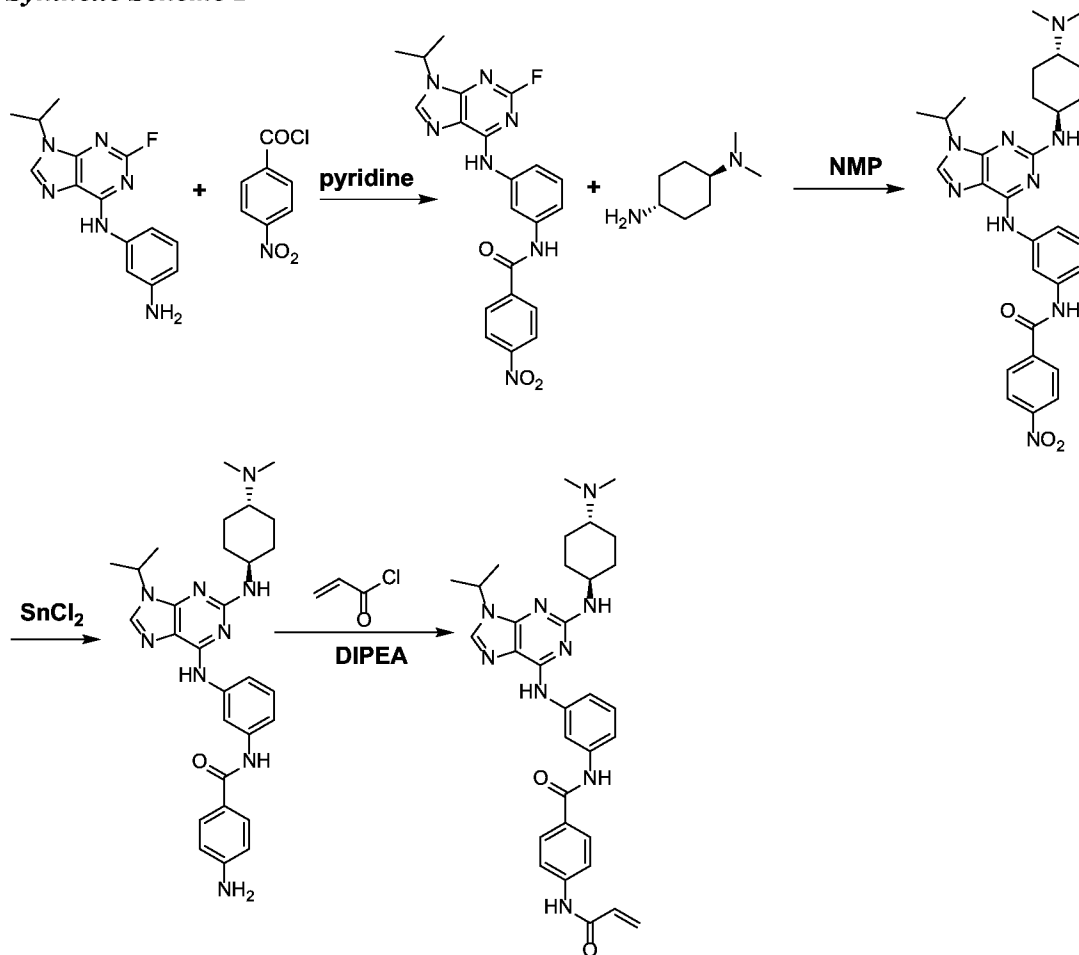
4-Acrylamido-N-(3-((2-(2-(2-hydroxyethyl)piperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide



[00345] To the solution of the aniline (26 mg, 0.05mmol)) obtained above in 5 mL of acetonitrile was added diisopropylethylamine (13 mg, 2.0 equiv). The reaction mixture was cooled to 0 °C and then treated with 4-chlorobut-2-enoyl chloride (15 mg, 3.0 equiv) in CH_2Cl_2 . After the stirring for 10 min at 0 °C, the reaction was then quenched with Sat. NaHCO_3 and extracted with 30 mL of chloroform and 2-propanol (4:1). The solvent was removed at reduce pressure and the crude was purified with HPLC to give the final product THZ-4-124-1 (15 mg, 55%) MS 569 (M+1), ^1H NMR (DMSO-d_6): 10.42 (s, 1H), 10.15 (s, 1H), 9.53 (s, 1H), 8.40 (d, $J = 12.0$ Hz, 2H), 7.93 (d, $J = 7.2$ Hz, 2H), 7.79 (d, $J = 7.2$ Hz, 2H), 7.52 (d, $J = 7.2$ Hz, 1H), 7.27 (m, 2H), 6.43 (m, 1H), 6.28 (d, $J = 15$ Hz, 1H), 5.78 (d, $J = 9.6$ Hz, 1H), 4.99 (s, 1H), 4.65 (m, 2H), 3.45 (m, 2H), 2.88 (t, $J = 6.8$ Hz, 1H), 1.85 (m, 1H), 1.72 (m, 1H), 1.52 (s, 6H), 1.61-1.30 (m, 12H).

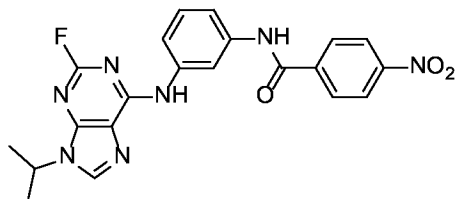
Example 2. 4-Acrylamido-N-(3-((2-((trans-4-(dimethylamino)cyclohexyl)amino)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide (THZ-5-38-1)

Synthetic Scheme 2



[00346] The synthesis of THZ-4-124-1 follows *Synthetic Scheme 2*. The reagents and conditions used for the synthesis are: (1) pyridine, 80 °C (2) NMP, 135°C (3) SnCl₂, Ethyl acetate and Methanol (4) acryl chloride, acetonitrile, 0 °C

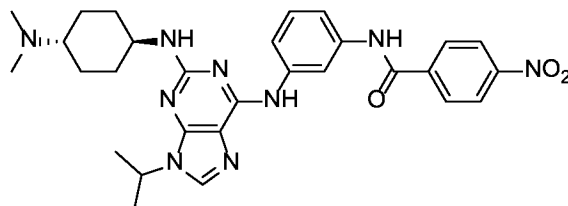
***N*-(3-((2-Fluoro-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-nitrobenzamide**



[00347] To a stirred solution of N1-(2-fluoro-9-isopropyl-9H-purin-6-yl)benzene-1,3-diamine (286 mg, 1.0 mmol) in 10 mL of pyridine was added 4-nitrobenzoyl chloride (277 mg, 1.5 equiv) and resulting solution was heated to 80 °C. The reaction mixture was stirred

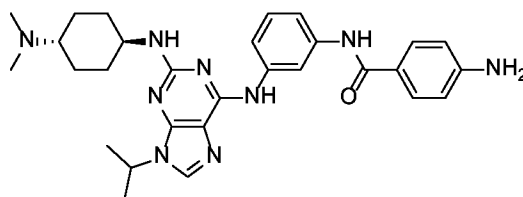
for 2 h and concentrated under reduced pressure. The crude was purified by silica gel with CH₂Cl₂/methanol (10/1) to give of the product (326 mg, 75%)

N-(3-((2-(((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)amino)-9-isopropyl-9*H*-purin-6-yl)amino)phenyl)-4-nitrobenzamide



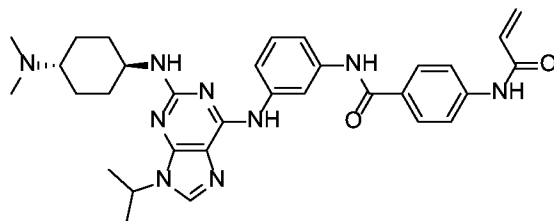
[00348] The nitro compound (326 mg, 0.75 mmol) obtained from above reaction was dissolved in 3 mL of NMP and then was added with *trans*-N1,N1-dimethylcyclohexane-1,4-diamine (213 mg, 2.0 equiv). The solution was heated to 135 °C for 2h and then cooled down to RT. The product was purified by HPLC to give the product (208 mg, 50%).

4-Amino-N-(3-((2-((*trans*-4-(dimethylamino)cyclohexyl)amino)-9-isopropyl-9*H*-purin-6-yl)amino)phenyl)benzamide



[00349] The nitro compound from step 2 (208 mg, 0.37 mmol) was suspended in 5 mL of ethyl acetate/methanol (5:1) and treated with SnCl₂ (177 mg, 2.5 equiv). After stirring for 2 h at 80 °C, the reaction mixture was cooled to room temperature and poured into saturated aqueous NaHCO₃. The mixture was stirred for 10 min and the aqueous phase was then extracted with 30 mL of chloroform and 2-propanol (4:1). The combined organic layer was washed with water and brine, dried over MgSO₄, filtered through a pad of celite and concentrated under reduced pressure. The resulting crude product was purified by flash column chromatography with CH₂Cl₂/methanol (10/1) to provide the title compound (126 mg, 65%).

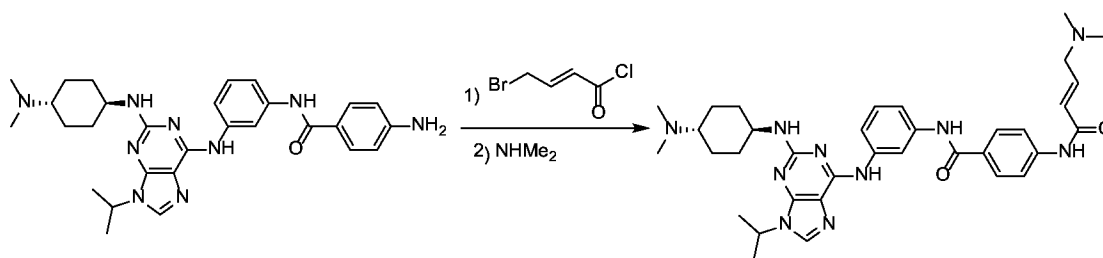
4-Acrylamido-N-(3-((2-((trans-4-(dimethylamino)cyclohexyl)amino)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide



[00350] To the solution of the aniline (26 mg, 0.05mmol)) obtained above in 5 mL of acetonitrile was added diisopropylethylamine (13 mg, 2.0 equiv). The reaction mixture was cooled to 0 °C and then treated with 4-chlorobut-2-enoyl chloride (15 mg, 3.0 equiv) in CH₂Cl₂. After the stirring for 10 min at 0 °C, the reaction was then quenched with Sat. NaHCO₃ and extracted with 30 mL of chloroform and 2-propanol (4:1). The solvent was removed at reduce pressure and the crude was purified with HPLC to give the final product (17 mg, 60%) MS 582 (M+1), ¹H NMR (DMSO-d₆):10.45 (s,1H), 10.17 (s, 1H), 9.63 (br, 1H), 9.43 (br, 1H), 8.26 (br, 1H), 8.25 (s, 1H), 7.98 (d, *J* = 7.2 Hz, 2H), 7.79 (d, *J* = 7.2 Hz, 2H), 7.65 (br, 1H), 7.45 (br, 1H), 7.28 (t, *J* = 7.8 Hz, 1H), 6.48 (m, 1H), 6.28 (d, *J* = 15 Hz, 1H), 5.78 (d, *J* = 9.6 Hz, 1H), 4.62 (m, 1H), 2.75-2.60 (m, 2H), 2.55 (s, 6H), 2.22-1.65 (m, 4H), 1.51 (d, *J* = 6.6 Hz, 6H), 1.55-1.25 (m, 4H).

Example 3. 4-((E)-4-(Dimethylamino)but-2-enamido)-N-(3-((2-(((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)amino)-9-isopropyl-9H-purin-6-yl)amino)phenyl)benzamide (THZ-3-49-1)

Synthetic Scheme 3



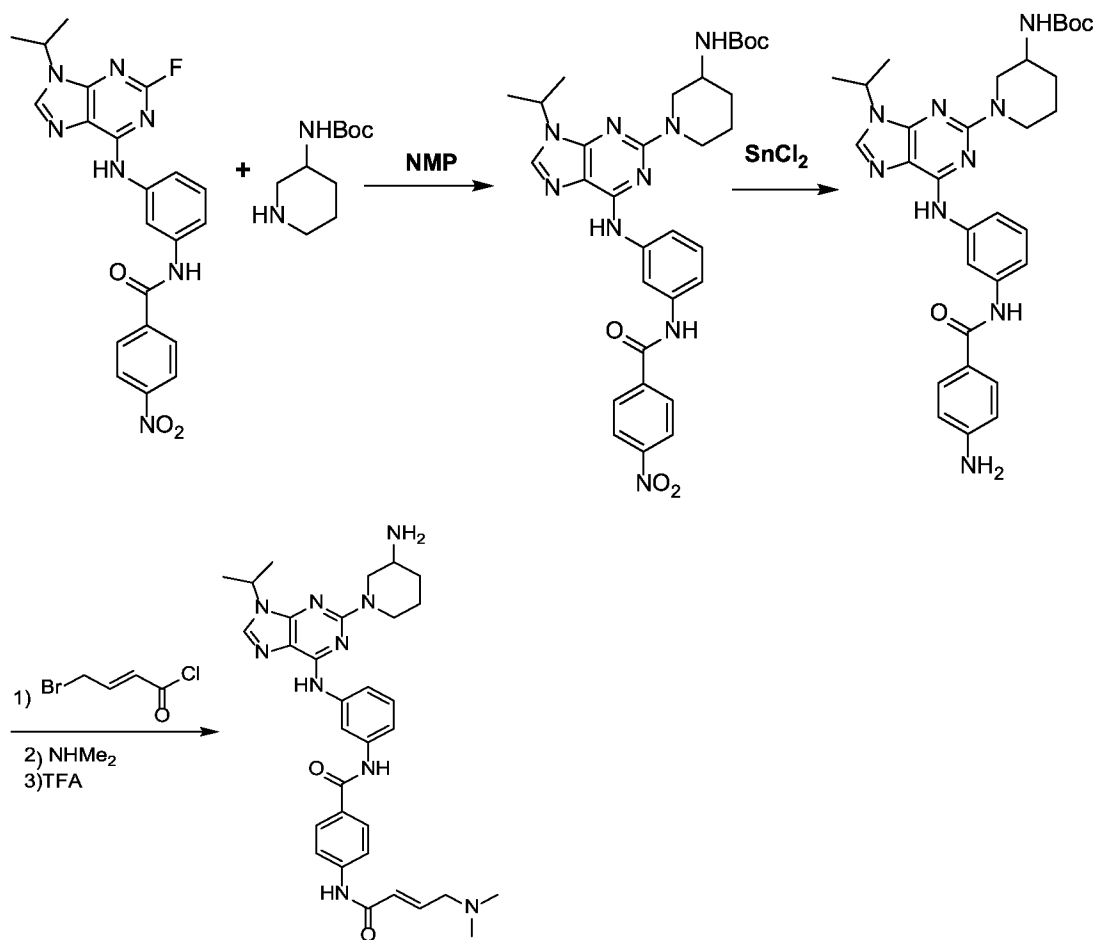
[00351] To the solution of the aniline (53 mg) obtained above in 10 mL of acetonitrile was added diisopropylethylamine (26 mg, 2.0 equiv). The reaction mixture was cooled to 0 °C and then treated with 4-chlorobut-2-enoyl chloride (54 mg, 3.0 equiv) in CH₂Cl₂. The reaction mixture was stirred for 10 min at 0 °C and then treated with a solution of dimethylamine in

THF (3mL, 1M). The reaction mixture was then warmed to room temperature, stirred for 1 h and concentrated under reduced pressure. The resulting crude product was purified by preparative HPLC to give the final product (28.8 mg, 45%). MS 639 (M+1).

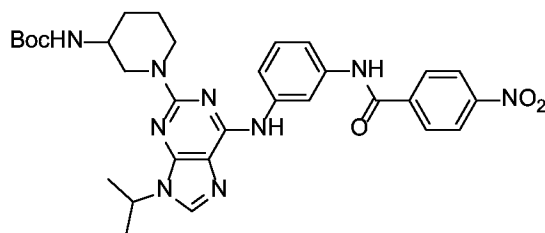
Example 4. (E)-N-(3-((2-(3-Aminopiperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-(4-(dimethylamino)but-2-enamido)benzamide (THZ-4-119-1)

[00352] The synthesis of THZ-4-119-1 follows *Synthetic Scheme 4*. The reagents and conditions used for the synthesis are: (1) NMP, 135°C (2) SnCl₂, Ethyl acetate and Methanol (3) a) 4-bromobut-2-enoyl chloride, CH₃CN, NMe₂, 0°C-RT b) TFA, CHCl₃.

Synthetic Scheme 4

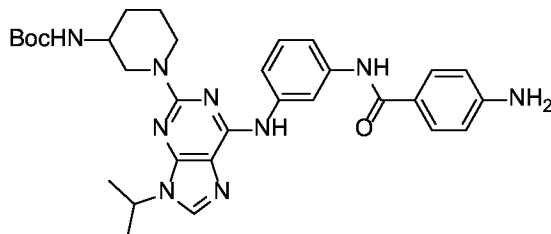


tert-butyl (1-(9-iso-Propyl-6-((3-(4-nitrobenzamido)phenyl)amino)-9H-purin-2-yl)piperidin-3-yl)carbamate



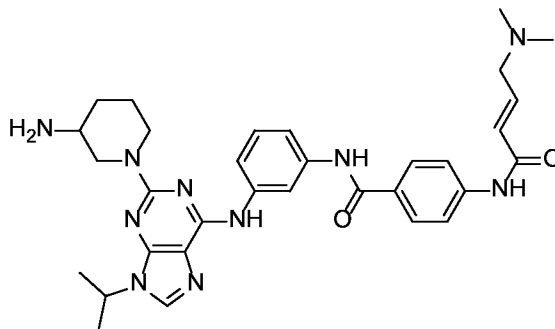
[00353] To a stirred solution of N-(3-((2-fluoro-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-nitrobenzamide (435 mg) in NMP (3mL) was added tert-butyl piperidin-3-ylcarbamate (300 mg, 1.5 equiv) and then the resulting solution was heated to 130 °C for 6 h. After cooling down to RT, the solution was then extracted with ethyl acetate, washed with water and brine and then dried on Na₂SO₄. The crude was obtained after removing the solvent and then was used in the next step directly.

tert-butyl (1-(6-((3-(4-Aminobenzamido)phenyl)amino)-9-isopropyl-9H-purin-2-yl)piperidin-3-yl)carbamate



[00354] The crude from step 1 was suspended in 5 mL of ethyl acetate/methanol (5:1) and treated with SnCl₂ (562 mg, 2.5 equiv). After stirring for 2 h at 80 °C, the reaction mixture was cooled to room temperature and poured into saturated aqueous NaHCO₃. The mixture was stirred for 10 min and the aqueous phase was then extracted with 30 mL of chloroform and 2-propanol (4:1). The combined organic layer was washed with water and brine, dried over MgSO₄, filtered through a pad of celite and concentrated under reduced pressure. The resulting crude product was purified by flash column chromatography with CH₂Cl₂/methanol (10/1) to provide the product (230 mg, 40% from two steps).

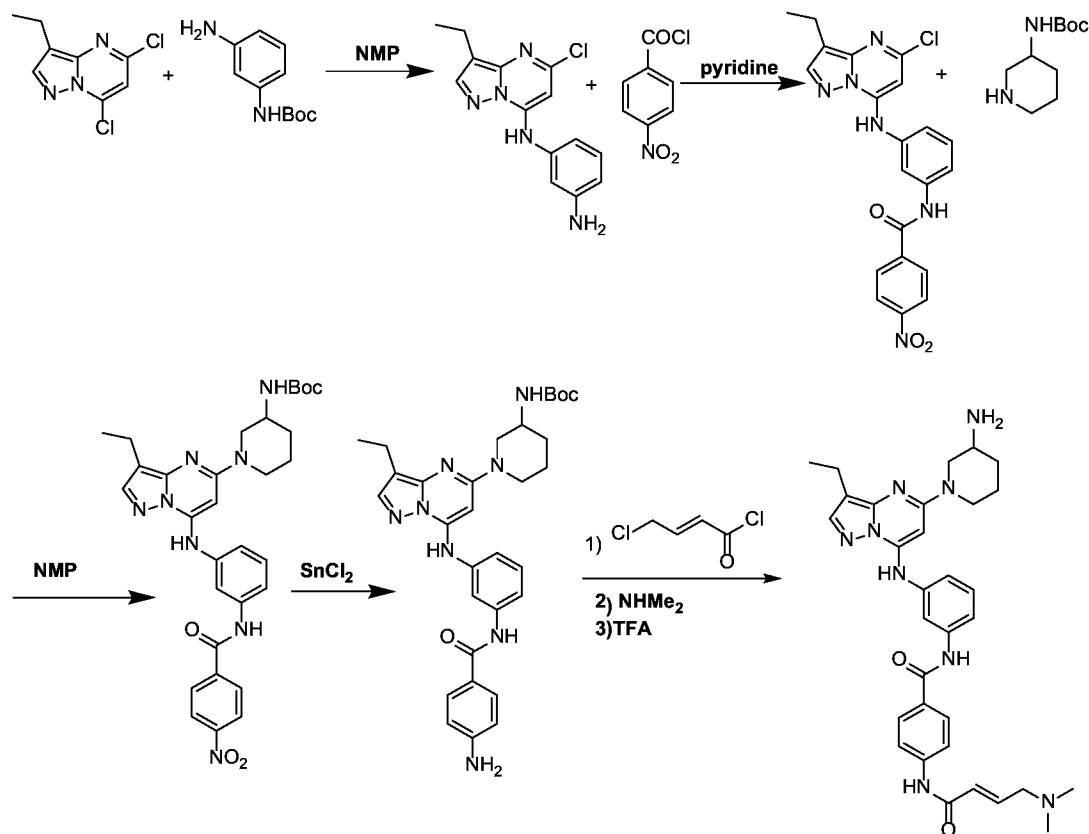
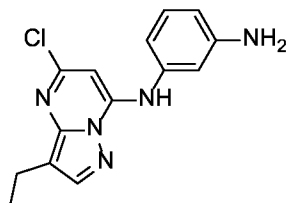
(E)-N-(3-((2-(3-Aminopiperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)-4-(4-(dimethylamino)but-2-enamido)benzamide



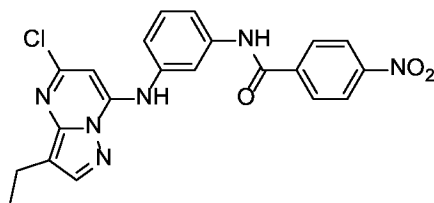
[00355] To the solution of the aniline (58 mg) obtained above in 10 mL of acetonitrile was added diisopropylethylamine (26 mg, 2.0 equiv). The reaction mixture was cooled to 0 °C and then treated with 4-chlorobut-2-enoyl chloride (54 mg, 3.0 equiv) in CH₂Cl₂. The reaction mixture was stirred for 10 min at 0 °C and then treated with a solution of dimethylamine in THF (3mL, 1M). The reaction mixture was then warmed up to room temperature, stirred for 1 h and concentrated under reduced pressure. The resulting crude product was then dissolved in CHCl₃ (3mL) and TFA (1mL). The solution was then allowed for stirring for 2 h. After removing the solvent, the crude was purified by preparative HPLC to give the final product (24.8 mg, 35%). MS 597 (M+1) ¹H NMR (DMSO-d₆): 10.64 (s, 1H), 10.20 (s, 1H), 10.01 (br, 1H), 9.56 (s, 1H), 8.60 (s, 1H), 8.17 (s, 1H), 8.02 (m, 3H), 7.95 (d, *J* = 7.2 Hz, 2H), 7.80 (d, *J* = 7.2 Hz, 2H), 7.45 (d, *J* = 8.4 Hz, 1H), 7.26 (t, *J* = 7.8 Hz, 1H), 7.20 (d, *J* = 8.4 Hz, 1H), 6.78 (m, 1H), 6.50 (d, *J* = 15 Hz, 1H), 4.66 (m, 1H), 4.53 (m, 1H), 4.21 (m, 1H), 3.96 (d, *J* = 7.2 Hz, 2H), 3.37-3.25 (m, 4H), 2.83 (s, 6H), 1.97 (m, 1H), 1.76 (m, 1H), 1.59-1.55 (m, 2H), 1.50 (d, *J* = 6.6 Hz, 6H).

Example 5. (E)-N-(3-((5-(3-Aminopiperidin-1-yl)-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)amino)phenyl)-4-(4-(dimethylamino)but-2-enamido)benzamide (THZ-4-128-1)

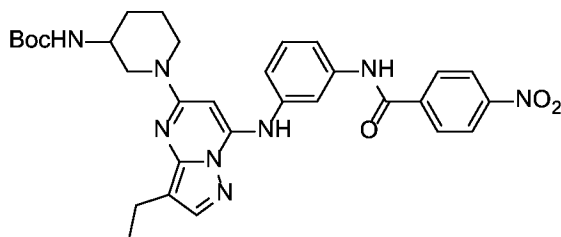
[00356] The synthesis of THZ-4-128-1 follows *Synthetic Scheme 5*. The reagents and conditions used for the synthesis are: (1) a) NMP, DIPEA, 100 °C b) TFA, CHCl₃ (2) pyridine, 80 °C (3) NMP, DIPEA, 135 °C (4) SnCl₂, Ethyl acetate and Methanol (5) a) 4-bromobut-2-enoyl chloride, CH₃CN, NHMe₂, 0 °C-RT b) TFA, CHCl₃.

Synthetic Scheme 5**N1-(5-Chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)benzene-1,3-diamine**

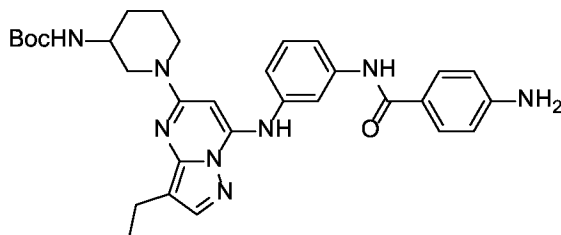
[00357] To a solution of 5,7-dichloro-3-ethylpyrazolo[1,5-a]pyrimidine (215 mg) in NMP (N-Methyl-2-pyrrolidone) was added tert-butyl (3-aminophenyl)carbamate (230 mg, 1.1 equiv) and diisopropylethylamine (129 mg, 1.0 equiv). The solution was heated for 2 h at 100 °C. The cooled solution was diluted with 100 mL of ethyl acetate and then washed with water. After removing the solvent, the crude was obtained which was dissolved in CHCl_3 (3mL) and TFA (1mL). The resulting solution was stirred for 1 h and then the solvent was removed in the reduced pressure. The crude was then purified by silica gel with CH_2Cl_2 /methanol (10/1) to give the product (215 mg, 75%).

N-(3-((5-Chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)amino)phenyl)-4-nitrobenzamide

[00358] To a stirred solution of the above product (215 mg, 0.75 mmol) in 10 mL of pyridine was added 4-nitrobenzoyl chloride (210 mg, 1.5 equiv) and resulting solution was heated to 80 °C. The reaction mixture was stirred for 2 h and concentrated under reduced pressure. The crude was purified by silica gel with CH₂Cl₂/methanol (10/1) to give the product (212 mg, 65%).

tert-Butyl (1-(3-ethyl-7-((3-(4-nitrobenzamido)phenyl)amino)pyrazolo[1,5-a]pyrimidin-5-yl)piperidin-3-yl)carbamate

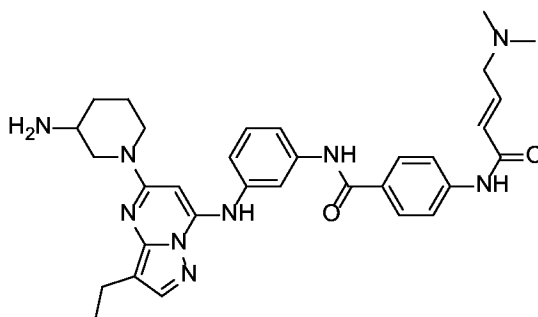
[00359] To a stirred solution of the product from step 2 (212 mg) in NMP (3mL) was added tert-butyl piperidin-3-ylcarbamate (145 mg, 1.5 equiv) and then the resulting solution was heated to 130 °C for 6 h. After cooling down to RT, the solution was then extracted with ethyl acetate washed with water and brine and dried on Na₂SO₄. The crude was obtained after removing the solvent and then was used in the next step directly.

tert-butyl (1-(7-((3-(4-Aminobenzamido)phenyl)amino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-3-yl)carbamate

[00360] The crude from step 3 was suspended in 5 mL of ethyl acetate/methanol (5:1) and treated with SnCl₂ (281 mg, 2.5 equiv). After stirring for 2 h at 80 °C, the reaction mixture

was cooled to room temperature and poured into saturated aqueous NaHCO_3 . The mixture was stirred for 10 min and the aqueous phase was then extracted with 30 mL of chloroform and 2-propanol (4:1). The combined organic layer was washed with water and brine, dried over MgSO_4 , filtered through a pad of celite and concentrated under reduced pressure. The resulting crude product was purified by flash column chromatography with CH_2Cl_2 /methanol (10/1) to provide the product (82 mg, 30% from two steps).

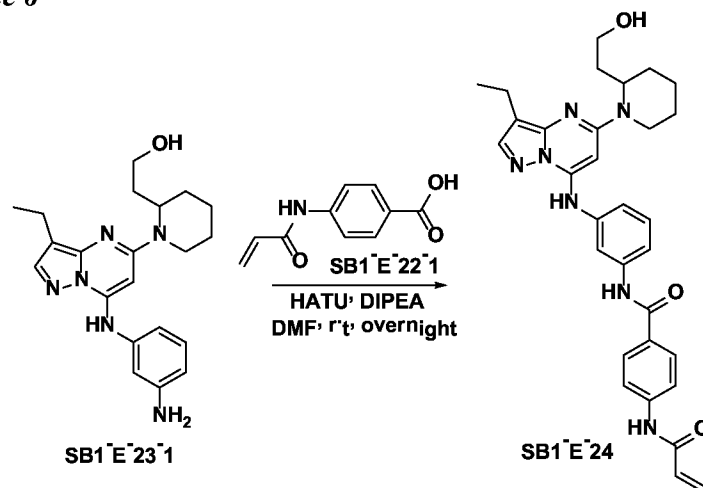
(E)-N-(3-((5-(3-Aminopiperidin-1-yl)-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)amino)phenyl)-4-(4-(dimethylamino)but-2-enamido)benzamide



[00361] To the solution of the aniline (57 mg) obtained above in 10 mL of acetonitrile was added diisopropylethylamine (26 mg, 2.0 equiv). The reaction mixture was cooled to 0 °C and then treated with 4-chlorobut-2-enoyl chloride (54 mg, 3.0 equiv) in CH_2Cl_2 . The reaction mixture was stirred for 10 min at 0 °C and then treated with a solution of dimethylamine in THF (3mL, 1M). The reaction mixture was then warmed to room temperature, stirred for 1 h and concentrated under reduced pressure. The resulting crude product was then dissolved in CHCl_3 (3mL) and TFA (1mL). The solution was then allowed for stirring for 2 h. After removing the solvent, the crude was purified by preparative HPLC to give the final product (15 mg, 25%). MS 582 (M+1) ^1H NMR (DMSO-d_6): 10.64 (s, 1H), 10.32 (s, 1H), 10.09 (br, 1H), 9.44 (s, 1H), 8.03 (m, 1H), 7.98 (br, 2H), 7.95 (d, $J = 7.2$ Hz, 2H), 7.80 (d, $J = 7.2$ Hz, 2H), 7.43 (d, $J = 8.4$ Hz, 1H), 7.37 (t, $J = 7.8$ Hz, 1H), 7.15 (d, $J = 8.4$ Hz, 1H), 6.78 (m, 1H), 6.50 (d, $J = 15$ Hz, 1H), 6.06 (s, 1H), 4.31 (m, 1H), 3.96 (d, $J = 7.2$ Hz, 2H), 3.86 (m, 1H), 3.20-3.10 (m, 3H), 2.79 (s, 6H), 2.59 (q, $J = 8.4$ Hz, 2H), 1.97 (m, 1H), 1.76 (m, 1H), 1.59 (m, 2H), 1.23 (d, $J = 7.8$ Hz, 3H).

Example 6. 4-Acrylamido-N-(3-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-24)

Synthetic Scheme 6

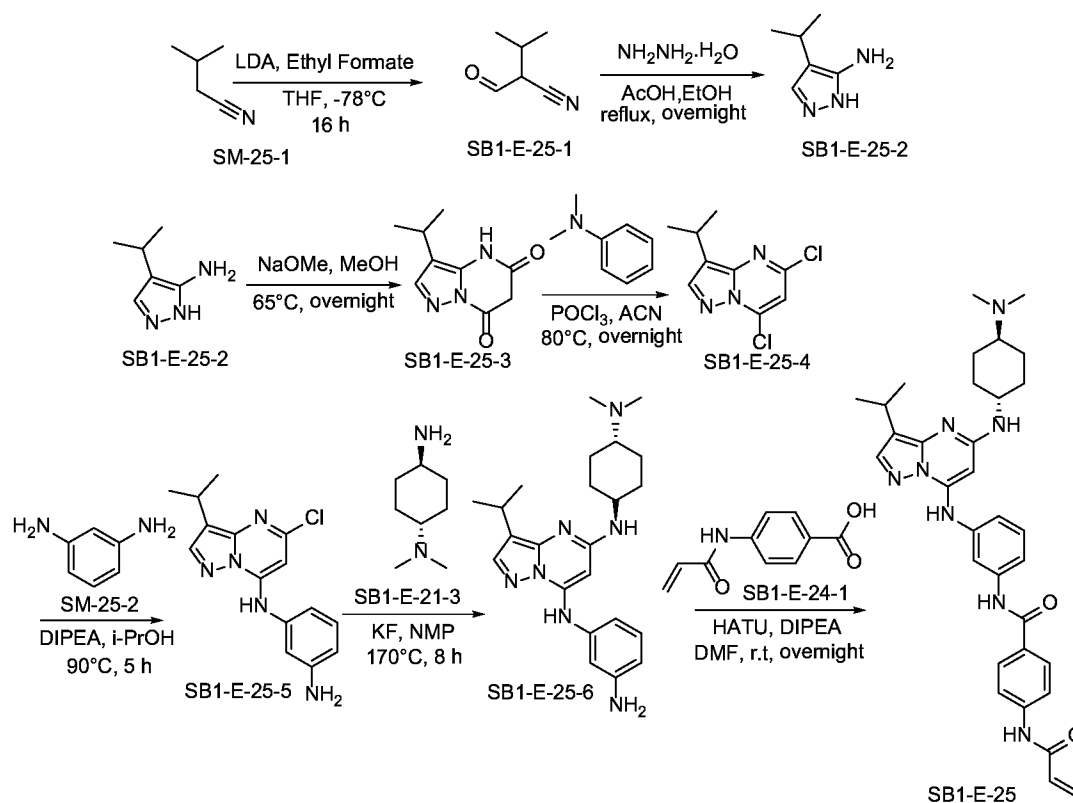


4-Acrylamido-N-(3-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-24)

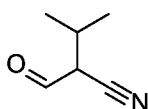
[00362] The mixture of **SB1-E-23-1** (100 mg, 0.263 mmol), **SB1-E-22-1** (100 mg, 0.523 mmol), HATU (200 mg, 0.526 mmol), DIPEA (0.5 mL) and DMF (5 mL) was stirred at r.t overnight. After completion, the mixture was purified by prep-TLC (DCM/MeOH = 15/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-24** (off-white solid, 23 mg, 16%). HPLC: 99% (254 nm); LCMS (m/z): 554 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.45 (s, 1 H), 10.27 (s, 1H), 9.63 (bs, 1 H), 8.01 (s, 1 H), 7.97 (d, *J* = 9.0 Hz, 2 H), 7.83 (m, 3 H), 7.49 (d, *J* = 8.5 Hz, 1 H), 7.39 (t, *J* = 8.5 Hz, 1 H), 7.19 (d, *J* = 7.5 Hz, 1 H), 6.48 (dd, *J*₁ = 16.5 Hz, *J*₂ = 10.5 Hz, 1 H), 6.31 (d, *J* = 16.5 Hz, 1 H), 6.03 (s, 1 H), 5.81 (d, *J* = 10.5 Hz, 1 H), 4.58 (s, 1 H), 4.17 (m, 1 H), 3.33-3.43 (m, 2 H), 2.99 (m, 1 H), 2.55-2.60 (m, 2 H), 1.18-1.89 (m, 12 H).

Example 7. 4-Acrylamido-N-(3-(5-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-3-isopropylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-25)

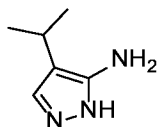
Synthetic Scheme 7



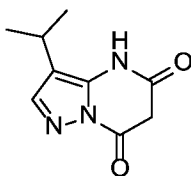
2-Formyl-3-methylbutanenitrile (SB1-E-25-1)



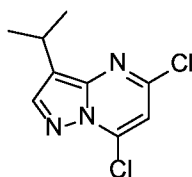
[00363] To a solution of **SM-25-1** (10.0 g, 120 mmol) in THF (10 mL), LDA (2 M, 60 mL, 120 mmol) was added slowly at -78°C . After completion, the mixture was added to a solution of ethyl formate (9.0 g, 121.5 mmol) in THF (40 mL) at -78°C . After completion, the mixture was stirred at 0°C for 3 h. The solvent was removed, then water (100 mL) was added, and the resulting mixture was extracted with Et_2O (200 mL $\times$ 3). The combined organic layer was washed with brine (100 mL $\times$ 2), dried over sodium sulfate, filtered through Celite, and concentrated under reduced pressure to give the crude **SB1-E-25-1** (colorless oil, 12.5 g, 94% yield). The crude product was used directly for the next step without further purification.

4-iso-Propyl-1H-pyrazol-5-amine (SB1-E-25-2)

[00364] To a solution of **SB1-E-25-1** (12.5 g, 112 mmol) in EtOH (200 mL), hydrazine hydrate (28 g, 560 mmol) and AcOH (26.9 g, 448 mmol) was added. The mixture was stirred at 80°C for 4h. The solvent was removed, then water (200 ml) was added, and the resulting mixture was extracted with DCM (300 mL × 3). The combined organic layer was washed with brine (100 mL × 2), dried over sodium sulfate, filtered through Celite, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (DCM/ MeOH = 15 / 1 to 8 / 1) to afford **SB1-E-25-2** (yellow solid, 13.3 g, 95% yield). LCMS (m/z): 126 [M + H]⁺.

3-iso-Propylpyrazolo[1,5-a]pyrimidine-5,7(4H,6H)-dione (SB1-E-25-3)

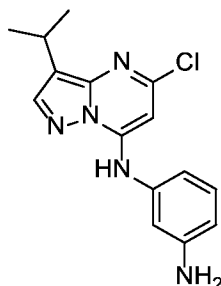
[00365] To a solution of **SB1-E-25-2** (1.7 g, 13.6 mmol) in CH₃OH (20 ml), **SM-25-2** (5.4 g, 40.8 mmol) and sodium methoxide (3.7 g, 68 mmol) was added. The mixture was stirred at 70°C for 4h. After completion, the solvent was removed, water (200 ml) was added, then 1M HCl aq. (40 mL) was added to adjust the pH to 3. The mixture was filtered and the filter residue was evaporated to dryness under reduced pressure to give the crude **SB1-E-25-3** (off-white solid, 2.5 g, 95% yield). LCMS (m/z): 194 [M + H]⁺.

5,7-Dichloro-3-iso-propylpyrazolo[1,5-a]pyrimidine (SB1-E-25-4)

[00366] To a solution of **SB1-E-25-3** (2.4 g, 12.4 mmol) in CH₃CN (30 ml), POCl₃ (9.4 g, 62 mmol) and N,N-dimethylaniline (4.5 g, 37.2 mmol) was added. The mixture was stirred at 80°C for 8h. The mixture was concentrated and water (40 mL) was added. The mixture was filtered and concentrated to remove the solvent. The residue was washed with water (100ml)

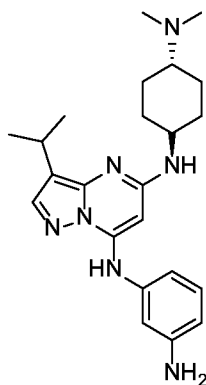
and then evaporated to dryness under reduced pressure to give the crude **SB1-E-25-4** (brown solid, 2.7 g, 85% yield). LCMS (m/z): 230 [M + H]⁺.

N¹-(5-Chloro-3-isopropylpyrazolo[1,5-a]pyrimidin-7-yl)benzene-1,3-diamine (SB1-E-25-5)



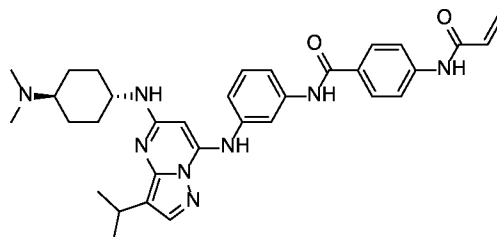
[00367] To a solution of **SB1-E-25-4** (2.6 g, 11.3 mmol), in i-PrOH (20 mL), 1,3-diaminobenzene (1.47 g, 13.6 mmol) and DIPEA (2.92 g, 22.6 mmol) was added. The mixture was stirred at 110 °C for 8h. The mixture was concentrated, water (20 mL) was added, and the resulting mixture was extracted with DCM (30 mL × 3). The combined organic layer was washed with brine (20 mL × 2), dried over sodium sulfate, filtered through Celite, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/ethyl acetate = 8 / 1 to 4 / 1) to afford **SB1-E-25-5** (off-white solid, 2.2 g, 65% yield). LCMS (m/z): 302 [M + H]⁺.

N7-(3-Aminophenyl)-N5-((1s,4s)-4-(dimethylamino)cyclohexyl)-3-isopropylpyrazolo[1,5-a]pyrimidine-5,7-diamine (SB1-E-25-6)



[00368] The mixture of **SB1-E-25-5** (350 mg, 1.16 mmol), **SB1-E-21-3** (200 mg, 1.41 mmol), KF (400 mg, 6.88 mmol) and NMP (2 mL) was stirred at 170°C for 8 h, after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 10/1) to obtain **SB1-E-25-6** (light brown solid, 130 mg, yield 28%). LCMS (m/z): 408 [M + H]⁺.

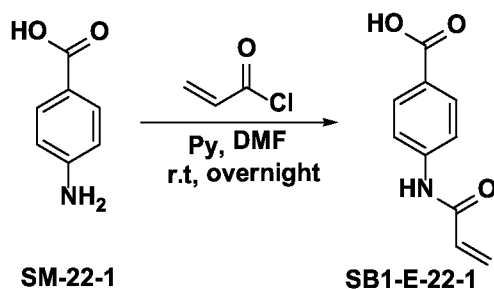
4-Acrylamido-N-(3-(5-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-3-isopropylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-25)

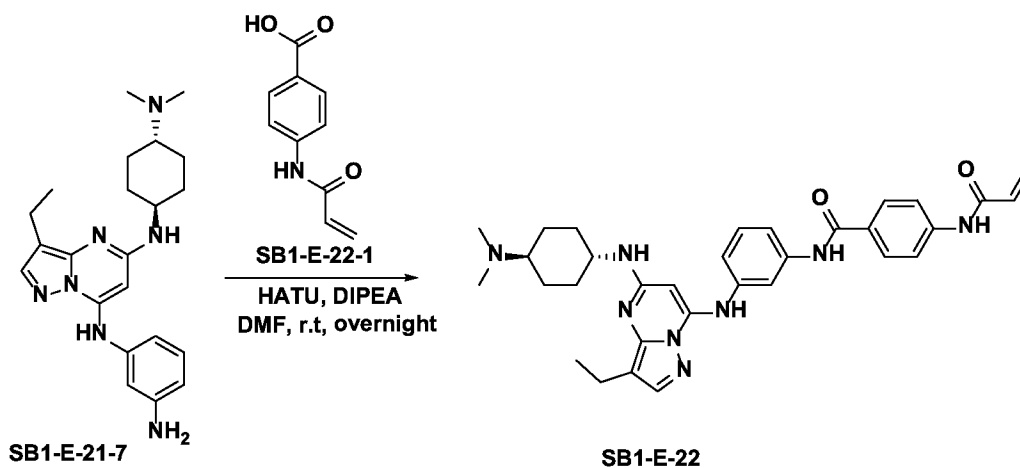


[00369] The mixture of **SB1-E-25-5** (40 mg, 0.0981 mmol), **SB1-E-24-1** (35 mg, 0.183 mmol), HATU (75 mg, 0.197 mmol) and DMF (5 mL) was stirred at r.t overnight. After completion, the mixture was purified by prep-TLC (DCM/MeOH = 8/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-25** (gray solid, 15 mg, yield 26%). HPLC: 97% (254 nm); LCMS (m/z): 581 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.44 (s, 1 H), 10.26 (s, 1H), 9.07 (s, 1 H), 7.97 (d, *J* = 8.5 Hz, 2 H), 7.85 (s, 1 H), 7.82 (d, *J* = 8.5 Hz, 2 H), 7.67 (s, 1 H), 7.64 (t, *J* = 4.0 Hz, 1 H), 7.37 (t, *J* = 8.0 Hz, 1 H), 7.10 (d, *J* = 7.5 Hz, 1 H), 6.62 (d, *J* = 7.0 Hz, 1 H), 6.47 (dd, *J*₁ = 17.0 Hz, *J*₂ = 10.5 Hz, 1 H), 6.31 (d, *J* = 17.0 Hz, 1 H), 5.81 (d, *J* = 10.5 Hz, 1 H), 3.63 (s, 1 H), 3.00 (m, 1 H), 1.77-2.17 (m, 11 H), 1.09-1.29 (m, 10 H).

