(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 July 2005 (21.07.2005)

PCT

(10) International Publication Number
WO 2005/066151 A2

(51) International Patent Classification[7]: C07D 333/00

(21) International Application Number:
PCT/US2004/042009

(22) International Filing Date:
14 December 2004 (14.12.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/531,371 19 December 2003 (19.12.2003) US

(71) Applicant *(for all designated States except US)*: **SYRRX, INC.** [US/US]; 10410 Science Center Drive, San Diego, California 92121 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BRESSI, Jerome, C.** [US/US]; 3799 Ibis Street, San Diego, California 92103 (US). **GANGLOFF, Anthony, R.** [US/US]; 4969 Dick Street, San Diego, California 92115 (US). **JENNINGS, Andrew, J.** [GB/US]; 605 Bonair Way, La Jolla, 92037 (US).

(74) Agent: **WEITZ, David, J.**; SYRRX, INC., 10410 Science Center Drive, San Diego, California 92121 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

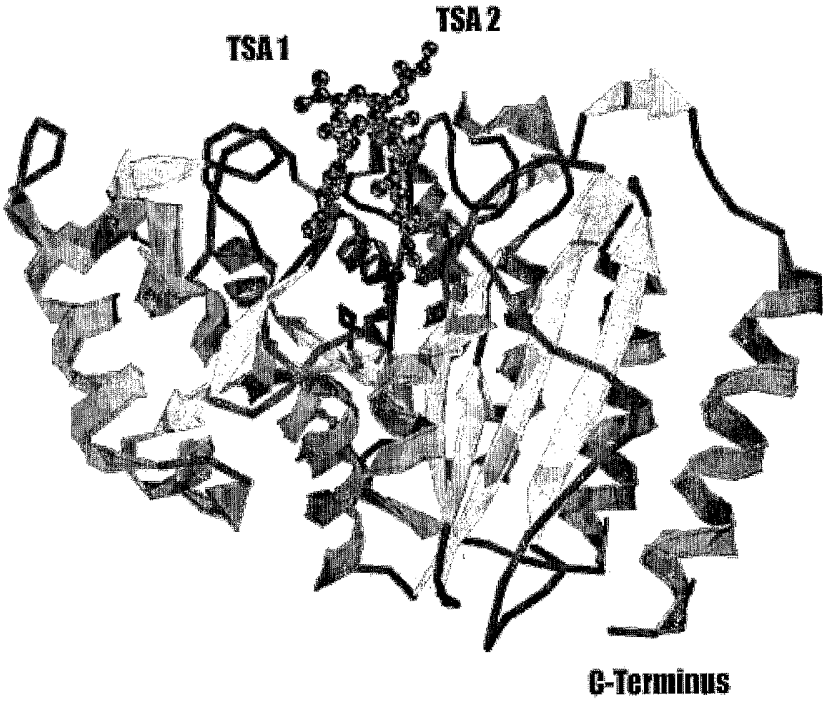
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

*[Continued on next page]*

(54) Title: HISTONE DEACETYLASE INHIBITORS

(57) Abstract: Histone deacetylase inhibitors and uses thereof are provided that have the general formula (I) wherein Z, L and M are as defined herein.

Z—L—M (I)




WO 2005/066151 A2

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— *without international search report and to be republished upon receipt of that report*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# HISTONE DEACETYLASE INHIBITORS

## FIELD OF THE INVENTION

**[0001]** The invention relates to compounds that may be used to inhibit histone deacetylases (HDACs) as well as compositions of matter and kits comprising these compounds. The present invention also relates to methods for inhibiting HDAC as well as treatment methods using compounds according to the present invention.

## DESCRIPTION OF RELATED ART

**[0002]** DNA in eukaryotic cells is tightly complexed with proteins (histones) to form chromatin. Histones are small, positively charged proteins that are rich in basic amino acids (positively charged at physiological pH), which contact the phosphate groups (negatively charged at physiological pH) of DNA. There are five main classes of histones H1, H2A, H2B, H3, and H4. The amino acid sequences of H2A, H2B, H3, and H4 show remarkable conservation between species, wherein H1 varies somewhat and in some cases is replaced by another histone, e.g., H5. Four pairs of each of H2A, H2B, H3 and H4 together form a disk-shaped octomeric protein core, around which DNA (about 140 base pairs) is wound to form a nucleosome. Individual nucleosomes are connected by short stretches of linker DNA associated with another histone molecule to form a structure resembling a beaded string, which is itself arranged in a helical stack, known as a solenoid.

**[0003]** The majority of histones are synthesized during the S phase of the cell cycle, and newly synthesized histones quickly enter the nucleus to become associated with DNA. Within minutes of its synthesis, new DNA becomes associated with histones in nucleosomal structures.

**[0004]** A small fraction of histones, more specifically, the amino acid side chains thereof, are enzymatically modified by post-translational addition of methyl, acetyl, or phosphate groups, neutralizing the positive charge of the side chain, or converting it to a negative charge. For example, lysine and arginine groups may be methylated, lysine groups may be acetylated, and serine groups may be phosphorylated. For lysine, the -$(CH_2)_4$-$NH_2$ sidechain may be acetylated, for example by an acetyltransferase enzyme to give the amide -$(CH_2)_4$-NHC(=O)$CH_3$. Methylation, acetylation, and phosphorylation of

amino termini of histones that extend from the nucleosomal core affects chromatin structure and gene expression. Spencer and Davie 1999. Gene 240:1 1-12.

**[0005]** Acetylation and deacetylation of histones is associated with transcriptional events leading to cell proliferation and/or differentiation. Regulation of the function of transcriptional factors is also mediated through acetylation. Recent reviews on histone deacetylation include Kouzarides, et al., 1999. Curr. Opin. Genet. Dev. 9:1, 40-48 and Pazin, et al. 1997. 89:3 325-328.