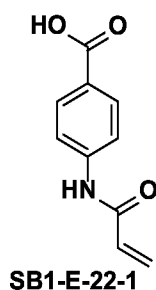
Example 8. 4-Acrylamido-N-(3-(5-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-22)

Synthetic Scheme 8



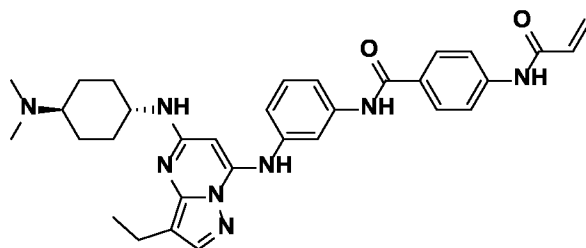


4-Acrylamidobenzoic acid (SB1-E-22-1)



[00370] To the solution of SM-22-1 (500 mg, 3.65 mmol) in pyridine (20 mL) was added acrylyl chloride (500 mg, 5.52 mmol), the mixture was stirred at r.t overnight, after completion, the mixture was poured to a ice-water (20 mL), filtered, the solid was washed with H₂O, dried to obtain SB1-E-22-1 (light yellow solid, 600 mg, yield 86%). LCMS (m/z): 192 [M + H]⁺.

4-Acrylamido-N-(3-(5-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)benzamide (SB1-E-22)

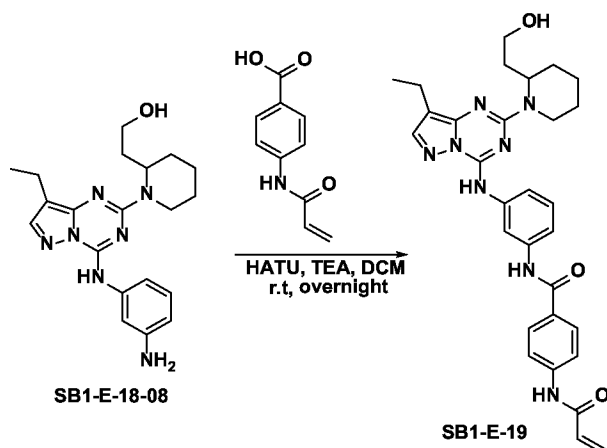


[00371] The mixture of SB1-E-21-7 (50 mg, 0.127 mmol), SB1-E-22-1 (45 mg, 0.235 mmol), HATU (88 mg, 0.231 mmol), DIPEA (0.3 mL) and DMF (2 mL) was stirred at r.t overnight, after completion, concentrated to remove the solvent, the residue was purified by

prep-TLC (DCM/MeOH = 10/) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05%NH₄HCO₃) to obtain SB1-E-22 (light gray solid, 7 mg, yield 10%). HPLC: 95% (214 nm); LCMS (m/z): 567 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.44 (s, 1 H), 10.25 (s, 1 H), 9.06 (s, 1H), 7.97 (d, *J* = 9.0 Hz, 2 H), 7.85 (d, *J* = 5.0 Hz, 1 H), 7.82 (d, *J* = 9.0 Hz, 2 H), 7.70 (s, 1 H), 7.63 (d, *J* = 8.0 Hz, 1 H), 7.37 (t, *J* = 8.5 Hz, 1 H), 7.10 (d, *J* = 7.0 Hz, 1 H), 6.61 (d, *J* = 7.5 Hz, 1 H), 6.47 (dd, *J*₁ = 16.5 Hz, *J*₂ = 9.5 Hz, 1 H), 6.31 (d, *J* = 16.5 Hz, 1 H), 5.81 (d, *J* = 9.5 Hz, 1 H), 5.63 (s, 1 H), 3.68 (s, 1 H), 2.54 (q, *J* = 7.5 Hz, 2 H), 2.15 (s, 6 H), 1.77-2.15 (m, 5 H), 1.11-1.27 (m, 7 H).

Example 9. 4-Acrylamido-N-(3-(8-ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenyl)benzamide (SB1-E-19)

Synthetic Scheme 9



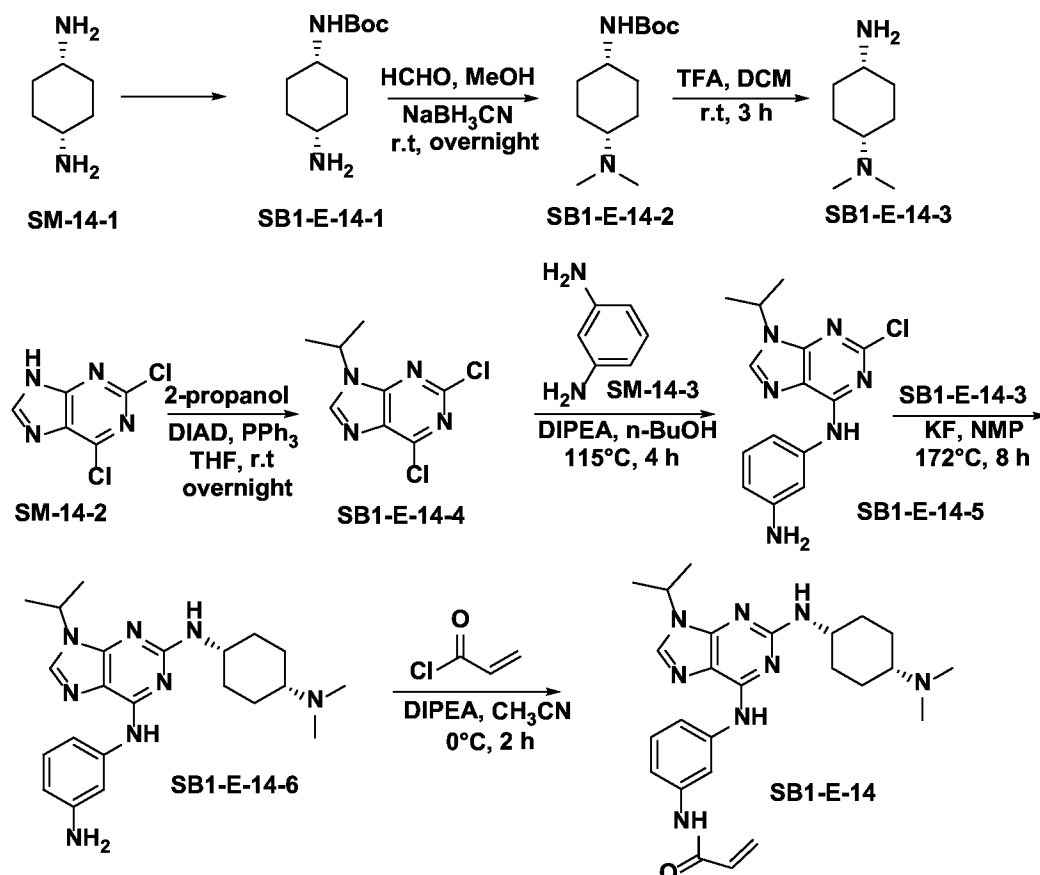
4-Acrylamido-N-(3-(8-ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenyl)benzamide (SB1-E-19)

[00372] A mixture of SB1-E-18-08 (70 mg, 0.18 mmol), 4-acrylamidobenzoic acid (52 mg, 0.27 mmol), HATU (68 mg, 0.18 mmol) and triethylamine (54 mg, 0.54 mmol) in DCM (3 mL) was stirred at r.t overnight, diluted with dichloromethane (10 mL), washed with water (10 mL) and saturated sodium bicarbonate solution (10 mL×2), dried over anhydrous sodium sulfate filtered and concentrated in vacuo, purified by prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05%TFA) to get SB1-E-19, also referred to herein as E19 and E-19 (white solid, 25 mg, yield:25%). HPLC: 100% (254 nm); LCMS (m/z): 555 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ : 10.45 (s, 1H), 10.19 (s, 1H), 8.49 (s, 1H), 7.97 (d, *J*=8.5 Hz, 2H), 7.88 (s, 1H), 7.82 (d, *J*=8.5 Hz, 1H), 7.45-7.51 (m, 2H), 7.34 (t, *J*=8.0 Hz, 1H),

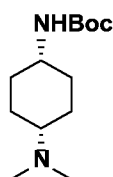
6.48 (dd, $J=16.5, 10$ Hz, 1H), 6.32 (d, $J=17.0$ Hz, 1H), 5.82 (d, $J=10.0$ Hz, 1H), 5.00 (s, 1H), 4.66 (d, $J=10.0$ Hz, 1H), 2.91 (t, $J=13.0$ Hz, 1H), 2.50-2.54 (m, 2H), 1.56-1.71 (m, 8H), 1.38-1.40 (m, 1H), 1.20-1.23 (m, 4H).

Example 10. *N*-(3-(2-((1*s*,4*s*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)phenyl)acrylamide (SB1-E-14)

Synthetic Scheme 10



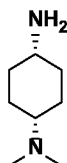
***tert*-Butyl (1*s*,4*s*)-4-(dimethylamino)cyclohexylcarbamate (SB1-E-14-2)**



[00373] To the solution of **SB1-E-14-1** (1.0 g, 4.67 mmol), MeOH (30 mL) and HCHO (600 mg, 20.0 mmol) was added NaBH₃CN (1.5 g, 23.9 mmol), the mixture was stirred at r.t overnight. After completion, concentrated to remove the solvent, then extracted with ethyl

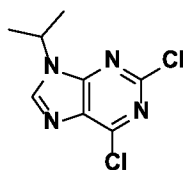
acetate (100 mL $\times$ 4), the organic phase was washed with H₂O (50 mL), brine (50 mL $\times$ 2), dried with Na₂SO₄. Filtered, concentrated to remove the solvent, the residue was purified by silica gel (DCM/MeOH = 10/1, 4/1) to obtain **SB1-E-14-2** (light brown solid, 800 mg, yield 71%). LCMS (m/z): 243 [M + H]⁺.

(1s,4s)-N1,N1-Dimethylcyclohexane-1,4-diamine (SB1-E-14-3)

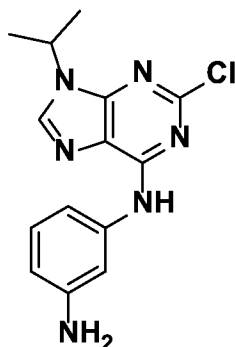


[00374] The mixture of **SB1-E-14-2** (350 mg, 1.44 mmol), DCM (3 mL) and TFA (3 mL) was stirred at r.t for 3 h. after completion, concentrated to remove the solvent to obtain **SB1-E-14-3** (light yellow sticky oil, 200 mg, yield 98%). LCMS (m/z): 143 [M + H]⁺.

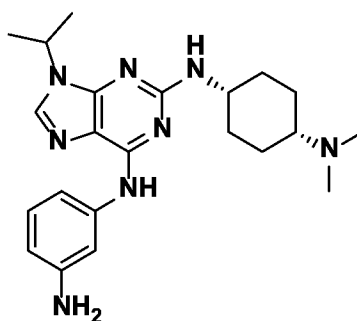
2,6-Dichloro-9-isopropyl-9H-purine (SB1-E-14-4)



[00375] To a solution of **SM-14-2** (3.0 g, 15.3 mmol) and 2-propanol (2.75 g, 45.9 mmol) in THF (30 mL), PPh₃ (8.02 g, 30.6 mmol) was added. The mixture was stirred at room temperature for 10min. Then DIEA (6.18 g, 30.6 mmol) was added. The final mixture was stirred at 70°C for 3h. after completion, concentrated to remove the solvent, water (30 mL) was added, the resulting mixture was extracted with DCM (50 mL $\times$ 3). The combined organic layer was washed with brine (50 mL $\times$ 2), dried over sodium sulfate, filtered through Celite, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (ethyl acetate/acetone = 20 / 1 to 10 /1) to afford **SB1-E-14-4** (off-white solid, 2.34 g, 66% yield).

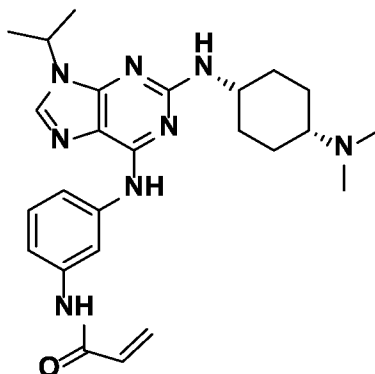
N1-(2-Chloro-9-isopropyl-9H-purin-6-yl)benzene-1,3-diamine (SB1-E-14-5)

[00376] The mixture of **SB1-E-14-4** (1.2 g, 5.19 mmol), **SM-14-3** (850 mg, 7.86 mmol), n-BuOH (30 mL) and DIPEA (2 mL) was stirred at 115°C for 4 h. after completion, concentrated to remove the solvent, the residue was purified by silica gel (DCM/MeOH = 50/1) to obtain **SB1-E-14-5** (light brown solid, 1.2 g, yield 76%). LCMS (m/z): 303 [M + H]⁺.

N6-(3-Aminophenyl)-N2-((1s,4s)-4-(dimethylamino)cyclohexyl)-9-isopropyl-9H-purine-2,6-diamine (SB1-E-14-6)

[00377] The mixture of **SB1-E-14-5** (370 mg, 1.22 mmol), **SB1-E-14-3** (200 mg, 1.41 mmol), KF (360 mg, 6.20 mmol) and NMP (2 mL) was stirred at 172°C for 8 h. after completion, the mixture was purified by silica gel (DCM/MeOH = 10/1, 8/1, 6/1) to obtain **SB1-E-14-6** (brown solid, 150 mg, yield 30%). LCMS (m/z): 409 [M + H]⁺.

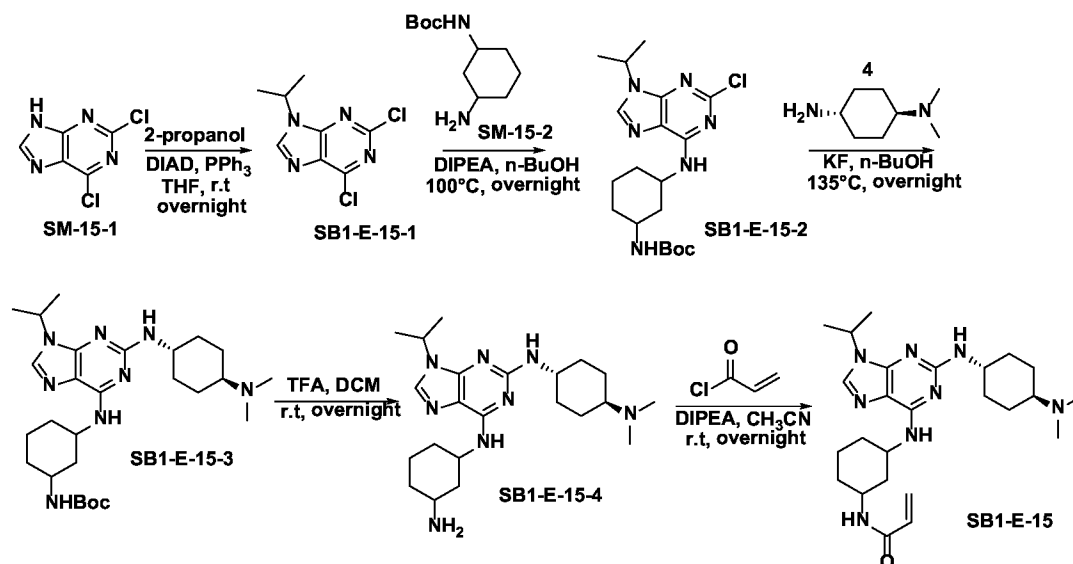
***N*-(3-(2-((1*s*,4*s*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)phenyl)acrylamide (SB1-E-14)**



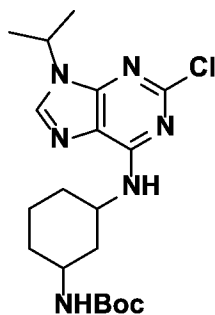
To a solution of **SB1-E-14-6** (60 mg, 0.147 mmol), DIPEA (0.5 mL) in CH₃CN (4 mL) was added the solution of acryloyl chloride (20 mg, 0.221 mmol) in CH₃CN (1 mL) dropwise, the mixture was stirred at 0°C for 2 h. after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 30/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-14** (off-white solid, 20 mg, yield 29%). HPLC: 100% (254 nm); LCMS (m/z): 463 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 400 MHz): δ 10.04 (s, 1 H), 9.38 (s, 1 H), 8.44 (s, 1 H), 7.95 (s, 1 H), 7.63 (d, *J* = 7.2 Hz, 1 H), 7.25 (s, 1 H), 7.20 (t, *J* = 8.0 Hz, 1 H), 6.47 (dd, *J*₁ = 16.8 Hz, *J*₂ = 9.6 Hz, 1 H), 6.26 (d, *J* = 16.8 Hz, 1 H), 5.75 (d, *J* = 9.6 Hz, 1 H), 4.59 (m, 1 H), 3.95 (m, 1 H), 2.20 (s, 6 H), 2.07 (m, 1 H), 1.48-1.76 (m, 14 H).

Example 11. *N*-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)cyclohexyl)acrylamide (SB1-E-15)

Synthetic Scheme 11

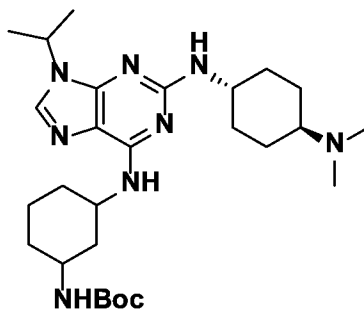


***tert*-butyl 3-(2-Chloro-9-isopropyl-9*H*-purin-6-ylamino)cyclohexylcarbamate (SB1-E-15-2)**



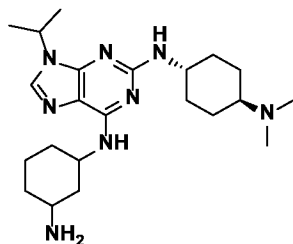
[00378] The mixture of SB1-E-15-1 (520 mg, 2.25 mmol), SM-15-2 (490 mg, 2.29 mmol), n-BuOH (15 mL) and DIPEA (1 mL) was stirred at 100°C overnight, after completion, concentrated to remove the solvent, the residue was purified by silica gel (PE/ethyl acetate = 2/1) to obtain SB1-E-15-2 (light broen solid, 380 mg, yield 41%). LCMS (m/z): 409 [M + H]⁺.

*tert-butyl 3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)cyclohexylcarbamate (SB1-E-15-3)*



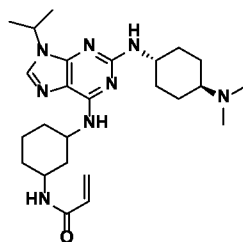
[00379] The mixture of **SB1-E-15-2** (180 mg, 0.440 mmol), **4** (150 mg, 1.05 mmol), KF (110 mg, 1.89 mmol) and n-BuOH (1.5 mL) was stirred at 135°C overnight, after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 6/1) to obtain **SB1-E-15-3** (light brown solid, 25 mg, yield 11%). LCMS (m/z): 515 [M + H]⁺.

*N6-(3-Aminocyclohexyl)-N2-((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)-9-isopropyl-9*H*-purine-2,6-diamine (SB1-E-15-4)*



[00380] The mixture of **SB1-E-15-3** (25 mg, 0.0486 mmol), DCM (3 mL) and TFA (3 mL) was stirred at r.t overnight. after completion, concentrated to remove the solvent to obtain **SB1-E-15-4** (light brown sticky oil, 20 mg, yield 95%). LCMS (m/z): 415 [M + H]⁺.

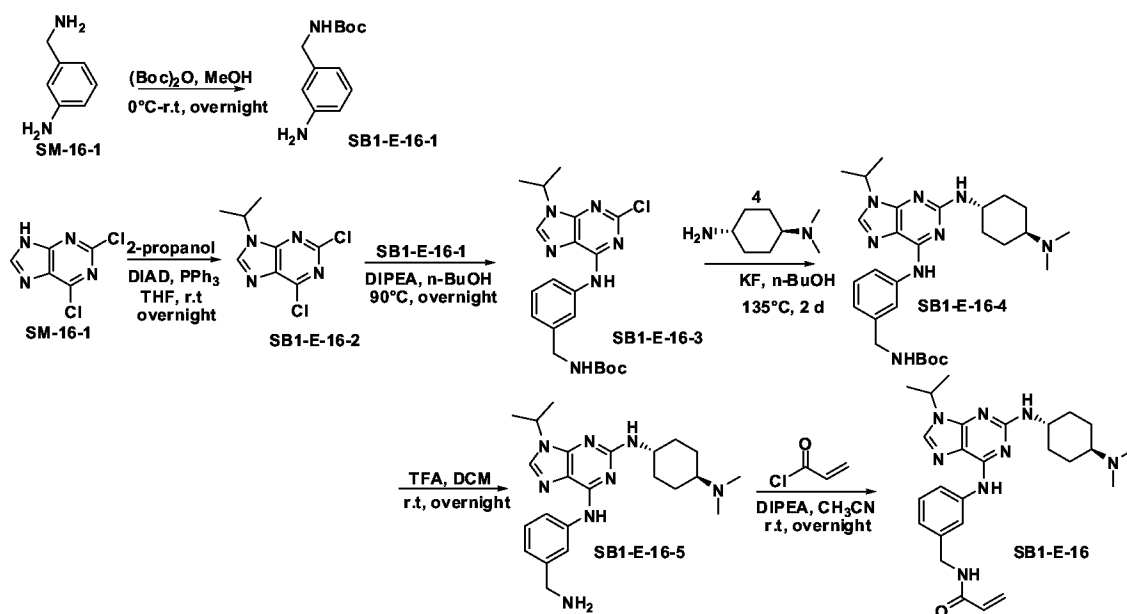
*N-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)cyclohexyl)acrylamide (SB1-E-15)*



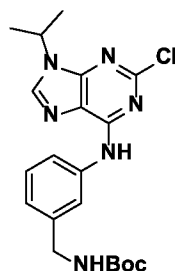
[00381] To a solution of **SB1-E-15-4** (20 mg, 0.0482 mmol), CH₃CN (4 mL) and DIPEA (0.5 mL) was added acryloyl chloride (7 mg, 0.0773 mmol) in CH₃CN (1 mL) dropwise, the mixture was stirred at r.t overnight. After completion, the mixture was purified by prep-TLC (DCM/MeOH = 8/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-15** (white solid, 5 mg, yield 24%). HPLC: 100% (254 nm); LCMS (m/z): 469 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 8.03 (m, 1 H), 7.79 (s, 1 H), 6.79 (s, 1 H), 6.34 (dd, *J*₁ = 17.0 Hz, *J*₂ = 12.0 Hz, 1 H), 6.07 (d, *J* = 17.0 Hz, 1 H), 5.56 (d, *J* = 12.0 Hz, 1 H), 4.51 (m, 1 H), 4.07 (s, 1 H), 3.61 (s, 1 H), 2.22 (s, 7 H), 2.00 (s, 2 H), 1.81 (m, 5 H), 1.19-1.65 (m, 17 H).

Example 12. *N*-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)benzyl)acrylamide (SB1-E-16**)**

Synthetic Scheme 12

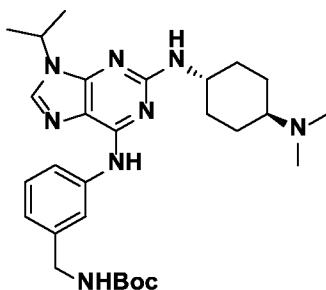


***tert*-butyl 3-(2-Chloro-9-isopropyl-9*H*-purin-6-ylamino)benzylcarbamate (**SB1-E-16-3**)**



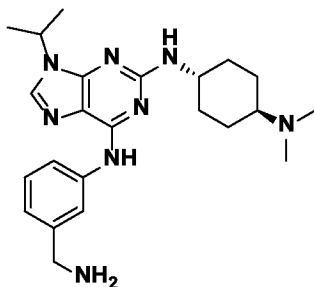
[00382] The mixture of **SB1-E-16-2** (500 mg, 2.16 mmol), **SB1-E-16-1** (490 mg, 2.20 mmol), n-BuOH (20 mL) and DIPEA (1 mL) was stirred at 90°C overnight, after completion, concentrated to remove the solvent, the residue was purified by silica gel (PE/ethyl acetate = 2/1) to obtain **SB1-E-16-3** (off-white solid, 360 mg, yield 40%). LCMS (m/z): 417 [M + H]⁺.

*tert-butyl 3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9H-purin-6-ylamino)benzylcarbamate (SB1-E-16-4)*



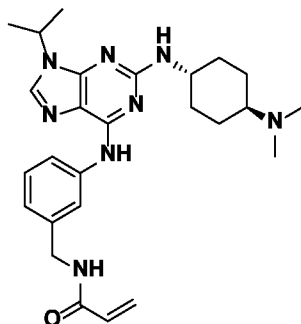
[00383] The mixture of **SB1-E-16-3** (210 mg, 0.504 mmol), **4** (150 mg, 1.05 mmol), KF (90 mg, 1.55 mmol) and n-BuOH (2 mL) was stirred at 135°C for 2 days, after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 10/1) to get **SB1-E-16-4** (light yellow solid, 90 mg, yield 34%. LCMS (m/z): 523 [M + H]⁺.

*N6-(3-(Aminomethyl)phenyl)-N2-((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)-9-isopropyl-9H-purine-2,6-diamine (SB1-E-16-5)*



[00384] The mixture of **SB1-E-16-4** (50 mg, 0.0957 mmol), DCM (5 mL) and TFA (3 mL) was stirred at r.t overnight, after completion, concentrated to remove the solvent to get **SB1-E-16-5** (light brown solid, 40 mg, 95%). LCMS (m/z): 423 [M + H]⁺.

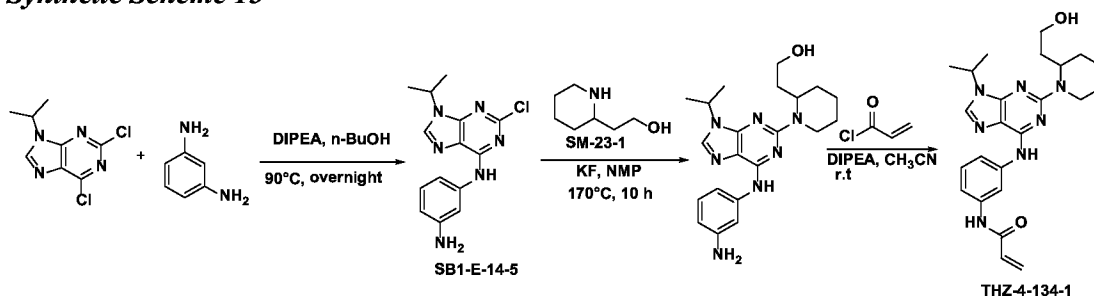
***N*-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-9-isopropyl-9*H*-purin-6-ylamino)benzyl)acrylamide (SB1-E-16)**

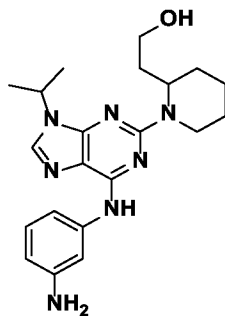


[00385] To a solution of **SB1-E-16-5** (40 mg, 0.0947 mmol), CH₃CN (9 mL) and DIPEA (1 mL) was added acryloyl chloride (13 mg, 0.144 mmol) in CH₃CN (1 mL) dropwise, the mixture was stirred at r.t overnight, after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 8/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-16** (white solid, 4.5 mg, yield 10%). HPLC: 95% (214 nm); LCMS (m/z): 477 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 9.40 (s, 1 H), 8.60 (d, 1 H), 7.94 (s, 1 H), 7.88 (d, 1 H), 7.22 (t, *J* = 8.0 Hz, 1 H), 6.87 (d, *J* = 7.5 Hz, 1 H), 6.30 (dd, *J*₁ = 17.0 Hz, *J*₂ = 10.0 Hz, 1 H), 6.14 (d, *J* = 17.0 Hz, 1 H), 5.62 (d, *J* = 10.0 Hz, 1 H), 4.57 (m, 1 H), 4.36 (d, *J* = 6.0 Hz, 2 H), 1.84-2.36 (m, 10 H), 1.49 (s, 3 H), 1.46 (s, 3 H), 1.23-1.34 (m, 5 H).

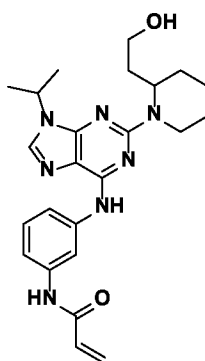
***Example 13. N*-(3-((2-(2-(2-Hydroxyethyl)piperidin-1-yl)-9-isopropyl-9*H*-purin-6-yl)amino)phenyl)acrylamide (THZ-4-134-1)**

Synthetic Scheme 13



2-(1-(6-((3-Aminophenyl)amino)-9-isopropyl-9H-purin-2-yl)piperidin-2-yl)ethan-1-ol

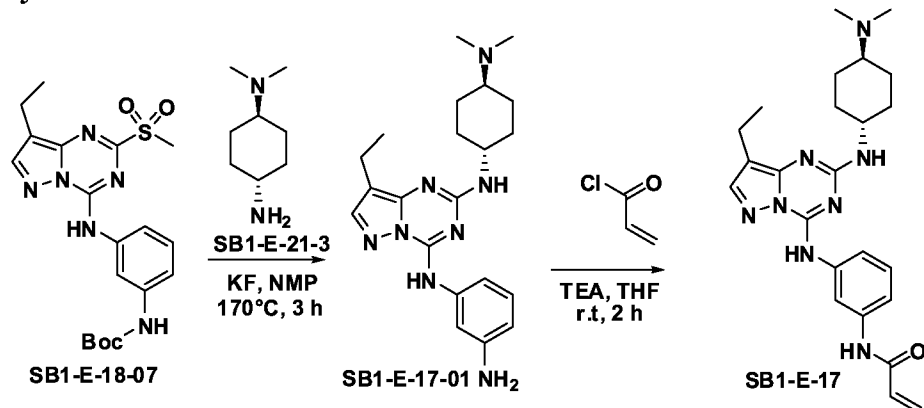
[00386] The mixture of **SB1-E-14-5** (1.1 g, 3.72 mmol), **SM-23-1** (800 mg, 6.19 mmol), KF (1.0 g, 17.2 mmol) and NMP (3 mL) was stirred at 168°C for 12 h, after completion, concentrated to remove the solvent, the residue was purified by silica gel (PE/ethyl acetate = 2/1, 1/1) to obtain desired product (1.2 g, yield 81%). LCMS (m/z): 396 [M + H]⁺.

N-(3-((2-(2-(2-Hydroxyethyl)piperidin-1-yl)-9-isopropyl-9H-purin-6-yl)amino)phenyl)acrylamide (THZ-4-134-1)

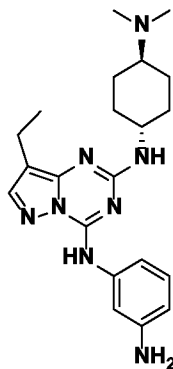
[00387] To a solution of free amine obtained from above reaction (30 mg, 0.076 mmol), DIPEA (0.7 mL) in CH₃CN (12 mL) was added the solution of acryloyl chloride (11 mg, 0.12 mmol) in CH₃CN (2 mL) dropwise, the mixture was stirred at 0°C for 3 h. after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 30/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **THZ-4-134-1** (off-white solid, 23 mg, yield 70%). HPLC: 98% (254 nm); LCMS (m/z): 450 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 600 MHz): δ 10.42 (s, 1 H), 9.50 (s, 1 H), 8.34 (s, 1 H), 7.25 (s, 1 H), 7.52 (d, *J* = 7.8 Hz, 1H), 7.25-7.16 (m, 2 H), 6.45 (dd, *J*₁ = 17.2 Hz, *J*₂ = 10.0 Hz, 1 H), 6.27 (d, *J* = 17.2 Hz, 1 H), 5.77 (d, *J* = 10.0 Hz, 1 H), 4.97 (br, 1 H), 4.61 (m, 1 H), 3.34-3.38 (m, 3 H), 2.87 (t, *J* = 12 Hz, 1 H), 1.83 (m, 1 H), 1.74 (m, 1 H), 1.69 (m, 3 H), 1.60-1.50 (m, 9 H), 1.34 (m, 1 H).

Example 14. *N*-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-8-ethylpyrazolo[1,5-*a*][1,3,5]triazin-4-ylamino)phenyl)acrylamide (compound SB1-E-17)

Synthetic Scheme 14

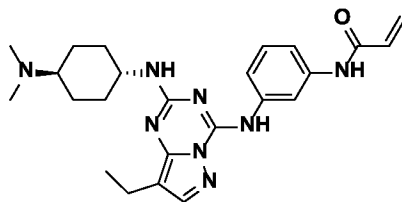


N-(3-Aminophenyl)-*N*2-((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)-8-ethylpyrazolo[1,5-*a*][1,3,5]triazine-2,4-diamine (SB1-E-17-01)



[00388] To a stirred mixture of SB1-E-18-07 (60 mg, 0.14 mmol) and SB1-E-21-3 (30 mg, 0.21 mmol) in N-methyl-2-pyrrolidone (1 mL) was added KF (24 mg, 0.42 mmol). This mixture was heated at 170°C for 3 h, cooled to r.t, filtered, purified by prep-TLC (DCM/MeOH=6/1) to get SB1-E-17-01 (white solid, 40 mg, yield: 73%). MS (ESI): *m/z* 395 [M+H]⁺.

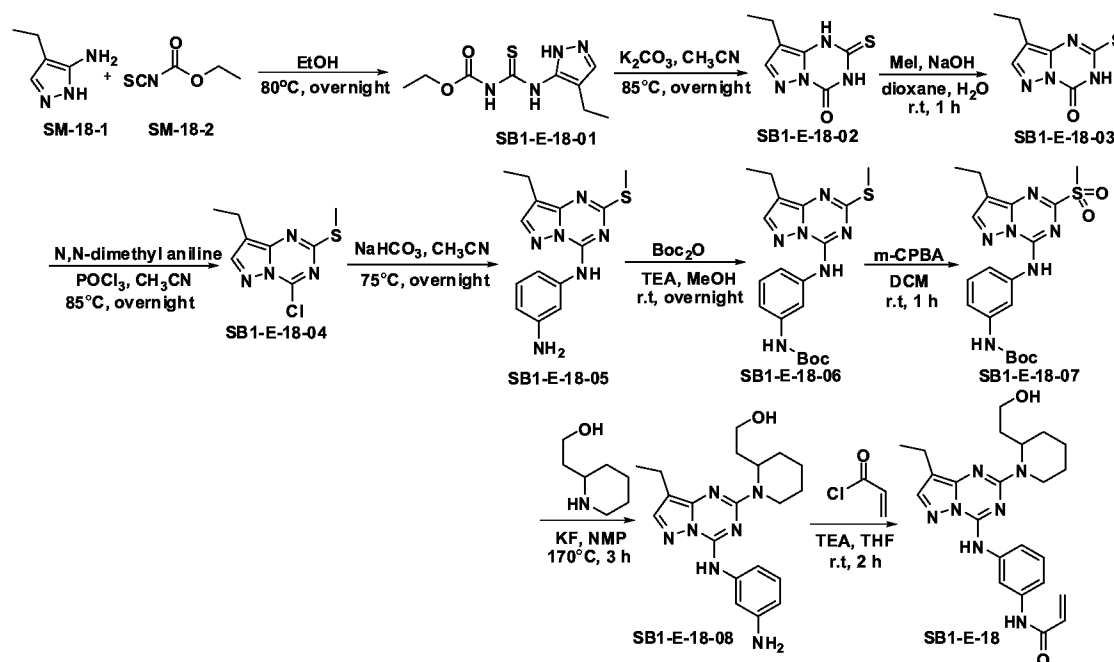
N-(3-(2-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-8-ethylpyrazolo[1,5-*a*][1,3,5]triazin-4-ylamino)phenyl)acrylamide (compound SB1-E-17)

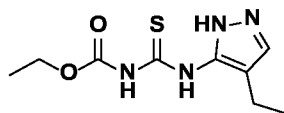


[00389] To a solution of **SB1-E-17-01** (40 mg, 0.10 mmol) in THF (1 mL) was added Acryloyl chloride (14 mg, 0.15 mmol) and Triethylamine (30 mg, 0.30 mmol) was stirred at r.t for 2 h. After completion, the reaction mixture was diluted with dichloromethane (10 ml), washed with water (10 mL) and saturated sodium bicarbonate solution (10 mL×2), dried over anhydrous sodium sulfate, concentrated, purified by prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to get **SB1-E-17**, also referred to herein as **E17** and **E-17** (white solid, 4 mg, yield:11%). MS (ESI): *m/z* 449 [M+H]⁺. ¹H NMR (300 MHz, DMSO) δ : 9.98 (s, 1H), 9.65 (s, 1H), 8.14 (s, 1H), 7.76 (s, 1H), 7.52 (d, *J*=8.1 Hz, 1H), 7.45 (d, *J*=7.8 Hz, 1H), 7.29 (t, *J*=8.1 Hz, 1H), 6.64 (s, 1H), 6.42-6.51 (m, 1H), 6.23-6.29 (m, 1H), 5.70-5.74 (m, 1H), 3.69-3.72 (m, 1H), 2.51-2.56 (m, 2H), 2.36 (s, 6H), 2.03-2.06 (m, 2H), 1.86-1.90 (m, 2H), 1.18-1.37 (m, 8H).

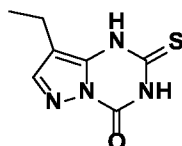
Example 15. *N*-(3-(8-Ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-*a*][1,3,5]triazin-4-ylamino)phenyl)acrylamide (SB1-E-18)

Synthetic Scheme 15

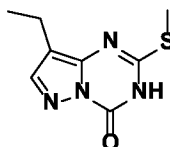


ethyl N-[(4-Ethyl-1H-pyrazol-5-yl)carbamothioyl]carbamate (SB1-E-18-01)

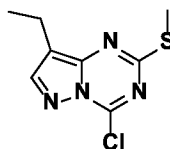
[00390] To a solution of SM-18-1 (2.8 g, 25.2 mmol) in ethanol (50.0 mL) was added ethoxycarbonyl isothiocyanate (3.3 g, 25.2 mL) in one portion at r.t. The mixture was stirred at 80 °C overnight. The reaction mixture was concentrated under reduced pressure to afford the residue, purified by flash column chromatography (PE/ethyl acetate = 3/1) to get **SB1-E-18-01** (white solid, 4 g, yield: 65%). LCMS (m/z): 243 [M + H]⁺.

8-Ethyl-2-thioxo-2,3-dihydropyrazolo[1,5-a][1,3,5]triazin-4(1H)-one (SB1-E-18-02)

[00391] To a solution of **SB1-E-18-01** (3.9 g, 16.1 mmol) in acetonitrile (40 mL) was added K₂CO₃ (6.67 g, 48.3 mmol) in one portion at r.t. The mixture was heated at 85°C overnight, cooled, acidified with AcOH. The solid was filtered off to get **SB1-E-18-02** (yellow solid, 2.1 g, yield: 66%). LCMS (m/z): 197 [M + H]⁺.

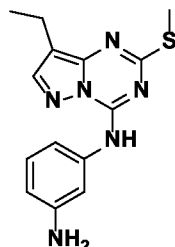
8-Ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4(3H)-one (SB1-E-18-03)

[00392] To a stirred mixture of **SB1-E-18-02** (2.1 g, 10.7 mmol) and NaOH (0.86 g, 21.4 mmol) in Dioxane/H₂O (30/8 mL) was added iodomethane (1.52 g, 10.7 mol). This mixture was stirred at r.t for 1h, acidified with Hydrochloric acid, concentrated to remove the solvent, the residue was purified by silica gel (DCM/MeOH = 30/1) to get **SB1-E-18-03** (white solid, 2.0 g, yield: 89%). LCMS (m/z): 211 [M + H]⁺.

4-Chloro-8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazine (SB1-E-18-04)

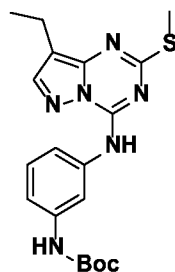
[00393] To a stirred mixture **SB1-E-18-03** (2.0 g, 9.5 mmol) and N,N-dimethyl aniline (2.3 g, 19.0 mmol) in acetonitrile (10 mL) under argon was added POCl_3 (20 mL, 219 mmol). This mixture was heated at 85°C overnight, cooled, the reaction mixture was concentrated under reduced pressure to afford the residue **SB1-E-18-04** (white solid, 2.2 g, yield: 100% used next step directly). LCMS (m/z): 229 $[\text{M} + \text{H}]^+$.

N1-(8-Ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-yl)benzene-1,3-diamine (SB1-E-18-05)



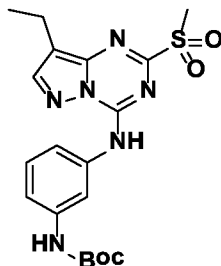
[00394] To a stirred mixture **SB1-E-18-04** (2.2 g, 9.5 mmol), benzene-1,3-diamine (1.23 g, 11.4 mmol) and NaHCO_3 (130.4 mg, 0.95 mmol) in acetonitrile (25 mL). This mixture was heated at 75°C overnight, cooled, filtered and concentrated to remove the solvent, the residue was purified by silica gel (PE/ethyl acetate = 3/1 to 1/1) to get **SB1-E-18-05** (white solid, 1.1 g, yield: 38%). LCMS (m/z): 301 $[\text{M} + \text{H}]^+$.

tert-Butyl 3-(8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenylcarbamate (SB1-E-18-06)



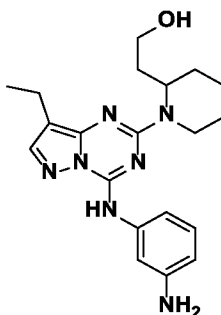
[00395] To a solution of **SB1-E-18-05** (1.1 g, 3.67 mmol) in MeOH (20.0 mL) was added Di-tert-butyl dicarbonate (1.2 g, 5.5 mmol) and TEA (1.1 g, 11.0 mmol) in one portion at r.t. The reaction was stirred at r.t. overnight. The reaction mixture was concentrated under reduced pressure to afford the residue, purified by flash column chromatography (PE/ethyl acetate = 3/1) to get **SB1-E-18-06** (white solid, 1.26 g, yield: 86%). LCMS (m/z): 401 $[\text{M} + \text{H}]^+$.

tert-Butyl 3-(8-ethyl-2-(methylsulfonyl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenylcarbamate (SB1-E-18-07)



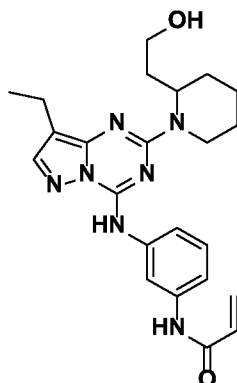
[00396] To a solution of **SB1-E-18-06** (600 mg, 1.5 mmol) in DCM (15 mL) was added 3-Chloroperbenzoic acid (776mg, 4.5 mmol) in one portion at r.t. The mixture was stirred at r.t for 1 h. The reaction mixture was quenched with sat Na₂S₂O₃ solution(10 mL), diluted with DCM (50 mL) and washed with saturated aqueous NaCl (3 × 50 mL), dried over anhydrous Na₂SO₄, filtered and concentrated to give **SB1-E-18-07** (yellow solid, 620 mg, yield:96%), used for next step directly. LCMS (m/z): 433 [M + H]⁺.

2-(1-(4-(3-Aminophenylamino)-8-ethylpyrazolo[1,5-a][1,3,5]triazin-2-yl) piperidin-2-yl)ethanol (SB1-E-18-08)



[00397] To a stirred mixture **SB1-E-18-07** (360 mg, 0.84 mmol) and 2-(piperidin-2-yl)ethanol (215 mg, 1.67 mmol) in N-methyl-2-pyrrolidone (3 mL) was added KF (146 mg, 2.51 mmol). This mixture was heated at 170°C for 3 h, cooled, filtered, the crude was purified by silica gel (PE/ethyl acetate = 2/1) to get **SB1-E-18-08** (yellow solid, 150 mg, yield: 47%). LCMS (m/z): 382 [M + H]⁺.