**[0006]** The correlation between acetylation status of histones and the transcription of genes has been known for quite some time. Certain enzymes, specifically acetylases (e.g., histone acetyltransferases (HAT) and deacetylases (histone deacetylases or HDACs), which regulate the acetylation state of histones have been identified in many organisms and have been implicated in the regulation of numerous genes, confirming a link between acetylation and transcription. In general, histone acetylation is believed to correlate with transcriptional activation, whereas histone deacetylation is believed to be associated with gene repression.

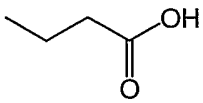
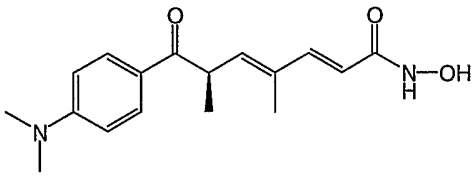
**[0007]** A growing number of histone deacetylases (HDACs) have been identified. HDACs function as part of large multiprotein complexes, which are tethered to the promoter and repress transcription. Well characterized transcriptional repressors such as MAD, nuclear receptors and YY1 associate with HDAC complexes to exert their repressor function.

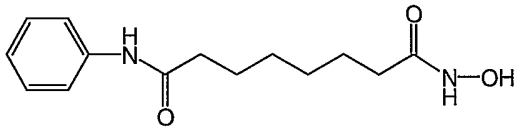
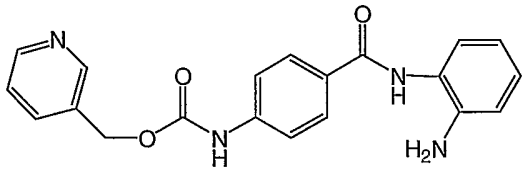
**[0008]** Studies of HDAC inhibitors have shown that these enzymes play an important role in cell proliferation and differentiation. HDACs are believed to be associated with a variety of different disease states including, but not limited to cell proliferative diseases and conditions (Marks, P.A., Richon, V.M., Breslow, R. and Rifkind, R.A., J. Natl. Cancer Inst. (Bethesda) 92, 1210-1215, 2000) such as leukemia (Lin et al. 1998. Nature 391: 811-814; Grignani, et al.1998. Nature 391: 815-818; Warrell et al. 1998. J. Natl. Cancer Inst. 90:1621-1625; Gelmetti et al. 1998. Mol. Cell Biol. 18:7185-7191; Wang et al. 1998. PNAS 951 0860-10865), melanomas/squamous cell carcinomas (Gillenwater, et al., 1998, Int. J. Cancer 75217-224; Saunders, et al., 1999, Cancer Res. 59:399-404), breast cancer, prostrate cancer, bladder cancer (Gelmetti et al. 1998. Mol. Cell Biol. 18:7185-7191; Wang et al. 1998. PNAS 951 0860-10865), lung cancer, ovarian cancer and colon cancer

(Hassig, et al., 1997, Chem. Biol. 4:783-789; Archer, et al., 1998, PNAS, 956791-6796; Swendeman, et al., 1999, Proc. Amer. Assoc. Cancer Res. 40, Abstract #3836).

**[0009]** Histone deacetylase inhibitors are potent inducers of growth arrest, differentiation, or apoptotic cell death in a variety of transformed cells in culture and in tumor bearing animals (*Histone deacetylase inhibitors as new cancer drugs*, Marks, P.A., Richon, V.M., Breslow, R. and Rifkind, R.A., Current Opinions in Oncology, 2001, Nov. 13 (6): 477-83; *Histone deacetylases and cancer: causes and therapies,* Marks, P., Rifkind, R.A., Richon, V.M., Breslow, R., Miller, T. and Kelly, W.K., Nat. Rev. Cancer 2001 Dec.1 (3):194-202). In addition, HDAC inhibitors are useful in the treatment or prevention of protozoal diseases (US Patent 5,922,837) and psoriasis (PCT Publication No. WO 02/26696).

**[0010]** A variety of inhibitors of HDAC have been reported. Some of these inhibitors are described in the following table:

| Inhibitors | References |
|---|---|
| Butyrates  | Marks PA, et al., J. Natl. Cancer Inst. 2000, 92:1210–1216; Weidle UH, et al., Anticancer Res. 2000, 20:1471–1486; Gore SD, et al., Exp. Opin. Invest. Drugs 2000, 9:2923–2934; Sowa Y, et al., Biofactors 2000, 12:283–287 |
| Trichostatin A  | Marks PA, et al., J. Natl. Cancer Inst. 2000, 92:1210–1216; Weidle UH, et al., Anticancer Res. 2000, 20:1471–1486; Nervi C, et al., Cancer Res. 2001, 61:1247–1249; Suzuki T, et al., Int. J. Cancer 2000, 88:992–997. |

| | |
|---|---|
| Suberoylanilidine hydroxamic acid  | Marks PA, et al., J. Natl. Cancer Inst. 2000, 92:1210–1216; Kelly WK, et al., Proc. Amer. Soc. Clin. Oncol. 2001, 20:87a; Butler LM, et al., Cancer Res. 2000, 60:5165–5170. |
| MS-275  | Lee BI, et al., Cancer Res. 2001, 61:931–934. |

**[0011]** Additional examples of HDAC inhibitors can be found in Marks PA, et al., J. Natl. Cancer Inst. 2000, 92:1210–1216 & Weidle UH, et al., Anticancer Res. 2000, 20:1471–1486 and PCT Publication Nos. WO 02/26696, WO 02/062773, and WO 01/18171.

**[0012]** Despite the various HDAC inhibitors that have been reported to date, a need continues to exist for new and more effective inhibitors of HDACs.

## SUMMARY OF THE INVENTION

**[0013]** The present invention relates to compounds that have activity for inhibiting HDACs.

**[0014]** The present invention also provides compositions, articles of manufacture and kits comprising these compounds.

**[0015]** In one embodiment, a pharmaceutical composition is provided that comprises a HDAC inhibitor according to the present invention as an active ingredient. Pharmaceutical compositions according to the invention may optionally comprise 0.001%-100% of one or more HDAC inhibitors of this invention. These pharmaceutical compositions may be administered or coadministered by a wide variety of routes, including for example, orally, parenterally, intraperitoneally, intravenously, intraarterially, transdermally, sublingually, intramuscularly, rectally, transbuccally, intranasally, liposomally, via inhalation, vaginally, intraoccularly, via local delivery (for example by

catheter or stent), subcutaneously, intraadiposally, intraarticularly, or intrathecally. The compositions may also be administered or coadministered in slow release dosage forms.

**[0016]** The invention is also directed to kits and other articles of manufacture for treating disease states associated with HDAC.

**[0017]** In one embodiment, a kit is provided that comprises a composition comprising at least one HDAC inhibitor of the present invention in combination with instructions. The instructions may indicate the disease state for which the composition is to be administered, storage information, dosing information and/or instructions regarding how to administer the composition. The kit may also comprise packaging materials. The packaging material may comprise a container for housing the composition. The kit may also optionally comprise additional components, such as syringes for administration of the composition. The kit may comprise the composition in single or multiple dose forms.

**[0018]** In another embodiment, an article of manufacture is provided that comprises a composition comprising at least one HDAC inhibitor of the present invention in combination with packaging materials. The packaging material may comprise a container for housing the composition. The container may optionally comprise a label indicating the disease state for which the composition is to be administered, storage information, dosing information and/or instructions regarding how to administer the composition. The kit may also optionally comprise additional components, such as syringes for administration of the composition. The kit may comprise the composition in single or multiple dose forms.

**[0019]** Also provided are methods for preparing compounds, compositions and kits according to the present invention. For example, several synthetic schemes are provided herein for synthesizing compounds according to the present invention.

**[0020]** Also provided are methods for using compounds, compositions, kits and articles of manufacture according to the present invention.

**[0021]** In one embodiment, the compounds, compositions, kits and articles of manufacture are used to inhibit HDAC.

**[0022]** In one embodiment, the compounds, compositions, kits and articles of manufacture are used to treat a disease state for which HDAC possesses activity that contributes to the pathology and/or symptomology of the disease state.

**[0023]** In another embodiment, a compound is administered to a subject wherein HDAC activity within the subject is altered, preferably reduced.

**[0024]** In another embodiment, a prodrug of a compound is administered to a subject that is converted to the compound *in vivo* where it inhibits HDAC.

**[0025]** In another embodiment, a method of inhibiting HDAC is provided that comprises contacting HDAC with a compound according to the present invention.

**[0026]** In another embodiment, a method of inhibiting HDAC is provided that comprises causing a compound according to the present invention to be present in a subject in order to inhibit HDAC *in vivo*.

**[0027]** In another embodiment, a method of inhibiting HDAC is provided that comprises administering a first compound to a subject that is converted *in vivo* to a second compound wherein the second compound inhibits HDAC *in vivo*.

**[0028]** In another embodiment, a therapeutic method is provided that comprises administering a compound according to the present invention.

**[0029]** In another embodiment, a method of inhibiting cell proliferation is provided that comprises contacting a cell with an effective amount of a compound according to the present invention.

**[0030]** In another embodiment, a method of inhibiting cell proliferation in a patient is provided that comprises administering to the patient a therapeutically effective amount of a compound according to the present invention.

**[0031]** In another embodiment, a method of treating a condition in a patient which is known to be mediated by HDAC, or which is known to be treated by HDAC inhibitors, comprising administering to the patient a therapeutically effective amount of a compound according to the present invention.

**[0032]** In another embodiment, a method is provided for using a compound according to the present invention in order to manufacture a medicament for use in the treatment of disease state which is known to be mediated by HDAC, or which is known to be treated by HDAC inhibitors.

**[0033]** In another embodiment, a method is provided for treating a disease state for which HDAC possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising: causing a compound according to the present

invention to be present in a subject in a therapeutically effective amount for the disease state.

**[0034]** In another embodiment, a method is provided for treating a disease state for which HDAC possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising: administering a first compound to a subject that is converted *in vivo* to a second compound such that the second compound is present in the subject in a therapeutically effective amount for the disease state.

**[0035]** In another embodiment, a method is provided for treating a disease state for which HDAC possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising: administering a compound according to the present invention to a subject such that the compound is present in the subject in a therapeutically effective amount for the disease state.

**[0036]** In another embodiment, a method is provided for treating a cell proliferative disease state comprising treating cells with a compound according to the present invention in combination with an anti-proliferative agent, wherein the cells are treated with the compound according to the present invention before, at the same time, and/or after the cells are treated with the anti-proliferative agent, referred to herein as combination therapy. It is noted that treatment of one agent before another is referred to herein as sequential therapy, even if the agents are also administered together. It is noted that combination therapy is intended to cover when agents are administered before or after each other (sequential therapy) as well as when the agents are administered at the same time.

**[0037]** Examples of diseases that may be treated by administration of compounds and compositions according to the present invention include, but are not limited to protozoal diseases and cell proliferative diseases and conditions such as leukemia, melanomas, squamous cell carcinomas, breast cancer, prostrate cancer, bladder cancer, lung cancer including non small-cell lung cancer and small-cell lung cancer, ovarian cancer, colon cancer, squamous cell carcinoma, astrocytoma, Kaposi's sarcoma, glioblastoma, bladder cancer, head and neck cancer, glioma, colorectal cancer, genitourinary cancer and gastrointestinal cancer.