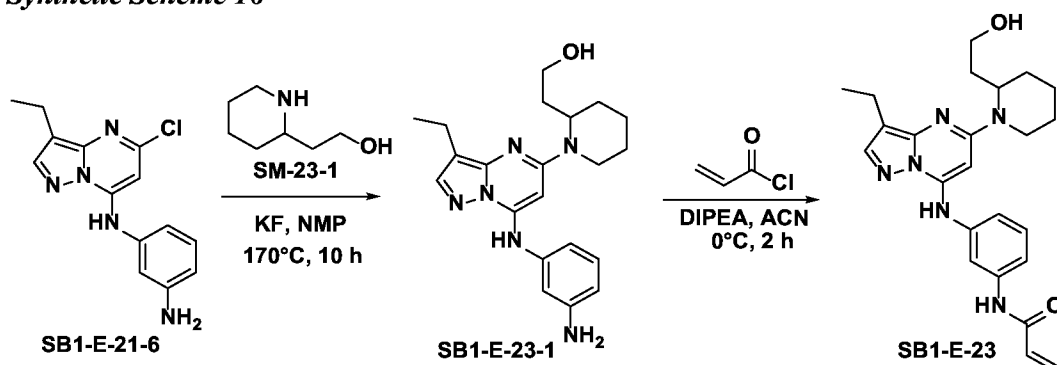
***N*-(3-(8-Ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a][1,3,5] triazin-4-ylamino)phenyl)acrylamide (SB1-E-18)**



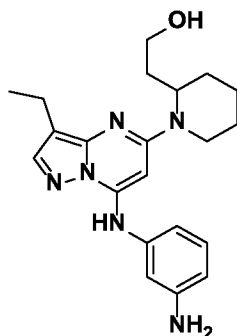
[00398] To a solution of **SB1-E-18-08** (70 mg, 0.18 mmol) in THF (2 mL) was added Acryloyl chloride (18 mg, 0.20 mmol) and triethylamine (54 mg, 0.54 mmol) was stirred at r.t for 2 h. After completion, the reaction mixture was diluted with dichloromethane (10 ml), washed with water (10 mL) and saturated sodium bicarbonate solution (10 mL × 2), dried over anhydrous sodium sulfate, concentrated, purified by prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to get **SB1-E-18**, also referred to herein as **E-18** and **E18** (white solid, 13 mg, yield:16%). HPLC: 100% (254 nm); LCMS (m/z): 555 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ : 10.17 (s, 1H), 10.07 (s, 1H), 8.34 (s, 1H), 7.84 (s, 1H), 7.51 (s, 1H), 7.30-7.34 (m, 2H), 6.46 (dd, *J*=17, 10.0 Hz, 1H), 6.28 (d, *J*=17 Hz, 1H), 5.77 (d, *J*=11.5 Hz, 1H), 4.98 (s, 1H), 4.65 (d, *J*=13 Hz, 1H), 4.56 (s, 1H), 2.88 (t, *J*=12.5 Hz, 1H), 2.47-2.50 (m, 2H), 1.56-1.88 (m, 8H), 1.36-1.38 (m, 1H), 1.19-1.23 (m, 4H).

***Example 16. N*-(3-(3-Ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-23)**

Synthetic Scheme 16

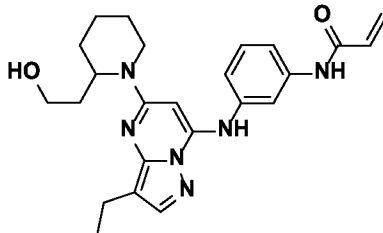


2-(1-(7-(3-Aminophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (SB1-E-23-1)



[00399] The mixture of **SB1-E-21-6** (1.1 g, 3.82 mmol), **SM-23-1** (800 mg, 6.19 mmol), KF (1.0 g, 17.2 mmol) and NMP (3 mL) was stirred at 168°C for 12 h, after completion, concentrated to remove the solvent, the residue was purified by silica gel (PE/ethyl acetate = 2/1, 1/1) to obtain **SB1-E-23-1** (light brown solid, 1.0 g, yield 69%). LCMS (m/z): 381 [M + H]⁺.

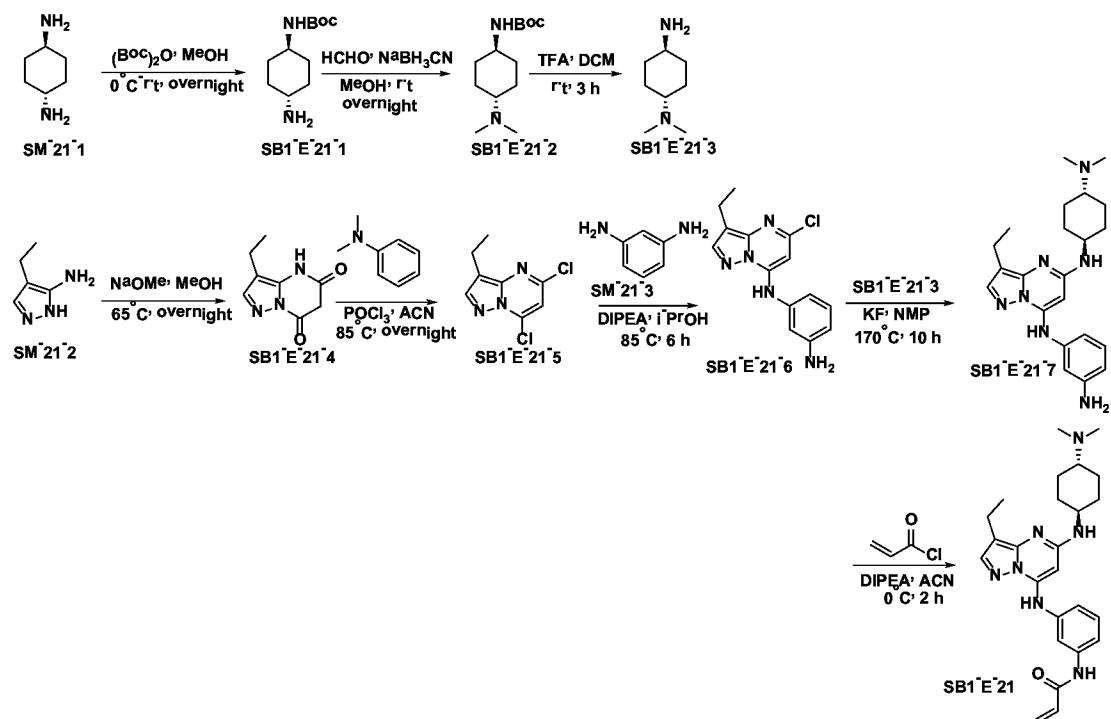
N-(3-(3-Ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-23)



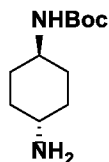
[00400] To a solution of **SB1-E-23-1** (150 mg, 0.394 mmol), DIPEA (0.7 mL) in CH₃CN (12 mL) was added the solution of acryloyl chloride (54 mg, 0.597 mmol) in CH₃CN (2 mL) dropwise, the mixture was stirred at 0°C for 3 h. after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 30/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05% NH₄HCO₃) to obtain **SB1-E-23**, also referred to herein as **E-9** and **E9** (off-white solid, 15 mg, yield 9%). HPLC: 98% (254 nm); LCMS (m/z): 435 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.23 (s, 1 H), 9.29 (s, 1H), 7.88 (s, 1 H), 7.76 (s, 1 H), 7.33-7.36 (m, 2 H), 7.16-7.19 (m, 1 H), 6.45 (dd, *J*₁ = 17.2 Hz, *J*₂ = 10.0 Hz, 1 H), 6.27 (d, *J* = 17.2 Hz, 1 H), 6.01 (s, 1 H), 5.77 (d, *J* = 10.0 Hz, 1 H), 4.58 (m, 2 H), 4.26 (m, 1 H), 3.34-3.38 (m, 1 H), 2.87 (t, 1 H), 2.54 (q, *J* = 7.2 Hz, 2 H), 1.28-1.84 (m, 8 H), 1.22 (t, *J* = 7.6 Hz, 3 H).

Example 17. *N*-(3-(5-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-21)

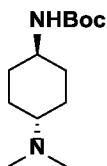
Synthetic Scheme 17



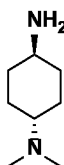
***tert*-Butyl (1*r*,4*r*)-4-aminocyclohexylcarbamate (SB1-E-21-1)**



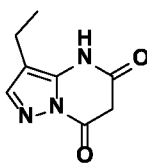
[00401] To a solution of SM-21-1 (2.0 g, 17.5 mmol) in MeOH (100 mL) was added the solution of (Boc)₂O (1.1 g, 5.04 mmol) in MeOH (60 mL) dropwise for 30 min, the mixture was stirred at r.t overnight. After completion, concentrated to remove the solvent, the residue was added H₂O (50 mL), further stirred at r.t for 20 min, then filtered, the filtrate was extracted with ethyl acetate (120 mL × 2), the organic phase was washed with brine (50 mL × 2), dried with Na₂SO₄. Filtered, concentrated to remove the solvent to obtain SB1-E-21-1 (off-white solid, 900 mg, yield 83%).

tert-Butyl (1*r*,4*r*)-4-(dimethylamino)cyclohexylcarbamate (SB1-E-21-2)

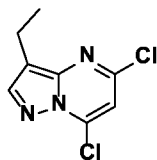
[00402] To a solution of **SB1-E-21-1** (850 mg, 3.97 mmol) and HCHO (600 mg, 20.0 mmol) in MeOH (30 mL) was added NaBH₃CN (1.1 g, 17.5 mmol), the mixture was stirred at r.t overnight, after completion, concentrated to remove the solvent, the residue was extracted with ethyl acetate (100 mL × 4), the organic phase was washed with brine (50 mL × 2), dried with Na₂SO₄. Filtered, concentrated to remove the solvent, the residue was purified by silica gel (DCM/MeOH = 10/1, 5/1) to obtain **SB1-E-21-2** (light brown solid, 800 mg, yield 83%). LCMS (m/z): 243 [M + H]⁺.

(1*r*,4*r*)-N1,N1-Dimethylcyclohexane-1,4-diamine (SB1-E-21-3)

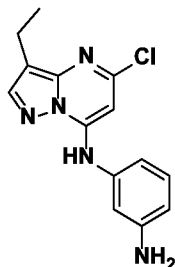
[00403] The mixture of **SB1-E-21-2** (350 mg, 1.44 mmol), DCM (3 mL) and TFA (3 mL) was stirred at r.t for 3 h, after completion, concentrated to remove the solvent to get **SB1-E-21-3** (light yellow sticky oil, 200 mg, yield 98%). LCMS (m/z): 143 [M + H]⁺.

3-Ethylpyrazolo[1,5-a]pyrimidine-5,7(4*H*,6*H*)-dione (SB1-E-21-4)

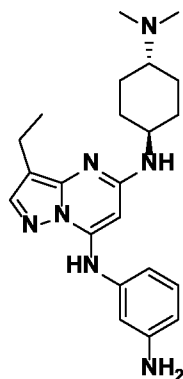
[00404] The mixture of **SM-21-2** (5.0 g, 24.8 mmol), dimethyl malonate (10 mL, 87.0 mmol), MeOH (80 mL) and NaOMe (7.0 g, 129.6 mmol) was stirred at 65°C overnight, after completion, concentrated to remove the solvent, the residue was added H₂O (10 mL), 2 M HCl to make PH <7, then filtered, the solid was washed with H₂O (50 mL), dried to obtain **SB1-E-21-4** (light yellow solid, 2.6 g, yield 58%). LCMS (m/z): 180 [M + H]⁺.

5,7-Dichloro-3-ethylpyrazolo[1,5-a]pyrimidine (SB1-E-21-5)

[00405] To a suspension of **SB1-21-4** (2.6 g, 14.5 mmol) in CH₃CN (20 mL) was added N,N-dimethylaniline (3.6 g, 29.7 mmol), POCl₃ (11.5 g, 75.0 mmol) dropwise, the mixture was stirred at 85°C overnight. After completion, cooled to 0°C, added H₂O (50 mL) to quench the reaction, filtered, the solid was washed with H₂O (50 mL), dried to obtain **SB1-E-21-5** (light brown solid, 2.7 g, 86%). LCMS (m/z): 216 [M + H]⁺

N1-(5-Chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)benzene-1,3-diamine (SB1-E-21-6)

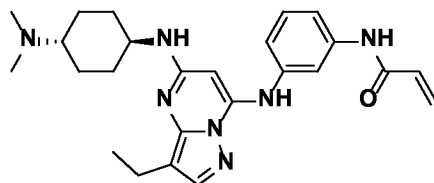
[00406] The mixture of **SB1-E-21-5** (2.6 g, 12.0 mmol), **SM-21-3** (1.5 g, 13.9 mmol), DIPEA (5 mL) and i-PrOH (30 mL) was stirred at 85°C for 6 h, after completion, concentrated to remove the solvent, the residue was purified by silica gel (DCM/MeOH = 200/1) to obtain **SB1-E-21-6** (brown solid, 2.8 g, yield 81%). LCMS (m/z): 288 [M + H]⁺.

N7-(3-Aminophenyl)-N5-((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)-3-ethylpyrazolo[1,5-a]pyrimidine-5,7-diamine (SB1-E-21-7)

[00407] The mixture of **SB1-E-21-6** (400 mg, 1.39 mmol), **SB1-E-21-3** (200 mg, 1.41 mmol), KF (400 mg, 6.88 mmol) and NMP (1.5 mL) was stirred at 145°C for 10 h in a sealed

tube. After completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 6/1) to obtain **SB1-E-21-7** (light brown solid, 160 mg, yield 29%).
LCMS (m/z): 394 [M + H]⁺.

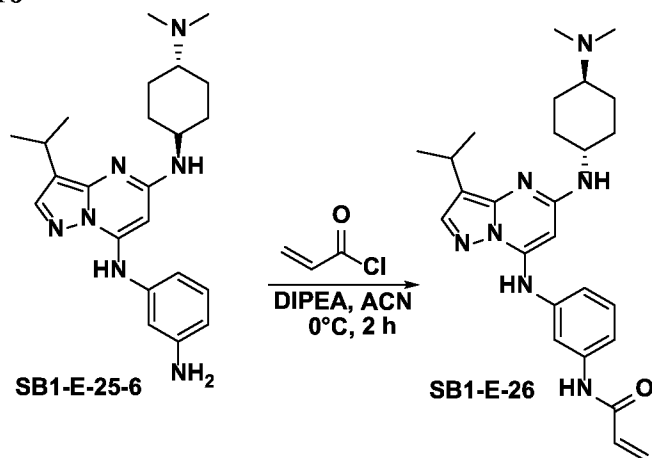
***N*-(3-(5-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-21)**



[00408] To a solution of **SB1-E-21-7** (60 mg, 0.152 mmol) and DIPEA (0.3 mL) in CH₃CN (3 mL) was added acrylyl chloride (25 mg, 0.276 mmol) in CH₃CN (1 mL) dropwise, the mixture was stirred at 0°C for 3 h. after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/ MeOH = 10/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05%NH₄HCO₃) to obtain **SB1-E-21**, also referred to herein as **E-21** and **E21** (off-white solid, 7 mg, yield 10%). HPLC: 99% (254 nm); LCMS (m/z): 448 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.26 (s, 1 H), 9.07 (s, 1H), 7.69 (s, 2 H), 7.54 (d, *J* = 9.0 Hz, 1 H), 7.36 (t, *J* = 8.5 Hz, 1 H), 7.09 (d, *J* = 7.0 Hz, 1 H), 6.63 (d, *J* = 7.0 Hz, 1 H), 6.46 (dd, *J*₁ = 17.5 Hz, *J*₂ = 12.0 Hz, 1 H), 6.28 (d, *J* = 17.5 Hz, 1 H), 5.78 (d, *J* = 12.0 Hz, 1 H), 5.62 (s, 1 H), 2.55 (m, 4 H), 2.17 (s, 6 H), 1.78-2.13 (m, 4 H), 1.12-1.27 (m, 8 H).

Example 18. *N*-(3-(5-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-3-isopropylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-26)

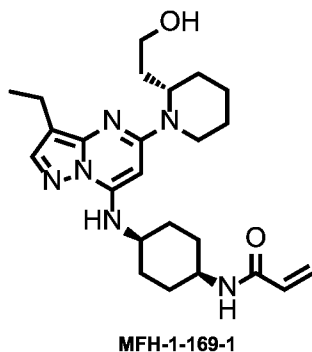
Synthetic Scheme 18

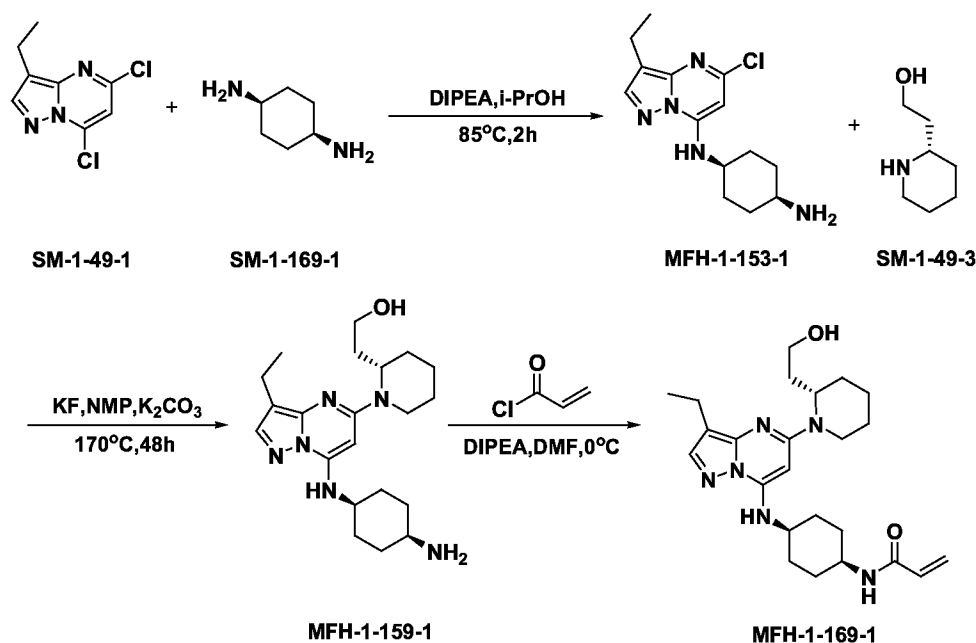


N-(3-(5-((1*r*,4*r*)-4-(Dimethylamino)cyclohexylamino)-3-isopropylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (SB1-E-26)

[00409] To a solution of **SB1-E-25-6** (70 mg, 0.172 mmol) and DIPEA (0.5 mL) in CH₃CN (5 mL) was added acrylyl chloride (30 mg, 0.331 mmol) in CH₃CN (1 mL), the mixture was stirred at r.t for 15 h, after completion, concentrated to remove the solvent, the residue was purified by prep-TLC (DCM/MeOH = 10/1) and prep-HPLC (C18 column, CH₃CN/H₂O, containing 0.05%NH₄HCO₃) to obtain **SB1-E-26**, also referred to herein as **E-26** and **E26** (white solid, 12 mg, yield 15%). HPLC: 100% (254 nm); LCMS (m/z): 462 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ 10.26 (s, 1H), 9.06 (s, 1 H), 7.70 (s, 1 H), 7.67 (s, H), 7.54 (d, *J* = 6.5 Hz, 1H), 7.36 (t, *J* = 6.5 Hz, 1 H), 7.08 (d, *J* = 1.5 Hz, 1 H), 6.62 (d, *J* = 6.0 Hz, 1 H), 6.45 (dd, *J*₁ = 16.0 Hz, *J*₂ = 9.5 Hz, 1 H), 6.28 (d, *J* = 16.0 Hz, 1 H), 5.78 (d, *J* = 9.5 Hz, 1 H), 5.62 (s, 1 H), 3.00 (m, 1 H), 2.18 (s, 7 H), 2.06 (d, *J* = 10.5 Hz, 1 H), 1.80 (d, *J* = 10.5 Hz, 1 H), 1.12-1.29 (m, 11 H).

Example 19. N-((1*R*,4*s*)-4-((3-ethyl-5-((*S*)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-*a*]pyrimidin-7-yl)amino)cyclohexyl)acrylamide (MFH-1-169-1)



Synthetic Scheme 19

(1s,4s)-N1-(5-chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)cyclohexane-1,4-diamine (MFH-1-153-1)

[00410] The mixture of **SM-1-49-1** (300 mg, 1.388 mmol), **SM-1-167-1** (182 mg, 1.6 mmol), DIPEA (270 mg) and i-PrOH (8 mL) was stirred at 85°C for 2 h. After completion, the solvent was removed and the residue was purified by silica gel ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain **MFH-1-153-1** (240 g, yield 59%). LCMS (m/z): 294 $[\text{M} + \text{H}]^+$.

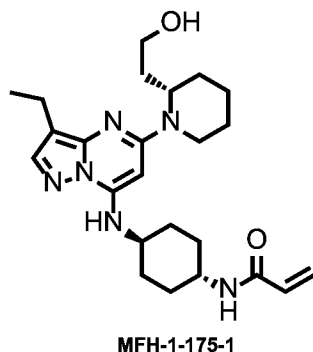
2-((S)-1-(7-((1s,4R)-4-aminocyclohexylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-159-1)

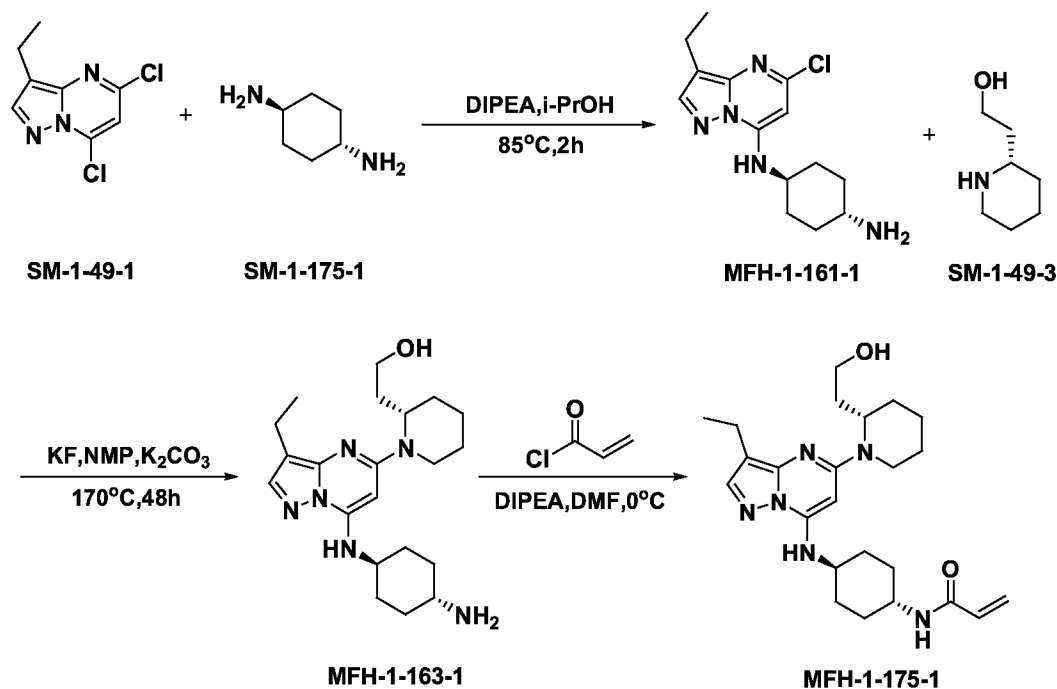
[00411] The mixture of **MFH-1-153-1** (230 mg, 0.783 mmol), **SM-1-49-3** (182 mg, 1.41 mmol), KF (205 mg, 3.5235 mmol), K_2CO_3 (194 mg, 1.41 mmol) and NMP (2 mL) was stirred at 170 °C for 48 h. After completion, the residue was extracted with chloroform/i-propanol (4/1) and the organic phase was washed with brine (50 mL $\times$ 2) and dried with Na_2SO_4 . The residue after removal of the solvent was purified by silica gel ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain **MFH-1-159-1** (50 mg, yield 16.5%). LCMS (m/z): 387 $[\text{M} + \text{H}]^+$.

N-((1R,4s)-4-(3-ethyl-5-((S)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)cyclohexyl)acrylamide (MFH-1-169-1)

[00412] To a solution of **MFH-1-159-1** (25 mg, 0.06468 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (8 mg, 0.0841 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0°C for 1 h. After completion, the solvent was removed and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-169-1** (off-white solid, 4.8 mg, yield 16%). HPLC: 97% (254 nm); LCMS (m/z): 441 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 7.97 (d, *J* = 7.2 Hz, 1H), 7.87 (s, 1H), 7.44 (s, 1H), 6.30 (dd, *J* = 17.1, 10.2 Hz, 1H), 6.09 (dd, *J* = 17.1, 2.1 Hz, 1H), 5.78 (s, 1H), 5.59 (dd, *J* = 10.2, 2.1 Hz, 1H), 4.49 (s, 1H), 4.15 (d, *J* = 12.3 Hz, 1H), 3.98 – 3.79 (m, 3H), 3.08 (t, *J* = 12.4 Hz, 2H), 2.61 – 2.52 (m, 2H), 1.95 (dd, *J* = 18.6, 10.5 Hz, 1H), 1.84 (dt, *J* = 12.9, 7.4 Hz, 2H), 1.79 – 1.57 (m, 10H), 1.56 – 1.44 (m, 1H), 1.18 (t, *J* = 7.5 Hz, 3H).

Example 20. N-((1S,4r)-4-((3-ethyl-5-((S)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-yl)amino)cyclohexyl)acrylamide (MFH-1-175-1)



Synthetic Scheme 20

(1*r*,4*r*)-N1-(5-chloro-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-yl)cyclohexane-1,4-diamine (MFH-1-161-1)

[00413] The mixture of SM-1-49-1 (300 mg, 1.388 mmol), SM-1-175-1 (250 mg, 2.19 mmol), DIPEA (270 mg) and i-PrOH (8 mL) was stirred at 85 °C for 1 h. After completion, the solvent was removed and the residue was purified by silica gel ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain MFH-1-161-1 (230 g, yield 56%). LCMS (m/z): 294 $[\text{M} + \text{H}]^+$.

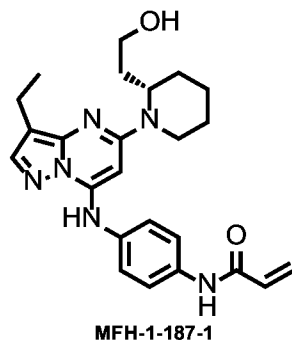
2-((*S*)-1-(7-((1*r*,4*S*)-4-aminocyclohexylamino)-3-ethylpyrazolo[1,5-*a*]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-163-1)

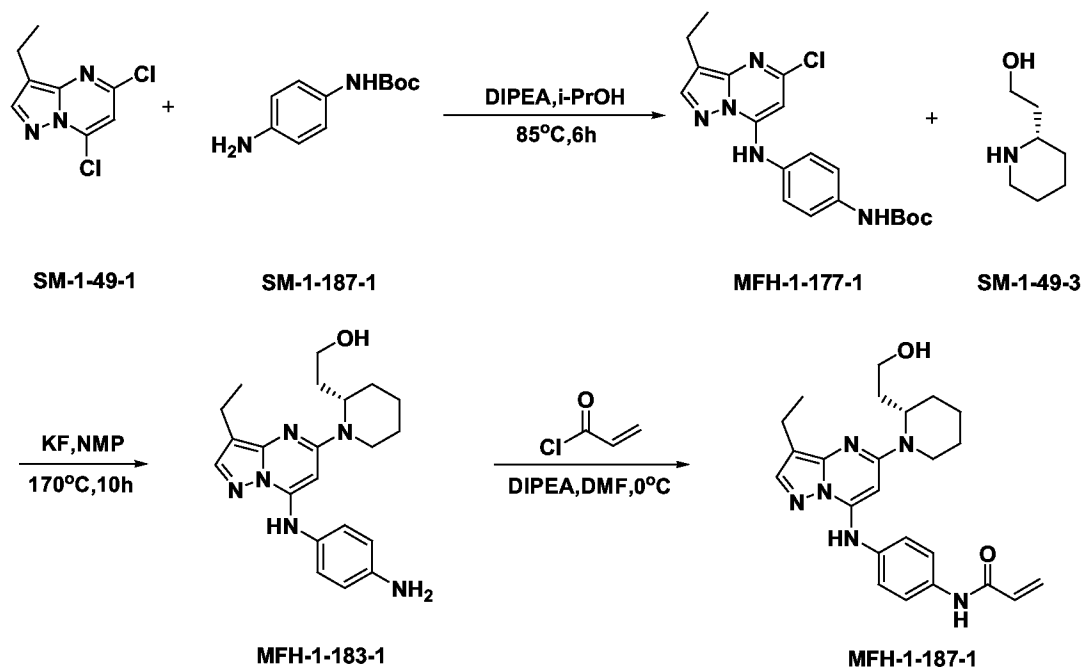
[00414] The mixture of MFH-1-161-1 (230 mg, 0.783 mmol), SM-1-49-3 (182 mg, 1.41 mmol), KF (205 mg, 3.5235 mmol), K_2CO_3 (194 mg, 1.41 mmol) and NMP (2 mL) was stirred at 170 °C for 48 h. After completion, the residue was extracted with chloroform and 2-propanol (4:1) and the organic phase was washed with brine (50 mL $\times$ 2) and dried with Na_2SO_4 . The residue after removal of solvent was purified by silica gel ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain MFH-1-163-1 (30 mg, yield 10%). LCMS (m/z): 387 $[\text{M} + \text{H}]^+$.

N-((1S,4r)-4-(3-ethyl-5-((S)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)cyclohexyl)acrylamide (MFH-1-175-1)

[00415] To a solution of **MFH-1-163-1** (30 mg, 0.07762 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (9 mg, 0.101 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0 °C for 1 h. After completion, the solvent was removed and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-175-1** (off-white solid, 12.8 mg, yield 37%). HPLC: 97% (254 nm); LCMS (m/z): 441 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 8.03 (d, *J* = 7.5 Hz, 1H), 7.90 (s, 1H), 6.24 (dd, *J* = 17.1, 10.1 Hz, 1H), 6.08 (dd, *J* = 17.1, 2.2 Hz, 1H), 5.77 (d, *J* = 10.8 Hz, 1H), 5.58 (dd, *J* = 10.1, 2.3 Hz, 1H), 4.49 (s, 1H), 4.14 (d, *J* = 12.4 Hz, 2H), 3.74 (s, 2H), 3.62 – 3.49 (m, 2H), 3.43 – 3.34 (m, 1H), 3.11 (t, *J* = 13.0 Hz, 1H), 2.57 (dt, *J* = 9.8, 4.9 Hz, 2H), 2.07 – 1.82 (m, 5H), 1.83 – 1.56 (m, 8H), 1.53 (d, *J* = 11.8 Hz, 1H), 1.39 (td, *J* = 12.9, 3.6 Hz, 2H), 1.25 – 1.13 (m, 3H).

Example 21. (S)-N-(4-((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-yl)amino)phenyl)acrylamide (MFH-1-187-1)



Synthetic Scheme 21***tert-butyl 4-(5-chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-ylamino)phenylcarbamate (MFH-1-177-1)***

[00416] The mixture of SM-1-49-1 (500 mg, 2.314 mmol), SM-1-187-1 (520 mg, 2.5 mmol), DIPEA (898 mg) and i-PrOH (8 mL) was stirred at 85 °C for 6 h. After completion, the solvent was removed and the residue was purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain MFH-1-177-1 (898 g, yield 100%). LCMS (m/z): 388 [M + H]⁺.

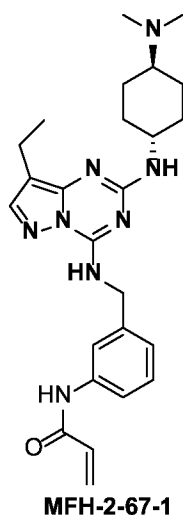
(S)-2-(1-(7-(4-aminophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-183-1)

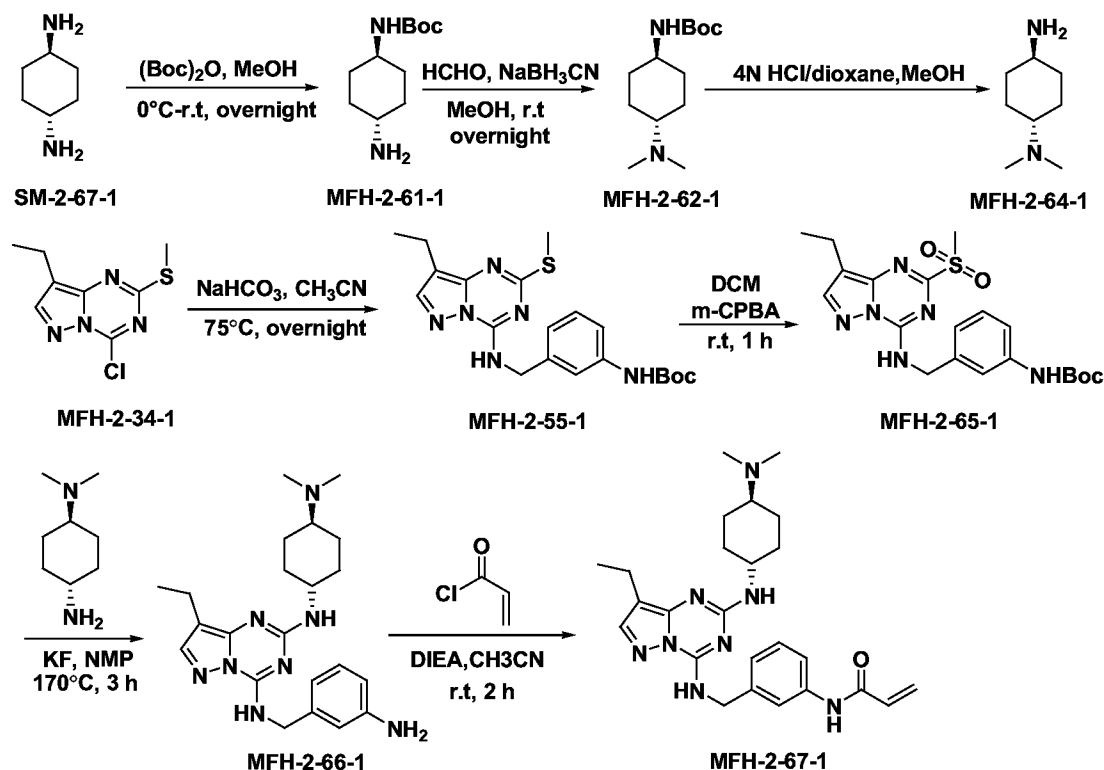
[00417] The mixture of MFH-1-177-1 (449 mg, 1.157 mmol), SM-1-49-3 (240 mg, 1.8512 mmol), KF (303 mg, 5.2 mmol) and NMP (2 mL) was stirred at 170 °C for 10 h. After completion, the solution was extracted with chloroform and 2-propanol (4:1) and the organic phase was washed with brine (50 mL × 2) and dried with Na₂SO₄. The solvent was removed and the residue was purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain MFH-1-183-1 (400 mg, yield 91%). LCMS (m/z): 381 [M + H]⁺.

(S)-N-(4-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-1-187-1)

[00418] To a solution of **MFH-1-183-1** (80 mg, 0.21 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (25 mg, 0.273 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0 °C for 1 h. After completion, the solvent was removed and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-187-1** (off-white solid, 33.6 mg, yield 36.8%). HPLC: 96% (254 nm); LCMS (m/z): 435 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 10.26 (s, 1H), 9.83 (s, 1H), 7.91 (s, 1H), 7.76 (t, *J* = 13.5 Hz, 2H), 7.42 (d, *J* = 8.9 Hz, 2H), 6.46 (dd, *J* = 17.0, 10.1 Hz, 1H), 6.28 (dd, *J* = 17.0, 1.9 Hz, 1H), 5.84 – 5.68 (m, 2H), 4.42 (s, 1H), 4.02 (s, 2H), 3.32 (ddd, *J* = 10.9, 8.2, 4.9 Hz, 2H), 3.00 (dd, *J* = 24.6, 11.8 Hz, 1H), 2.64 – 2.55 (m, 2H), 1.90 (td, *J* = 13.5, 5.1 Hz, 1H), 1.76 – 1.51 (m, 6H), 1.49 – 1.33 (m, 1H), 1.27 – 1.17 (m, 3H).

Example 22. N-(3-(((2-(((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)amino)-8-ethylpyrazolo[1,5-a][1,3,5]triazin-4-yl)amino)methyl)phenyl)acrylamide (MFH-2-67-1)



Synthetic Scheme 22**tert-butyl (1r,4r)-4-aminocyclohexylcarbamate (MFH-2-61-1)**

[00419] To a solution of **SM-2-67-1** (2.0 g, 17.5 mmol) in MeOH (100 mL) was added the solution of $(\text{Boc})_2\text{O}$ (1.1 g, 5.04 mmol) in MeOH (60 mL) dropwise for 30 min. The mixture was stirred at room temperature overnight. After completion, the solvent was removed and to the residue was added H_2O (50 mL) and further stirred at room temperature for 20 min and then filtered. The filtrate was extracted with ethyl acetate ($120\text{ mL} \times 2$) and the organic phase was washed with brine ($50\text{ mL} \times 2$) and dried with Na_2SO_4 . The solution was then concentrated under reduced pressure to obtain **MFH-2-61-1** (off-white solid, 900 mg, yield 83%).

tert-butyl (1r,4r)-4-(dimethylamino)cyclohexylcarbamate (MFH-2-62-1)

[00420] To a solution of **MFH-2-61-1** (850 mg, 3.97 mmol) and HCHO (600 mg, 20.0 mmol) in MeOH (30 mL) was added NaBH_3CN (1.1 g, 17.5 mmol) and the mixture was stirred at room temperature overnight. After completion, the solvent was removed and the residue was extracted with ethyl acetate ($100\text{ mL} \times 4$) and the organic phase was washed with brine ($50\text{ mL} \times 2$) and dried with Na_2SO_4 . The residue after removal of solvent was purified

by silica gel chromatography (DCM/MeOH = 10/1, 5/1) to obtain **MFH-2-62-1** (light brown solid, 800 mg, yield 83%). LCMS (m/z): 243 [M + H]⁺.

(1r,4r)-N1,N1-dimethylcyclohexane-1,4-diamine (MFH-2-64-1)

[00421] To a mixture of compound **MFH-2-62-1** (350 mg, 1.44 mmol) in methanol (5 mL) was added 4N HCl/dioxane (10 mL) and stirred for 3h at room temperature. The mixture was concentrated and the crude mixture was directly used in the next step. LCMS (m/z): 143 [M + H]⁺.

tert-butyl3-((8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)methyl)phenylcarbamate (MFH-2-55-1)

[00422] A stirred mixture of **MFH-2-34-1** (220 mg, 0.962 mmol), tert-butyl 3-(aminomethyl) phenylcarbamate (214 mg, 0.962 mmol) and NaHCO₃ (121 mg, 1.443 mmol) in acetonitrile (5 mL) was heated at 75 °C overnight and then was cooled to room temperature. The solution was filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (PE/ethyl acetate = 3:1 to 1:1) to afford **MFH-2-55-1** (white solid, 210 mg, yield: 52%). LCMS (m/z): 415 [M + H]⁺.

tert-butyl3-((8-ethyl-2-(methylsulfonyl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)methyl)phenylcarbamate (MFH-2-65-1)

[00423] To a solution of **MFH-2-55-1** (110 mg, 0.2654 mmol) in DCM (3 mL) was added 3-chloroperbenzoic acid (137mg, 0.7961 mmol) in one portion at room temperature and was stirred at for 1 h. The reaction mixture was quenched with a saturated Na₂S₂O₃ solution (10 mL), diluted with DCM (50 mL), washed with saturated aqueous NaCl (3 × 50 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated to give **MFH-2-65-1** (yellow solid, 118 mg, yield:100%), which was used in next step directly. LCMS (m/z): 447 [M + H]⁺.

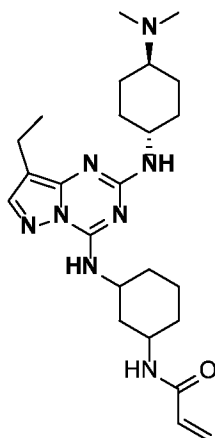
N4-(3-aminobenzyl)-N2-((1r,4r)-4-(dimethylamino)cyclohexyl)-8-ethylpyrazolo[1,5-a][1,3,5]triazine-2,4-diamine (MFH-2-66-1)

[00424] To a stirred mixture **MFH-2-65-1** (118 mg, 0.2654 mmol) and **MFH-2-64-1** (98 mg, 0.4554 mmol) in N-methyl-2-pyrrolidone (3 mL) was added KF (46 mg, 0.7962 mmol). This mixture was heated at 170 °C for 3 h and then was cooled and filtered. The crude mixture was purified by silica gel chromatography (MeOH/DCM = 0-20%) to afford **MFH-2-66-1** (yellow solid, 30 mg, yield: 28%). LCMS (m/z): 409 [M + H]⁺.

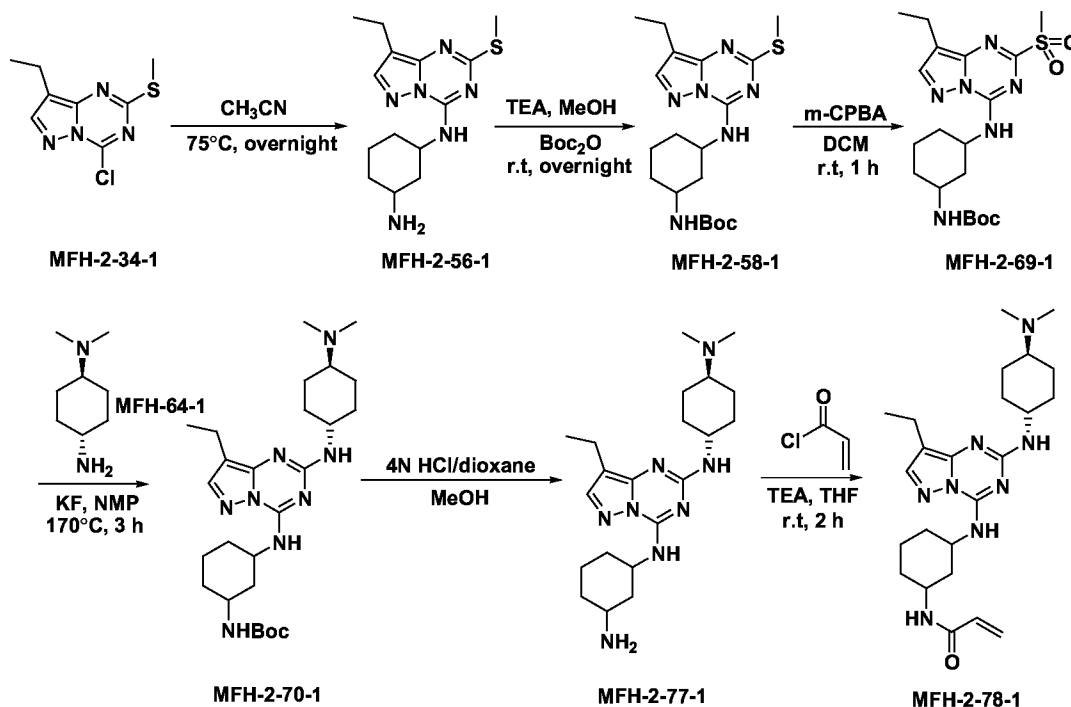
N-(3-((2-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-8-ethylpyrazolo[1,5-*a*][1,3,5]triazin-4-ylamino)methyl)phenyl)acrylamide (MFH-2-67-1)

[00425] To a solution of **MFH-2-66-1** (30 mg, 0.07343 mmol) in CH₃CN (2 mL) were added acryloyl chloride (9 mg, 0.1 mmol) and DIPEA (0.2 mL). The reaction was stirred at room temperature for 2 h. After completion, the reaction mixture was diluted with dichloromethane (10 mL), washed with water (10 mL) and a saturated sodium bicarbonate solution (10 mL × 2), and dried over anhydrous sodium sulfate. The residue after removal of the solvent was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-2-67-1** (off-white solid, 11.3 mg, yield 28%). HPLC: 97% (254 nm); LCMS (m/z): 463 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 10.16 (s, 1H), 9.81 (s, 1H), 9.53 (s, 1H), 8.75 (s, 1H), 7.95 (d, *J* = 40.1 Hz, 1H), 7.77 (s, 1H), 7.64 – 7.48 (m, 1H), 7.30 (s, 1H), 6.42 (dd, *J* = 16.9, 10.1 Hz, 1H), 6.31 – 6.14 (m, 1H), 5.75 (d, *J* = 11.4 Hz, 1H), 4.64 (d, *J* = 6.1 Hz, 2H), 3.17 (d, *J* = 8.6 Hz, 2H), 2.94 – 2.56 (m, 6H), 2.48 (s, 1H), 1.99 (dd, *J* = 87.3, 31.8 Hz, 4H), 1.51 (s, 2H), 1.39 – 0.96 (m, 6H).

Example 23. N-(3-((2-(((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)amino)-8-ethylpyrazolo[1,5-*a*][1,3,5]triazin-4-yl)amino)cyclohexyl)acrylamide (MFH-2-78-1)



MFH-2-78-1

Synthetic Scheme 23

N1-(8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-yl)cyclohexane-1,3-diamine (MFH-2-56-1)

[00426] **MFH-2-34-1** (220 mg, 0.96 mmol) and cyclohexane-1,3-diamine (330 mg, 2.88 mmol) were dissolved in acetonitrile (5 mL). The mixture was heated at 75°C overnight. The solvent was then removed under reduced pressure. The crude mixture was purified by silica gel chromatography ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain **MFH-2-56-1** (white solid, 193 mg, yield: 65%). LCMS (m/z): 307 $[\text{M} + \text{H}]^+$.

tert-butyl 3-(8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)cyclohexylcarbamate (MFH-2-58-1)

[00427] To a solution of **MFH-2-56-1** (193 mg, 0.63 mmol) in MeOH (6 mL) was added di-tert-butyl dicarbonate (206 mg, 0.94 mmol) and TEA (191 mg 1.89 mmol). The reaction mixture was stirred at room temperature overnight. The reaction mixture was concentrated under reduced pressure to afford the residue, which was purified by flash column chromatography ($\text{MeOH}/\text{DCM} = 0\text{-}20\%$) to afford **MFH-2-58-1** (210 mg, yield: 82%). LCMS (m/z): 407 $[\text{M} + \text{H}]^+$.

tert-butyl3-(8-ethyl-2-(methylsulfonyl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)cyclohexylcarbamate (MFH-2-69-1)

[00428] To a solution of **MFH-2-58-1** (210 mg, 0.51 mmol) in DCM (5 mL) was added 3-chloroperbenzoic acid (268 mg, 1.55 mmol). The mixture was stirred at room temperature for 1 h and then was quenched with a saturated Na₂S₂O₃ solution (5 mL). The reaction mixture was extracted with DCM (50 mL) and the organic layer was washed with saturated aqueous NaCl (3 × 50 mL), dried over anhydrous Na₂SO₄, filtered and concentrated to give **MFH-2-69-1** (226.6 mg, yield: 100%) as the crude product, which was used for next step directly. LCMS (m/z): 439 [M + H]⁺.

tert-butyl3-(2-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-8-ethylpyrazolo[1,5-a][1,3,5]triazin-4-ylamino)cyclohexylcarbamate (MFH-2-70-1)

[00429] To a stirred mixture **MFH-2-69-1** (226.6 mg, 0.51 mmol) and **MFH-2-64-1** (118 mg, 0.83 mmol) in N-methyl-2-pyrrolidone (3 mL) was added KF (90 mg, 1.551 mmol). This mixture was heated at 170 °C for 3 h, and then cooled and filtered. The crude mixture was then purified by silica gel chromatography (NH₃/MeOH(1.75N)/DCM = 0-20%) to afford **MFH-2-70-1** (120 mg, yield: 47%). LCMS (m/z): 501 [M + H]⁺.

N4-(3-aminocyclohexyl)-N2-((1*r*,4*r*)-4-(dimethylamino)cyclohexyl)-8-ethylpyrazolo[1,5-a][1,3,5]triazine-2,4-diamine (MFH-2-77-1)

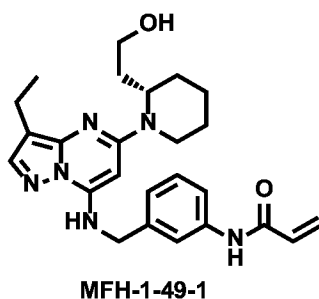
[00430] To a mixture of compound **MFH-2-70-1** (60 mg, xx mmol) in methanol (5 mL) was added 4N HCl/dioxane (5 mL) and the solution was stirred for 3h at room temperature. The mixture was concentrated under reduced pressure and the crude mixture was directly used in next step. LCMS (m/z): 401 [M + H]⁺.

N-(3-(2-((1*r*,4*r*)-4-(dimethylamino)cyclohexylamino)-8-ethylpyrazolo[1,5-a][1,3,5]triazin-4-ylamino)cyclohexyl)acrylamide (MFH-2-78-1)

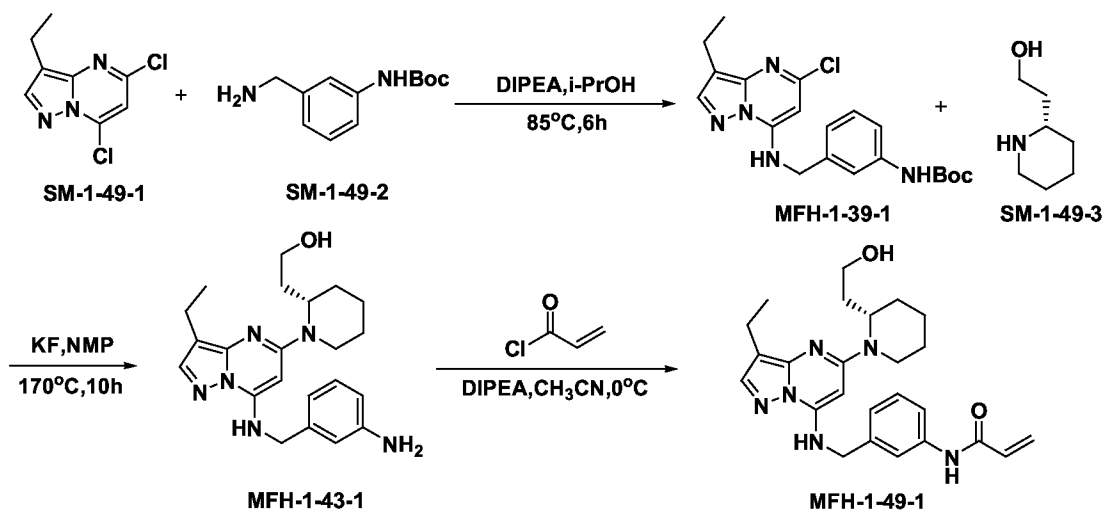
[00431] To a solution of **MFH-2-77-1** (48 mg, 0.12 mmol) in CH₃CN (2 mL) was added acryloyl chloride (14 mg, 0.156 mmol) and DIPEA (0.2 ml). The reaction mixture was stirred at room temperature for 2 h. After completion, the reaction mixture was diluted with dichloromethane (10 ml), washed with a saturated NaHCO₃ solution (10 mL × 2), and washed with water (10 mL). The organic layer was dried over anhydrous sodium sulfate, concentrated under reduced pressure and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to afford **MFH-2-78-1** (white solid, 25.2 mg,

yield: 46%). HPLC: 97% (254 nm); LCMS (m/z): 455 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 9.51 (s, 1H), 8.15 (s, 1H), 7.92 (s, 1H), 7.74 (s, 1H), 6.20 (dd, J = 16.9, 9.9 Hz, 1H), 6.15 – 6.03 (m, 1H), 5.58 (d, J = 9.8 Hz, 1H), 3.17 (s, 3H), 2.75 (d, J = 4.9 Hz, 6H), 2.49 (d, J = 2.3 Hz, 1H), 2.47 (dd, J = 7.5, 2.1 Hz, 1H), 2.23 – 1.91 (m, 5H), 1.90 – 1.71 (m, 3H), 1.45 (ddd, J = 45.3, 44.9, 21.3 Hz, 8H), 1.15 (s, 4H).

Example 24. (S)-N-(3-(((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-yl)amino)methyl)phenyl)acrylamide (MFH-1-49-1)



Synthetic Scheme 24



tert-butyl-3-((5-chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-ylamino)methyl)phenylcarbamate (MFH-1-39-1)

[00432] The mixture of SM-1-49-1 (400 mg, 1.85 mmol), SM-1-49-2 (452.6 mg, 2.0364 mmol), DIPEA (718 mg) and i-PrOH (5 mL) was stirred at 85 °C for 6 h. Then the reaction mixture was concentrated under reduced pressure and the residue was purified by silica gel

chromatography (PE/EA = 0-50%) to obtain **MFH-1-39-1** (white solid, 0.66 g, yield 88.7%).
LCMS (m/z): 402 [M + H]⁺.

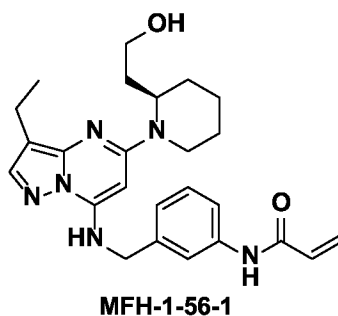
(S)-2-(1-(7-(3-aminobenzylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-43-1)

[00433] The mixture of **MFH-1-39-1** (660 mg, 1.6422 mmol), **SM-1-49-3** (318 mg, 2.4633 mmol), KF (429 mg, 7.4 mmol) and NMP (2 mL) was stirred at 170 °C for 10 h. After completion, the residue was extracted with chloroform and isopropanol (4:1) and the organic phase was washed with brine (50 mL × 2) and dried with Na₂SO₄. The solution was filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain **MFH-1-43-1** (396.3 mg, yield 61%).
LCMS (m/z): 395 [M + H]⁺.

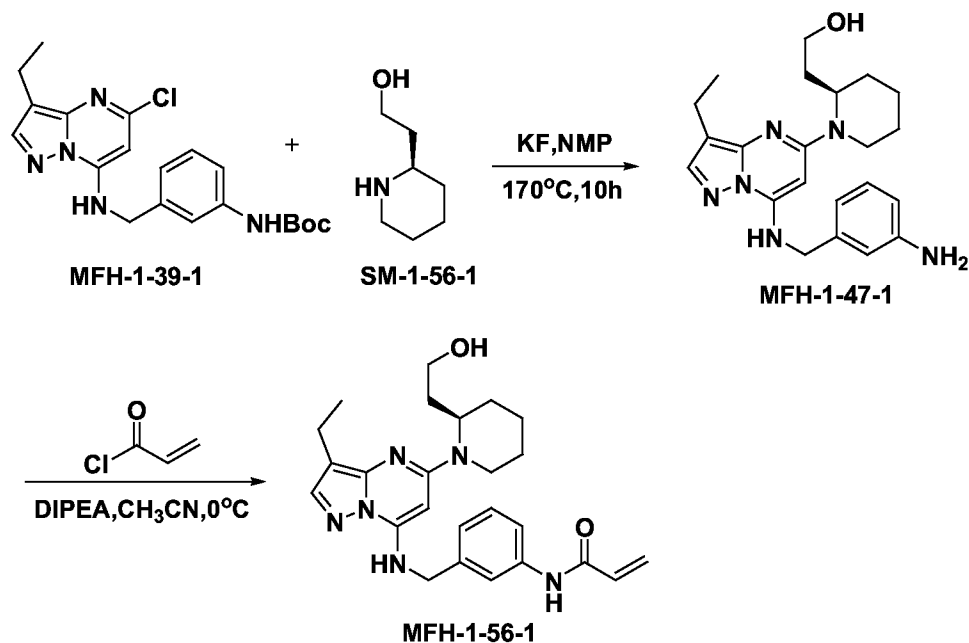
(S)-N-(3-((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)methyl)phenyl)acrylamide (MFH-1-49-1)

[00434] To a solution of **MFH-1-43-1** (60 mg, 0.15 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (18 mg, 0.20 mmol) in DCM (0.5 mL) dropwise. The mixture was then stirred at 0 °C for 1 h. After reaction completion, the reaction was concentrated to remove the solvent and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-49-1** (off-white solid, 8.6 mg, yield 12.6%). HPLC: 96% (254 nm); LCMS (m/z): 449 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 10.14 (s, 1H), 8.94 (s, 1H), 7.91 (s, 1H), 7.72 (s, 1H), 7.53 (d, *J* = 8.1 Hz, 1H), 7.30 (t, *J* = 7.8 Hz, 1H), 7.13 (d, *J* = 7.6 Hz, 1H), 6.41 (dd, *J* = 17.0, 10.1 Hz, 1H), 6.22 (dd, *J* = 17.0, 1.7 Hz, 1H), 5.73 (dd, *J* = 10.1, 1.7 Hz, 1H), 5.66 (s, 1H), 4.62 (d, *J* = 6.3 Hz, 2H), 4.41 (s, 1H), 3.96 (d, *J* = 11.7 Hz, 2H), 3.06 (t, *J* = 12.6 Hz, 1H), 2.60 – 2.51 (m, 2H), 1.96 (d, *J* = 5.0 Hz, 1H), 1.73 – 1.58 (m, 5H), 1.53 (s, 1H), 1.43 (d, *J* = 11.6 Hz, 2H), 1.12 (t, *J* = 7.5 Hz, 3H), 1.08 (s, 1H).

Example 25 *(R)-N-(3-((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)methyl)phenyl)acrylamide (MFH-1-56-1)*



Synthetic Scheme 25



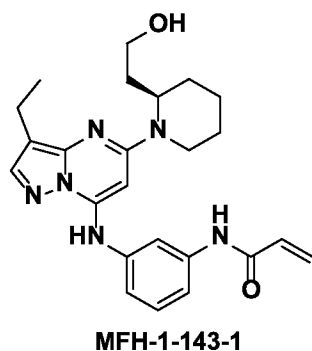
(R)-2-(1-(7-(3-aminobenzylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-47-1)

[00435] The mixture of **MFH-1-39-1** (330 mg, 0.8211 mmol), **SM-1-56-1** (248.6 mg, 1.3884 mmol), KF (242 mg, 4.1652 mmol) and NMP (1 mL) was stirred at 170 °C for 10 h. After completion, the residue was extracted with chloroform and 2-propanol (4:1). The organic phase was washed with brine (50 mL $\times$ 2) and dried with Na₂SO₄. The solvent was removed and the residue was purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain **MFH-1-56-1** (259 mg, yield 80%). LCMS (m/z): 395 [M + H]⁺.

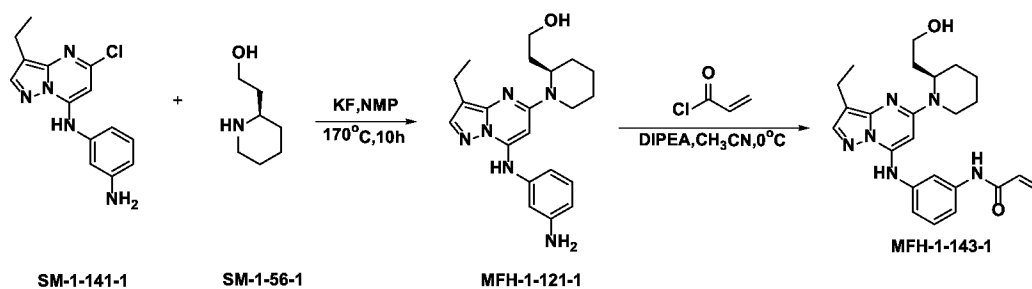
(R)-N-(3-((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)methyl)phenyl)acrylamide (MFH-1-56-1)

[00436] To a solution of **MFH-1-47-1** (60 mg, 0.152 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (18 mg, 0.198 mmol) in DCM (0.5 mL) dropwise. The mixture was then stirred at 0 °C for 1 h. After completion, the solution was concentrated and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-56-1** (off-white solid, 10 mg, yield 14.6%). HPLC: 98% (254 nm); LCMS (m/z): 449 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 10.16 (s, 1H), 9.04 (s, 1H), 7.93 (s, 1H), 7.76 (s, 1H), 7.54 (d, *J* = 8.1 Hz, 1H), 7.31 (t, *J* = 7.8 Hz, 1H), 7.14 (d, *J* = 7.6 Hz, 1H), 6.42 (dd, *J* = 17.0, 10.1 Hz, 1H), 6.24 (dd, *J* = 17.0, 1.7 Hz, 1H), 5.75 (dd, *J* = 10.1, 1.7 Hz, 1H), 5.68 (s, 1H), 4.65 (d, *J* = 6.3 Hz, 2H), 4.42 (s, 1H), 3.98 (d, *J* = 11.7 Hz, 2H), 3.09 (t, *J* = 12.6 Hz, 1H), 2.61 – 2.54 (m, 2H), 1.96 (d, *J* = 5.0 Hz, 1H), 1.76 – 1.60 (m, 5H), 1.58 (s, 1H), 1.44 (d, *J* = 11.6 Hz, 2H), 1.19 (t, *J* = 7.5 Hz, 3H), 1.10 (s, 1H).

Example 26 (R)-N-(3-((3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-1-143-1)



Synthetic Scheme 26



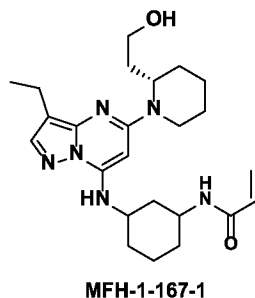
(R)-2-(1-(7-(3-aminophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-121-1)

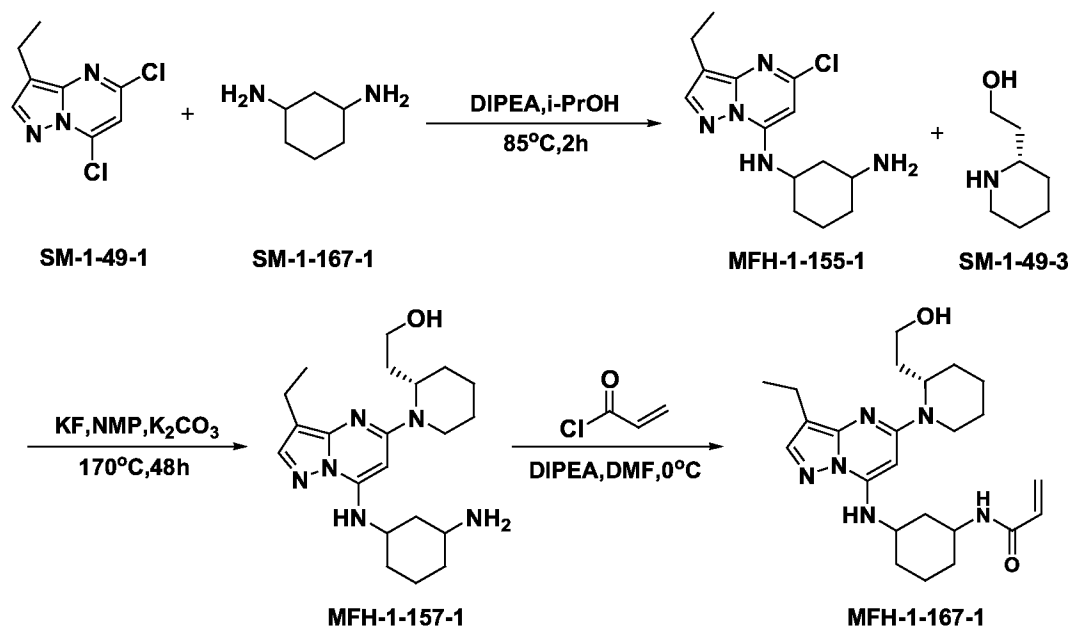
[00437] The mixture of **SM-1-141-1** (250 mg, 0.869 mmol), **SM-1-56-3** (168 mg, 1.3 mmol), KF (227 mg, 3.9 mmol) and NMP (2 mL) was stirred at 170 °C for 10 h. After completion, the residue was extracted with chloroform and 2-propanol (4:1). The organic phase was washed with brine (50 mL × 2) and dried with Na₂SO₄. The solvent was removed and the residue was purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain **MFH-1-43-1** (220 mg, yield 66.5%). LCMS (m/z): 381 [M + H]⁺.

(R)-N-(3-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-1-143-1)

[00438] To a solution of **MFH-1-121-1** (50 mg, 0.13141 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (15 mg, 0.17 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0 °C for 1 h. After completion, the solvent was removed and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-143-1** (off-white solid, 18 mg, yield 31.5%). HPLC: 96% (254 nm); LCMS (m/z): 435 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 10.29 (s, 1H), 9.89 (s, 1H), 7.92 (d, *J* = 11.7 Hz, 2H), 7.43 – 7.34 (m, 2H), 7.24 – 7.15 (m, 1H), 6.46 (dd, *J* = 17.0, 10.1 Hz, 1H), 6.28 (dd, *J* = 17.0, 1.9 Hz, 1H), 5.94 (s, 1H), 5.79 (dd, *J* = 10.1, 1.9 Hz, 1H), 4.51 (s, 1H), 4.07 (s, 1H), 3.48 – 3.40 (m, 2H), 3.35 – 3.31 (m, 1H), 3.02 (t, *J* = 12.8 Hz, 1H), 2.63 – 2.55 (m, 2H), 1.92 (td, *J* = 13.6, 5.2 Hz, 1H), 1.76 – 1.60 (m, 5H), 1.58 (s, 1H), 1.44 (d, *J* = 11.9 Hz, 1H), 1.28 – 1.08 (m, 4H).

Example 27 N-(3-(3-ethyl-5-((S)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)cyclohexyl)acrylamide (MFH-1-167-1)



Synthetic Scheme 27***N1-(5-chloro-3-ethylpyrazolo[1,5-a]pyrimidin-7-yl)cyclohexane-1,3-diamine (MFH-1-151-I)***

[00439] The mixture of **SM-1-49-1** (300 mg, 1.388 mmol), **SM-1-167-1** (500 mg, 4.442 mmol), DIPEA (270 mg) and i-PrOH (5 mL) was stirred at 85 °C for 2 h. After completion, the reaction was concentrated to remove the solvent and the residue was purified by silica gel ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain **MFH-1-155-1** (230 g, yield 56%). LCMS (m/z): 294 $[\text{M} + \text{H}]^+$.

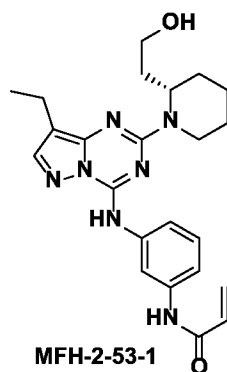
2-((S)-1-(7-(3-aminocyclohexylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-157-I)

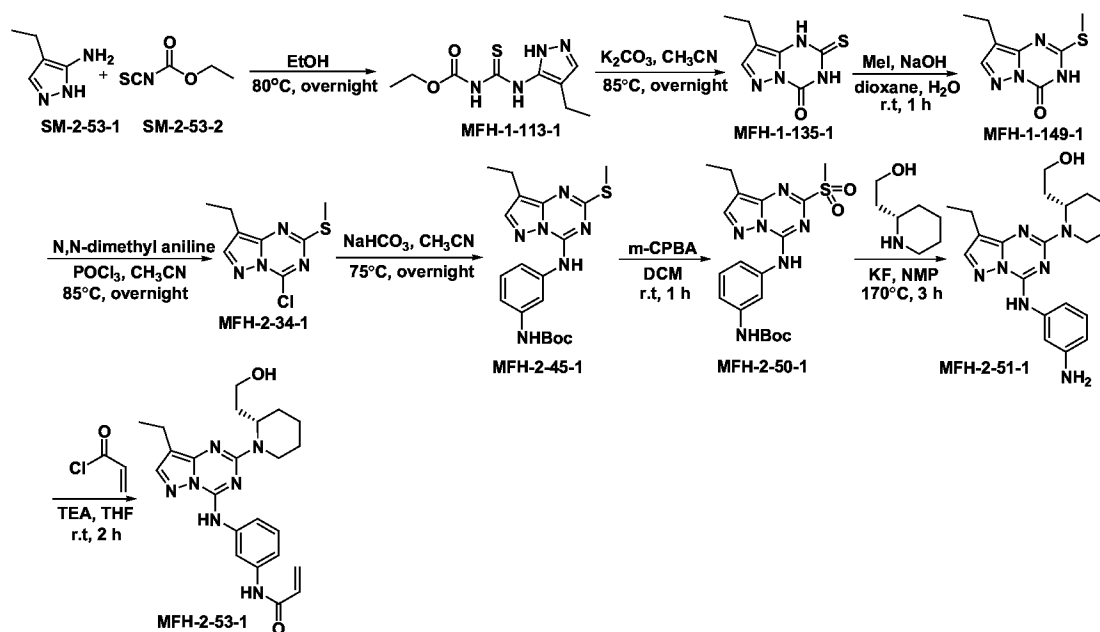
[00440] The mixture of **MFH-1-155-1** (230 mg, 0.783 mmol), **SM-1-49-3** (152 mg, 1.1745 mmol), KF (205 mg, 3.5235 mmol) and NMP (2 mL) was stirred at 170 °C for 10 h. After completion, the residue was extracted with chloroform and 2-propanol (4:1), the organic phase was washed with brine (50 mL $\times$ 2), and dried with Na_2SO_4 . The solution was filtered, concentrated to remove the solvent, and the residue was purified by silica gel chromatography ($\text{NH}_3/\text{MeOH}(1.75\text{N})/\text{DCM} = 0\text{-}20\%$) to obtain **MFH-1-157-1** (100 mg, yield 33%). LCMS (m/z): 387 $[\text{M} + \text{H}]^+$.

***N*-(3-(3-ethyl-5-((*S*)-2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-*a*]pyrimidin-7-ylamino)cyclohexyl)acrylamide (MFH-1-167-1)**

[00441] To a solution of **MFH-1-157-1** (30 mg, 0.07762 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acrylyl chloride (9 mg, 0.101 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0 °C for 1 h. After completion, the reaction was concentrated to remove the solvent and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to obtain **MFH-1-167-1** (off-white solid, 13 mg, yield 38%). HPLC: 96% (254 nm); LCMS (m/z): 441 [M + H]⁺; ¹H NMR (500 MHz, DMSO) δ 8.26 (s, 1H), 8.14 (dd, *J* = 18.8, 7.9 Hz, 1H), 8.05 (d, *J* = 7.3 Hz, 1H), 7.97 – 7.83 (m, 2H), 6.41 – 6.29 (m, 1H), 6.21 (ddd, *J* = 17.1, 10.1, 2.0 Hz, 1H), 6.09 (dddd, *J* = 12.3, 10.2, 3.9, 2.2 Hz, 2H), 5.83 (d, *J* = 9.4 Hz, 1H), 5.69 – 5.51 (m, 3H), 4.49 (s, 2H), 4.12 (d, *J* = 4.8 Hz, 2H), 3.88 – 3.81 (m, 2H), 3.11 (dd, *J* = 22.2, 12.4 Hz, 2H), 2.60 – 2.56 (m, 2H), 2.01 – 1.96 (m, 2H), 1.69 (d, *J* = 12.3 Hz, 6H), 1.54 (s, 2H), 1.48 (d, *J* = 11.4 Hz, 2H), 1.10 (dd, *J* = 24.9, 12.8 Hz, 1H).

***Example 28 (S)*-N-(3-(8-ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-*a*][1,3,5]triazin-4-ylamino)phenyl)acrylamide (MFH-2-53-1)**



Synthetic Scheme 28**ethyl N-[(4-ethyl-1H-pyrazol-5-yl)carbamothioyl]carbamate (MFH-1-113-1)**

[00442] To a solution of **SM-2-53-1** (2.8 g, 25.2 mmol) in ethanol (50.0 mL) was added ethoxycarbonyl isothiocyanate (3.3 g, 25.2 mL) in one portion at room temperature. The mixture was stirred at 80 °C overnight. The reaction mixture was concentrated under reduced pressure to afford the residue, which was purified by flash column chromatography (PE/ethyl acetate = 3:1) to afford **MFH-1-113-1** (white solid, 4 g, yield: 65%). LCMS (m/z): 243 [M + H]⁺.

8-ethyl-2-thioxo-2,3-dihydropyrazolo[1,5-a][1,3,5]triazin-4(1H)-one (MFH-1-135-1)

[00443] To a solution of **MFH-1-113-1** (3.9 g, 16.1 mmol) in acetonitrile (40 mL) was added K_2CO_3 (6.67 g, 48.3 mmol) in one portion at room temperature. The mixture was heated at 85 °C overnight, cooled, and then acidified with AcOH. The resulting solid was filtered off to afford **MFH-1-135-1** (yellow solid, 2.1 g, yield: 66%). LCMS (m/z): 197 [M + H]⁺.

8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4(3H)-one (MFH-1-149-1)

[00444] To a stirred mixture of **MFH-1-135-1** (2.1 g, 10.7 mmol) and NaOH (0.86 g, 21.4 mmol) in dioxane/H₂O (30/8 mL) was added iodomethane (1.52 g, 10.7 mol). This mixture was stirred at room temperature for 1h, acidified with hydrochloric acid, concentrated to

remove the solvent, and the residue was purified by silica gel chromatography (DCM/MeOH = 30:1) to afford **MFH-1-149-1** (white solid, 2.0 g, yield: 89%). LCMS (m/z): 211 [M + H]⁺.

4-chloro-8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazine (MFH-2-34-1)

[00445] To a stirred mixture **MFH-1-149-1** (2.0 g, 9.5 mmol) and N,N-dimethyl aniline (2.3 g, 19.0 mmol) in acetonitrile (10 mL) under argon was added POCl₃ (20 mL, 219 mmol). This mixture was heated at 85 °C overnight. Then the reaction mixture was concentrated under reduced pressure to afford the residue **MFH-2-34-1** (white solid, 2.2 g, yield: 100% used next step directly). LCMS (m/z): 229 [M + H]⁺.

tert-butyl 3-(8-ethyl-2-(methylthio)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenylcarbamate (MFH-2-45-1)

[00446] A stirred mixture **MFH-2-34-1** (2.2 g, 9.5 mmol), tert-butyl 3-aminophenylcarbamate (2.37 g, 11.4 mmol) and NaHCO₃ (130.4 mg, 0.95 mmol) in acetonitrile (25 mL) was heated at 75 °C overnight and then cooled to room temperature. The solvent was removed and the residue was purified by silica gel chromatography (PE/ethyl acetate = 3/1 to 1/1) to afford **MFH-2-45-1** (white solid, 2.52 g, yield: 67%). LCMS (m/z): 401 [M + H]⁺.

tert-butyl 3-(8-ethyl-2-(methylsulfonyl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenylcarbamate (MFH-2-50-1)

[00447] To a solution of **MFH-2-45-1** (600 mg, 1.5 mmol) in DCM (15 mL) was added 3-chloroperbenzoic acid (776 mg, 4.5 mmol) in one portion at room temperature and stirred for 1 h. The reaction mixture was quenched with a saturated Na₂S₂O₃ solution (10 mL), diluted with DCM (50 mL), washed with saturated aqueous NaCl (3 × 50 mL), dried over anhydrous Na₂SO₄, filtered and concentrated to give **MFH-2-50-1** (yellow solid, 620 mg, yield: 96%), which was used in the next step directly. LCMS (m/z): 433 [M + H]⁺.

(S)-2-(1-(4-(3-aminophenylamino)-8-ethylpyrazolo[1,5-a][1,3,5]triazin-2-yl)piperidin-2-yl)ethanol (MFH-2-51-1)

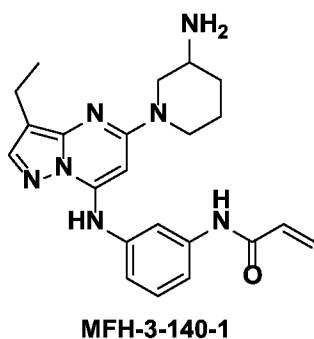
[00448] To a stirred mixture of **MFH-2-50-1** (360 mg, 0.84 mmol) and (S)-2-(piperidin-2-yl)ethanol (215 mg, 1.67 mmol) in N-methyl-2-pyrrolidone (3 mL) was added KF (146 mg, 2.51 mmol). This mixture was heated at 170 °C for 3 h, cooled, and filtered. The crude

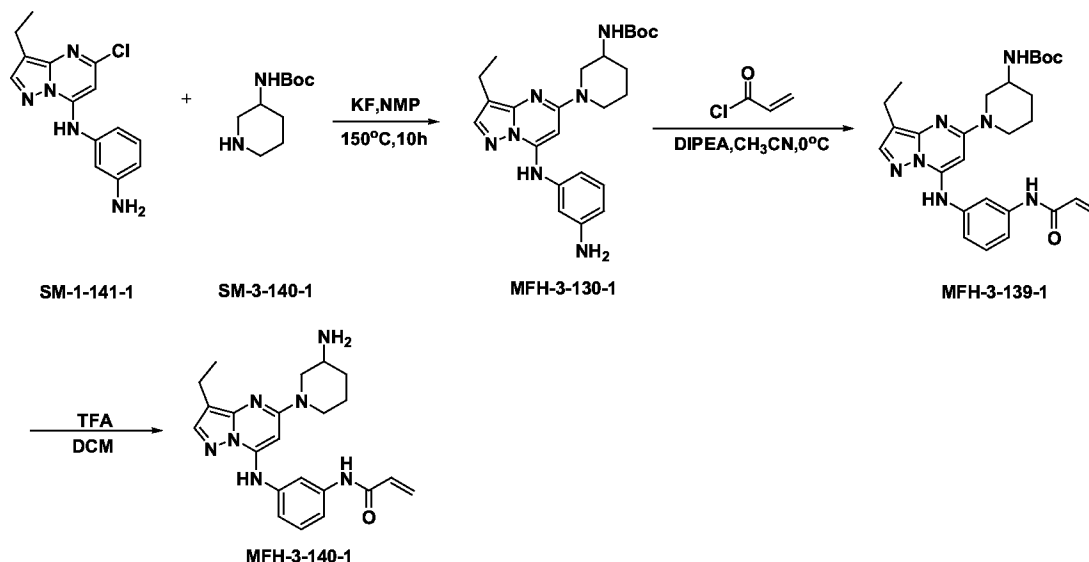
mixture was purified by silica gel chromatography (MeOH/DCM = 0-20%) to afford **MFH-2-51-1** (yellow solid, 150 mg, yield: 47%). LCMS (m/z): 382 [M + H]⁺.

(S)-N-(3-(8-ethyl-2-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a][1,3,5]triazin-4-ylamino)phenyl)acrylamide (MFH-2-53-1)

[00449] To a solution of **MFH-2-51-1** (70 mg, 0.18 mmol) in THF (2 mL) were added acryloyl chloride (18 mg, 0.20 mmol) and triethylamine (54 mg, 0.54 mmol). The reaction was stirred at room temperature for 2 h. After completion, the reaction mixture was diluted with dichloromethane (10 ml), washed with water (10 mL) and saturated sodium bicarbonate solution (10 mL × 2), dried over anhydrous sodium sulfate, concentrated and the crude mixture was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05% TFA) to afford **MFH-2-53-1** (white solid, 13 mg, yield: 16%). HPLC: 97% (254 nm); LCMS (m/z): 436 [M + H]⁺; ¹H NMR (DMSO-*d*₆, 500 MHz): δ : 10.17 (s, 1H), 10.07 (s, 1H), 8.34 (s, 1H), 7.84 (s, 1H), 7.51 (s, 1H), 7.30-7.34 (m, 2H), 6.46 (dd, *J* = 17, 10.0 Hz, 1H), 6.28 (d, *J* = 17 Hz, 1H), 5.77 (d, *J* = 11.5 Hz, 1H), 4.98 (s, 1H), 4.65 (d, *J* = 13 Hz, 1H), 4.56 (s, 1H), 2.88 (t, *J* = 12.5 Hz, 1H), 2.47-2.50 (m, 2H), 1.56-1.88 (m, 8H), 1.36-1.38 (m, 1H), 1.19-1.23 (m, 4H).

Example 29 N-(3-(5-(3-aminopiperidin-1-yl)-3-ethylpyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-3-140-1)



Synthetic Scheme 29

tert-butyl-1-(7-(3-aminophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-3-ylcarbamate (MFH-3-130-1)

[00450] To a stirred mixture SM-1-141-1 (150 mg, 0.5213 mmol) and SM-3-140-1 (157 mg, 0.782 mmol) in N-methyl-2-pyrrolidone (1 mL) was added KF (136 mg, 2.3458 mmol). After heating at 150 °C for 10 h, the reaction mixture was cooled and filtered. After removal of the solvent, the crude mixture was purified by silica gel chromatography (MeOH/DCM = 0-20%) to afford MFH-3-130-1 (110 mg, yield: 47%). LCMS (m/z): 452 [M + H]⁺.

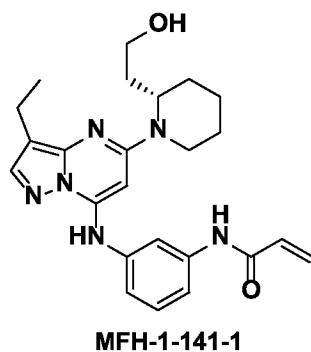
tert-butyl-1-(7-(3-acrylamidophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-3-ylcarbamate (MFH-3-139-1)

[00451] To a solution of MFH-3-130-1 (110 mg, 0.24 mmol) in CH₃CN (2 mL) was added acryloyl chloride (28 mg, 0.3167 mmol) and DIPEA (0.2 mL). The reaction was stirred at room temperature for 2 h and then was diluted with dichloromethane (10 mL). The solution was washed with saturated NaHCO₃ (10 mL × 2) and water (10 mL). The organic layer was dried over anhydrous sodium sulfate and then concentrated under reduced pressure. The residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05% TFA) to afford MFH-3-139-1 (56.6 mg, yield: 46%). LCMS (m/z): 506 [M + H]⁺.

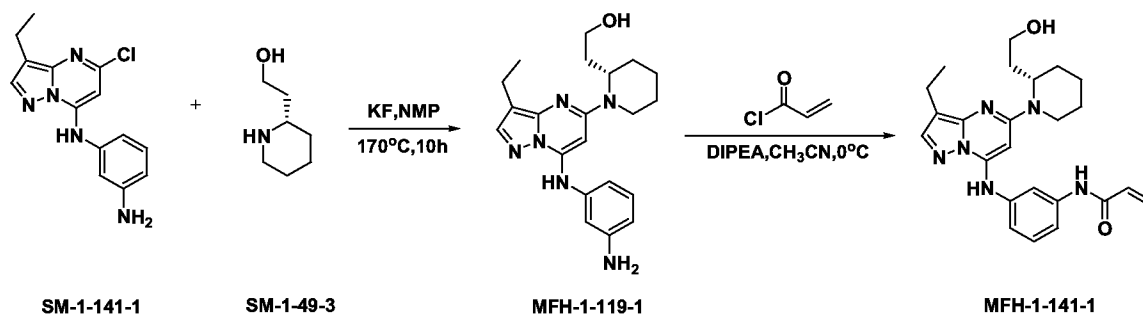
***N*-(3-(5-(3-aminopiperidin-1-yl)-3-ethylpyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-3-140-1)**

[00452] To a mixture of compound **MFH-3-139-1** (56.6 mg,) in DCM (5 mL) was added TFA (2 mL). The reaction mixture was stirred for 1h at room temperature. The mixture was concentrated under reduced pressure and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05%TFA) to afford **MFH-3-140-1** (20 mg, yield:44%). LCMS (m/z): 406 [M + H]⁺. ¹H NMR (500 MHz, DMSO) δ 10.32 (s, 1H), 9.48 (s, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.94 (s, 2H), 7.84 (s, 1H), 7.38 (t, *J* = 8.0 Hz, 1H), 7.32 (d, *J* = 8.2 Hz, 1H), 7.17 (d, *J* = 8.6 Hz, 1H), 6.46 (dd, *J* = 17.0, 10.2 Hz, 1H), 6.28 (dd, *J* = 17.0, 1.8 Hz, 1H), 6.03 (s, 1H), 5.80 (dd, *J* = 10.1, 1.8 Hz, 1H), 4.30 (s, 1H), 3.85 (s, 1H), 3.22 (s, 1H), 3.13 (dd, *J* = 12.6, 9.2 Hz, 2H), 2.66 – 2.57 (m, 2H), 1.98 (s, 1H), 1.81 – 1.74 (m, 1H), 1.56 (dd, *J* = 16.8, 9.0 Hz, 2H), 1.25 (t, *J* = 7.5 Hz, 3H).

***Example 30 (S)*-N-(3-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-*a*]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-1-141-1)**



Synthetic Scheme 30



(S)-2-(1-(7-(3-aminophenylamino)-3-ethylpyrazolo[1,5-a]pyrimidin-5-yl)piperidin-2-yl)ethanol (MFH-1-119-1)

[00453] The mixture of **SM-1-141-1** (250 mg, 0.87 mmol), **SM-1-49-3** (168 mg, 1.3 mmol), KF (227 mg, 3.9 mmol) and NMP (2 mL) was stirred at 170 °C for 10 h. After completion, the residue was extracted with chloroform and isopropanol (4:1). The organic phase was washed with brine (50 mL × 2) and dried with Na₂SO₄. The mixture was filtered, concentrated to remove the solvent under reduced pressure, and purified by silica gel chromatography (MeOH/DCM = 0-20%) to obtain **MFH-1-43-1** (250 mg, yield 75.6%). LCMS (m/z): 381 [M + H]⁺.

(S)-N-(3-(3-ethyl-5-(2-(2-hydroxyethyl)piperidin-1-yl)pyrazolo[1,5-a]pyrimidin-7-ylamino)phenyl)acrylamide (MFH-1-141-1)

[00454] To a solution of **MFH-1-119-1** (50 mg, 0.13 mmol) and DIPEA (0.2 mL) in CH₃CN (2 mL) was added acryloyl chloride (15 mg, 0.17 mmol) in DCM (0.5 mL) dropwise. The mixture was stirred at 0 °C for 1 h. After completion, the reaction was concentrated under reduced pressure, and the residue was purified by prep-HPLC (C18 column, MeOH/H₂O, containing 0.05% TFA) to obtain **MFH-1-141-1** (off-white solid, 33.7 mg, yield 59%). HPLC: 96% (254 nm); LCMS (m/z): 435 [M + H]⁺.

Biological Assays of the Compounds

Pulldown Assay

[00455] Jurkat cells were treated with DMSO, 1 μM or 200 nM of compound E9, E17, or dinaciclib (*Figure 2*). 6 hours after treatment, cells were washed and harvested by resuspending in lysis buffer (50 mM Hepes pH 7.4, 150 mM NaCl, 1% NP-40, 5 mM EDTA, protease and phosphatase inhibitors) and lysing on ice 30 minutes. Lysates were cleared by centrifugation at 15,000 rpm 30 minutes. Biotin-labeled THZ1 was added to 1 μM to lysates and rotated at 4 °C overnight. Streptavidin-agarose beads were washed and 30 μL slurry was added to each lysate and rotated for 1 hour at 4 °C. Beads were washed 5 times with lysis buffer and 50 μL 2X LDS buffer was added to each sample. Samples were boiled and equal volume of protein was loaded onto gel. Gel was transferred to nitrocellulose and blotted for Cyclin K and Cyclin H.

[00456] We conclude that pre-treatment of cells with compound E9, E17 or dinaciclib, but not DMSO, blocks biotin-THZ1 from being able to bind to CDK12, which blocks the pulldown of Cyclin K. This indicates that compound E9 is able to engage CDK12 in cells at

1 μ M and 200nM and block binding of bio-THZ1. We do not see a similar loss of pulldown of Cyclin H, indicating that E9 and E17 are not able to bind to CDK7 and block its association with bio-THZ1.

Jurkat Proliferation Assay

[00457] Jurkat cells were seeded at a density of 25,000 cells/ well in 96-well plates. Cells were then treated with the indicated compounds in a 10-pt dose escalation format from 1 nM to 10 μ M or DMSO control for 72 hrs. After 72 hrs, cells were assayed using CellTiter-Glo Luminescent Cell Viability Assay (Promega) to determine cell viability by measuring the amount of ATP present in each sample cell population, which is an indicator of cell metabolic activity. Results are graphed as fraction of the DMSO control at 72 hrs. All data points were performed in biological triplicate. Error bars are +/- SD.

[00458] These results suggest that dinaciclib has the most anti-proliferative effect on Jurkat cells with an IC₅₀ below 10 nM. However, the covalent inhibitors E9, E17, and E18 all display potent activity with IC₅₀s in the sub-100 nM range.

Growth Assay

[00459] Jurkat cells were treated with 1 μ M of compound E9, E17, Dinaciclib or DMSO control. 4 hours after treatment, cells were either not treated or washed three times with RPMI media to remove all compound. Cells were replated and allowed to grow for 68 hours. Cells were assayed using celltiter glo (Promega) to determine cell viability by measuring the amount of ATP present, which is an indicator of cell metabolic activity. Results are graphed as luminescent values (*Figure 1*).

[00460] We can conclude that the covalent nature of the compounds E9 and E17 allow for a long term effect in cells, even after compound is removed. Conversely, dinaciclib has a strong effect on cell viability when it is maintained in culture, however, once it is removed, cells are able to reinitiate growth. Taken together, this indicates that the covalent nature of E9 and E17 has the advantage of short dosing periods translating into longer term effects.