**[0038]** It is noted in regard to all of the above embodiments that the present invention is intended to encompass pharmaceutically acceptable salts and solvates (e.g., hydrates) of

the compounds, regardless of whether such salts and solvates are specified since it is well know in the art to administer pharmaceutical agents in a salt or solvated form. It is further noted that prodrugs may also be administered which are altered *in vivo* and become a compound according to the present invention. The various methods of using the compounds of the present invention are intended, regardless of whether prodrug delivery is specified, to encompass the administration of a prodrug that is converted in vivo into a compound according to the present invention.

## BRIEF DESCRIPTION OF THE FIGURES

**[0039]** Figure 1 illustrates a ribbon diagram overview of the structure of HDAC8, highlighting the secondary structural elements of the protein.

**[0040]** Figure 2A illustrates particular examples of substituent $R_1$ that may be employed in the Z moiety.

**[0041]** Figure 2B illustrates particular examples of Z moieties that the compounds of the present invention may comprise.

**[0042]** Figure 2C illustrates examples of moieties, Q, that the leader group may comprise to link the leader group (L) to the remainder of the compound.

**[0043]** Figure 2D illustrates particular examples of moieties that the leader groups may comprise.

**[0044]** It is noted in regard to Figures 2A-2D that the squiggle line is intended to indicate a bond to an adjacent moiety. It is also noted that the substituents shown may optionally be further substituted beyond what is shown. Further, one or more heteroatoms may optionally be substituted for the carbon atoms shown. In regard to Figure 2D, it is noted that the leader groups moieties may be incorporated into the leader group in either possible orientation.

**[0045]** Figure 3 illustrates residues 1-482 of HDAC1 and a 6-histidine tag at the N-terminus (SEQ. I.D. No. 1).

**[0046]** Figure 4 illustrates the DNA sequence (SEQ. I.D. No. 2) that was used to encode SEQ. I.D. No. 1.

**[0047]** Figure 5 illustrates residues 1-488 of HDAC2 and a 6-histidine tag at the C-terminus (SEQ. I.D. No. 3).

**[0048]** Figure 6 illustrates the DNA sequence (SEQ. I.D. No. 4) that was used to encode SEQ. I.D. No. 3.

**[0049]** Figure 7 illustrates residues 73-845 of HDAC6 and a 6-histidine tag at the C-terminus (SEQ. I.D. No. 5).

**[0050]** Figure 8 illustrates the DNA sequence (SEQ. I.D. No. 6) that was used to encode SEQ. I.D. No. 5.

**[0051]** Figure 9 illustrates residues 1-377 of HDAC8 and a 6-histidine tag at the N-terminus (SEQ. I.D. No. 7).

**[0052]** Figure 10 illustrates the DNA sequence (SEQ. I.D. No. 8) that was used to encode SEQ. I.D. No. 7.

## DEFINITIONS

**[0053]** Unless otherwise stated, the following terms used in the specification and claims shall have the following meanings for the purposes of this Application.

**[0054]** "Alicyclic" means a moiety comprising a non-aromatic ring structure. Alicyclic moieties may be saturated or partially unsaturated with one or more double or triple bonds. Alicyclic moieties may also optionally comprise heteroatoms such as nitrogen, oxygen and sulfur. Examples of alicyclic moieties include, but are not limited to moieties with C3 - C8 rings such as cyclopropyl, cyclohexane, cyclopentane, cyclopentene, cyclopentadiene, cyclohexane, cyclohexene, cyclohexadiene, cycloheptane, cycloheptene, cycloheptadiene, cyclooctane, cyclooctene, and cyclooctadiene.

**[0055]** "Aliphatic" means a moiety characterized by a straight or branched chain arrangement of constituent carbon atoms and may be saturated or partially unsaturated with one or more double or triple bonds.

**[0056]** "Alkoxy" means an oxygen moiety having a further alkyl substituent.

**[0057]** "Alkyl" represented by itself means a straight or branched, saturated or unsaturated, aliphatic radical having a chain of carbon atoms, optionally with oxygen (See "oxaalkyl") or nitrogen atoms (See "aminoalkyl") between the carbon atoms. $C_X$ alkyl and $C_{X-Y}$ alkyl are typically used where X and Y indicate the number of carbon atoms in the chain. For example, $C_{1-6}$ alkyl includes alkyls that have a chain of between 1 and 6 carbons (e.g., methyl, ethyl, propyl, isopropyl, butyl, *sec*-butyl, isobutyl, *tert*-butyl, vinyl,

allyl, 1-propenyl, isopropenyl, 1-butenyl, 2-butenyl, 3-butenyl, 2-methylallyl, ethynyl, 1-propynyl, 2-propynyl, and the like). Alkyl represented along with another radical (e.g., as in arylalkyl) means a straight or branched, saturated or unsaturated aliphatic divalent radical having the number of atoms indicated or when no atoms are indicated means a bond (e.g., $(C_{6-10})$aryl$(C_{0-3})$alkyl includes phenyl, benzyl, phenethyl, 1-phenylethyl 3-phenylpropyl, and the like).

**[0058]** "Alkylene", unless indicated otherwise, means a straight or branched, saturated or unsaturated, aliphatic, divalent radical. $C_X$ alkylene and $C_{X-Y}$ alkylene are typically used where X and Y indicate the number of carbon atoms in the chain. For example, $C_{1-6}$ alkylene includes methylene ($-CH_2-$), ethylene ($-CH_2CH_2-$), trimethylene ($-CH_2CH_2CH_2-$), tetramethylene ($-CH_2CH_2CH_2CH_2-$) 2-butenylene ($-CH_2CH=CHCH_2-$), 2-methyltetramethylene ($-CH_2CH(CH_3)CH_2CH_2-$), pentamethylene ($-CH_2CH_2CH_2CH_2CH_2-$) and the like).

**[0059]** "Alkylidene" means a straight or branched unsaturated, aliphatic, divalent radical having a general formula $=CR_aR_b$. $C_X$ alkylidene and $C_{X-Y}$ alkylidene are typically used where X and Y indicate the number of carbon atoms in the chain. For example, $C_{1-6}$ alkylidene includes methylidene ($=CH_2$), ethylidene ($=CHCH_3$), isopropylidene ($=C(CH_3)_2$), propylidene ($=CHCH_2CH_3$), allylidene ($=CH-CH=CH_2$), and the like).

**[0060]** "Amino" means a nitrogen moiety having two further substituents where, for example, a hydrogen or carbon atom is attached to the nitrogen. For example, representative amino groups include $-NH_2$, $-NHCH_3$, $-N(CH_3)_2$, $-NHC_{1-10}$-alkyl, $-N(C_{1-10}$-alkyl$)_2$, -NHaryl, -NHheteroaryl, $-N(aryl)_2$, $-N(heteroaryl)_2$, and the like. Optionally, the two substituents together with the nitrogen may also form a ring. Unless indicated otherwise, the compounds of the invention containing amino moieties may include protected derivatives thereof. Suitable protecting groups for amino moieties include acetyl, *tert*-butoxycarbonyl, benzyloxycarbonyl, and the like.

**[0061]** "Aminoalkyl" means an alkyl, as defined above, except where one or more substituted or unsubstituted nitrogen atoms (-N-) are positioned between carbon atoms of the alkyl. For example, an $(C_{2-6})$ aminoalkyl refers to a chain comprising between 2 and 6 carbons and one or more nitrogen atoms positioned between the carbon atoms.

**[0062]** "Animal" includes humans, non-human mammals (e.g., dogs, cats, rabbits, cattle, horses, sheep, goats, swine, deer, and the like) and non-mammals (e.g., birds, and the like).

**[0063]** "Aromatic" means a moiety wherein the constituent atoms make up an unsaturated ring system, all atoms in the ring system are $sp^2$ hybridized and the total number of pi electrons is equal to 4n+2. An aromatic ring may be such that the ring atoms are only carbon atoms or may include carbon and non-carbon atoms (see Heteroaryl).

**[0064]** "Aryl" means a monocyclic or fused bicyclic ring assembly wherein each ring is aromatic or when fused with a second ring forms an aromatic ring assembly. If one or more ring atoms is not carbon (e.g., N, S), the aryl is a heteroaryl. $C_X$ aryl and $C_{X-Y}$ aryl are typically used where X and Y indicate the number of atoms in the ring.

**[0065]** "Bicycloalkyl" means a saturated or partially unsaturated fused bicyclic or bridged polycyclic ring assembly.

**[0066]** "Bicycloaryl" means a bicyclic ring assembly wherein the rings are linked by a single bond or fused and at least one of the rings comprising the assembly is aromatic. $C_X$ bicycloaryl and $C_{X-Y}$ bicycloaryl are typically used where X and Y indicate the number of carbon atoms in the bicyclic ring assembly and directly attached to the ring.

**[0067]** "Carbamoyl" means the radical $-OC(O)NR_aR_b$ where $R_a$ and $R_b$ are each independently two further substituents where a hydrogen or carbon atom is alpha to the nitrogen. It is noted that carbamoyl moieties may include protected derivatives thereof. Examples of suitable protecting groups for carbamoyl moieties include acetyl, *tert*-butoxycarbonyl, benzyloxycarbonyl, and the like. It is noted that both the unprotected and protected derivatives fall within the scope of the invention.

**[0068]** "Carbocycle" means a ring consisting of carbon atoms.

**[0069]** "Carbocyclic ketone derivative" means a carbocyclic derivative having a –C(O)– substituent.

**[0070]** "Carbonyl" means the radical -C(O)-. It is noted that the carbonyl radical may be further substituted with a variety of substituents to form different carbonyl groups including acids, acid halides, amides, esters, and ketones.

**[0071]** "Carboxy" means the radical -C(O)O-. It is noted that compounds of the invention containing carboxy moieties may include protected derivatives thereof, i.e.,

where the oxygen is substituted with a protecting group. Suitable protecting groups for carboxy moieties include benzyl, *tert*-butyl, and the like.

**[0072]** "Cyano" means the radical -CN.

**[0073]** "Cycloalkyl" means a non-aromatic, saturated or partially unsaturated, monocyclic, fused bicyclic or bridged polycyclic ring assembly. $C_X$ cycloalkyl and $C_{X-Y}$ cycloalkyl are typically used where X and Y indicate the number of carbon atoms in the ring assembly. For example, $C_{3-10}$ cycloalkyl includes cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclohexenyl, 2,5-cyclohexadienyl, bicyclo[2.2.2]octyl, adamantan-1-yl, decahydronaphthyl, oxocyclohexyl, dioxocyclohexyl, thiocyclohexyl, 2-oxobicyclo[2.2.1]hept-1-yl, and the like.

**[0074]** "Cycloalkylene" means a divalent saturated or partially unsaturated, monocyclic ring or bridged polycyclic ring assembly. $C_X$ cycloalkylene and $C_{X-Y}$ cycloalkylene are typically used where X and Y indicate the number of carbon atoms in the ring assembly.