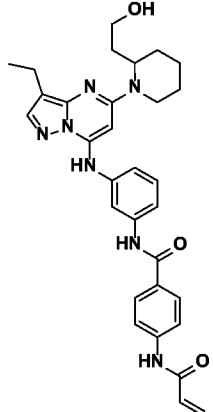
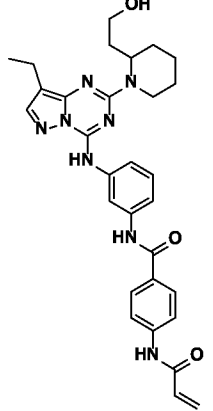
Washout Expression Assay

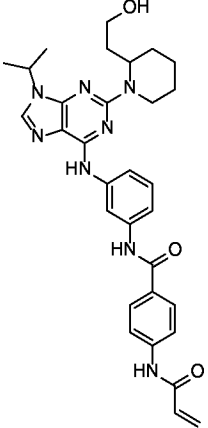
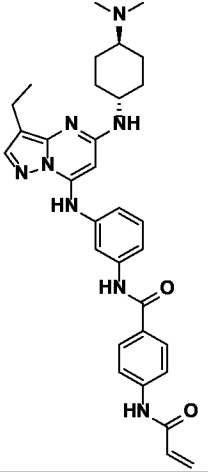
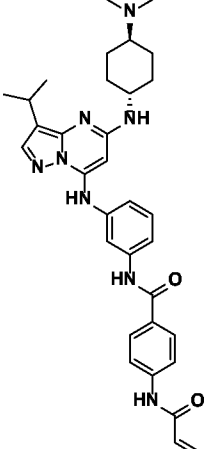
[00461] Jurkat cells were treated with 1 μ M of compound E9, E17, Dinaciclib or DMSO control (*Figure 3*). 4 hours after treatment, cells were either not treated or washed three times with RPMI media to remove all compound. Cells were replated and allowed to grow for 6 hours. Cells were harvested, washed 3 times with PBS and resuspended in RIPA buffer

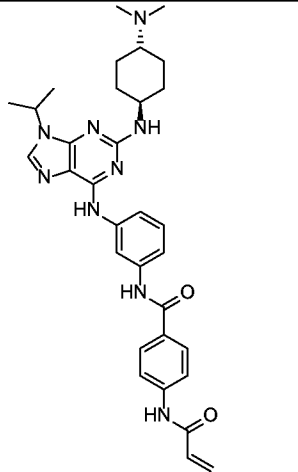
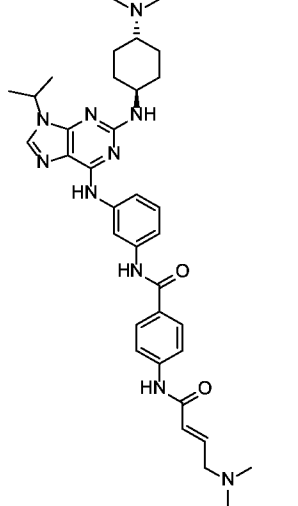
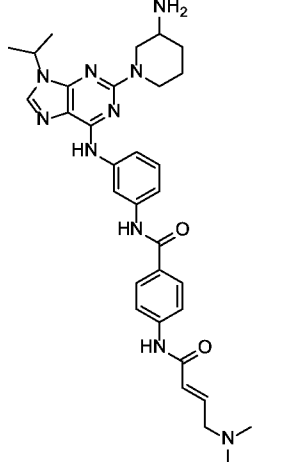
(25mM Tris-HCl (pH 7.6), 150mM NaCl, 1% NP-40, 1% sodium deoxycholate, 0.1% SDS). Equal amount of protein was loaded onto gel and blotted for Pol II Ser2 (Millipore 04-1571), total pol II (Santa Cruz 17798), Tubulin (Cell Signaling 11H10) or MCL1 (Cell Signaling 4572S)

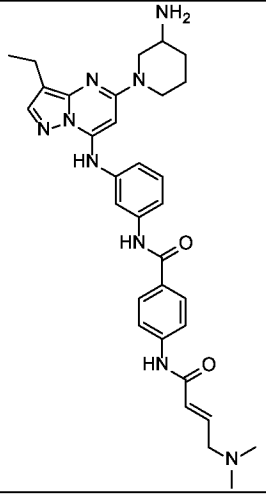
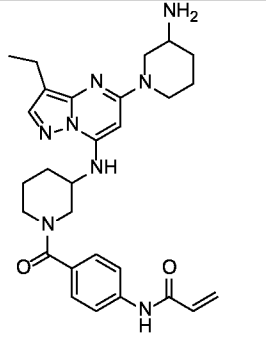
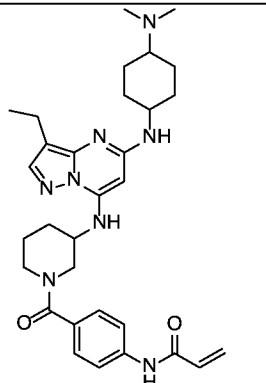
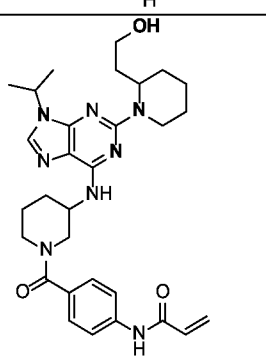
[00462] We can see that when we treat with any of the compounds that Ser2 phosphorylation and MCL1 levels are decreased. However, when we washout the compounds, only our covalent compounds are able to have an effect after the washout whereas dinaciclib is unable to continue this effect.

Table A1. Biological evaluation of the exemplified compounds (IC₅₀ values/nM)

Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
SB1-E-24		774	140	---	1260
SB1-E-19		383	123	---	295

Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
THZ-4-124-1		122	373	117	976
SB1-E-22		246	88.9	---	28300
SB1-E-25		410	387	---	33400

Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
THZ-5-38-1		25.9	220	---	563
THZ-3-49-1		9.43	445	4029	---
THZ-4-119-1		11.5	519	1960	---

Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
THZ-4-128-1		46.8	73.4	1037	17100
THZ-4-141-1		3600	3570	---	>1000
THZ-4-148-1		>10000	1710	---	7050
THZ-4-149-1		4430	2290	---	>1000

Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
X1		---	---	---	---
X2		---	---	---	---
X3		---	---	---	---

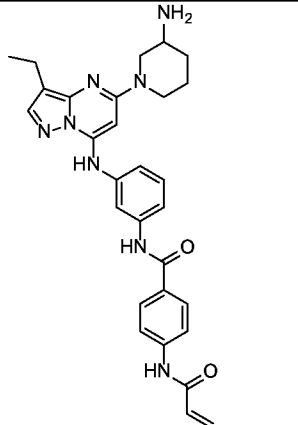
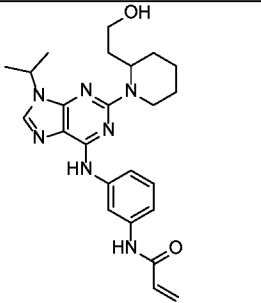
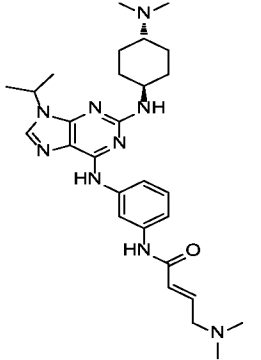
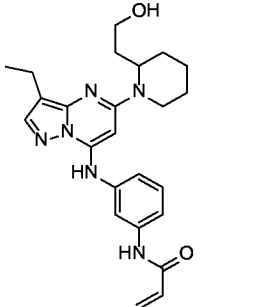
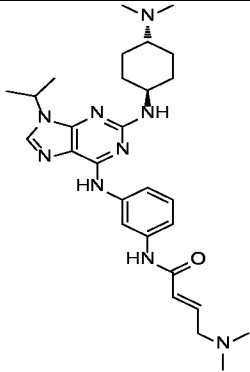
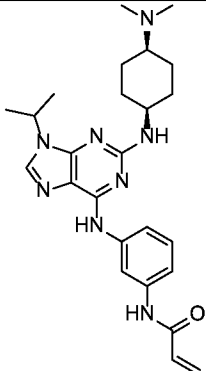
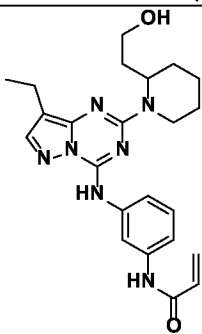
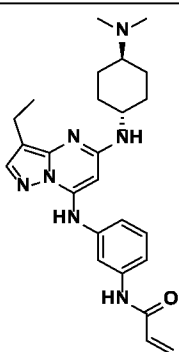
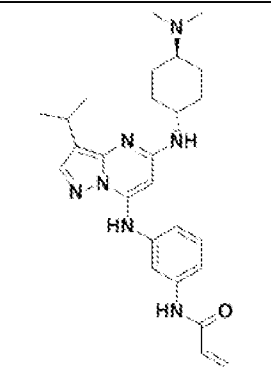
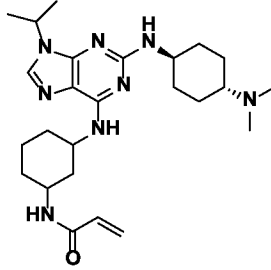
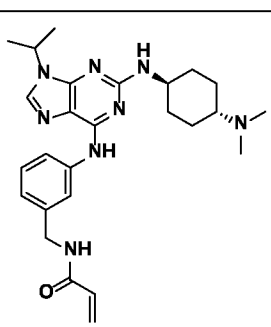
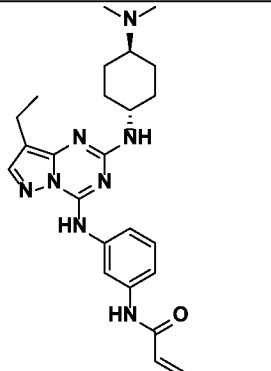
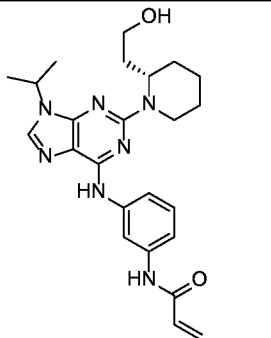
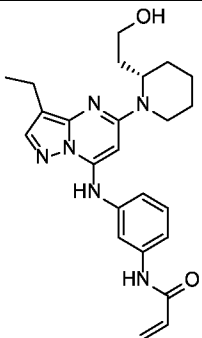
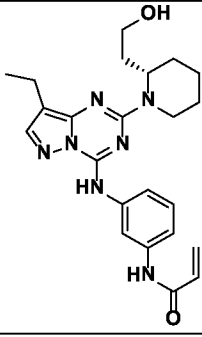
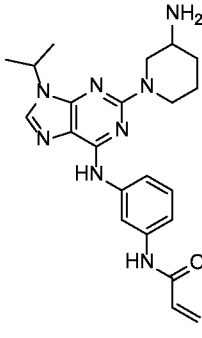
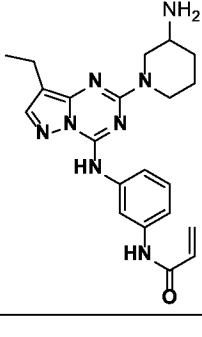
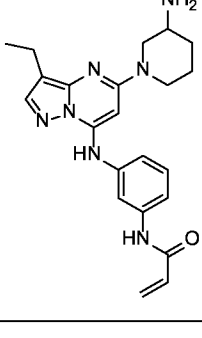
Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
X4		---	---	---	---

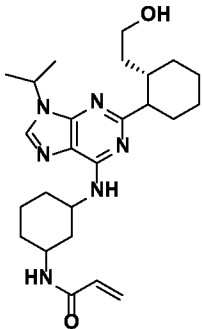
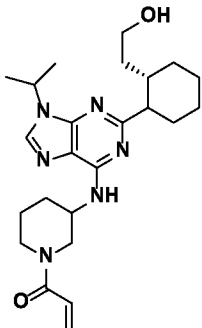
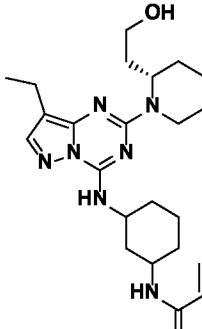
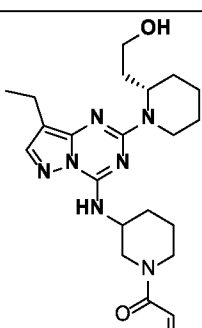
Table A2. Biological evaluation of additional exemplified compounds (IC50 values/nM)

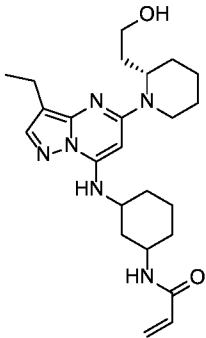
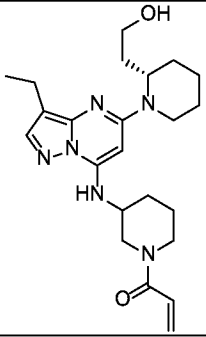
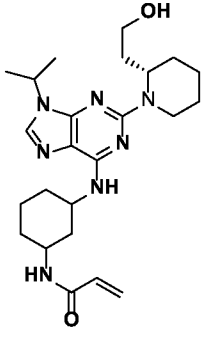
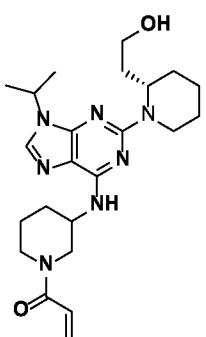
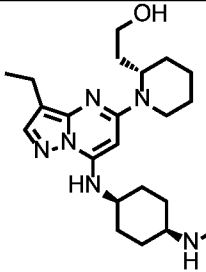
Compound	Structure	CDK7/CycH	CDK9/CycT	Jurkat	CDK2/CycA
THZ-4-134-1		1180	379	522	163
THZ-5-18-1		121	1530	1336	---
E-9(SB1-E-23)		1090	21.6	78.8	250

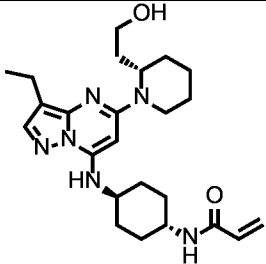
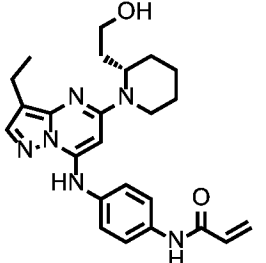
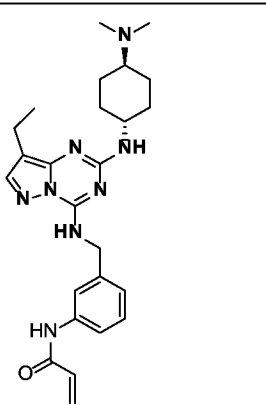
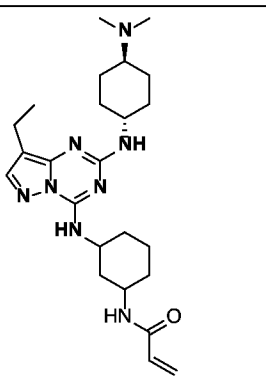
THZ-5-18-1		121	1530	1336	---
E-1(SB1-E-14)		254	1360	---	735
SB1-E-18		461	41.8	19.2	15.0
SB1-E-21		1210	226	318	1220

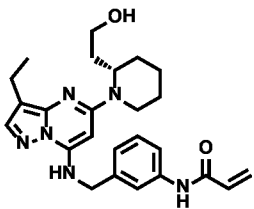
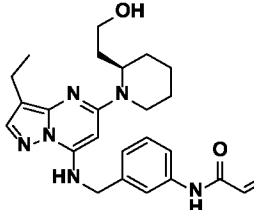
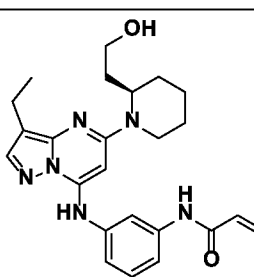
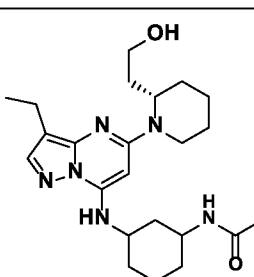
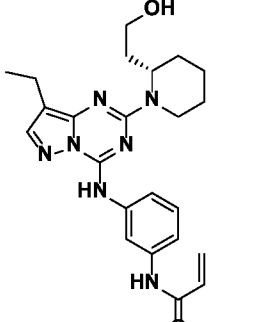
SB1-E-26		1090	429	518	939
SB1-E-15		763	58.9	---	1480
SB1-E-16		255	116	---	30.3
SB1-E-17		1020	171	60.6	247
Y1		---	---	---	---

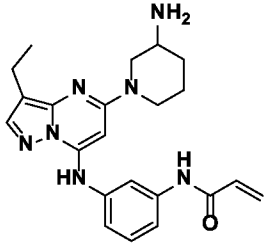
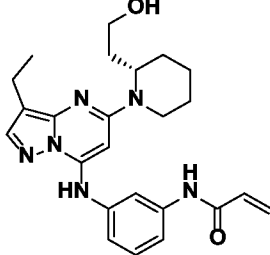
Y2		---	---	---	---
Y3		---	---	---	---
Y4		---	---	---	---
Y5		---	---	---	---
Y6		---	---	---	---

Y7		---	---	---	---
Y8		---	---	---	---
Y9		---	---	---	---
Y10		---	---	---	---

Y11		---	---	---	---
Y12		---	---	---	---
Y13		---	---	---	---
Y14		---	---	---	---
MFH-1-169-1		7250	135	---	3880

MFH-1-175-1		442	48.2	---	1080
MFH-1-187-1		279	23.5	---	171
MFH-2-67-1		23.7	103	---	1020
MFH-2-78-1		842	68.7	---	>1000

MFH-1-49-1		165	2.8	---	27.6
MFH-1-56-1		345	300		1530
MFH-1-143-1		2510	859		>10000
MFH-1-167-1		739	24.7		328
MFH-2-53-1		1100	61.6		53.5

MFH-3-140-1		356	465		4190
MFH-1-141-1		1210	23.9		932

Example 31. KiNativ™ kinome profiling

[00463] Jurkat cells were seeded at a density of 100 million cells/ 50 mL. Cells were treated with E9 (1 μ M) or DMSO control for 6 hrs. Cells were washed twice with cold phosphate-buffered saline (PBS). PBS-washed cell pellets were flash frozen and subjected to KiNativ™ kinome profiling at ActivX Biosciences, Inc. according to their specifications using their desthiobiotin-ATP probe. Peptide sequences shown in Table A4 belong to the indicated kinase(s) and were detected by mass spectrometry (MS) under DMSO control conditions following enrichment for biotinylated proteins by streptavidin pulldown and subsequent proteolysis. Kinases labeled by the reactive desthiobiotin-ATP probe indicate that the kinase was accessible to desthiobiotin-ATP probe binding. Results shown are normalized to these paired DMSO controls and numbers represent the percentage (compared to DMSO control) of MS signal lost for sequences of an indicated kinase, *eg* – numbers approaching 100% indicate that test compound effectively out-competed the desthiobiotin ATP probe for binding to the kinase, resulting in decreased labeling and enrichment for peptides representing this kinase. This result suggests that E9 binds predominantly CDK12 and CDK13 in Jurkat cells (Figure 10)

Example 32. Jurkat Gene expression analysis

[00464] Jurkat cells were seeded at a density of 5 million cells/ 10 mL. Cells were then treated with 200 nM or 1 μ M of the indicated compounds or with DMSO control for 6 hrs. Total RNA was extracted from 5 million cells using the RNeasy Plus Mini Kit (Qiagen) with

a gDNA eliminator mini column to remove genomic DNA. mRNA was reverse transcribed into cDNA using the SuperScript III First-Strand Synthesis Kit (Life Technologies) using an oligo-dT primer to capture polyadenylated mRNAs. Quantitative PCR (qPCR) using transcript-specific Taqman probes (Applied Biosystems) was used to assess the effect of compound treatment on the expression of the indicated mRNA transcripts. All experiments shown were performed in biological triplicate. Each individual biological sample was qPCR-amplified in technical duplicate. Error bars are +/- SD. Expression data from drug treatments were normalized to GAPDH probe.

[00465] These results suggest that the covalent inhibitors E9, E17, and E18 as well as Dinaciclib (*Figure 6*), a reversible inhibitor, potently downregulate the key T-ALL transcription factors TAL1, RUNX1, and MYB at a dose of 200 nM. Inhibitors E21 and E26 downregulate these factors to a lesser degree at 200 nM and only potently reduce these transcripts at 1 μ M. Furthermore, the magnitude with which these inhibitors downregulate the expression of these transcription factors at 200 nM correlates with their effective IC₅₀s on Jurkat T-ALL cell proliferation. For example, Dinaciclib and E18 downregulate these transcription factor genes by at least 80% at 200 nM and have IC₅₀s less than 20 nM. E9 and E17 downregulate these transcription factor genes by at least 40% at 200 nM and have IC₅₀s less than 100 nM. Lastly, E21 and E26 downregulate these genes between 0-60% and have IC₅₀s greater than 300 nM. This suggests that the magnitude of the reduction in expression of these transcription factor genes may serve as an indicator of overall phenotypic response to the inhibitor.

Example 33. Mutagenesis analysis

[00466] Genome Editing: The CRISPR/Cas9 system was used to mutate the endogenous CDK12 and CDK13 loci to encode for CDK12 C1039S and CDK13 C1017S, both of which are putative CDK12/13 inhibitor-refractory mutants. Target-specific oligonucleotides were cloned into pX330, which carries a codon-optimized version of Cas9 and was further modified to express GFP for identifying transfectants. Cells were co-transfected (X-tremeGENE 9 (Roche)) with 1) pX330 expressing Cas9 and CDK12-targeting guide RNAs and 2) a pUC57-AMP construct bearing 1500 bp of modified CDK12 reference genome* that is centered around the CRISPR targeting site in CDK12. Two days after transfection, cells were sorted using GFP as a marker of transfected cells and cells were re-plated for five days. Cells were then re-plated at low density to facilitate the isolation of individual clones. Individual clones were isolated, expanded, and PCR genotyped using mutant specific PCR

primers. Following initial PCR screening, individual clones were Sanger sequenced to confirm the presence of the desired mutation. Western blot confirmed the presence of intact CDK12 kinase. The process was sequentially repeated with Cas9/sgRNA constructs to target and replace the CDK13 genetic loci. Subsequent experiments were conducted using a CDK12 C1039S/ CDK13 C1017S clone and a wild type control clone that was carried through the entirety of the CRISPR protocol but that was verified by Sanger sequencing to be wild type for CDK12 and CDK13. The genomic sequence complementary to the CDK12 -directed guide RNA that was cloned into pX330 and used in the genome editing experiments is: GGCAGGATTGCCATGAGTTG. The genomic sequence complementary to the CDK13 -directed guide RNA that was cloned into pX330 and used in the genome editing experiments is: GGCAAGATTGTCATGAGTTA. * The reference genome sequence used as a repair template for CDK12 and CDK13 CRISPR was edited to 1) introduce DNA coding for serine, 2) introduce mutations to either remove the PAM site (NGG) targeted by CRISPR/Cas9 or introduce sufficient wobble mutations such that the guide RNA could not recognize the repair template and thus could not be cut by CRISPR/Cas9, and 3) introduce mutations that could allow for mutant and wild type-specific PCR amplification.

[00467] HAP1 cell proliferation assay: HAP1 wild type and double mutants cells were seeded at a density of 12,000 cells/ well in 96-well plates. Twenty four hours cells were then treated with the indicated compounds in a 10-pt dose escalation format from 1 nM to 10 μ M or DMSO control for 72 hrs. After 72 hrs, cells were assayed using CellTiter-Glo Luminescent Cell Viability Assay (Promega) to determine cell viability by measuring the amount of ATP present in each sample cell population, which is an indicator of cell metabolic activity. Results are graphed as fraction of the DMSO control at 72 hrs. All data points were performed in biological triplicate. Error bars are +/- SD.

[00468] HAP1 cells expressing inhibitor-refractory mutations in CDK12 (C1039S) and CDK13 (C1017S) were 4-fold less sensitive to E17 compared to control wild type HAP1 cells. This result indicates that a significant portion of intracellular E17 activity comes from covalent inhibition of CDK12 and/or CDK13. Mutation of these targeted cysteines to a less nucleophilic serine is sufficient to rescue a significant portion of anti-proliferative activity at concentrations less than 350 nM.

EQUIVALENTS AND SCOPE

[00469] In the claims articles such as “a,” “an,” and “the” may mean one or more than one unless indicated to the contrary or otherwise evident from the context. Claims or descriptions

that include “or” between one or more members of a group are considered satisfied if one, more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context. The invention includes embodiments in which exactly one member of the group is present in, employed in, or otherwise relevant to a given product or process. The invention includes embodiments in which more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process.

[00470] Furthermore, the invention encompasses all variations, combinations, and permutations in which one or more limitations, elements, clauses, and descriptive terms from one or more of the listed claims is introduced into another claim. For example, any claim that is dependent on another claim can be modified to include one or more limitations found in any other claim that is dependent on the same base claim. Where elements are presented as lists, *e.g.*, in Markush group format, each subgroup of the elements is also disclosed, and any element(s) can be removed from the group. It should be understood that, in general, where the invention, or aspects of the invention, is/are referred to as comprising particular elements and/or features, certain embodiments of the invention or aspects of the invention consist, or consist essentially of, such elements and/or features. For purposes of simplicity, those embodiments have not been specifically set forth *in haec verba* herein. It is also noted that the terms “comprising” and “containing” are intended to be open and permits the inclusion of additional elements or steps. Where ranges are given, endpoints are included. Furthermore, unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or sub-range within the stated ranges in different embodiments of the invention, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise.

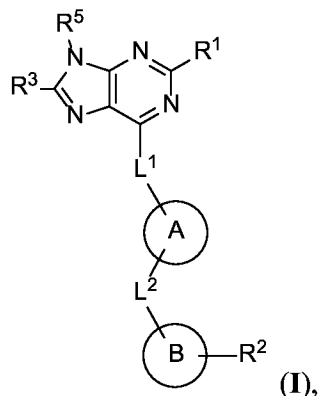
[00471] This application refers to various issued patents, published patent applications, journal articles, and other publications, all of which are incorporated herein by reference. If there is a conflict between any of the incorporated references and the instant specification, the specification shall control. In addition, any particular embodiment of the present invention that falls within the prior art may be explicitly excluded from any one or more of the claims. Because such embodiments are deemed to be known to one of ordinary skill in the art, they may be excluded even if the exclusion is not set forth explicitly herein. Any particular embodiment of the invention can be excluded from any claim, for any reason, whether or not related to the existence of prior art.

[00472] Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation many equivalents to the specific embodiments described herein. The scope of the present embodiments described herein is not intended to be limited to the above Description, but rather is as set forth in the appended claims. Those of ordinary skill in the art will appreciate that various changes and modifications to this description may be made without departing from the spirit or scope of the present invention, as defined in the following claims.

CLAIMS

What is claimed is:

1. A compound of Formula (I):



or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-NR^aR^b$, $-OR^b$, $-SR^b$, $-C(=O)R^b$, $-C(=O)OR^b$, or $-C(=O)NR^aR^b$, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

R^3 is hydrogen, halogen, or optionally substituted C_1 - C_6 alkyl;

R^5 is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

L^1 is a bond, $-NR^{L1}-(CH_2)_t$, $-O-$, or $-S-$;

R^{L1} is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

t is 0 or an integer between 1 and 5, inclusive;

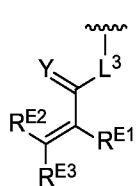
Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl;

L^2 is a bond, optionally substituted C_{1-4} alkylene, $-C(=O)-$, $-NR^{L^2}-$, $-C(=O)NR^{L^2}-$, -

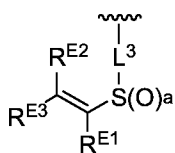
$NR^{L^2}C(=O)-$, $-O-$, or $-S-$, wherein R^{L^2} is hydrogen, optionally substituted C_1-C_6 alkyl, or a nitrogen protection group;

Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and

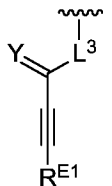
R^2 is any of Formulae (i-1)-(i-41):



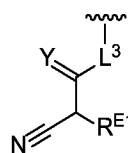
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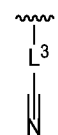
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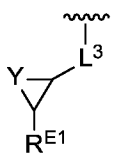
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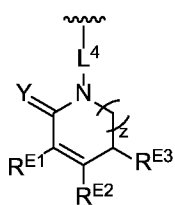
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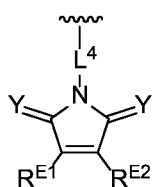
(i-5)



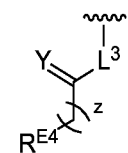
(i-6)



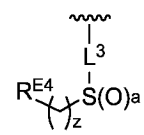
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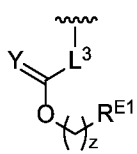
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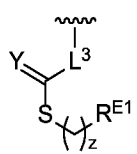
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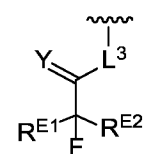
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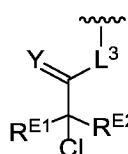
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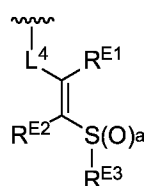
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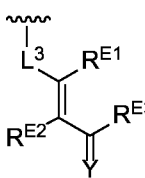
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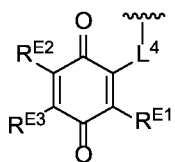
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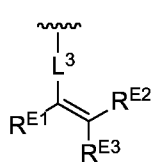
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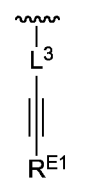
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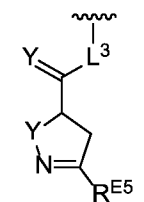
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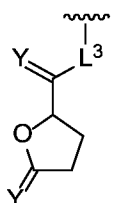
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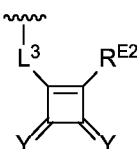
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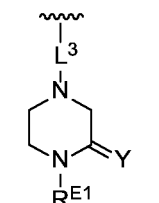
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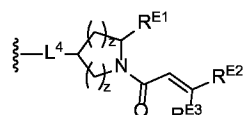
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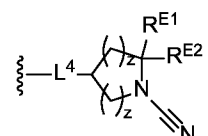
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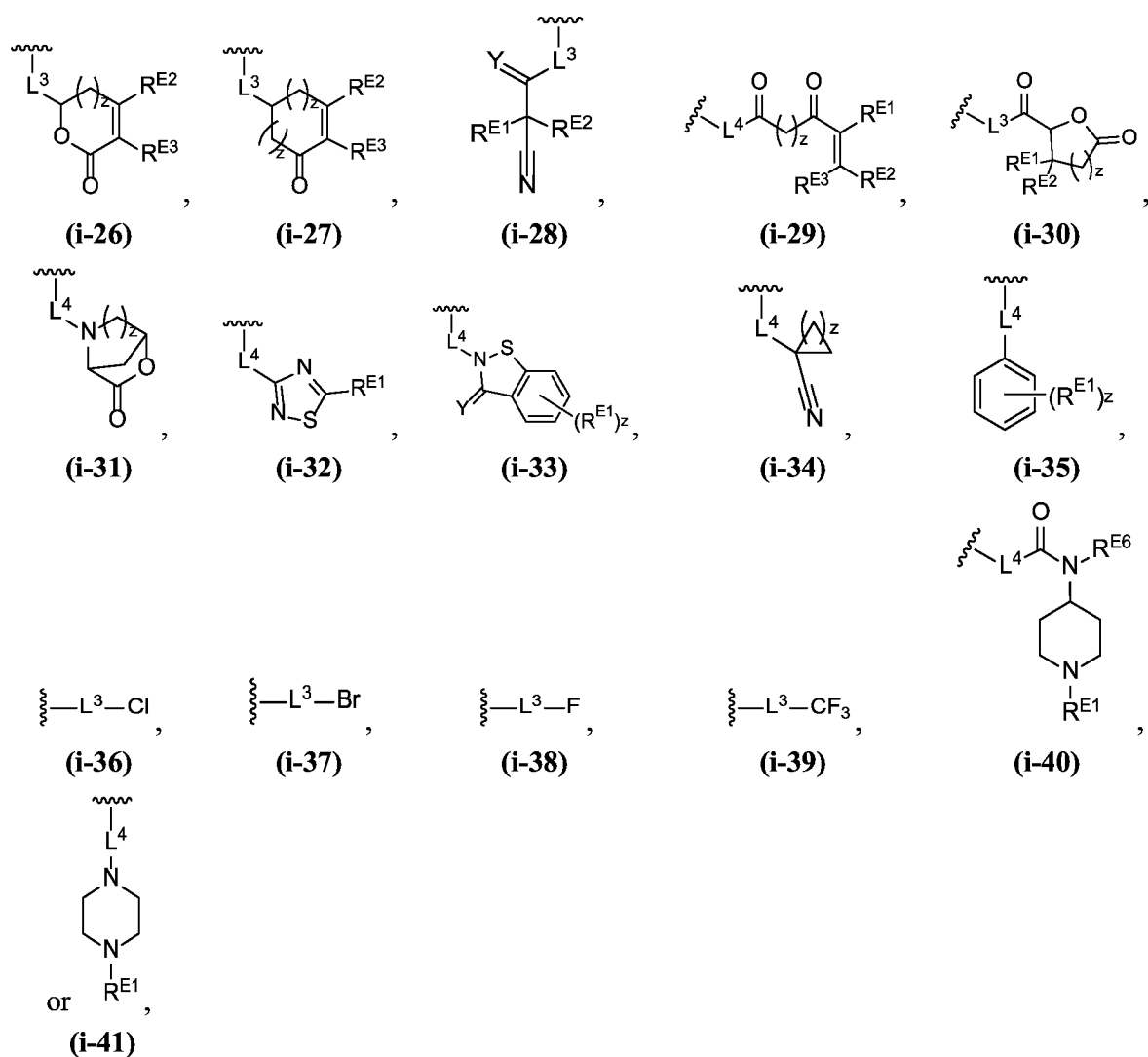
(i-23)



(i-24)



(i-25)



L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C=O-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted

aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain;

each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, $-CN$, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, and $-SR^{EE}$, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring;

or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

R^{E5} is halogen;

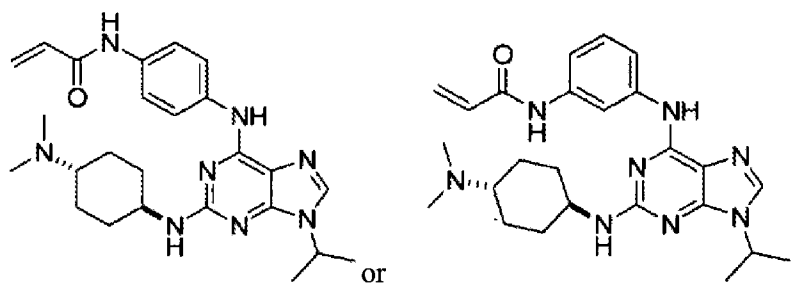
R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

each instance of Y is independently O, S, or NR^{E7} , wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

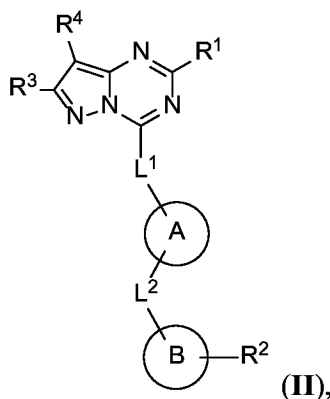
a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits; and

provided that the compound is not



2. A compound of Formula (II):



or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-NR^aR^b$, $-OR^b$, $-SR^b$, $-C(=O)R^b$, $-C(=O)OR^b$, or $-C(=O)NR^aR^b$, wherein each instance of R^a and R^b is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

each of R^3 and R^4 is independently hydrogen, halogen, or optionally substituted C_1 - C_6 alkyl;

L^1 is a bond, $-NR^{L1}-(CH_2)_t-$, $-O-$, or $-S-$;

R^{L1} is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

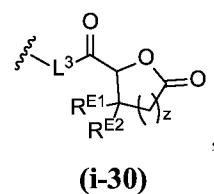
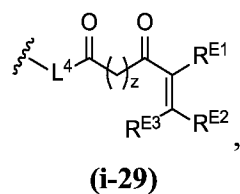
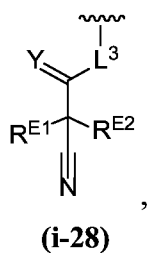
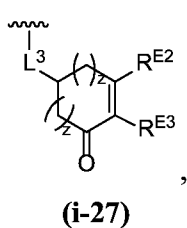
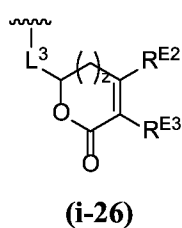
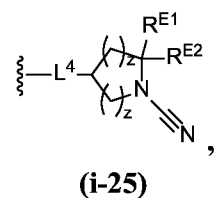
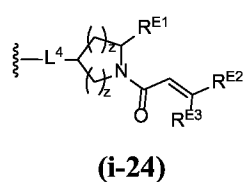
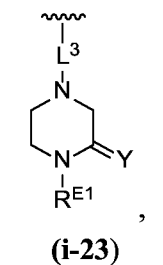
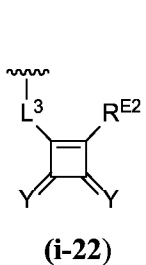
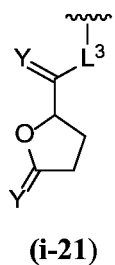
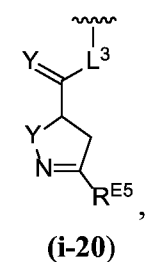
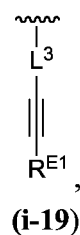
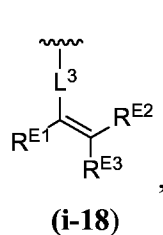
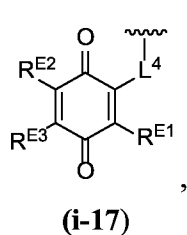
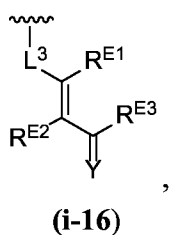
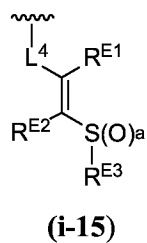
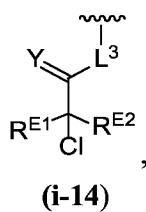
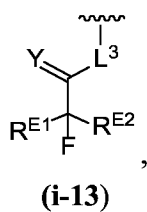
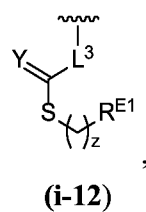
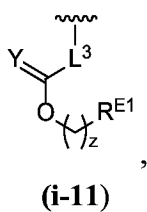
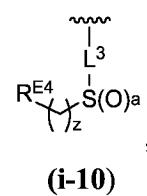
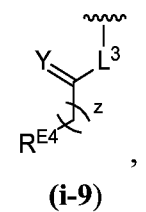
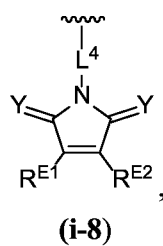
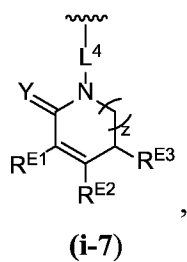
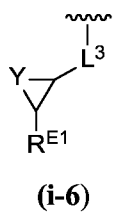
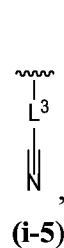
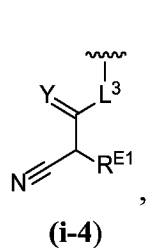
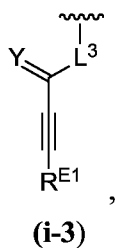
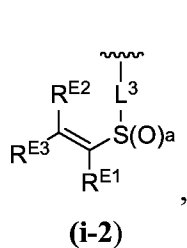
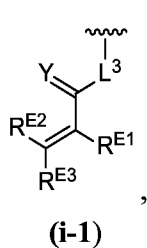
t is 0 or an integer between 1 and 5, inclusive;

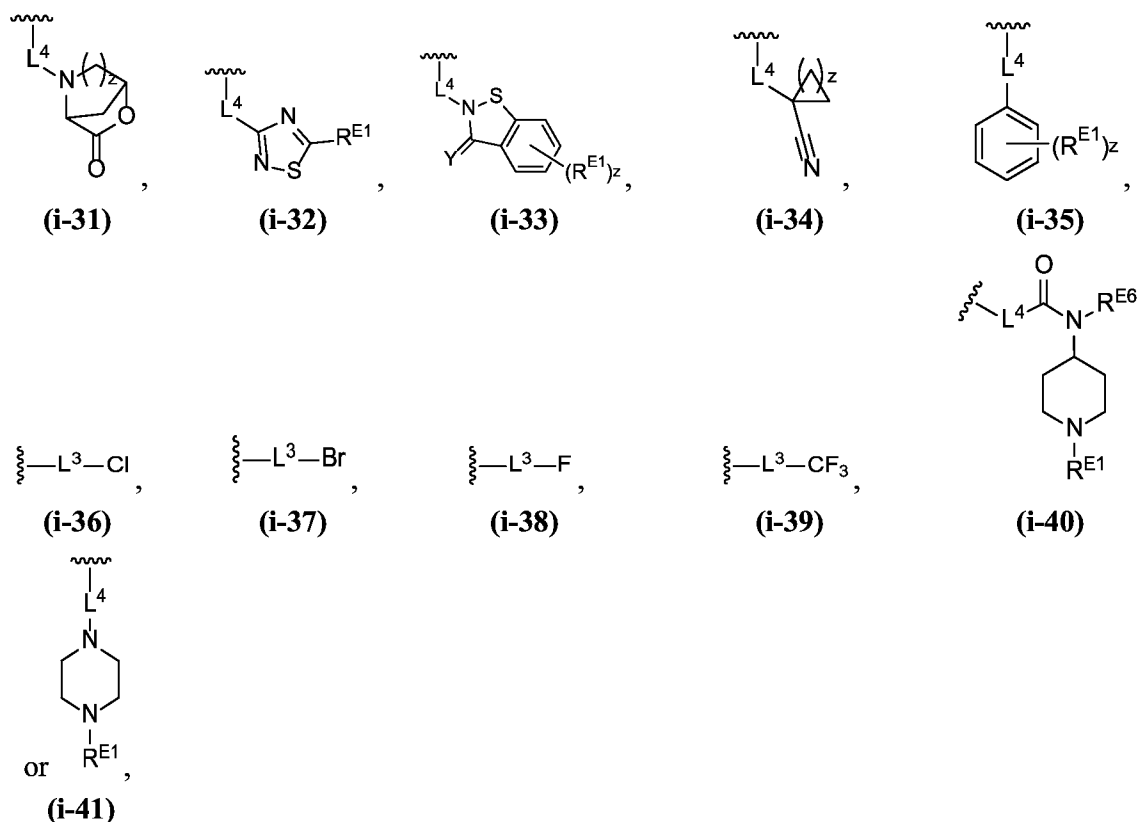
Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl;

L^2 is a bond, optionally substituted C_{1-4} alkylene, $-C(=O)-$, $-NR^{L2}-$, $-C(=O)NR^{L2}-$, $-NR^{L2}C(=O)-$, $-O-$, or $-S-$, wherein R^{L2} is hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protection group;

Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and

R² is any of Formulae (i-1)-(i-41):





wherein:

L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C(=O)-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain; each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, $-CN$, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, -

$\text{Si}(\text{R}^{\text{EE}})_3$, and $-\text{SR}^{\text{EE}}$, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring;

or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

R^{E5} is halogen;

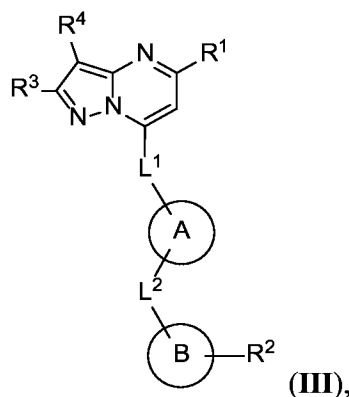
R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

each instance of Y is independently O, S, or NR^{E7} , wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits.