**[0075]** "Disease" specifically includes any unhealthy condition of an animal or part thereof and includes an unhealthy condition that may be caused by, or incident to, medical or veterinary therapy applied to that animal, i.e., the "side effects" of such therapy.

**[0076]** "Halo" means fluoro, chloro, bromo or iodo.

**[0077]** "Halo-substituted alkyl", as an isolated group or part of a larger group, means "alkyl" substituted by one or more "halo" atoms, as such terms are defined in this Application. Halo-substituted alkyl includes haloalkyl, dihaloalkyl, trihaloalkyl, perhaloalkyl and the like (e.g. halo-substituted $(C_{1-3})$alkyl includes chloromethyl, dichloromethyl, difluoromethyl, trifluoromethyl, 2,2,2-trifluoroethyl, perfluoroethyl, 2,2,2-trifluoro-1,1-dichloroethyl, and the like).

**[0078]** "Heteroatom" refers to an atom that is not a carbon atom. Particular examples of heteroatoms include, but are not limited to nitrogen, oxygen, sulfur and halogens.

**[0079]** "Heteroatom moiety" includes a moiety where the atom by which the moiety is attached is not a carbon. Examples of heteroatom moieties include -N=, $-NR_c-$, $-N^+(O^-)=$, -O-, -S- or $-S(O)_2-$, wherein $R_c$ is further substituent.

**[0080]** "Heterobicycloalkyl" means bicycloalkyl, as defined in this Application, provided that one or more of the atoms forming the ring is a heteroatom. For example hetero$(C_{9-12})$bicycloalkyl as used to define Z in this application includes, but is not limited

to, 3-aza-bicyclo[4.1.0]hept-3-yl, 2-aza-bicyclo[3.1.0]hex-2-yl , 3-aza-bicyclo[3.1.0]hex-3-yl, and the like.

**[0081]** "Heterocycloalkylene" means cycloalkylene, as defined in this Application, provided that one or more of the ring member carbon atoms indicated, is replaced by a heteroatom.

**[0082]** "Heteroaryl" means an aryl ring, as defined in this Application, where one or more of the atoms forming the ring is a heteroatom.

**[0083]** "Heterobicycloaryl" means bicycloaryl, as defined in this Application, provided that one or more of the atoms forming the ring is a heteroatom. For example, hetero($C_{8-10}$)bicycloaryl as used in this Application includes, but is not limited to, 2-amino-4-oxo-3,4-dihydropteridin-6-yl, and the like.

**[0084]** "Heterocycloalkyl" means cycloalkyl, as defined in this Application, provided that one or more of the atoms forming the ring is a heteroatom.

**[0085]** "Hydroxy" means the radical -OH.

**[0086]** "Imine derivative" means a derivative comprising the moiety -C(NR)-, wherein R comprises a hydrogen or carbon atom alpha to the nitrogen.

**[0087]** "Isomers" mean any compound having an identical molecular formulae but differing in the nature or sequence of bonding of their atoms or in the arrangement of their atoms in space. Isomers that differ in the arrangement of their atoms in space are termed "stereoisomers". Stereoisomers that are not mirror images of one another are termed "diastereomers" and stereoisomers that are nonsuperimposable mirror images are termed "enantiomers" or sometimes "optical isomers". A carbon atom bonded to four nonidentical substituents is termed a "chiral center". A compound with one chiral center has two enantiomeric forms of opposite chirality. A mixture of the two enantiomeric forms is termed a "racemic mixture". A compound that has more than one chiral center has $2^{n-1}$ enantiomeric pairs, where $n$ is the number of chiral centers. Compounds with more than one chiral center may exist as ether an individual diastereomers or as a mixture of diastereomers, termed a "diastereomeric mixture". When one chiral center is present a stereoisomer may be characterized by the absolute configuration of that chiral center. Absolute configuration refers to the arrangement in space of the substituents attached to the chiral center. Enantiomers are characterized by the absolute configuration of their

chiral centers and described by the *R*- and *S*-sequencing rules of Cahn, Ingold and Prelog. Conventions for stereochemical nomenclature, methods for the determination of stereochemistry and the separation of stereoisomers are well known in the art (e.g., see "Advanced Organic Chemistry", 4th edition, March, Jerry, John Wiley & Sons, New York, 1992).

**[0088]** "Nitro" means the radical $-NO_2$.

**[0089]** "Oxaalkyl" means an alkyl, as defined above, except where one or more oxygen atoms (-O-) are positioned between carbon atoms of the alkyl. For example, an $(C_{2-6})$oxaalkyl refers to a chain comprising between 2 and 6 carbons and one or more oxygen atoms positioned between the carbon atoms.

**[0090]** "Oxoalkyl" means an alkyl, further substituted with a carbonyl group. The carbonyl group may be an aldehyde, ketone, ester, amide, acid or acid chloride.

**[0091]** "Pharmaceutically acceptable" means that which is useful in preparing a pharmaceutical composition that is generally safe, non-toxic and neither biologically nor otherwise undesirable and includes that which is acceptable for veterinary use as well as human pharmaceutical use.

**[0092]** "Pharmaceutically acceptable salts" means salts of inhibitors of the present invention which are pharmaceutically acceptable, as defined above, and which possess the desired pharmacological activity. Such salts include acid addition salts formed with inorganic acids such as hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid, and the like; or with organic acids such as acetic acid, propionic acid, hexanoic acid, heptanoic acid, cyclopentanepropionic acid, glycolic acid, pyruvic acid, lactic acid, malonic acid, succinic acid, malic acid, maleic acid, fumaric acid, tartatic acid, citric acid, benzoic acid, *o*-(4-hydroxybenzoyl)benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, 1,2-ethanedisulfonic acid, 2-hydroxyethanesulfonic acid, benzenesulfonic acid, *p*-chlorobenzenesulfonic acid, 2-naphthalenesulfonic acid, *p*-toluenesulfonic acid, camphorsulfonic acid, 4-methylbicyclo[2.2.2]oct-2-ene-1-carboxylic acid, glucoheptonic acid, 4,4'-methylenebis(3-hydroxy-2-ene-1-carboxylic acid), 3-phenylpropionic acid, trimethylacetic acid, tertiary butylacetic acid, lauryl sulfuric acid, gluconic acid, glutamic acid, hydroxynaphthoic acid, salicylic acid, stearic acid, muconic acid and the like.