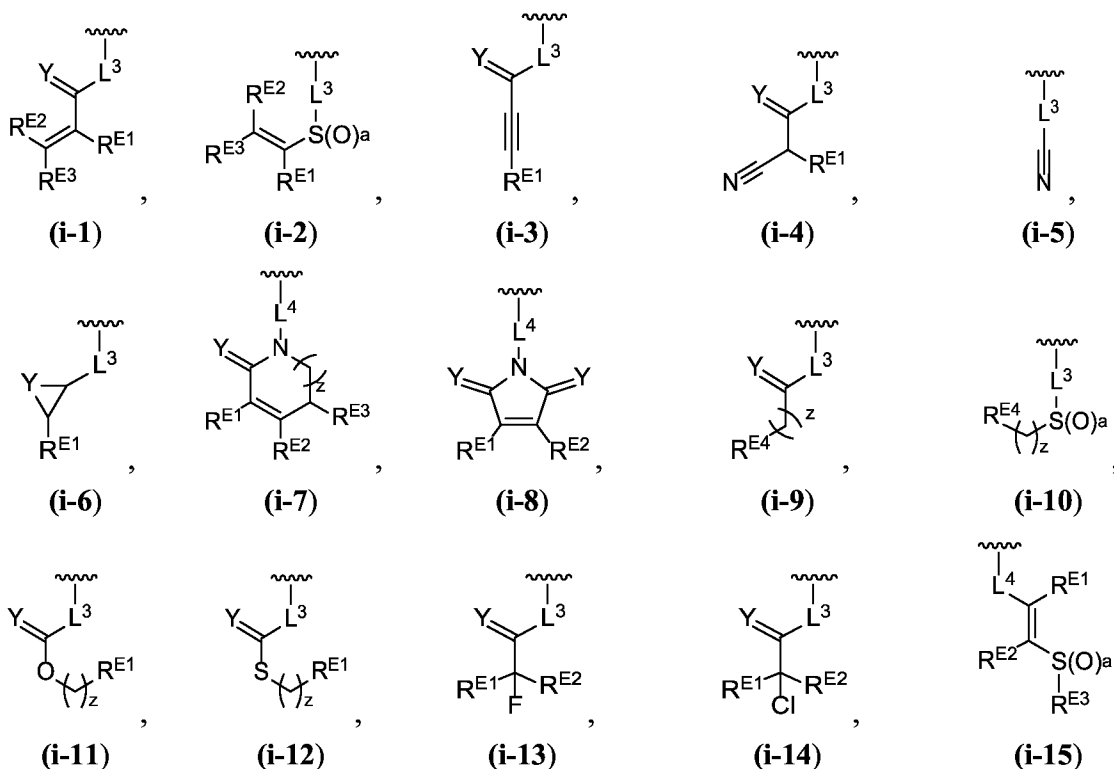
3. A compound of Formula (III):

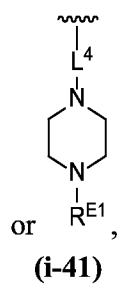
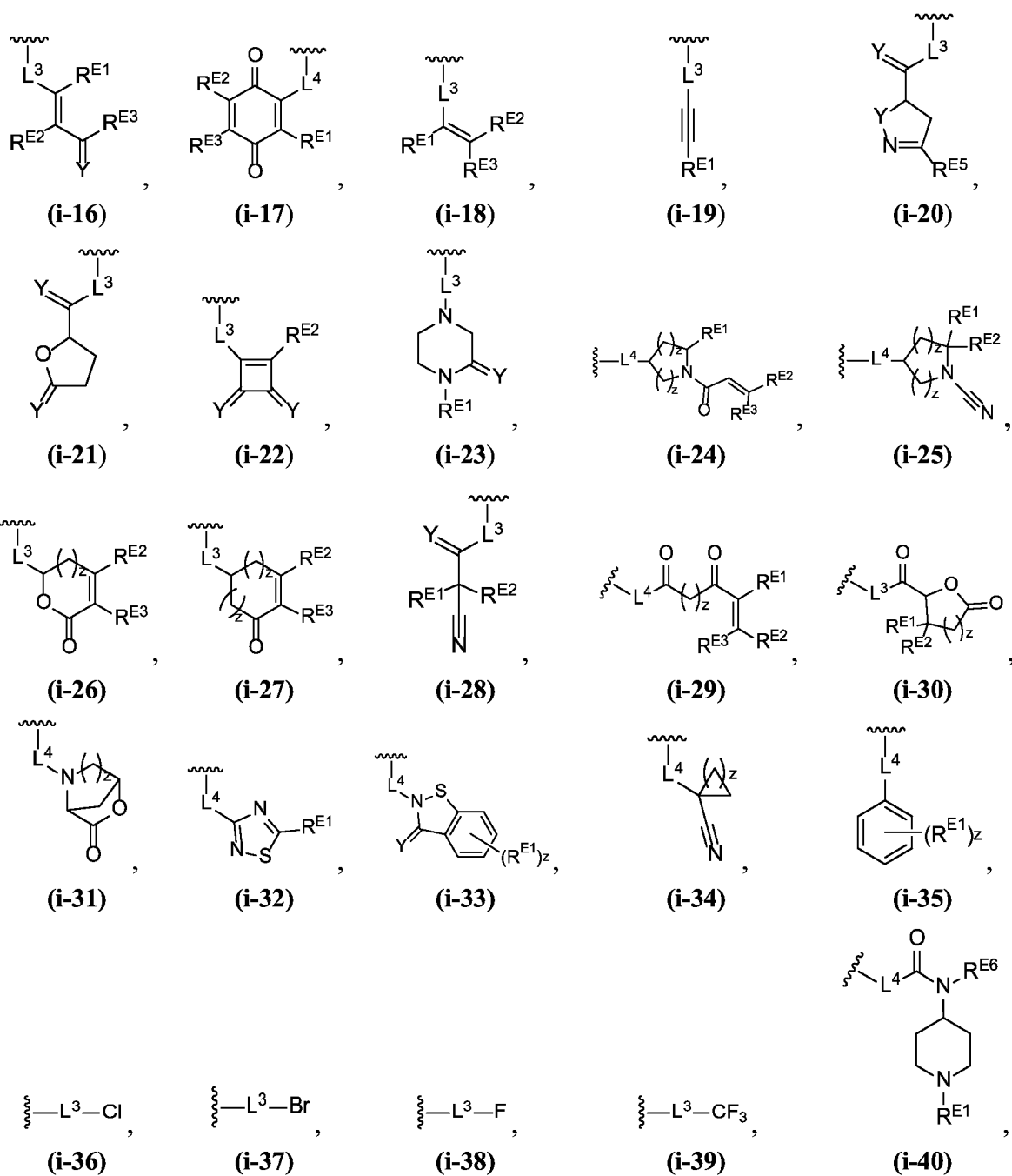


or a pharmaceutically acceptable salt thereof, wherein:

R^1 is optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-\text{NR}^{\text{a}}\text{R}^{\text{b}}$, $-\text{OR}^{\text{b}}$, $-\text{SR}^{\text{b}}$, $-\text{C}(=\text{O})\text{R}^{\text{b}}$, $-\text{C}(=\text{O})\text{OR}^{\text{b}}$, or $-\text{C}(=\text{O})\text{NR}^{\text{a}}\text{R}^{\text{b}}$, wherein each instance of R^{a} and R^{b} is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, or a nitrogen protecting group when attached to

nitrogen, or an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur; or R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring; each of R³ and R⁴ is independently hydrogen, halogen, or optionally substituted C₁-C₆ alkyl; L¹ is a bond, -NR^{L1}-(CH₂)_t-, -O-, or -S-; R^{L1} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group; t is 0 or an integer between 1 and 5, inclusive; Ring A is optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; L² is a bond, optionally substituted C₁₋₄ alkylene, -C(=O)-, -NR^{L2}-, -C(=O)NR^{L2}-, -NR^{L2}C(=O)-, -O-, or -S-, wherein R^{L2} is hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protection group; Ring B is absent, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl; and R² is any of Formulae (i-1)-(i-41):





wherein:

L^3 is a bond or an optionally substituted C_{1-4} hydrocarbon chain, optionally wherein one or more carbon units of the hydrocarbon chain are independently replaced with $-C=O-$, $-O-$, $-S-$, $-NR^{L3a}-$, $-NR^{L3a}C(=O)-$, $-C(=O)NR^{L3a}-$, $-SC(=O)-$, $-C(=O)S-$, $-OC(=O)-$, $-C(=O)O-$, $-NR^{L3a}C(=S)-$, $-C(=S)NR^{L3a}-$, *trans*- $CR^{L3b}=CR^{L3b}-$, *cis*- $CR^{L3b}=CR^{L3b}-$, $-C\equiv C-$, $-S(=O)-$, $-S(=O)O-$, $-OS(=O)-$, $-S(=O)NR^{L3a}-$, $-NR^{L3a}S(=O)-$, $-S(=O)_2-$, $-S(=O)_2O-$, $-OS(=O)_2-$, $-S(=O)_2NR^{L3a}-$, or $-NR^{L3a}S(=O)_2-$, wherein R^{L3a} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group, and wherein each occurrence of R^{L3b} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{L3b} groups are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

L^4 is a bond or an optionally substituted, branched or unbranched C_{1-6} hydrocarbon chain; each of R^{E1} , R^{E2} , and R^{E3} is independently hydrogen, halogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, $-CN$, $-CH_2OR^{EE}$, $-CH_2N(R^{EE})_2$, $-CH_2SR^{EE}$, $-OR^{EE}$, $-N(R^{EE})_2$, $-Si(R^{EE})_3$, and $-SR^{EE}$, wherein each occurrence of R^{EE} is independently hydrogen, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, or optionally substituted heteroaryl, or two R^{EE} groups are joined to form an optionally substituted heterocyclic ring;

or R^{E1} and R^{E3} , or R^{E2} and R^{E3} , or R^{E1} and R^{E2} are joined to form an optionally substituted carbocyclic or optionally substituted heterocyclic ring;

R^{E4} is a leaving group;

R^{E5} is halogen;

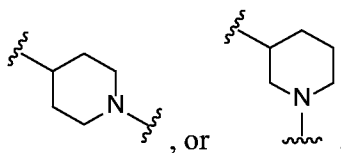
R^{E6} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

each instance of Y is independently O, S, or NR^{E7} , wherein R^{E7} is hydrogen, substituted or unsubstituted C_{1-6} alkyl, or a nitrogen protecting group;

a is 1 or 2; and

each instance of z is independently 0, 1, 2, 3, 4, 5, or 6, as valency permits.

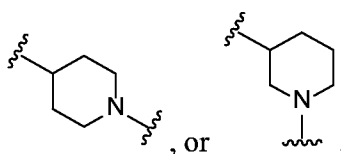
4. The compound of any one of claims 1-3, wherein Ring A comprises an optionally substituted phenyl ring.
5. The compound of any one of claims 1-3, wherein Ring A comprises an optionally substituted cyclohexyl ring.
6. The compound of any one of claims 1-3, wherein Ring A comprises an optionally substituted piperidine ring.
7. The compound of claim 6, wherein Ring A is:



wherein L^1 is attached to the carbon atom, and each carbon atom may, optionally, be further substituted.

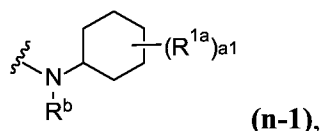
8. The compound any one of claims 1-7, wherein L^1 is $-NR^{L1}-$.
9. The compound any one of claims 1-7, wherein L^1 is $-NH-$.
10. The compound of any one of claims 1-7, wherein L^1 is $-NR^{L1}-(CH_2)_t-$; and t is an integer between 1 and 5, inclusive.
11. The compound of any one of claims 1-7, wherein L^1 is $-NR^{L1}-CH_2-$.
12. The compound of any one of claims 1-7, wherein L^1 is $-NH-CH_2-$.
13. The compound of any one of claims 1-12, wherein L^2 is $-(C=O)-$.
14. The compound of any one of claims 1-12, wherein L^2 is $-NR^{L2}(C=O)-$.
15. The compound of any one of claims 1-12, wherein L^2 is a bond.

16. The compound of any one of claims 1-15, wherein Ring B is absent.
17. The compound of any one of claims 1-15, wherein Ring B is an optionally substituted phenyl ring.
18. The compound of any one of claims 1-15, wherein Ring B is an optionally substituted piperidine ring.
19. The compound of any one of claims 1-15, wherein Ring B is:



wherein in L¹ is attached to the carbon atom, and each carbon atom may, optionally, be further substituted.

20. The compound of any one of claims 1-19, wherein each of R^a and R^b is independently hydrogen or optionally substituted alkyl.
21. The compound of claim 20, wherein R¹ is of Formula (n-1):



wherein:

each instance of R^{1a} is independently hydrogen, halogen, optionally substituted C₁-C₆ alkyl, -N(R^{N1})₂, or -OR^{O1};

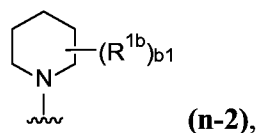
each instance of R^{N1} is independently hydrogen, optionally substituted C₁-C₆ alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C₁-C₆ alkyl, or an oxygen protecting group; and

a₁ is 0 or an integer between 1 and 6, inclusive.

22. The compound of claim 21, wherein a₁ is 1.

23. The compound of claim 22, wherein R^{1a} is optionally substituted C_1 - C_6 alkyl.
24. The compound of claim 23, wherein R^{1a} is substituted C_1 - C_6 alkyl.
25. The compound of claim 24, wherein R^{1a} is hydroxy C_1 - C_6 alkyl.
26. The compound of claim 24, wherein R^{1a} is $-CH_2CH_2OH$
27. The compound of claim 22, wherein R^{1a} is $-N(R^{N1})_2$.
28. The compound of claim 27, wherein R^{1a} is $-NH_2$.
29. The compound of claim 27, wherein R^{1a} is $-N(CH_3)_2$.
30. The compound of claim 20, wherein R^a and R^b are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring.
31. The compound of claim 30, wherein R^1 is of Formula (n-2):

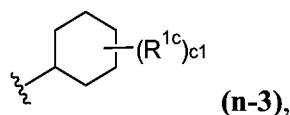


wherein:

- each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;
- each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;
- R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and
- $b1$ is 0 or an integer between 1 and 6, inclusive.

32. The compound of claim 31, wherein $b1$ is 1.
33. The compound of claim 32, wherein R^{1b} is optionally substituted C_1 - C_6 alkyl.

34. The compound of claim 33, wherein R^{1b} is substituted C_1-C_6 alkyl.
35. The compound of claim 34, wherein R^{1b} is hydroxyl C_1-C_6 alkyl.
36. The compound of claim 35, wherein R^{1b} is $-CH_2CH_2OH$
37. The compound of claim 32, wherein R^{1b} is $-N(R^{N1})_2$.
38. The compound of claim 37, wherein R^{1b} is $-NH_2$.
39. The compound of claim 37, wherein R^{1b} is $-N(CH_3)_2$.
40. The compound of any one of claims 1-19, wherein R^1 is of Formula **(n-3)**:



wherein:

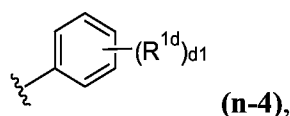
each instance of R^{1c} is independently hydrogen, halogen, optionally substituted C_1-C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1-C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1-C_6 alkyl, or an oxygen protecting group; and

$c1$ is 0 or an integer between 1 and 6, inclusive.

41. The compound of any one of claims 1-19, wherein R^1 is of Formula **(n-4)**:



wherein:

each instance of R^{1d} is independently hydrogen, halogen, $-CN$, $-NO_2$, $-N_3$, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted aryl, optionally substituted heterocyclyl, optionally substituted heteroaryl, $-OR^A$, $-N(R^B)_2$, $-SR^A$, $-C(=O)R^C$, -

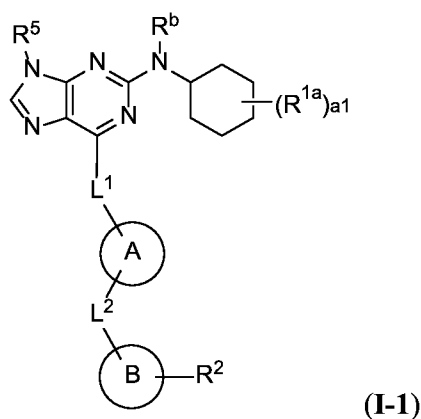
$C(=O)OR^A$, $-OC(=O)R^C$, $-C(=O)N(R^B)_2$, $-NR^B C(=O)R^C$, $-OC(=O)N(R^B)_2$, $-NR^B C(=O)OR^A$, $-NR^B C(=O)N(R^B)_2$, $S(=O)R^C$, $-SO_2R^C$, $-NR^B SO_2R^C$, or $-SO_2N(R^B)_2$;

each instance of R^A is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, an oxygen protecting group when attached to oxygen, or a sulfur protecting group when attached to sulfur;

each instance of R^B is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted acyl, or a nitrogen protecting group, or two R^B groups are taken together with their intervening atoms to form an optionally substituted heterocyclic ring; and

d1 is 0 or an integer between 1 and 5, inclusive.

42. The compound of claim 1, wherein the compound is of Formula (I-1):



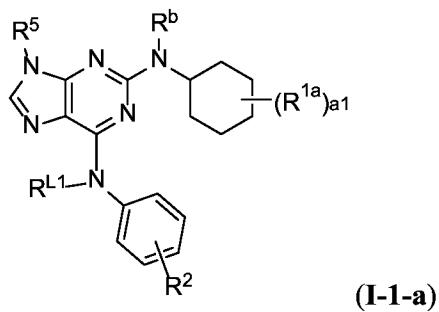
or a pharmaceutically acceptable salt thereof, wherein

each instance of R^{1a} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, $-N(R^{N1})_2$, or $-OR^{O1}$;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

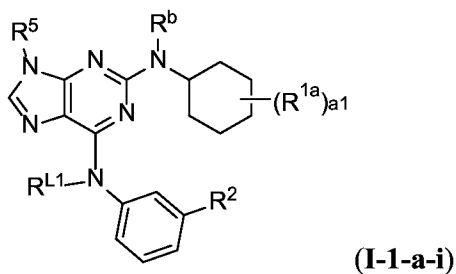
a1 is 0 or an integer between 1 and 6, inclusive.

43. The compound of claim 42, wherein the compound is of Formula (I-1-a):



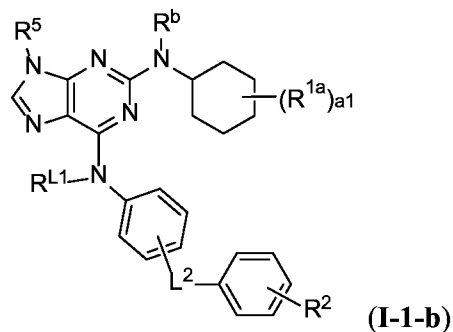
or a pharmaceutically acceptable salt thereof.

44. The compound of claim 42, wherein the compound is of Formula (I-1-a-i):



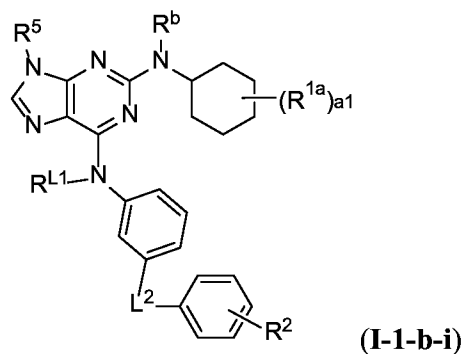
or a pharmaceutically acceptable salt thereof.

45. The compound of claim 42, wherein the compound is of Formula (I-1-b):



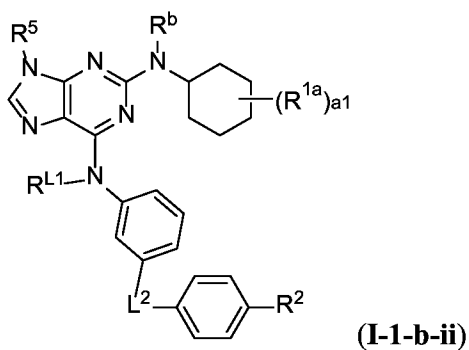
or a pharmaceutically acceptable salt thereof.

46. The compound of claim 45, wherein the compound is of Formula (I-1-b-i):



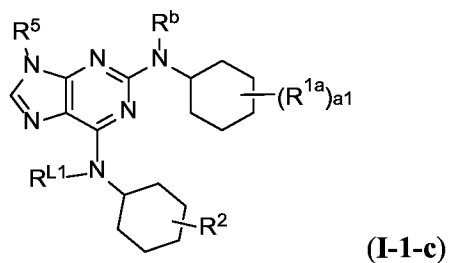
or a pharmaceutically acceptable salt thereof.

47. The compound of claim 45, wherein the compound is of Formula (I-1-b-ii):



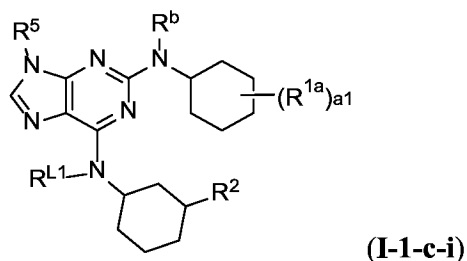
or a pharmaceutically acceptable salt thereof.

48. The compound of claim 52, wherein the compound is of Formula (I-1-c):



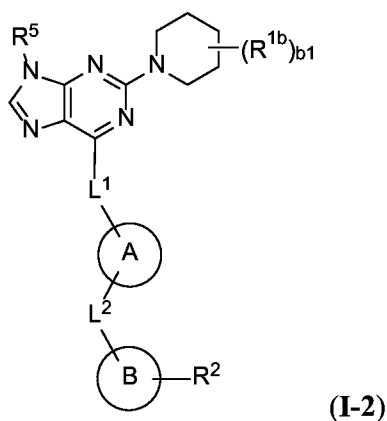
or a pharmaceutically acceptable salt thereof.

49. The compound of claim 47, wherein the compound is of Formula (I-1-c-i):



or a pharmaceutically acceptable salt thereof.

50. The compound of claim 1, wherein the compound is of Formula (I-2):



or a pharmaceutically acceptable salt thereof, wherein:

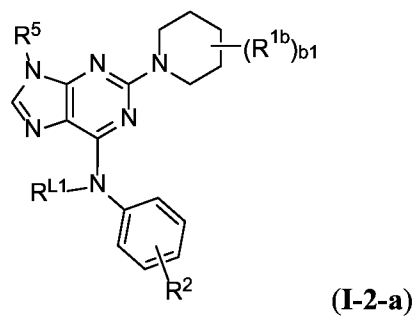
each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, - $N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

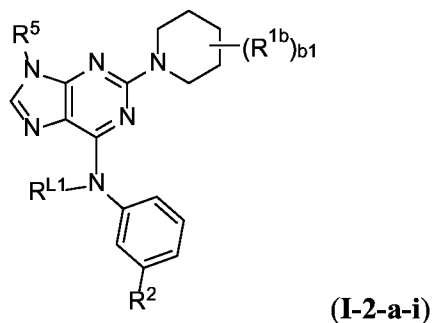
$b1$ is 0 or an integer between 1 and 6, inclusive.

51. The compound of claim 49, wherein the compound is of Formula (I-2-a):



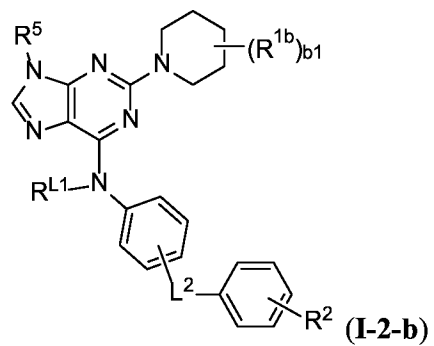
or a pharmaceutically acceptable salt thereof.

52. The compound of claim 49, wherein the compound is of Formula (I-2-a-i):



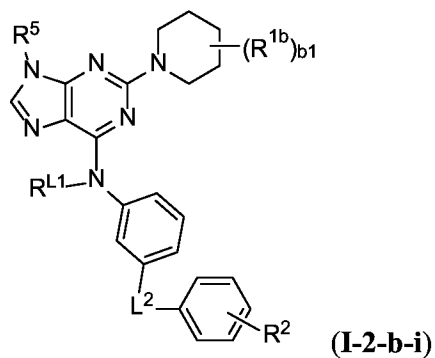
or a pharmaceutically acceptable salt thereof.

53. The compound of claim 49, wherein the compound is of Formula (I-2-b):



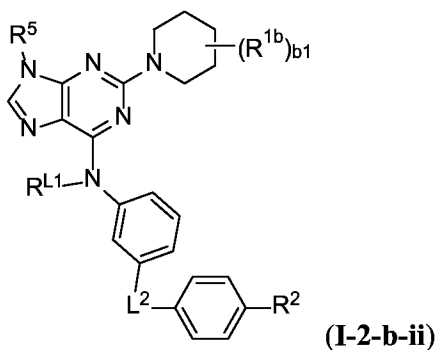
or a pharmaceutically acceptable salt thereof.

54. The compound of claim 53, wherein the compound is of Formula (I-2-b-i):



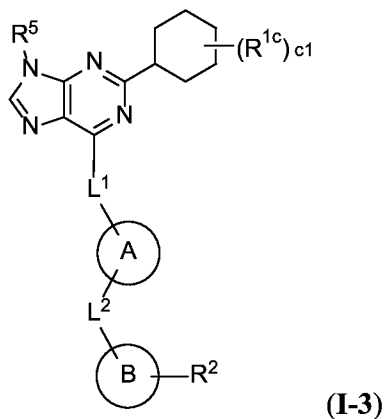
or a pharmaceutically acceptable salt thereof.

55. The compound of claim 53, wherein the compound is of Formula (I-2-b-ii):



or a pharmaceutically acceptable salt thereof.

56. The compound of claim 1, wherein the compound is of Formula (I-3):



or a pharmaceutically acceptable salt thereof, wherein

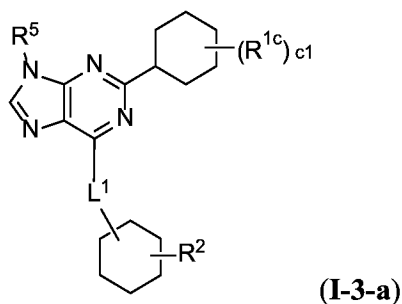
each instance of R^{1c} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, - $N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

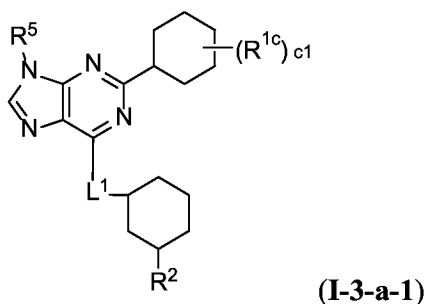
$c1$ is 0 or an integer between 1 and 6, inclusive.

57. The compound of claim 56, wherein the compound is of Formula **(I-3-a)**:



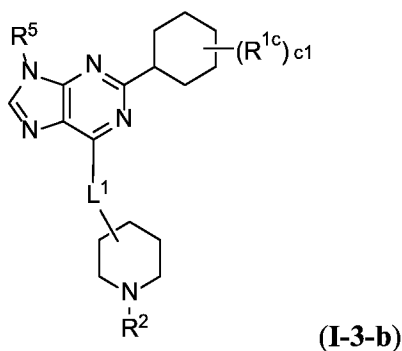
or a pharmaceutically acceptable salt thereof.

58. The compound of claim 56, wherein the compound is of Formula **(I-3-a-1)**:



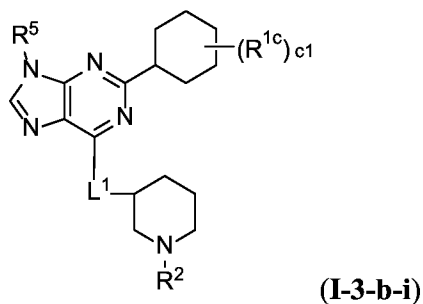
or a pharmaceutically acceptable salt thereof.

59. The compound of claim 56, wherein the compound is of Formula **(I-3-b)**:



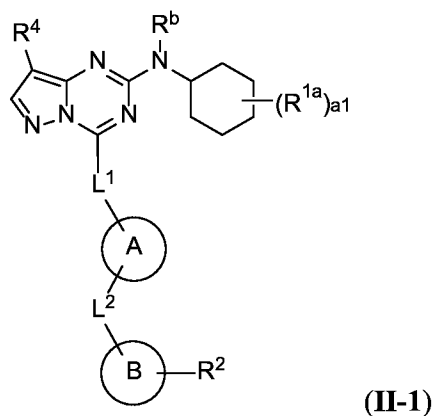
or a pharmaceutically acceptable salt thereof.

60. The compound of claim 56, wherein the compound is of Formula (I-3-b-i):



or a pharmaceutically acceptable salt thereof.

61. The compound of claim 2, wherein the compound is of Formula (II-1):



or a pharmaceutically acceptable salt thereof, wherein:

each instance of R^{1a} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, -

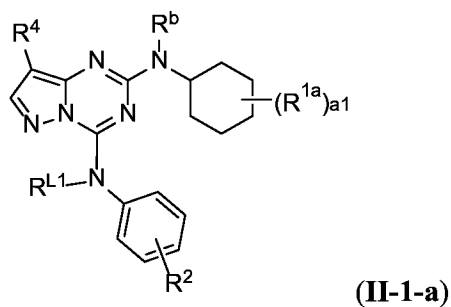
$N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

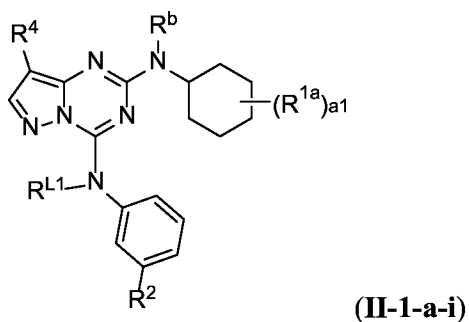
$a1$ is 0 or an integer between 1 and 6, inclusive.

62. The compound of claim 61, wherein the compound is of Formula (II-1-a):



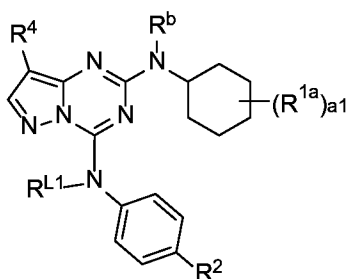
or a pharmaceutically acceptable salt thereof.

63. The compound of claim 61, wherein the compound is of Formula (II-1-a-i):



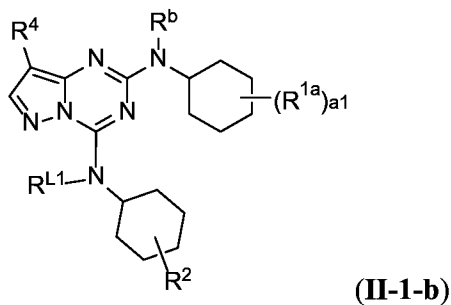
or a pharmaceutically acceptable salt thereof.

64. The compound of claim 61, wherein the compound is of Formula:



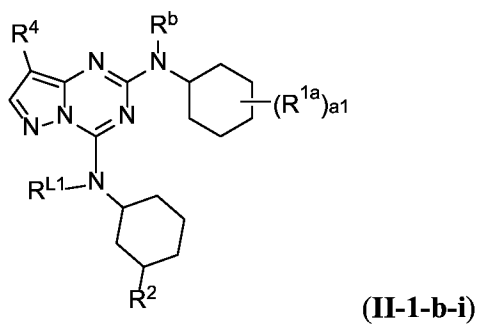
or a pharmaceutically acceptable salt thereof.

65. The compound of claim 61, wherein the compound is of Formula (II-1-b):



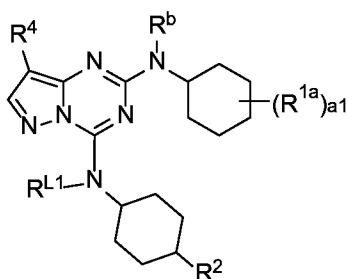
or a pharmaceutically acceptable salt thereof.

66. The compound of claim 61, wherein the compound is of Formula (II-1-b-i):



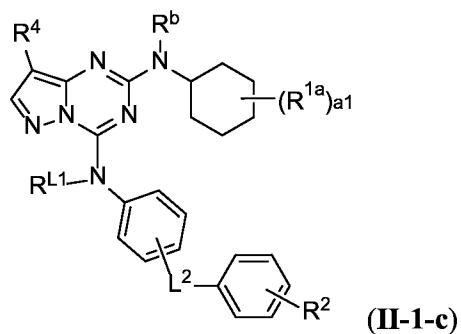
or a pharmaceutically acceptable salt thereof.

67. The compound of claim 61, wherein the compound is of Formula:



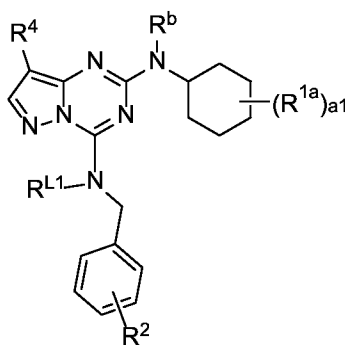
or a pharmaceutically acceptable salt thereof.

68. The compound of claim 61, wherein the compound is of Formula (II-1-c):



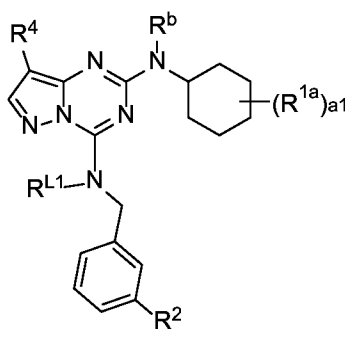
or a pharmaceutically acceptable salt thereof.

69. The compound of claim 61, wherein the compound is of the formula:



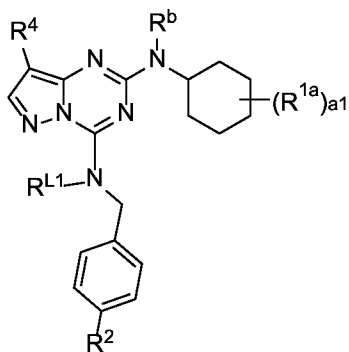
or a pharmaceutically acceptable salt thereof.

70. The compound of claim 61, wherein the compound is of the formula;



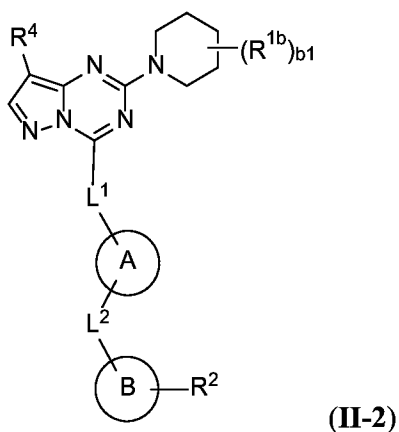
or a pharmaceutically acceptable salt thereof.

71. The compound of claim 61, wherein the compound is of the formula:



or a pharmaceutically acceptable salt thereof.

72. The compound of claim 2, wherein the compound is of Formula (II-2):



or a pharmaceutically acceptable salt thereof, wherein:

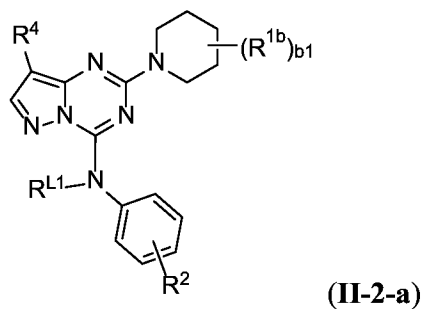
each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, - $N(R^{N1})_2$, or - OR^{O1} ;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

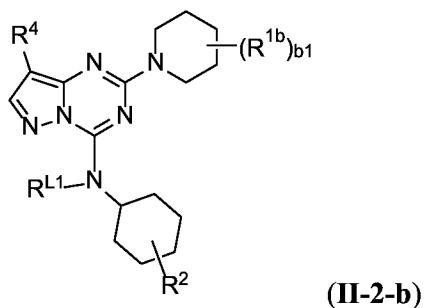
$b1$ is 0 or an integer between 1 and 6, inclusive.

73. The compound of claim 72, wherein the compound is of Formula (II-2-a):



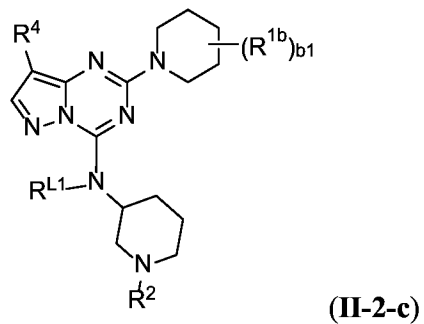
or a pharmaceutically acceptable salt thereof.

74. The compound of claim 72, wherein the compound is of Formula (II-2-b):



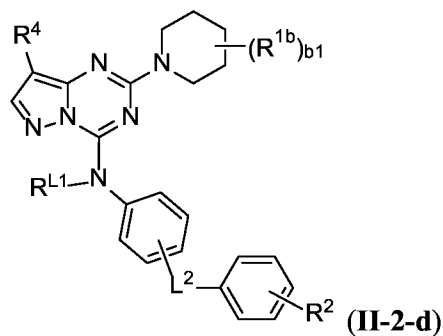
or a pharmaceutically acceptable salt thereof.

75. The compound of claim 72, wherein the compound is of Formula (II-2-c):



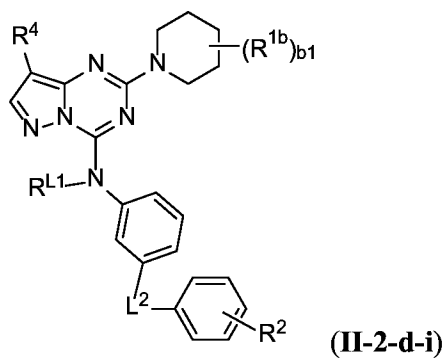
or a pharmaceutically acceptable salt thereof.

76. The compound of claim 72, wherein the compound is of Formula (II-2-d):



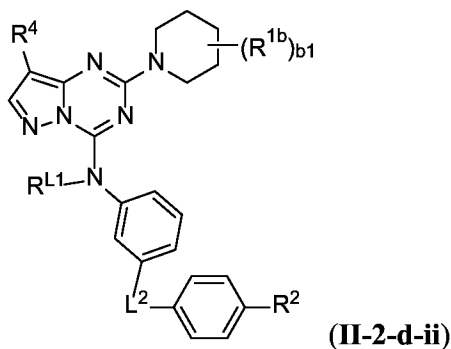
or a pharmaceutically acceptable salt thereof.

77. The compound of claim 76, wherein the compound is of Formula (II-2-d-i):



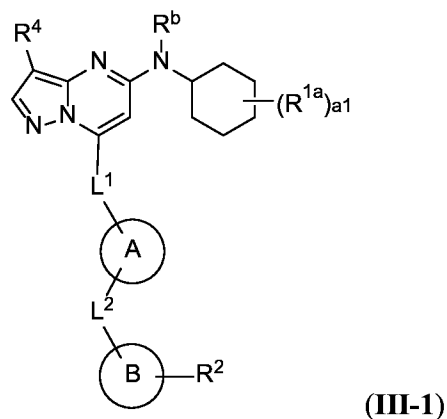
or a pharmaceutically acceptable salt thereof.

78. The compound of claim 76, wherein the compound is of Formula (II-2-d-ii):



or a pharmaceutically acceptable salt thereof.

79. The compound of claim 3, wherein the compound is of Formula (III-1):



or a pharmaceutically acceptable salt thereof, wherein:

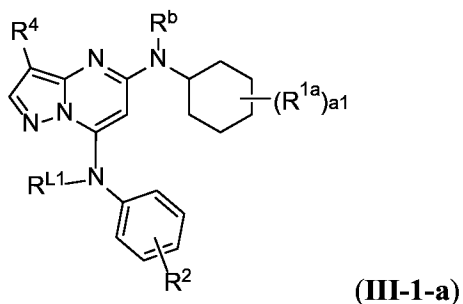
each instance of R^{1a} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, - $N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

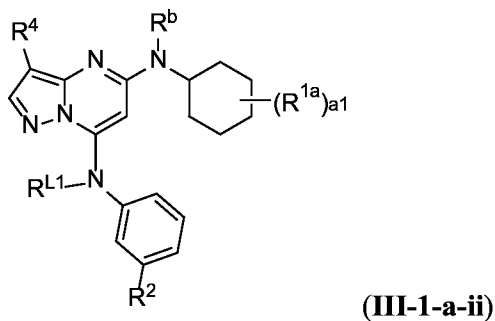
$a1$ is 0 or an integer between 1 and 6, inclusive.

80. The compound of claim 79, wherein the compound is of Formula (III-1-a):



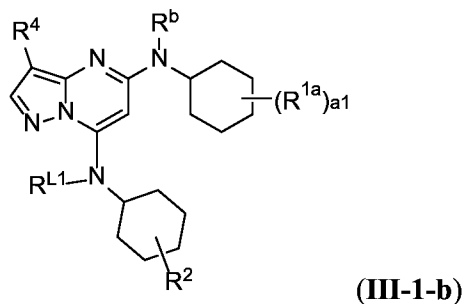
or a pharmaceutically acceptable salt thereof.

81. The compound of claim 79, wherein the compound is of Formula (III-1-a-ii):



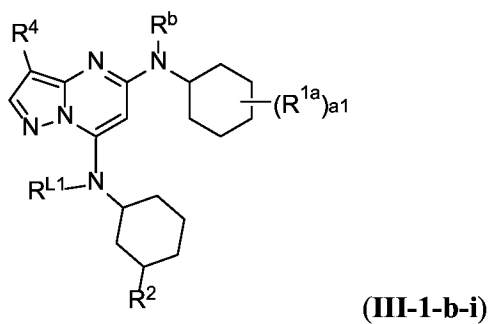
or a pharmaceutically acceptable salt thereof.

82. The compound of claim 79, wherein the compound is of Formula (III-1-b):



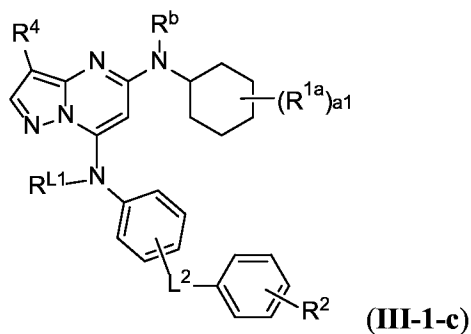
or a pharmaceutically acceptable salt thereof.

83. The compound of claim 79, wherein the compound is of Formula (III-1-b-i):



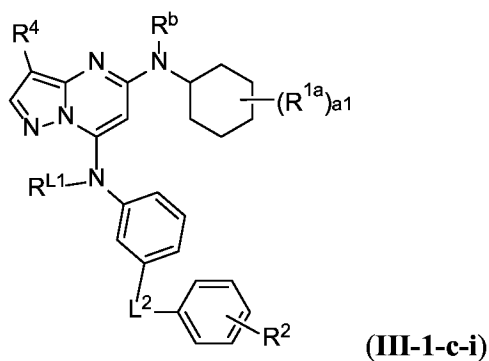
or a pharmaceutically acceptable salt thereof.

84. The compound of claim 79, wherein the compound is of Formula (III-1-c):



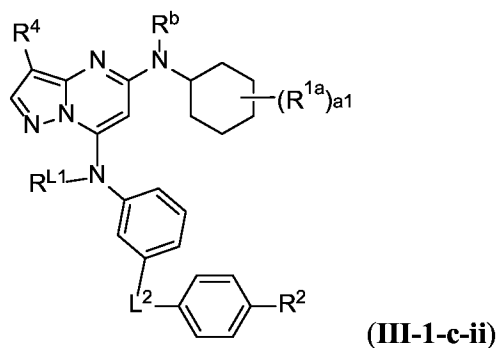
or a pharmaceutically acceptable salt thereof.

85. The compound of claim 79, wherein the compound is of Formula (III-1-c-i):



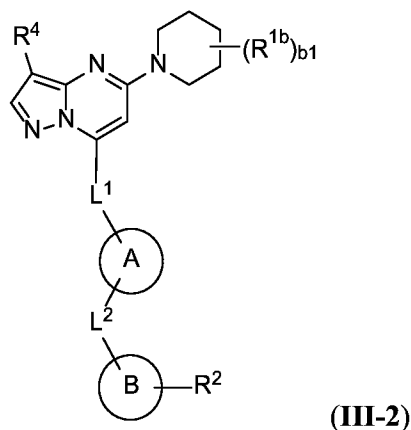
or a pharmaceutically acceptable salt thereof.

86. The compound of claim 79, wherein the compound is of Formula (III-1-c-ii):



or a pharmaceutically acceptable salt thereof.

87. The compound of claim 3, wherein the compound is of Formula (III-2):



or a pharmaceutically acceptable salt thereof, wherein:

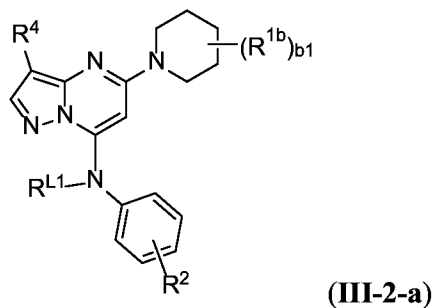
each instance of R^{1b} is independently hydrogen, halogen, optionally substituted C_1 - C_6 alkyl, - $N(R^{N1})_2$, or $-OR^{O1}$;

each instance of R^{N1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or a nitrogen protecting group;

R^{O1} is independently hydrogen, optionally substituted C_1 - C_6 alkyl, or an oxygen protecting group; and

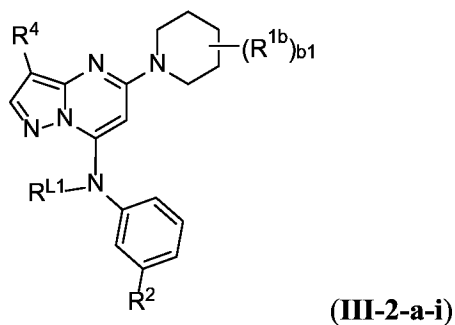
$b1$ is 0 or an integer between 1 and 6, inclusive.

88. The compound of claim 87, wherein the compound is of Formula (III-2-a):



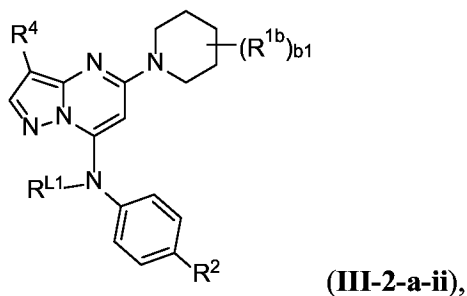
or a pharmaceutically acceptable salt thereof.

89. The compound of claim 87, wherein the compound is of Formula (III-2-a-i):



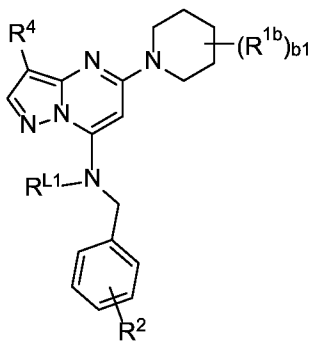
or a pharmaceutically acceptable salt thereof.