**[0093]** Pharmaceutically acceptable salts also include base addition salts which may be formed when acidic protons present are capable of reacting with inorganic or organic bases. Acceptable inorganic bases include sodium hydroxide, sodium carbonate, potassium hydroxide, aluminum hydroxide and calcium hydroxide. Acceptable organic bases include ethanolamine, diethanolamine, triethanolamine, tromethamine, *N*-methylglucamine and the like.

**[0094]** "Prodrug" means a compound that is convertible *in vivo* metabolically into an inhibitor according to the present invention. The prodrug itself may or may not also have HDAC inhibitory activity. For example, an inhibitor comprising a hydroxy group may be administered as an ester that is converted by hydrolysis *in vivo* to the hydroxy compound. Suitable esters that may be converted *in vivo* into hydroxy compounds include acetates, citrates, lactates, tartrates, malonates, oxalates, salicylates, propionates, succinates, fumarates, maleates, methylene-bis-b-hydroxynaphthoates, gentisates, isethionates, di-*p*-toluoyltartrates, methanesulfonates, ethanesulfonates, benzenesulfonates, p-toluenesulfonates, cyclohexylsulfamates and quinates.

**[0095]** "Protected derivatives" means derivatives of inhibitors in which a reactive site or sites are blocked with protecting groups. Protected derivatives are useful in the preparation of inhibitors or in themselves may be active as inhibitors. A comprehensive list of suitable protecting groups can be found in T.W. Greene, *Protecting Groups in Organic Synthesis*, 3rd edition, John Wiley & Sons, Inc. 1999.

**[0096]** "Substituted or unsubstituted" means that a given moiety may consist of only hydrogen substituents through available valencies (unsubstituted) or may further comprise one or more non-hydrogen substituents through available valencies (substituted) that are not otherwise specified by the name of the given moiety. For example, isopropyl is an example of an ethylene moiety that is substituted by $-CH_3$. In general, a non-hydrogen substituent may be any substituent that may be bound to an atom of the given moiety that is specified to be substituted. Examples of substituents include, but are not limited to, aldehyde, alicyclic, aliphatic, alkyl, alkylene, alkylidene, amide, amino, aminoalkyl, aromatic, aryl, bicycloalkyl, bicycloaryl, carbamoyl, carbocycle, carboxy, carbonyl group, cycloalkyl, cycloalkylene, ester, halo, heterobicycloalkyl, heterocycloalkylene, heteroaryl,

heterobicycloaryl, heterocycloalkyl, hydroxy, iminoketone, ketone, nitro, oxaalkyl, and oxoalkyl moieties, each of which may optionally also be substituted or unsubstituted.

**[0097]** "Sulfinyl" means the radical -S(O)-. It is noted that the sulfinyl radical may be further substituted with a variety of substituents to form different sulfinyl groups including sulfinic acids, sulfinamides, sulfinyl esters, and sulfoxides.

**[0098]** "Sulfonyl" means the radical -S(O)(O)-. It is noted that the sulfonyl radical may be further substituted with a variety of substituents to form different sulfonyl groups including sulfonic acids, sulfonamides, sulfonate esters, and sulfones.

**[0099]** "Therapeutically effective amount" means that amount which, when administered to an animal for treating a disease, is sufficient to effect such treatment for the disease.

**[0100]** "Thiocarbonyl" means the radical -C(S)-. It is noted that the thiocarbonyl radical may be further substituted with a variety of substituents to form different thiocarbonyl groups including thioacids, thioamides, thioesters, and thioketones.

**[0101]** "Treatment" or "treating" means any administration of a compound of the present invention and includes:

(1) preventing the disease from occurring in an animal which may be predisposed to the disease but does not yet experience or display the pathology or symptomatology of the disease,

(2) inhibiting the disease in an animal that is experiencing or displaying the pathology or symptomatology of the disease (i.e., arresting further development of the pathology and/or symptomatology), or

(3) ameliorating the disease in an animal that is experiencing or displaying the pathology or symptomatology of the diseased (i.e., reversing the pathology and/or symptomatology).

**[0102]** It is noted in regard to all of the definitions provided herein that the definitions should be interpreted as being open ended in the sense that further substituents beyond those specified may be included. Hence, a $C_1$ alkyl indicates that there is one carbon atom but does not indicate what are the substituents on the carbon atom. Hence, a $C_1$ alkyl comprises methyl (i.e., $-CH_3$) as well as $-CR_aR_bR_c$ where $R_a$, $R_b$, and $R_c$ may each

independently be hydrogen or any other substituent where the atom alpha to the carbon is a heteroatom or cyano. Hence, $CF_3$, $CH_2OH$ and $CH_2CN$ are all $C_1$ alkyls.

## DETAILED DESCRIPTION OF THE INVENTION

**[0103]** The present invention relates to compounds, compositions, kits and articles of manufacture that may be used to inhibit histone deacetylases (referred to herein as HDACs). The compounds may optionally be more particularly used as inhibitors of Class I HDACs such as HDAC1, HDAC2, HDAC6 and HDAC8.