90. The compound of claim 87, wherein the compound is of Formula (III-2-a-ii):



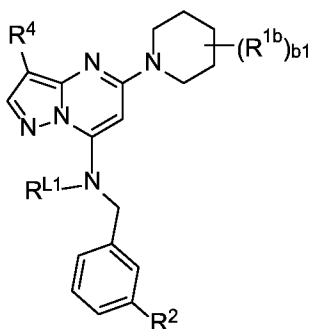
or a pharmaceutically acceptable salt thereof.

91. The compound of claim 87, wherein the compound is of the formula:



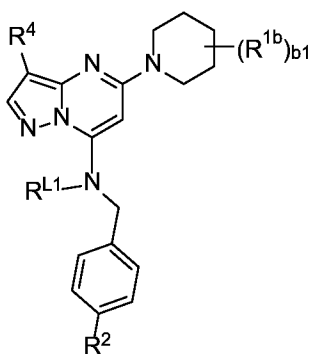
or a pharmaceutically acceptable salt thereof.

92. The compound of claim 87, wherein the compound is of the formula;



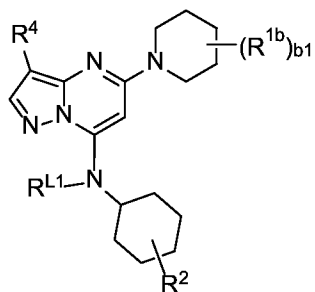
or a pharmaceutically acceptable salt thereof.

93. The compound of claim 87, wherein the compound is of the formula;



or a pharmaceutically acceptable salt thereof.

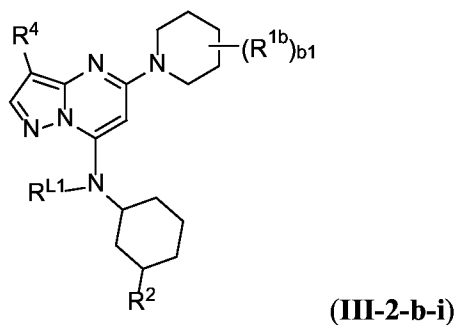
94. The compound of claim 87, wherein the compound is of Formula **(III-2-b)**:



(III-2-b)

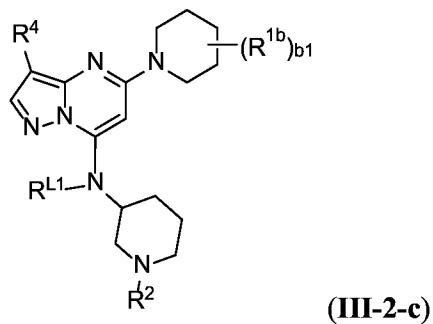
or a pharmaceutically acceptable salt thereof.

95. The compound of claim 87, wherein the compound is of Formula (III-2-b-i):



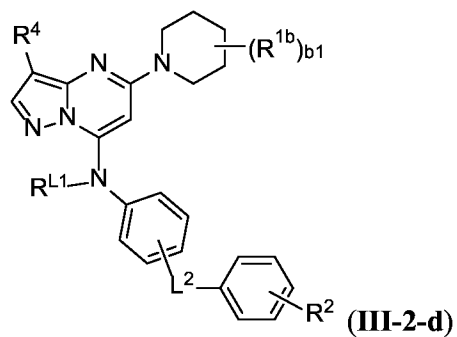
or a pharmaceutically acceptable salt thereof.

96. The compound of claim 87, wherein the compound is of Formula (III-2-c):



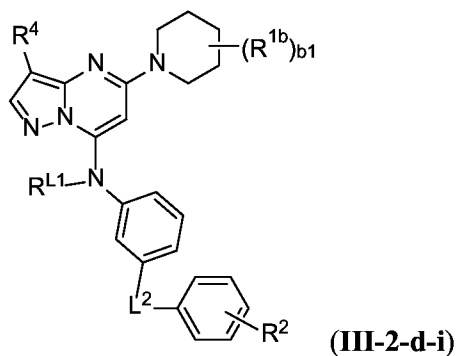
or a pharmaceutically acceptable salt thereof.

97. The compound of claim 87, wherein the compound is of Formula (III-2-d):



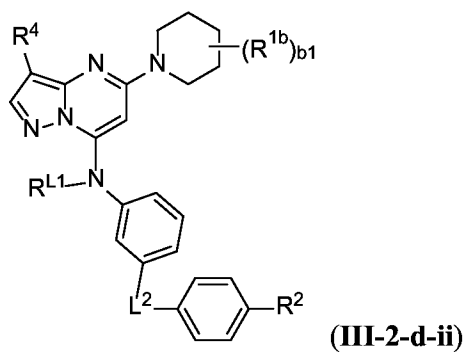
or a pharmaceutically acceptable salt thereof.

98. The compound of claim 87, wherein the compound is of Formula (III-2-d-i):



or a pharmaceutically acceptable salt thereof.

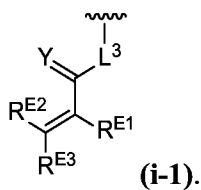
99. The compound of claim 87, wherein the compound is of Formula (III-2-d-ii):



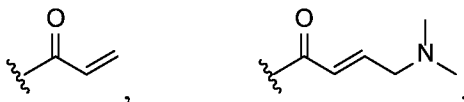
or a pharmaceutically acceptable salt thereof.

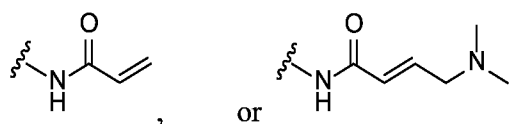
100. The compound of any one of claims 1-99, wherein R² comprises a dimethylamino group.

101. The compound of claim 99, wherein R² is of Formula (i-1):



102. The compound of claim 99, wherein R² is:





103. A compound of any one of the compounds in Tables A1 and A2, and pharmaceutically acceptable salts thereon.
104. A pharmaceutical composition comprising a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, and optionally a pharmaceutically acceptable excipient.
105. The pharmaceutical composition of claim 104, wherein the pharmaceutical composition comprises a therapeutically effective amount of the compound for use in treating a proliferative disease in a subject in need thereof.
106. A method of treating a proliferative disease in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105.
107. The method of claim 106, wherein the subject is a mammal.
108. The method of claim 106, wherein the subject is a human.
109. The method of any of claims 106-108, wherein the proliferative disease is associated with aberrant activities of a cyclin-dependent kinase (CDK).
110. The method of claim 109, wherein the proliferative disease is associated with overexpression of a cyclin-dependent kinase.
111. The method of any one of claims 109-110, wherein the CDK is CDK 7.
112. The method of any one of claims 109-110, wherein the CDK is CDK 12.

113. The method of any one of claims 109-110, wherein the CDK is CDK 13.
114. The method of any of claims 106-108, wherein the proliferative disease is associated with inhibition of apoptosis.
115. The method of any of claims 106-114, wherein the proliferative disease is cancer.
116. The method of claim 115, wherein the proliferative disease is associated with overexpression of a Myc protein.
117. The method of claim 115, wherein the proliferative disease is leukemia.
118. The method of claim 115, wherein the proliferative disease is chronic lymphocytic leukemia (CLL).
119. The method of claim 115, wherein the proliferative disease is acute lymphoblastic leukemia (ALL).
120. The method of claim 115, wherein the proliferative disease is melanoma.
121. The method of claim 115, wherein the proliferative disease is Burkitt's lymphoma.
122. The method of claim 115, wherein the proliferative disease is multiple myeloma.
123. The method of claim 115, wherein the proliferative disease is bone cancer.
124. The method of claim 115, wherein the proliferative disease is colorectal cancer.
125. The method of claim 115, wherein the proliferative disease is osteosarcoma.
126. The method of claim 115, wherein the proliferative disease is breast cancer.

127. The method of claim 115, wherein the proliferative disease is triple-negative breast cancer (TNBC).
128. The method of claim 115, wherein the proliferative disease is Ewing's sarcoma.
129. The method of claim 115, wherein the proliferative disease is brain cancer.
130. The method of claim 115, wherein the proliferative disease is neuroblastoma.
131. The method of claim 115, wherein the proliferative disease is lung cancer.
132. The method of claim 115, wherein the proliferative disease is small cell lung cancer (SCLC).
133. The method of claim 115, wherein the proliferative disease is non-small cell lung cancer (NSCLC).
134. The method of claim 115, wherein the proliferative disease is a benign neoplasm.
135. The method of any one of claims 106-108, wherein the proliferative disease is associated with angiogenesis.
136. The method of any one of claims 106-108, wherein the proliferative disease is an inflammatory disease.
137. The method of any one of claims 106-108, wherein the proliferative disease is rheumatoid arthritis.
138. The method of any one of claims 106-108, wherein the proliferative disease is an autoinflammatory disease.
139. The method of any one of claims 106-108, wherein the proliferative disease is an autoimmune disease.

140. A method of inhibiting the activity of a cyclin-dependent kinase (CDK) in a biological sample or subject, the method comprising administering to the subject or contacting the biological sample with a therapeutically effective amount of a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105.
141. The method of claim 140, wherein the cyclin-dependent kinase is cyclin-dependent kinase 7 (CDK7).
142. The method of claim 140, wherein the cyclin-dependent kinase is cyclin-dependent kinase 12 (CDK12).
143. The method of claim 140, wherein the cyclin-dependent kinase is cyclin-dependent kinase 13 (CDK13).
144. The method of claim 141, wherein the compound is capable of covalently modifying Cys312 of CDK7.
145. The method of claim 142, wherein the compound is capable of covalently modifying Cys1039 of CDK12.
146. The method of claim 143, wherein the compound is capable of covalently modifying Cys1017 of CDK13.
147. A method of inhibiting transcription in a biological sample or subject, the method comprising:
administering to the subject or contacting the biological sample with a therapeutically effective amount of a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105.
148. The method of claim 142, wherein transcription is inhibited for MYC, KLF2, E2F2, CDK6, CCND3, E2F3, HNRPDL, TET1, or IL7R.

149. A method of inhibiting cell growth in a biological sample or subject, the method comprising:

administering to the subject or contacting the biological sample with a therapeutically effective amount of a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105.

150. A method of inducing apoptosis of a cell in a biological sample or subject, the method comprising:

administering to the subject or contacting the biological sample with a therapeutically effective amount of a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105.

151. The method of any of claims 106-150, further comprising administering to the subject a therapeutically effective amount of one or more pharmaceutical agents in combination with the compound, the pharmaceutically acceptable salt thereof, or the pharmaceutical composition.

152. The method of any of claims 106-150, further comprising administering to the subject or contacting the biological sample with a therapeutically effective amount of one or more pharmaceutical agents in combination with the compound, the pharmaceutically acceptable salt thereof, or the pharmaceutical composition.

153. The method of claim 151 or 152, wherein the pharmaceutical agent is an anti-proliferative agent.

154. The method of claim 151 or 152, wherein the pharmaceutical agent is an inhibitor of a cyclin-dependent kinase (CDK).

155. The method of claim 154, wherein the pharmaceutical agent is an inhibitor of a cyclin-dependent kinase 7 (CDK7).

156. The method of claim 154, wherein the pharmaceutical agent is an inhibitor of a cyclin-dependent kinase 12 (CDK12).

157. The method of claim 154, wherein the pharmaceutical agent is an inhibitor of a cyclin-dependent kinase 13 (CDK13).

158. The method of claim 155, wherein the pharmaceutical agent is capable of covalently modifying Cys312 of CDK7.

159. The method of claim 156, wherein the pharmaceutical agent is capable of covalently modifying Cys1039 of CDK12.

160. The method of claim 157, wherein the pharmaceutical agent is capable of covalently modifying Cys1017 of CDK13.

161. A kit comprising:

a compound of any of claims 1-103, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition of any of claims 104 or 105; and

instructions for administering to a subject or contacting a biological sample with the compound, or a pharmaceutically acceptable salt thereof, or the pharmaceutical composition.

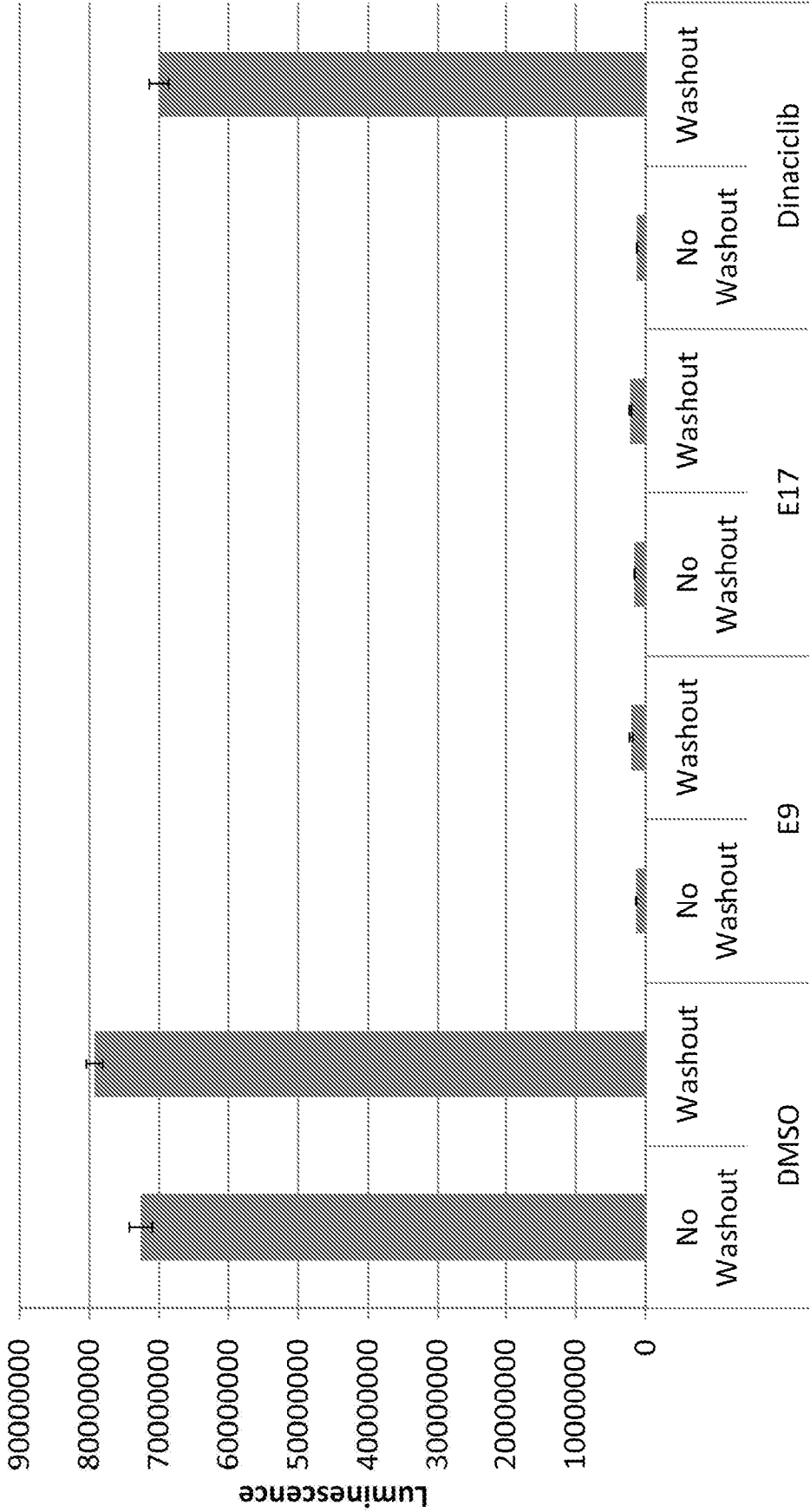


Figure 1

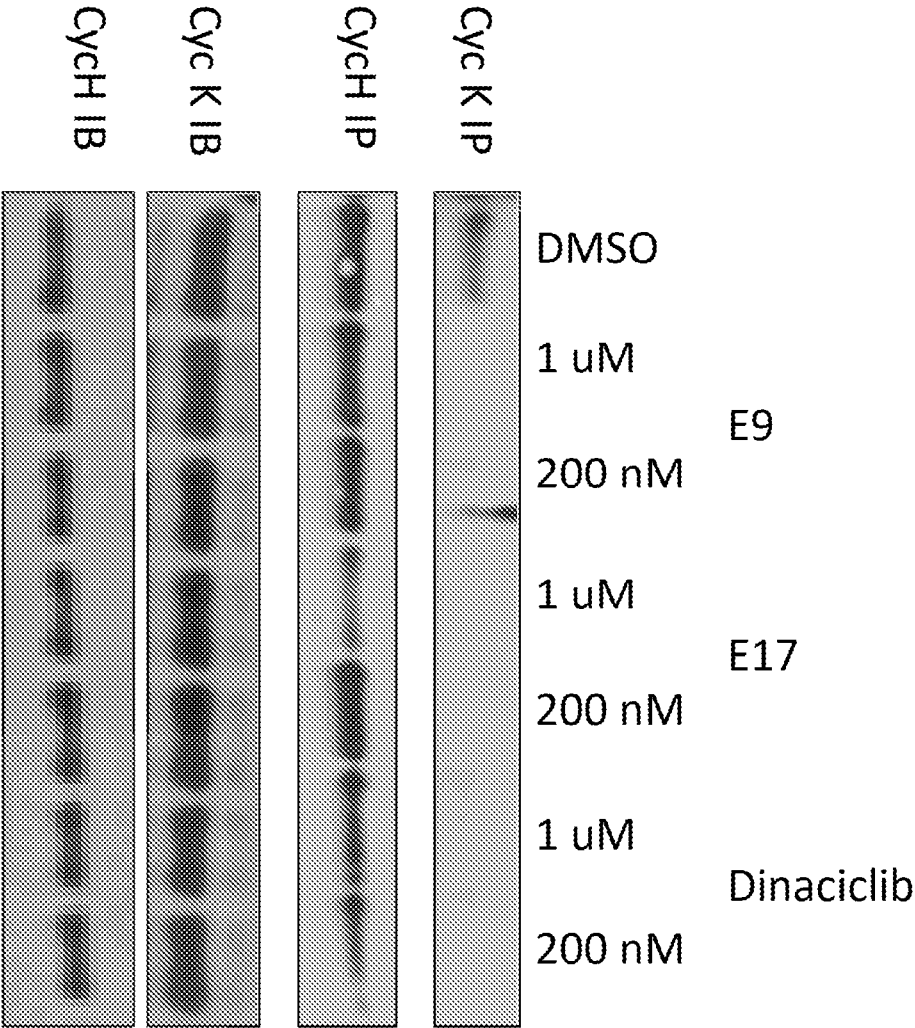


Figure 2

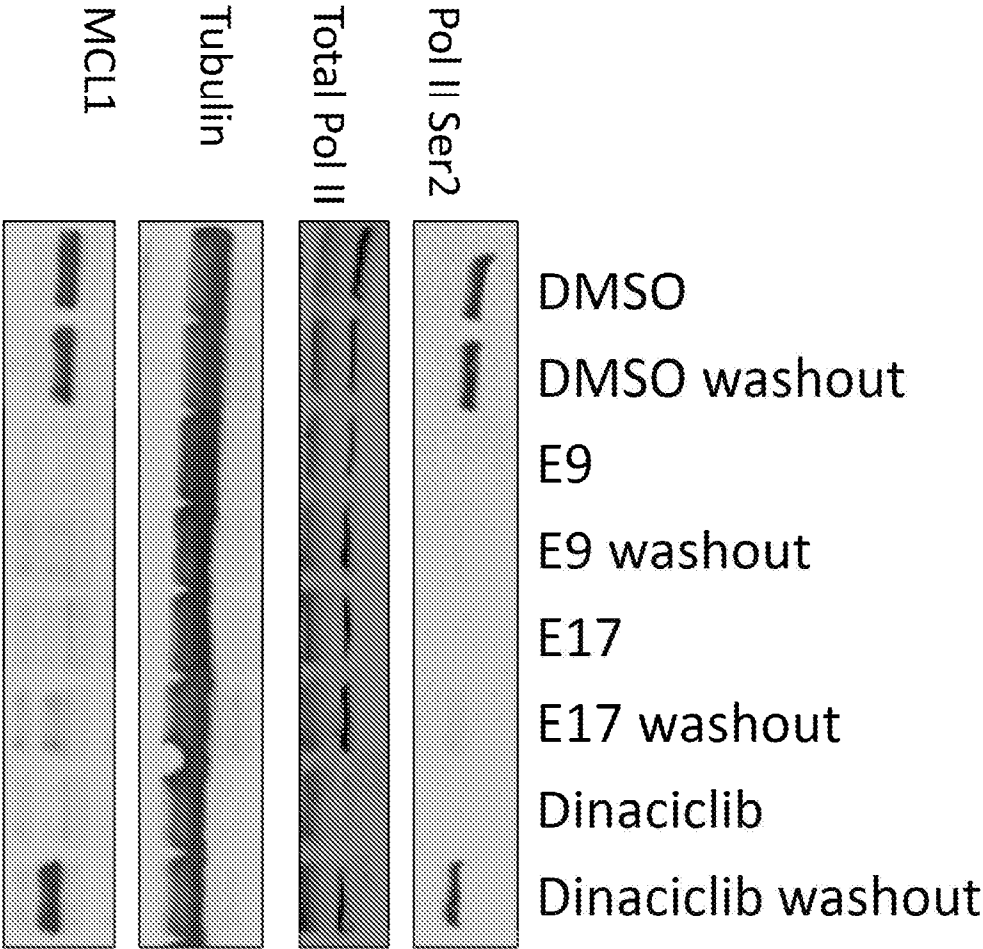


Figure 3

Table 1. Evaluation of Exemplified Compounds in NB cells (IC50 nM)		
	MYCN-amplified	MYCN-nonamplified
	KELLY	SH-SY5Y
SB1-E-23 (E-9)	17.29	42.70
SB1-E-17	24.90	320.11
SB1-E-21	76.31	662.16
SB1-E-26	154.77	525.87
Dinaciclilb	3.85	13.28

Figure 4

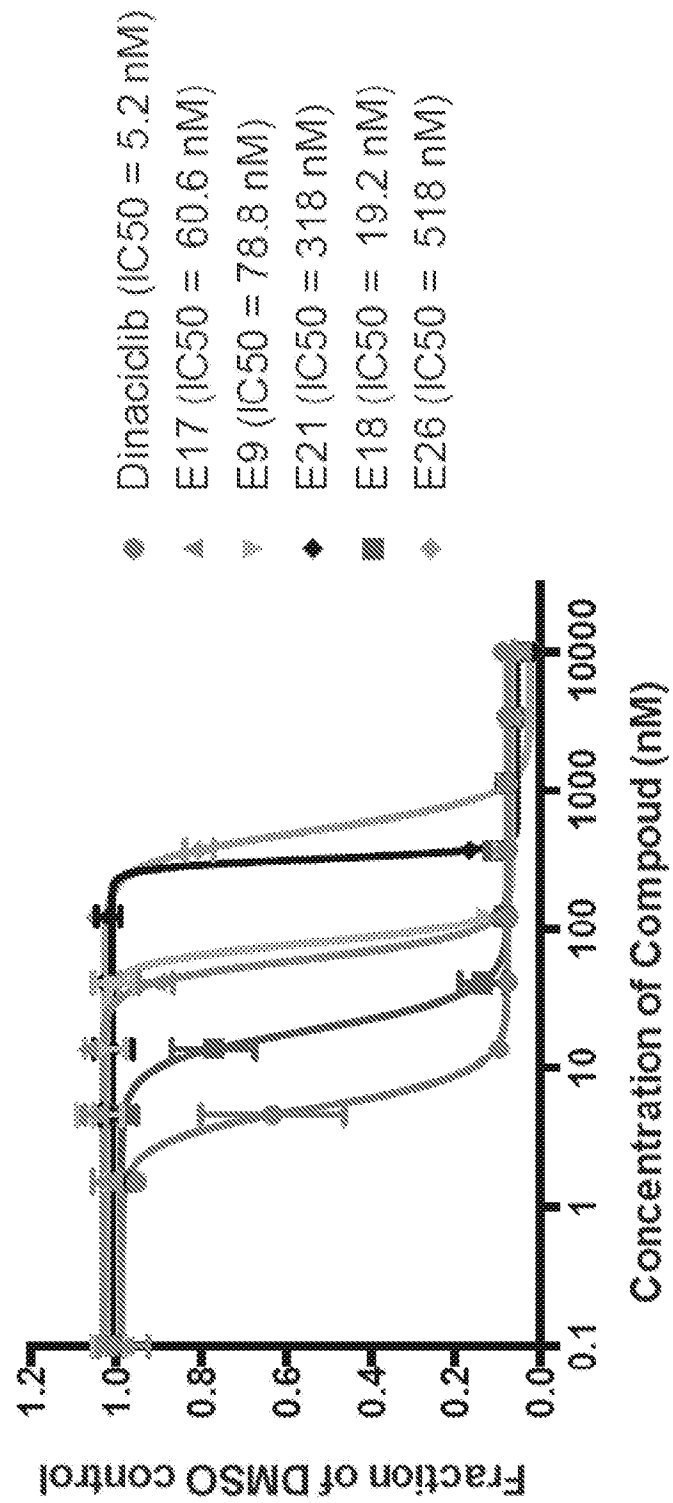


Figure 5

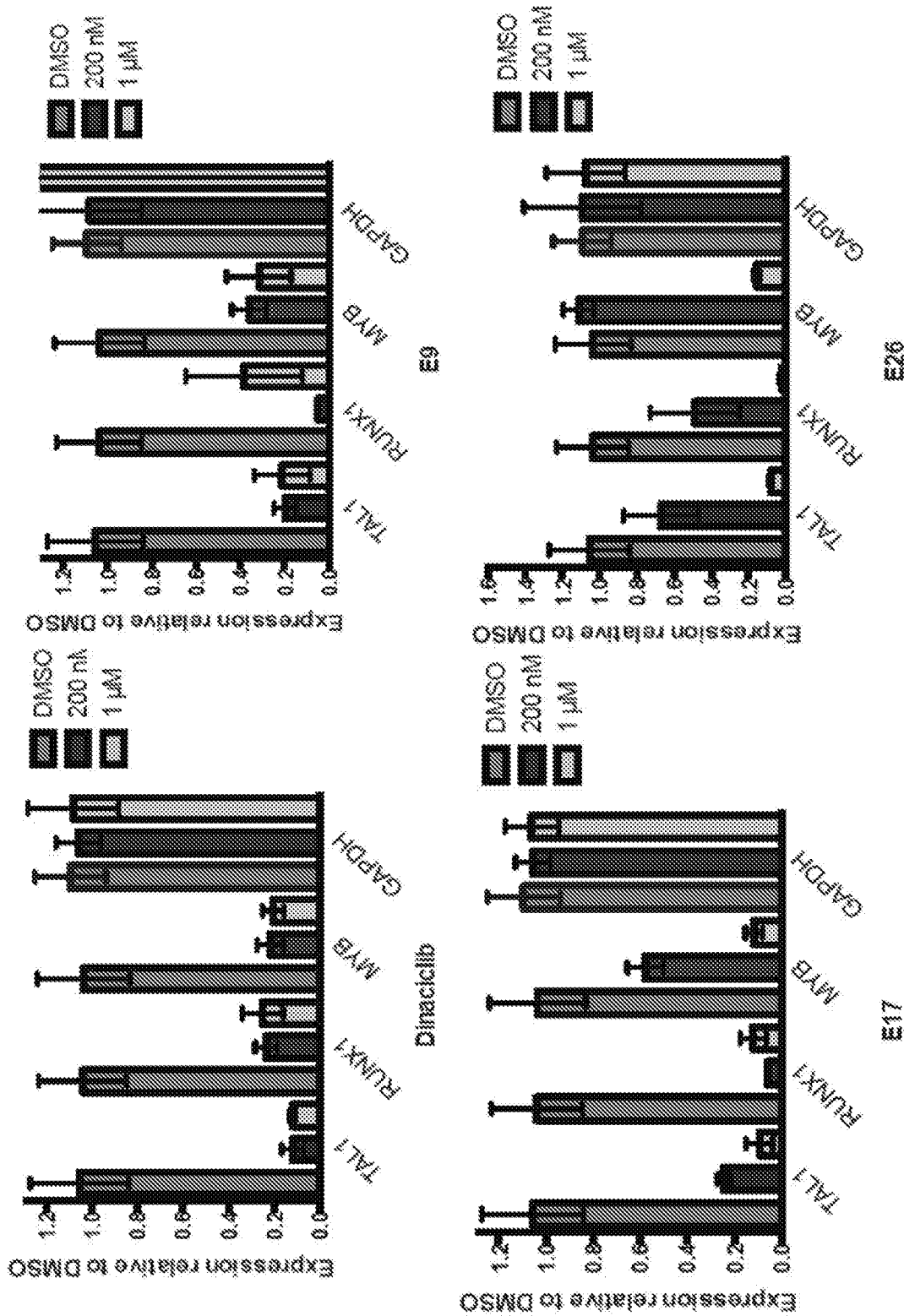


Figure 6

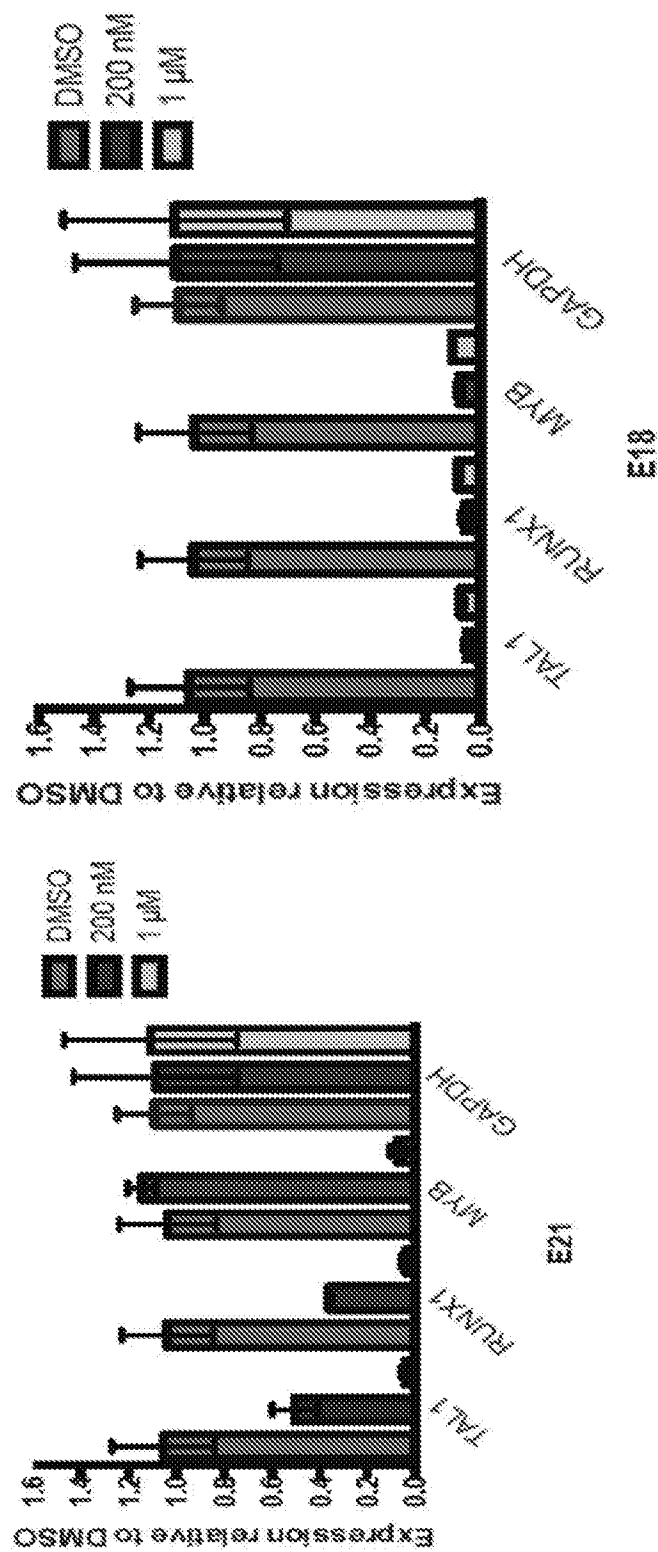
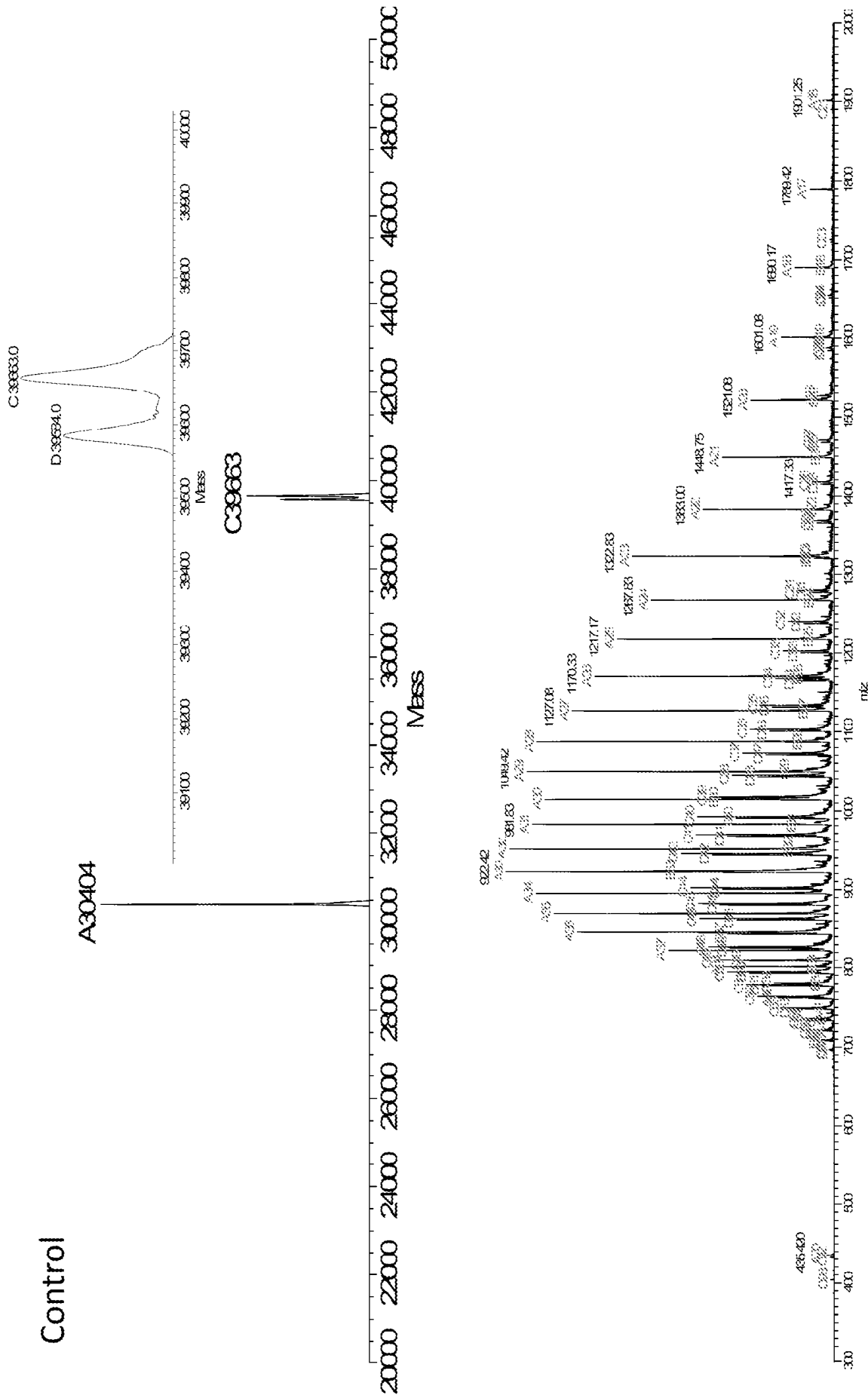


Figure 6 - continued



E-9 5x 1 Hr RT

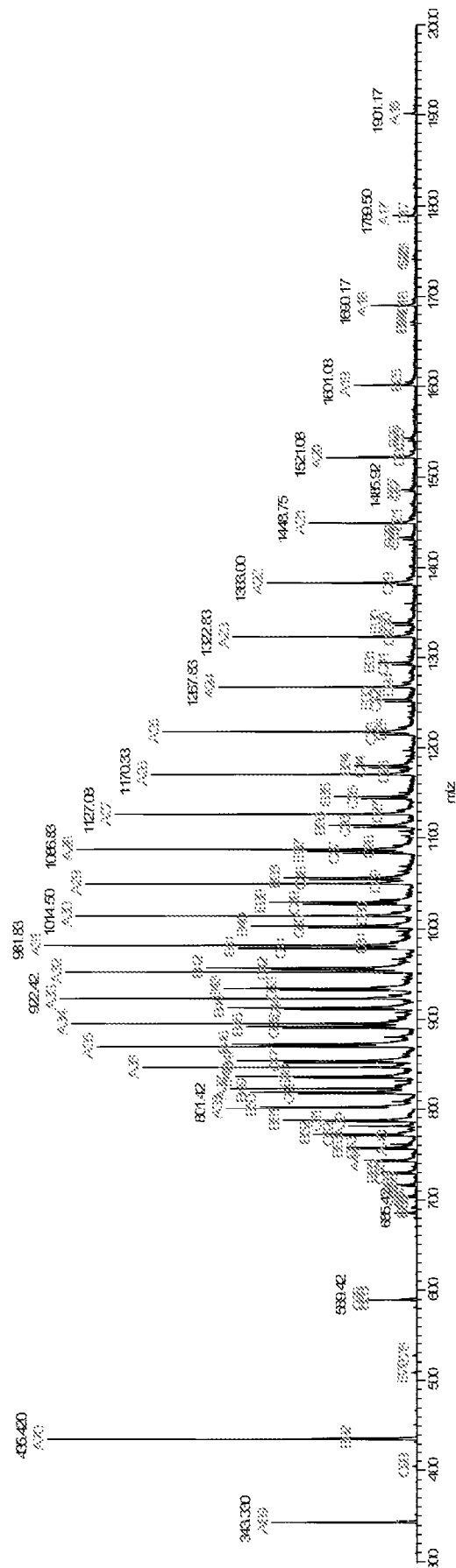
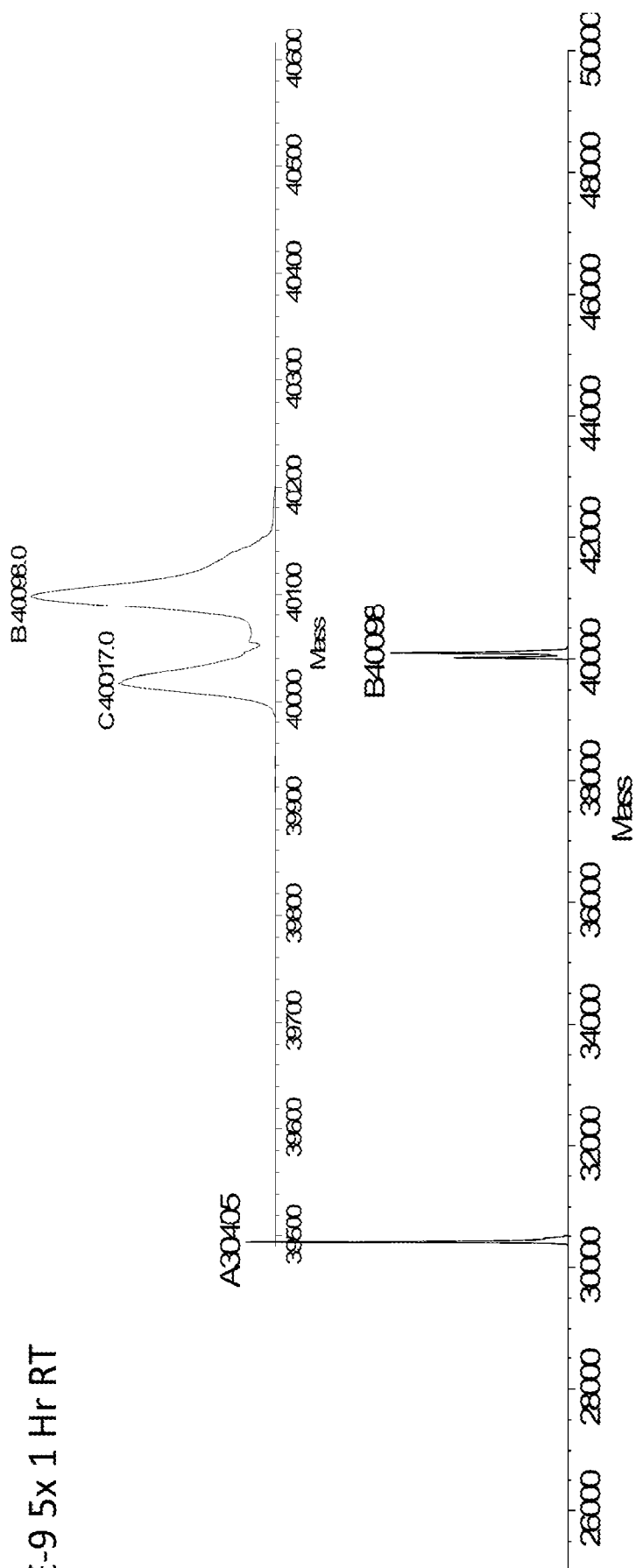


Figure 8

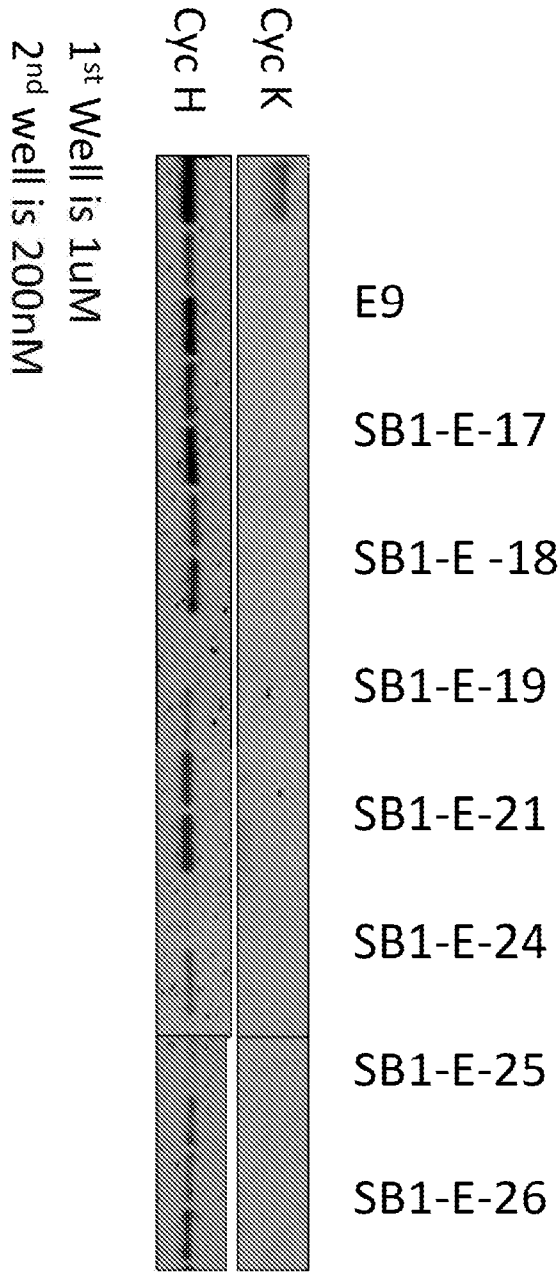


Figure 9

*Table A4. Jurkat cells treated with indicated compounds at 1 μ M.**

Kinase	Reference	Sequence	SEQ ID NO:	Labeling Site	E9 1 μ M
ABL, ARG	UniRef100_P00519, UniRef100_P42684	LMTGDTYTAHAGAKFP IK	1	Activation Loop	-10.4
ABL, ARG	UniRef100_P00519, UniRef100_P42684	YSLTVAVKTLKEDTME VEEFLK	2	Lys1	-15.1
ACK	UniRef100_Q07912	TVSVAVKCLKPDVLSQ PEAMDDFIR	3	Lys1	12
AKT1	UniRef100_P31749	GTFGKVILVK	4	ATP Loop	-14.8
AKT2, AKT3	UniRef100_Q9Y243, UniRef100_P31751	GTFGKVILVR	5	ATP Loop	-20.3
AMPKa1	UniRef100_Q96E92	IGHYILGDTLGVGTFGK VK	6	ATP Loop	-15.2
AMPKa1	UniRef100_Q96E92	VGKHELTGHKVAVKIL NR	7	Lys1	0.9
AMPKa1, AMPKa2	UniRef100_P54646, UniRef100_Q96E92	VAVKILNR	8	Lys1	-12.6
AMPKa1, AMPKa2	UniRef100_P54646, UniRef100_Q96E92	DLKPENVLLDAHMINAK	9	Lys2	4.5
ARAF	UniRef100_P10398	DLKSNNIFLHEGLTVK	10	Lys2	-11.7
ATR	UniRef100_Q13535	FYIMMCKPK	11	ATP	-17.4
AurA	UniRef100_O14965	FILALKVLFK	12	Lys1	51.7
AurA	UniRef100_O14965	DIKPENLLLGSAGELK	13	Lys2	55.7
AurA, AurB, AurC	UniRef100_O14965, UniRef100_Q9UQB9, UniRef100_Q96GD4	GKFGNVYLAR	14	ATP Loop	-11.7
AurB	UniRef100_Q96GD4	SHFIVALKVLFK	15	Lys1	-34.4
BARK1	UniRef100_P25098	DLKPANILLDEHGHVR	16	Lys2	-5.8
BRAF	UniRef100_P15056	DLKSNNIFLHEDLTVK	17	Lys2	-7.4
CaMK1d	UniRef100_Q8IU85	LFAVKCIPK	18	Lys1	-8.1
CaMK1d	UniRef100_Q8IU85	DLKPENLLYYSQDEES K	19	Lys2	-13.4
CaMK2a, CaMK2b, CaMK2d, CaMK2g	UniRef100_Q53H78, UniRef100_Q13557, UniRef100_Q13555, UniRef100_Q9UQM 7	DLKPENLLLASK	20	Lys2	0
CaMK2d	UniRef100_Q13557	IPTGQEYAAKIINTKK	21	Lys1	6
CaMK2g	UniRef100_Q13555	TSTQEYAAKIINTK	22	Lys1	0.3
CaMK4	UniRef100_Q16566	IVEHQVLMKTVCCTPG YCAPEILR	23	Activation Loop	-29.9
CaMK4	UniRef100_Q16566	GTQKPYALKVLK	24	Lys1	-6.7
CaMK4	UniRef100_Q16566	DLKPENLLYATPAPDA PLK	25	Lys2	-43.6

Figure 10

CaMKK2	UniRef100_Q96RR4	LAYNENDNTYYAMKVL SK	26	Lys1	-10.3
CaMKK2	UniRef100_Q96RR4	DIKPSNLLVGEDGHIK	27	Lys2	-9.6
CCRK	UniRef100_Q8IZL9	DLKPANLLISASGQLK	28	Lys2	-6.5
CDC2	UniRef100_Q5H9N4	DLKPQNLLIDDKGTIK	29	Lys2	-12.9
CDC2	UniRef100_Q5H9N4	DLKPQNLLIDDK	30	Lys2	-32.6
CDK10	UniRef100_Q15131	DLKVSNLLMTDK	31	Lys2	18.2
CDK11, CDK8	UniRef100_P49336, UniRef100_Q9BWU 1	DLKPANILVMGEGPER	32	Lys2	-5.7
CDK2	UniRef100_P24941	LTGEVVALKK	33	Lys1	-48.7
CDK2	UniRef100_P24941	DLKPQNLLINTEGAIK	34	Lys2	-29.1
CDK5	UniRef100_Q00535	NRETHEIVALKR	35	Lys1	4.5
CDK5	UniRef100_Q00535	DLKPQNLLINR	36	Lys2	-10.6
CDK6	UniRef100_Q00534	DLKPQNILVTSSGQIK	37	Lys2	-9.4
CDK7	UniRef100_P50613	DKNTNQIVAICK	38	Lys1	17.5
CDK7	UniRef100_P50613	DLKPNNLLLDENGVLK	39	Lys2	5.8
CDK9	UniRef100_P50750	DMKAANVLITR	40	Lys2	27.7
CDK13	UniRef100_Q14004	DIKCSNILLNNR	41	Lys2	77.6
CHK1	UniRef100_B4DT73	DIKPENLLLLDER	42	Lys2	-7.7
CHK1	UniRef100_B4DT73	LSKGDGLEFK	43	Protein Kinase Domain	7.9
CHK2	UniRef100_O96017	VAIKIISK	44	Lys1	-18.2
CHK2	UniRef100_O96017	DLKPENVLLSSQEEDC LIK	45	Lys2	-6
CK1a	UniRef100_P48729	DIKPDNFLMGIGR	46	Lys2	10.8
CK1d, CK1e	UniRef100_P49674, UniRef100_P48730	DVKPDNFLMGLGKK	47	Lys2	27.3
CK1g2	UniRef100_P78368	DVKPENFLVGRPGTK	48	Lys2	13.6
CK2a1	UniRef100_P68400	GGPNIITLADIVKDPVS R	49	Protein Kinase Domain	-31.5
CK2a2	UniRef100_P19784	DVKPHNVMIDHQKQK	50	Lys2	-3
CLK1	UniRef100_P49759	LTHTDLKPENILFVQSD YTEAYNPK	51	Lys2	54.2
CLK3	UniRef100_P49761	YEIVGNLGEFTGKVV ECLDHAR	52	ATP Loop	16.1
CDK12	UniRef100_Q9NYV4	DIKCSNILLNNSGQIK	53	Lys2	81.7
CSK	UniRef100_P41240	VSDFGTLKEASSTQDT GKLPVK	54	Activation Loop	-0.9
CSK	UniRef100_P41240	VAVKCIK	55	Lys1	-7.6
DGKA	UniRef100_P23743	IDPVPNTHPLLVFVNPK SGGK	56	ATP	-37.4
DGKH	UniRef100_Q86XP1	ATFSFCVSPLLVFVNS KSGDNQGVK	57	ATP	-18
DNAPK	UniRef100_P78527	KGGSWIQEINVAEK	58	ATP	-1.9
DNAPK	UniRef100_P78527	EHPFLVKGGEDLR	59	ATP	-21.7

Figure 10 (continued)

DRAK1	UniRef100_Q9UEE5	DVVHLDLKPQNILLTSE SPLGDIK	60	Lys2	17.9
eEF2K	UniRef100_O00418	YIKYNSNSGFVR	61	ATP	8.8
EphB2	UniRef100_P29323	FLEDDTSDPTYTSALG GKIPIR	62	Activation Loop	-23.4
Erk1	UniRef100_P27361	DLKPSNLLINTTCDLK	63	Lys2	-1.7
Erk2	UniRef100_P28482	DLKPSNLLLNTTCDLK	64	Lys2	-2.3
Erk5	UniRef100_Q13164	DLKPSNLLVNENCELK	65	Lys2	0.2
FAK	UniRef100_Q05397	CIGEGQFGDVHQGIYM SPENPALAVAIKTKC QEDGGVYSSSGLKQIP IK	66	Lys1	-13.5
FER	UniRef100_P16591	TSVAVKTCKEDLPOEL K	67	Activation Loop	-2.2
FER	UniRef100_P16591	LIKDDEYNPCQGSKFPI K	68	Lys1	0.2
FGR	UniRef100_P09769	IQSIAPSLQVITSKQRP R	69	Activation Loop	-6.6
FRAP	UniRef100_P42345	VAIKTLKPGTMSPEFL EEAQIMK	70	ATP	-15.5
FYN	UniRef100_P06241	QGAKFPIKWTAPAAAL YGR	71	Lys1	-21.6
FYN, SRC, YES	UniRef100_P12931, UniRef100_P07947, UniRef100_P06241		72	Activation Loop	5.8
GCK	UniRef100_Q12851	DTVTSELA AVKIVK	73	Lys1	-6
GCK	UniRef100_Q12851	DIKGANLLLLTLQGDVK	74	Lys2	-1.4
GCN2	UniRef100_Q9P2K8	LDGCCYAVKR	75	Lys1	-1.8
GCN2	UniRef100_Q9P2K8	DLKPVNIFLDSDDHVK	76	Lys2	6.4
GPRK5	UniRef100_P34947	DLKPENILLDDYGHIR	77	Lys2	17.9
GPRK6	UniRef100_P43250	DLKPENILLDDHGHIR	78	Lys2	16.3
GSK3A	UniRef100_P49840	DIKPQNLLVD ³ DTAVL K	79	Lys2	6.6
GSK3B	UniRef100_P49841	DIKPQNLLLD ³ DTAVLK	80	Lys2	8
HPK1	UniRef100_Q92918	DKVSGDLVALKMKV	81	Lys1	21.3
HPK1	UniRef100_Q92918	DIKGANILINDAGEVR	82	Lys2	10.7
IKKa	UniRef100_O15111	DLKPENIVLQDVGGK	83	Lys2	18.7
IKKb	UniRef100_O14920	WHNQETGEQIAIKQCR	84	Lys1	14.3
IKKb	UniRef100_O14920	DLKPENIVLQQGEQR	85	Lys2	16.9
IKKe	UniRef100_Q14164	SGELVAVKVFNTTSYL RPR	86	Lys1	-22.4
IKKe, TBK1	UniRef100_Q14164, UniRef100_Q9UHD2	DIKPGNIMR	87	Lys2	-26.9
ILK	UniRef100_Q13418	WQGNDIVVKVLK	88	Lys1	-22.3
ILK	UniRef100_Q13418	ISMADVKF ³ FCPGR	89	Protein Kinase Domain	-16.4
IRAK1	UniRef100_P51617	AIQFLHQD ³ SPSLIHGDI KSSNVLLDEF	90	Lys2	-1.3

Figure 10 (continued)

IRAK4	UniRef100_Q9NWZ3	GYVNNTTVAVKK	91	Lys1	-30.1
IRAK4	UniRef100_Q9NWZ3	DIKSANILLDEAFTAK	92	Lys2	-10.8
IRE1	UniRef100_O75460	DLKPHNILISMPNAHG K	93	Lys2	2.4
ITK	UniRef100_Q08881	FVLDDQYTSSTGTGKFP VK	94	Activation Loop	18.9
ITK	UniRef100_Q08881	VAIKTIR	95	Lys1	16.8
ITPK1	UniRef100_Q13572	ESIFFNSHNVSKPESS SVLTELDKIEGVFERPS DEVIR	96	ATP	-55
JAK1 domain1	UniRef100_P23458	QLASALSYLEDKDLVH GNVCTKNLLAR	97	Protein Kinase Domain	26.5
JAK1 domain2	UniRef100_P23458	IGDFGLTKAIETDKEYY TVK	98	Activation Loop	35.2
JAK1 domain2	UniRef100_P23458	YDPEGDNTGEQVAVK SLKPESGGNHIADLKK	99	Lys1	38.3
JNK1, JNK2, JNK3	UniRef100_P45983, UniRef100_P53779, UniRef100_P45984	DLKPSNIVVK	100	Lys2	-3.6
JNK2	UniRef100_P45984	YQQLKPIGSGAQGIVC AAFDTVLGINVAVKK	101	Lys1	-15.3
KHS1	UniRef100_Q9Y4K4	NVHTGELAAVKIIK	102	Lys1	-2
KHS1	UniRef100_Q9Y4K4	DIKGANILLTDHGDVK	103	Lys2	4.8
KHS2	UniRef100_Q8IVH8	NVNTGELAAIKVIK	104	Lys1	8.9
LATS1	UniRef100_O95835	ALYATKTLR	105	Lys1	7.2
LATS1	UniRef100_O95835	DIKPDNIIIDR	106	Lys2	3.5
LATS2	UniRef100_Q9NRM7	DIKPDNIIIDLDGHIK	107	Lys2	11.7
LCK	UniRef100_P06239	EGAKFPIKWTAPAIN YGTFTIK	108	Activation Loop	5.6
LKB1	UniRef100_Q15831	DIKPGNLLLTGGTLK	109	Lys2	2.6
LOK	UniRef100_O94804	NKETGALAAAKVIETK	110	Lys1	11.4
LOK	UniRef100_O94804	DLKAGNVLMTLEGDIR	111	Lys2	4.3
MAP2K1	UniRef100_Q02750	IMHRDVKPSNIVNSR	112	Lys2	-17.5
MAP2K1, MAP2K2	UniRef100_P36507, UniRef100_Q02750	DVKPSNIVNSR	113	Lys2	-2.4
MAP2K2	UniRef100_P36507	HQIMHRDVKPSNIVN SR	114	Lys2	2.7
MAP2K3	UniRef100_P46734	HAQSGTIMAVKR	115	Lys1	9.6
MAP2K3	UniRef100_P46734	DVKPSNVLINK	116	Lys2	26.7
MAP2K4	UniRef100_P45985	MVHKPSGQIMAVKR	117	Lys1	17.9
MAP2K4	UniRef100_P45985	DIKPSNILLDR	118	Lys2	10.2
MAP2K5	UniRef100_Q13163	DVKPSNMLVNTR	119	Lys2	8
MAP2K6	UniRef100_P52564	HVPSGQIMAVKR	120	Lys1	9.4
MAP2K6	UniRef100_P52564	DVKPSNVLINALGQVK	121	Lys2	-7.8
MAP2K7	UniRef100_O14733	DVKPSNILLDER	122	Lys2	-0.4

Figure 10 (continued)

MAP3K1	UniRef100_Q13233	DVKGANLLIDSTGQR	123	Lys2	-6.9
MAP3K15, MAP3K5, MAP3K6	UniRef100_Q99683, UniRef100_Q95382, UniRef100_Q6ZN16	IAIKEIPER	124	Lys1	12.5
MAP3K2	UniRef100_Q9Y2U5	ELAVKQVQFDPDSPET SKEVNALECEIQLLK	125	Lys1	8.8
MAP3K2, MAP3K3	UniRef100_Q9Y2U5, UniRef100_Q99759	DIKGANILR	126	Lys2	11.7
MAP3K3	UniRef100_Q99759	ELASKQVQFDPDSPET SKEVSALECEIQLLK	127	Lys1	5.6
MAP3K4	UniRef100_Q9Y6R4	DIKGANIFLTSSGLIK	128	Lys2	-3.9
MAP3K5	UniRef100_Q99683	DIKGDNLVINTYSGVLK	129	Lys2	13.5
MAPKAPK 3	UniRef100_Q16644	QVLGLGVNGKVLECF HR	130	ATP Loop	-9.5
MAPKAPK 3	UniRef100_Q16644	CALKLLYDSPK	131	Lys1	0.4
MARK1, MARK2	UniRef100_Q7KZI7, UniRef100_Q9P0L2	EVAVKIIDK	132	Lys1	11.7
MARK2	UniRef100_Q7KZI7	EVAVKIIDKTQLNSSL QK	133	Lys1	16.4
MARK2	UniRef100_Q7KZI7	FIVHRDLKAENLLLDAD MNIK	134	Lys2	17.4
MARK2, MARK3	UniRef100_P27448, UniRef100_Q7KZI7	DLKAENLLLDADMNIK EVAIKIIDKTQLNPTSLO K	135	Lys2	14.4
MARK3	UniRef100_P27448		136	Lys1	15
MARK3, MARK4	UniRef100_Q96L34, UniRef100_P27448	EVAIKIIDK	137	Lys1	12.6
MARK4	UniRef100_Q96L34	EVAIKIIDKTQLNPSSL QK	138	Lys1	-6
MARK4	UniRef100_Q96L34	DLKAENLLLDAAENIK	139	Lys2	3.5
MAST3	UniRef100_Q60307	DLKPDNLLITSLGHIK	140	Lys2	0.7
MASTL	UniRef100_Q96GX5	GAFGKVYLQK	141	ATP Loop	-7
MASTL	UniRef100_Q96GX5	LYAVKVVK	142	Lys1	-6.2
MLK1	UniRef100_P80192	DLKSSNILILQK	143	Lys2	-4.6
MLK2	UniRef100_Q02779	DLKSINILILEAIENHNL ADTVLK	144	Lys2	0.5
MLK3	UniRef100_Q16584	GELVAVKAAR	145	Lys1	-20.3
MLK3	UniRef100_Q16584	DLKSNNILLLOPIESDD MEHK	146	Lys2	7.4
MLKL	UniRef100_Q8NB16	APVAIKVFK	147	Lys1	-25.9
MPSK1	UniRef100_Q75716	LGEGGFSYVDLVEGLH DGHFYALKR	148	Lys1	5.8
MPSK1	UniRef100_Q75716	DLKPTNILLGDEGQPV LMDLGSMNQACIHVE GSR	149	Lys2	6.8
MSK1	UniRef100_Q75582	DIKLENILLDSNGHVVL	150	Lys2	27.4

Figure 10 (continued)

domain1		TDFGLSK			
MSK2 domain1	UniRef100_O75676	DLKLENVLLDSEGHIVL TDFGLSK	151	Lys2	-21.6
MST1	UniRef100_Q13043	ETGQIVAIKQVPVESDL QEIIK	152	Lys1	-1.6
MST1, MST2	UniRef100_Q13188, UniRef100_Q13043	DIKAGNILLNTEGHAK	153	Lys2	-0.4
MST2	UniRef100_Q13188	ESGQVVAIKQVPVESD LQEIIK	154	Lys1	-7.1
MST3	UniRef100_Q9Y6E0	VVAIKIIDLEEADEIEDI QQEITVLSQCDSPYVT K	155	Lys1	-0.1
MST3	UniRef100_Q9Y6E0	DIKAANVLLSEHGEVK	156	Lys2	12.3
MST4	UniRef100_Q9P289	TQQVVAIKIIDLEEAED EIEDIQEITVLSQCDS SYVTK	157	Lys1	-21.2
MST4, YSK1	UniRef100_O00506, UniRef100_Q9P289	DIKAANVLLSEQGDVK	158	Lys2	5.9
NDR1	UniRef100_Q15208	DTGHVYAMKILR	159	Lys1	4.4
NDR1	UniRef100_Q15208	DIKPDNLLLDISK	160	Lys2	2.8
NDR2	UniRef100_Q9Y2H1	DTGHIYAMKILR	161	Lys1	7.2
NDR2	UniRef100_Q9Y2H1	DIKPDNLLLDIAK	162	Lys2	-8.4
NEK1	UniRef100_Q96PY6	DIKSQNIFLTK	163	Lys2	-11.6
NEK3	UniRef100_P51956	SKNIFLTQNGK	164	Activation Loop	7.7
NEK4	UniRef100_P51957	DLKTQNVFLTR	165	Lys2	36.8
NEK6, NEK7	UniRef100_Q8TDX7, UniRef100_Q9HC98	DIKPANVFITATGVVK	166	Lys2	-9.9
NEK7	UniRef100_Q8TDX7	AACLLDGVVPVALLK	167	Lys1	-0.5
NEK8	UniRef100_Q86SG6	DLKTQNIILLDK	168	Lys2	-1.9
NEK9	UniRef100_Q8TD19	RTEDDSLIVVWKEVDLT R	169	Lys1	-23.5
NEK9	UniRef100_Q8TD19	DIKTLNIFLTK	170	Lys2	-33.2
NLK	UniRef100_Q9UBE8	DIKPGNLLVNSNCVLK	171	Lys2	14.3
OSR1	UniRef100_C9JIG9, UniRef100_Q95747	DVKAGNILLGEDGSVQ IADFGVSAFLATGGDIT R	172	Lys2	4.6
p38a	UniRef100_Q16539	DLKPSNLA VNEDCELK	173	Lys2	-15.9
p38a	UniRef100_Q16539	QELNKTIWEVPER	174	Protein Kinase Domain	6.5
p38b	UniRef100_Q15759	QELNKTVWEVPQR	175	Protein Kinase Domain	1.4
p38d, p38g	UniRef100_O15264, UniRef100_P53778	DLKPGNLAVNEDCELK	176	Lys2	-32.6
p70S6K	UniRef100_P23443	DLKPENIMLNHQGHVK	177	Lys2	6.5
p70S6K, p70S6Kb	UniRef100_Q9UBS0 , UniRef100_P23443	GGYGKVFQVR	178	ATP Loop	-9.6

Figure 10 (continued)

p70S6Kb	UniRef100_Q9UBS0	DLKPENIMLSQGHK	179	Lys2	-15.2
PAK2	UniRef100_Q13177	IGQGASGTVFTATDVA LGQEVAIKQINLQK	180	Lys1	-125.8
PAN3	UniRef100_Q58A45	VMDPTKILITGK	181	ATP	-8.1
PCTAIRE 1	UniRef100_Q00536	SKLTDNLVALKEIR	182	Lys1	-11.9
PCTAIRE 1, PCTAIRE 3	UniRef100_Q00536, UniRef100_Q07002	DLKPQNLLINER	183	Lys2	-8.6
PCTAIRE 2	UniRef100_Q00537	DLKPQNLLINEK	184	Lys2	10.4
PCTAIRE 2, PCTAIRE 3	UniRef100_Q00537, UniRef100_Q07002	SKLTENLVALKEIR	185	Lys1	14
PDK1	UniRef100_Q15530	EYAIKILEK	186	Lys1	6.8
PEK	UniRef100_Q9NZJ5	DLKPSNIFFTMDDVVK	187	Lys2	4.8
PHKg2	UniRef100_P15735	ATGHEFAVKIMEVTAE R	188	Lys1	15.8
PI4KA, PI4KAP2	UniRef100_A4QPH2 , UniRef100_P42356	SGTPMQSAAKAPYLA K	189	ATP	-23
PI4KB	UniRef100_Q9UBF8	VPHTQAVVLNSKDK	190	ATP	6.6
PI4KB	UniRef100_Q9UBF8	LLSVIVKCGDDLQCELL AFQVLK	191	ATP	-2.8
PIK3C2B	UniRef100_Q00750	VIFKCGDDLQDMLTL QMIR	192	ATP	-18
PIK3C3	UniRef100_Q8NEB9	TEDGGKYPVIFKHGDD LRQDQLILQIISLMDK	193	ATP	-27.6
PIK3C3	UniRef100_Q8NEB9	TEDGGKYPVIFKHGDD LR	194	ATP	-29.8
PIK3CA	UniRef100_P42336	RPLWLNWENPDIMSE LLFQNNIEIFKNGDDL RQDMLTLQIIR	195	ATP	-89.1
PIK3CB	UniRef100_P42338	VFGEDSVGVIFKNGDD LRQDMLTLQMLR	196	ATP	-25
PIK3CD	UniRef100_Q00329	TKVNWLAHNVS ^K DNRR Q	197	ATP	-0.2
PIK3CD	UniRef100_Q00329	VNWL ^A HNVS ^K DNRRQ	198	ATP	-9.6
PIK3CG	UniRef100_P48736	KKPLWLEFK	199	ATP	0.9
PIP4K2A	UniRef100_P48426	AKELPTLKDNDFINEG QK	200	ATP	-20.4
PIP4K2B	UniRef100_P78356	AKDLPTFKDNDFLNEG QK	201	ATP	-1.5
PIP4K2C	UniRef100_Q8TBX8	VKELPTLKDMDFLNK	202	ATP	9.1
PIP4K2C	UniRef100_Q8TBX8	TLVIKEVSSEDIADMHS NLSNYHQYIVK	203	ATP	-4.7
PIP5K3	UniRef100_Q9Y217	GGKSGAAFYATEDDDR FILK	204	ATP	21.8

Figure 10 (continued)

PITSLRE	UniRef100_P21127	DLKTSNLLLSHAGILK	205	Lys2	11.4
PKCa	UniRef100_P17252	KGTEELYAIKILK	206	Lys1	8.2
PKCa, PKCb	UniRef100_P05771, UniRef100_P17252	DLKLDNVMLDSEGHK	207	Lys2	-42.8
PKCh	UniRef100_P24723	VKETGDLYAVKVLK	208	Lys1	-25.5
PKCi	UniRef100_P41743	IYAMKVVK	209	Lys1	-29.6
PKCi	UniRef100_P41743	DLKLDNVLLDSEGHK	210	Lys2	2.6
PKD1, PKD2	UniRef100_Q9BZL6, UniRef100_Q15139	NIVHCDLKPENVLLAS ADPFQVK	211	Lys2	-1.8
PKD2	UniRef100_Q9BZL6	DVAVKVIDK	212	Lys1	-7.6
PKD3	UniRef100_O94806	DVAIKVIDK	213	Lys1	13.9
PKD3	UniRef100_O94806	NIVHCDLKPENVLLAS AEPFQVK	214	Lys2	-5.8
PKN1	UniRef100_Q16512	VLLSEFRPSGELFAIK LK	215	Lys1	33.7
PKN1	UniRef100_Q16512	DLKLDNLLLDTEGYVK	216	Lys2	-2.1
PKN2	UniRef100_Q16513	DLKLDNLLLDTEGFVK	217	Lys2	-3.9
PKR	UniRef100_P19525	IGDFGLVTSKNDGKR	218	Activation Loop	-2.2
PKR	UniRef100_P19525	DLKPSNIFLVDTK	219	Lys2	-9.4
PLK1	UniRef100_P53350	CFEISDADTKEVFAGKI VPK	220	Lys1	60.4
PLK1	UniRef100_P53350	DLKLGNLFLNEDLEVK	221	Lys2	58.8
PRP4	UniRef100_Q13523	CNHLHADIKPDNILLVNE SK	222	Lys2	14.5
PRP4	UniRef100_Q13523	AAGIGKDFKENPNLR	223	Protein Kinase Domain	16.9
PRPK	UniRef100_Q96S44	FLSGLELVKQGAEAR	224	ATP Loop	33.3
PYK2	UniRef100_Q14289	YIEDEYYKASVTR	225	Activation Loop	-33.3
QSK	UniRef100_Q9Y2K2	VAIKIIDKTQLDEENLKK	226	Lys1	8.6
RAF1	UniRef100_P04049	DMKSNNIFLHEGLTVK	227	Lys2	-4.7
ROCK1, ROCK2	UniRef100_Q75116, UniRef100_Q13464	DVKPDNMLLDK	228	Lys2	-3.9
RSK1 domain1	UniRef100_Q15418	LTDFGLSKEAIDHEKK	229	Activation Loop	0
RSK1 domain1	UniRef100_Q15418	KVTRPDSGHLAMKVL K	230	Lys1	-3
RSK1 domain1, RSK2 domain1, RSK3 domain1	UniRef100_P51812, UniRef100_Q15418, UniRef100_Q15349	DLKPENILLDEEGHIK	231	Lys2	5.2
RSK1 domain2	UniRef100_Q15418	DLKPSNIFYVDESGNP ECLR	232	Lys2	-10.4
RSK2 domain1	UniRef100_P51812	VLGQGSFGKVFLVK	233	ATP Loop	-18.6
RSK2	UniRef100_P51812	LTDFGLSKESIDHEKK	234	Activation Loop	5.8

Figure 10 (continued)

domain1					
RSK2 domain2	UniRef100_P51812	DLKPSNILYVDESGNP ESIR	235	Lys2	-13.8
RSKL1	UniRef100_Q96S38	VLGVIDKVLLVMDTR	236	ATP	0.8
SGK3	UniRef100_Q96BR1	FYAVKVLQK	237	Lys1	5.5
SGK3	UniRef100_Q96BR1	IVYRDLKPENILLDSVG HVVLTDFGLCK	238	Lys2	33.7
SLK	UniRef100_Q9H2G2	AQNKETSVLAAAKVID TK	239	Lys1	11
SLK	UniRef100_Q9H2G2	DLKAGNILFTLDGDIK	240	Lys2	11.3
SMG1	UniRef100_Q96Q15	DTVTIHSVGGTITILPTK TKPK	241	ATP	-1.5
SMG1	UniRef100_Q96Q15	SYPYLFKGLEDLHLDE R	242	ATP	-46.5
SNRK	UniRef100_Q9NRH2	VAVKVIDK	243	Lys1	3.6
SNRK	UniRef100_Q9NRH2	DLKPENVVFFEK	244	Lys2	1
SRPK1	UniRef100_Q96SB4	IIHTDIKPENILLSVNEQ YIR	245	Lys2	-5.8
SRPK1, SRPK2	UniRef100_P78362, UniRef100_Q96SB4	FVAMKVVK	246	Lys1	-18.5
STLK3	UniRef100_Q9UEW 8	DLKAGNILLGEDGSVQI ADFGVSAFLATGGDVT R	247	Lys2	15.8
STLK5	UniRef100_Q7RTN6	YSVKVLPWLSPEVLQQ NLQGYDAK	248	Activation Loop	-18.6
STLK5	UniRef100_Q7RTN6	SVKASHILISVDGK HTPTGTLVTIKITNLEN	249	Lys2	-6.5
STLK6	UniRef100_Q9C0K7	CNEER	250	Lys1	-7.3
STLK6	UniRef100_Q9C0K7	SIKASHILISGDGLVTL GLSHLHSLVK	251	Lys2	5.9
TAK1	UniRef100_Q43318	DLKPPNLLL VAGGTVL K	252	Lys2	-21.5
TAO1, TAO3	UniRef100_Q7L7X3, UniRef100_Q9H2K8	DIKAGNILLTEPGQVK	253	Lys2	11.1
TAO2	UniRef100_Q9UL54	DVKAGNILLSEPLVK	254	Lys2	1.6
TBK1	UniRef100_Q9UHD2	TGDLFAIKVFNNISFLR PVDVQMR	255	Lys1	-20.3
TLK1	UniRef100_Q9UKI8	YAAVKIHQLNK	256	Lys1	4.8
TLK1	UniRef100_Q9UKI8	YLNEIKPPIIHYDLKPG NILLVDGTACGEIK	257	Lys2	10.9
TLK2	UniRef100_Q86UE8	YVAVKIHQLNK	258	Lys1	2.4
TLK2	UniRef100_Q86UE8	YLNEIKPPIIHYDLKPG NILLVNGTACGEIK	259	Lys2	-1.7
TYK2 domain2	UniRef100_P29597	IGDFGLAKAVPEGHEY YR	260	Activation Loop	4.6
ULK1	UniRef100_Q75385	DLKPQNILLSNPAGR	261	Lys2	4.6
ULK3	UniRef100_D3DW67	EVVAIKCVAK	262	Lys1	-15.8
ULK3	UniRef100_D3DW67	NISHLDLKPQNILLSSL	263	Lys2	-7.2

Figure 10 (continued)

		EKPHLK			
Wnk1, Wnk2	UniRef100_Q9Y3S1, UniRef100_D3DUP1	GSFKTVYK	264	ATP Loop	-62.6
Wnk1, Wnk2, Wnk3	UniRef100_Q9Y3S1, UniRef100_D3DUP1 , UniRef100_Q9BYP7	DLKCDNIFITGPTGSVK	265	Lys2	-77.2
Wnk1, Wnk2, Wnk4	UniRef100_Q96J92, UniRef100_Q9Y3S1, UniRef100_D3DUP1	IGDLGLATLKR	266	Activation Loop	-41
YSK1	UniRef100_O00506	EVVAIKIIDLEEADEIE DIQQEITVLSQCDSPI TR	267	Lys1	-13
ZAK	UniRef100_Q9NYL2	WISQDKEVAVKK	268	Lys1	-6.9
ZAP70	UniRef100_P43403	ISDFGLSKALGADDSY YTAR	269	Activation Loop	7.6
ZAP70	UniRef100_P43403	QIDVAIKVLK	270	Lys1	-9.2
ZC1/HGK	UniRef100_O95819	TGQLAAIKVMDVTEDE EEEIKLEINMLKK	271	Lys1	-14.6
ZC1/HGK, ZC2/TNIK, ZC3/MINK	UniRef100_O95819, UniRef100_Q9UKE5 , UniRef100_Q8N4C8	DIKGQNVLLTENAEVK	272	Lys2	1.4
ZC2/TNIK	UniRef100_Q9UKE5	TGQLAAIKVMDVTGDE EEEIKQEINMLKK	273	Lys1	-21

Figure 10 (continued)

Table A1. Labeling Site Key Information.

Lys1	Conserved Lysine 1
Lys2	Conserved Lysine 2
ATP Loop	ATP binding loop,
Activation Loop	Activation loop
ATP	ATP site in non-canonical kinase (e.g. lipid kinase)
Protein Kinase Domain	Other lysine within kinase domain, possibly not in ATP binding site
Other	Labeling of residue outside of the protein kinase domain, possibly not in ATP binding site
	>90% Inhibition
	75 - 90% Inhibition
	50 - 75% Inhibition
	35 - 50% Inhibition
	No change
	> 100% increase in MS signal
Not colored	Variable or weak data not reaching significance despite >35% inhibition

CDK7	CDK12	CDK13	CDK7	CDK12	CDK13
CDKN1A	UBASH3A	RPL35A	TRAF5	HNRNPA1	HNRNPC
MYC	TRAF6	RPL31	TET1	FLI1	RPS11
RUNX1	TERF2	RPS14	ADAMTS1	FANCI	EEF1A1
MYB	TAL1	RPL37A	RBM39	FANCF	EIF4B
TAL1	SRSF1	RPL41	DDX17	FANCD2	
GATA3	SRPK1	RPL4	UBXN8	ETS1	
KLF2	SNRPF	RPL26	N4BP2I2	FRG	
HNRPDL	SNRPD2	RPS3	TEX19	ERCC4	
ASCL1	SNRPD1	RPL12	CDCA7	E2F8	
MYCN	SMC3	SNRPD2	ING5	E2F7	
INSM1	SMC1B	EIF4E	GNL3	E2F6	
NEUROD1	SMC1	INTS8	PRPF4B	E2F5	
NEUROG1	SMAD6	RPL39	OTUD6B	E2F3	
FOXG1	SMAD4	RPS7	ZNF586	CSTF3	
FOXA1	SMAD1	RPS5	ZCCHC8	CHEK2	
SOX2	SET	EEF2	PAPOLA	CHEK1	
SOX4	RUNX1	EIF3H	MAP2K7	CHD1	
BCL11A	RFC5	EIF3E	MGA	CENPA	
OTX2	RFC4	NPM3	GIMAP4	CDC6	
PHOX2B	RAD51D	SNRNP40	KIF1B	CCDC138	
PLK2	RAD51C	SNRPG	KAT5	BUB1B	
TAF1	POLA1	POLR2L	CCNL1	BRCA1	
CTGF	PIK3R3	RPL38	NUP98	BCL2	
WEE1	PARP9	RPL11	ZNF295	BCL11B	
SDIM	PARP1	RPL17	RBM23	ATR	
JUN	ORC3L	RPL7	RFC3	ATM	
PIM1	OBFC2A	EIF3K	SIPR1	APEX1	
IL8	NEK9	RPL14	FDXACB1		
FOS1	NDC80	POLR2H	CCDC94		
MCPH1	MYC	SNRPB	SRSF6		
PRPF38B	MYB	EEF1D	RAD50		
C9orf41	MED13	EIF3G	GIMAP6		
ZNF248	MDC1	RPS12	MSI2		
JMJD6	MCL1	RPS23	xiap		
CHORDC1	JMJD1C	SNORA38	mcl1		
ZNF37A	HNRPDL	EMG1			
RABGGTB	HNRNPH1	RPL37			
IL7R	HNRNPC	RPL13			

Figure 11

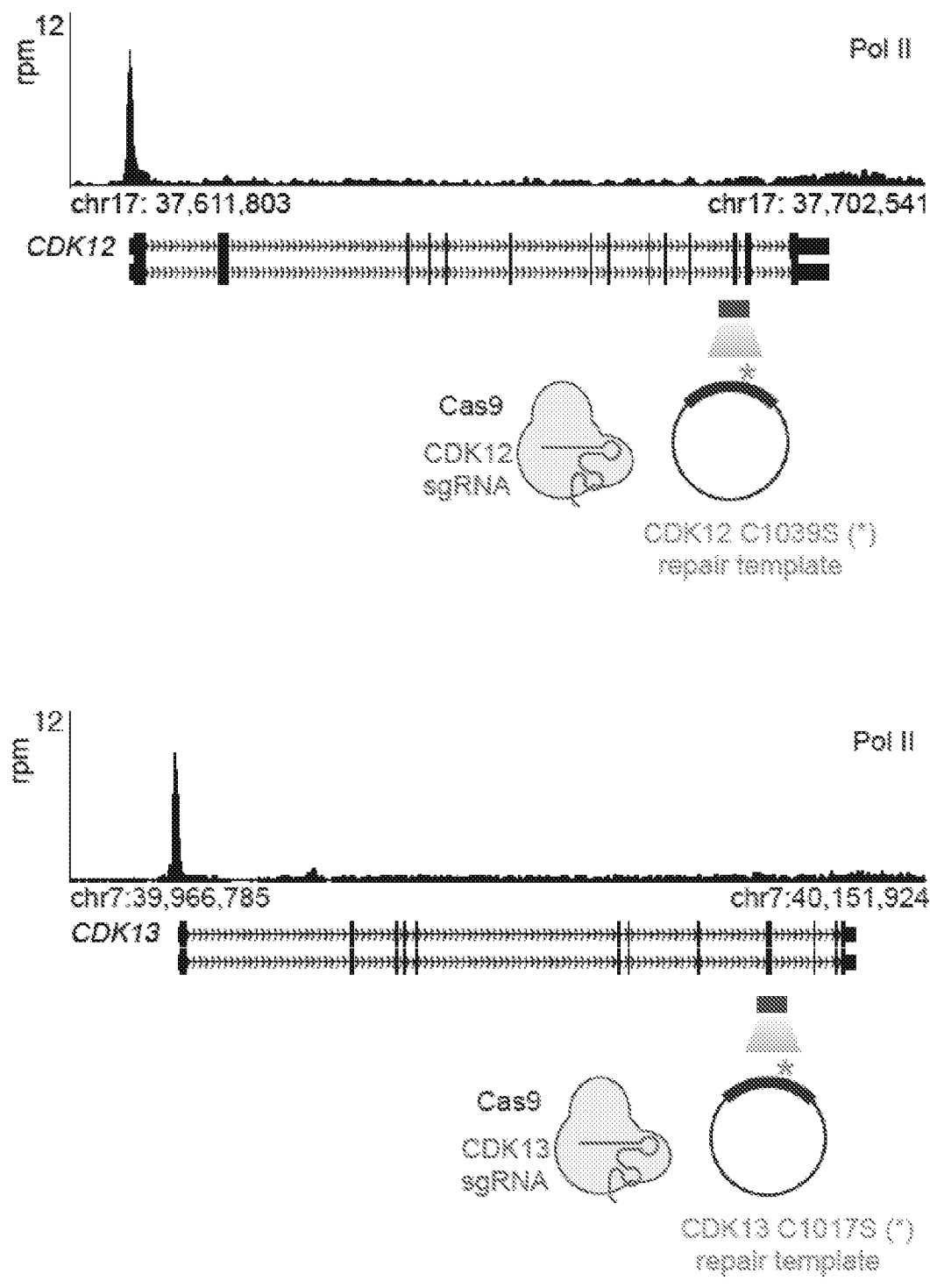


Figure 12

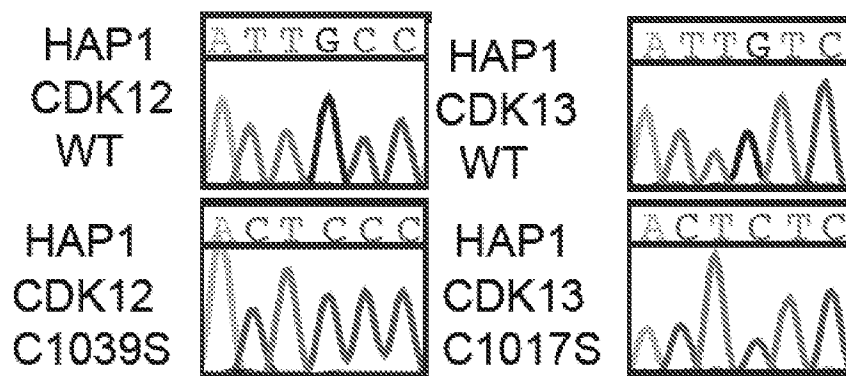
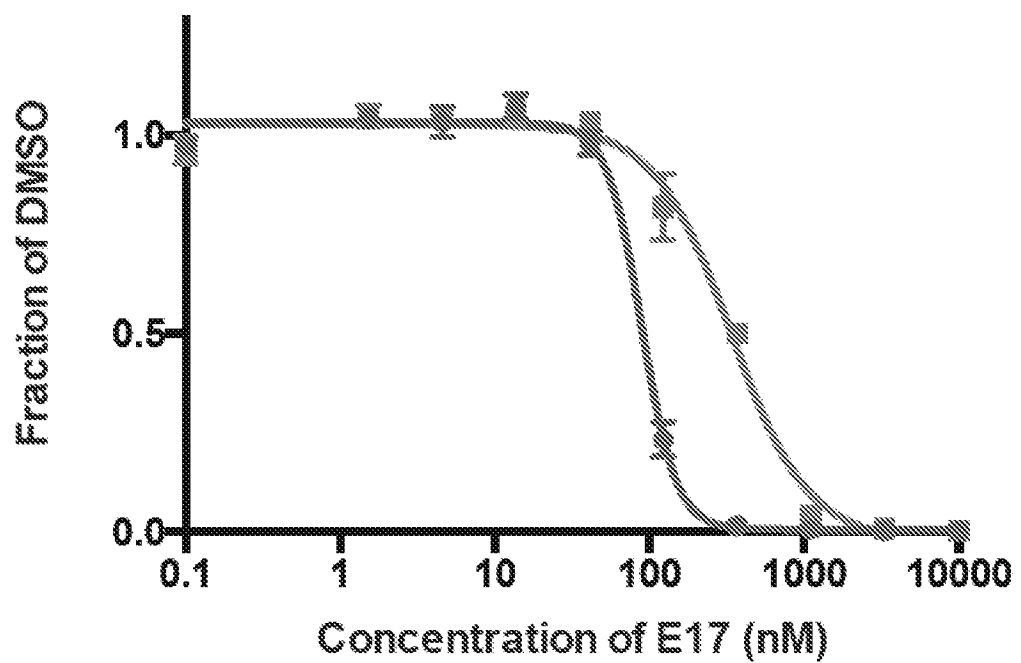
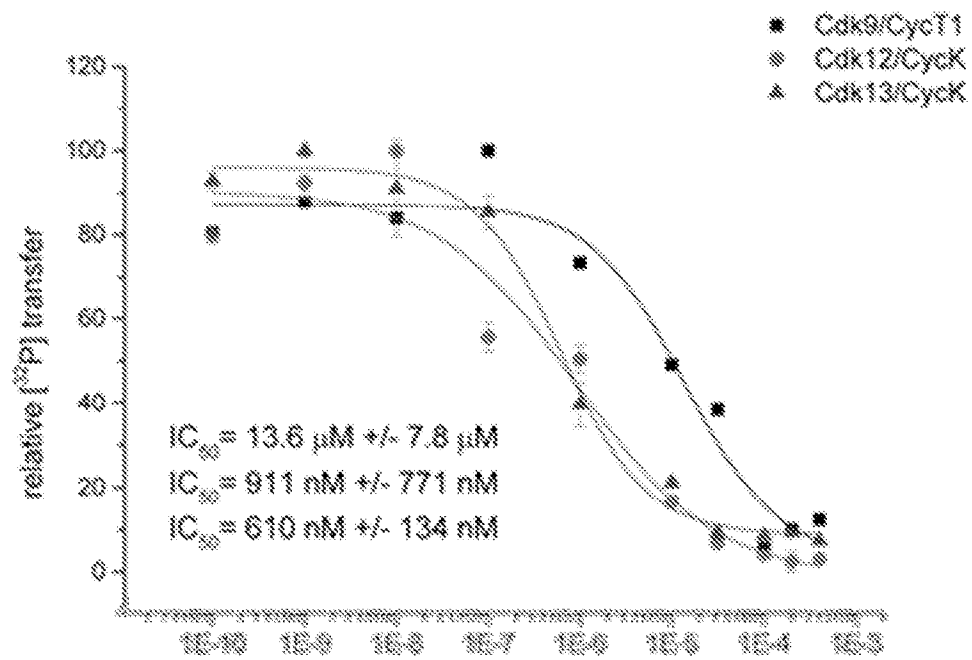


Figure 13

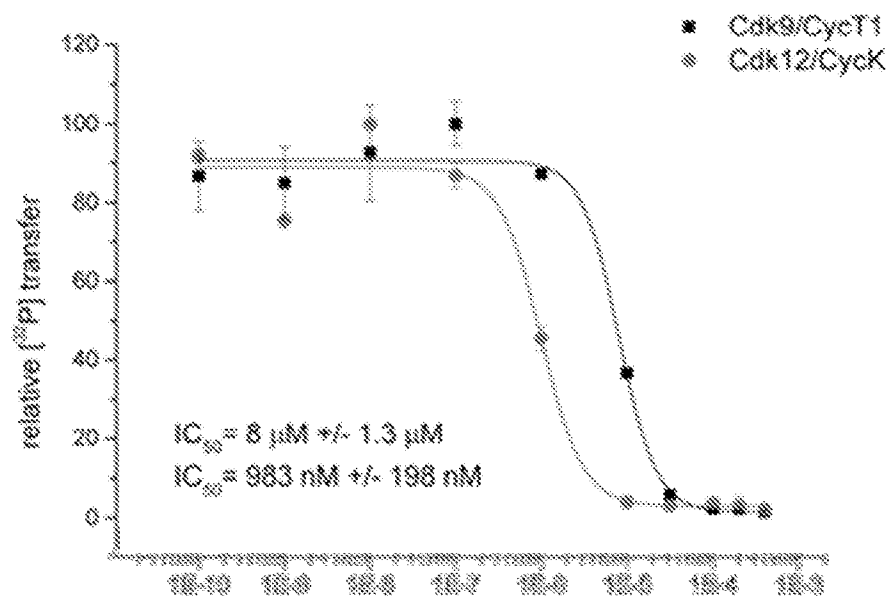


- WT CDK12/13 WT HAP1 cells
(IC₅₀ = 90 nM)
- CDK12 C1039S/CDK13 C1017S
HAP1 cells
(IC₅₀ = 350 nM)

Figure 14



Concentration of E-17



Concentration of E-9

Figure 15