**[0104]** At least seventeen human genes that encode proven or putative HDACs have been identified to date, some of which are described in Johnstone, R. W., "Histone-Deacetylase Inhibitors: Novel Drugs for the Treatment of Cancer", Nature Reviews, Volume I, pp. 287-299, (2002) and PCT Publication Nos. 00/10583, 01/18045, 01/42437 and 02/08273.

**[0105]** HDACs have been categorized into three distinct classes based on their relative size and sequence homology. The different HDACs (Homo sapiens), HDAC classes, sequences and references describing the different HDACs are provided in Tables 1 - 3.

**TABLE 1: CLASS I HDACs**

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| 1 | NP_004955 | Histone deacetylase: a regulator of transcription, Wolffe, A.P., Science 272 (5260), 371-372 (1996) |
| 2 | NP_001518 | Isolation and mapping of a human gene (RPD3L1) that is homologous to RPD3, a transcription factor in Saccharomyces cerevisiae; Furukawa,Y., Kawakami,T., Sudo,K., Inazawa,J., Matsumine,A., Akiyama,T. and Nakamura,Y., Cytogenet. Cell Genet. 73 (1-2), 130-133 (1996) |

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| 3 | NP_003874 | Isolation and characterization of cDNAs corresponding to an additional member of the human histone deacetylase gene family, Yang,W.M., Yao,Y.L., Sun,J.M., Davie,J.R. and Seto,E., J. Biol. Chem. 272 (44), 28001-28007 (1997) |
| 8 | NP_060956 | Buggy,J.J., Sideris,M.L., Mak,P., Lorimer,D.D., McIntosh,B. and Clark,J.M. Biochem. J. 350 Pt 1, 199-205 (2000) |
| 11 | NP_079103 | Cloning and Functional Characterization of HDAC11, a Novel Member of the Human Histone Deacetylase Family, Gao,L., Cueto,M.A., Asselbergs,F. and Atadja,P., J. Biol. Chem. 277 (28), 25748-25755 (2002) |

**TABLE 2: CLASS II HDACs**

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| 4 | NP_006028 | Transcriptional control. Sinful repression, Wolffe,A.P., Nature 387 (6628), 16-17 (1997) |
| 5 | NP_631944 | Prediction of the coding sequences of unidentified human genes. IX. The complete sequences of 100 new cDNA clones from brain which can code for large proteins in vitro, Nagase,T., Ishikawa,K., Miyajima,N., Tanaka,A., Kotani,H., Nomura,N. and Ohara,O., DNA Res. 5 (1), 31-39 (1998) |
| 6 | NP_006035 | Transcriptional control. Sinful repression, Wolffe,A.P., Nature 387 (6628), 16-17 (1997) |

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| 7 | NP_057680 | Isolation of a novel histone deacetylase reveals that class I and class II deacetylases promote SMRT-mediated repression, Kao,H.Y., Downes,M., Ordentlich,P. and Evans,R.M., Genes Dev. 14 (1), 55-66 (2000) |
| 9 | NP_478056 | MEF-2 function is modified by a novel co-repressor, MITR, Sparrow,D.B., Miska,E.A., Langley,E., Reynaud-Deonauth,S., Kotecha,S., Towers,N., Spohr,G., Kouzarides,T. and Mohun,T.J., EMBO J. 18 (18), 5085-5098 (1999) |
| 10 | NP_114408 | Isolation and characterization of mammalian HDAC10, a novel histone deacetylase, Kao,H.Y., Lee,C.H., Komarov,A., Han,C.C. and Evans,R.M., J. Biol. Chem. 277 (1), 187-193 (2002) |

**TABLE 3: CLASS III HDACs**

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| Sirtuin 1 | NP_036370 | Characterization of five human cDNAs with homology to the yeast SIR2 gene: Sir2-like proteins (sirtuins) metabolize NAD and may have protein ADP-ribosyltransferase activity; Frye,R.A.; Biochem. Biophys. Res. Commun. 260 (1), 273-279 (1999) |
| Sirtuin 2 | NP_085096 / NP_036369 | A 'double adaptor' method for improved shotgun library construction; Andersson,B., Wentland,M.A., Ricafrente,J.Y., Liu,W. and Gibbs,R.A.; Anal. Biochem. 236 (1), 107-113 (1996) |

| HDAC | GenBank Accession Number | Reference |
|---|---|---|
| **Sirtuin 3** | NP_036371 | Characterization of five human cDNAs with homology to the yeast SIR2 gene: Sir2-like proteins (sirtuins) metabolize NAD and may have protein ADP-ribosyltransferase activity; Frye,R.A.; Biochem. Biophys. Res. Commun. 260 (1), 273-279 (1999) |
| **Sirtuin 4** | NP_036372 | Characterization of five human cDNAs with homology to the yeast SIR2 gene: Sir2-like proteins (sirtuins) metabolize NAD and may have protein ADP-ribosyltransferase activity; Frye,R.A.; Biochem. Biophys. Res. Commun. 260 (1), 273-279 (1999) |
| **Sirtuin 5** | NP_112534 / NP_036373 | Characterization of five human cDNAs with homology to the yeast SIR2 gene: Sir2-like proteins (sirtuins) metabolize NAD and may have protein ADP-ribosyltransferase activity; Frye,R.A.; Biochem. Biophys. Res. Commun. 260 (1), 273-279 (1999) |
| **Sirtuin 6** | NP_057623 | Phylogenetic classification of prokaryotic and eukaryotic Sir2-like proteins; Frye,R.A.; Biochem. Biophys. Res. Commun. 273 (2), 793-798 (2000) |
| **Sirtuin 7** | NP_057622 | Phylogenetic classification of prokaryotic and eukaryotic Sir2-like proteins; Frye,R.A.; Biochem. Biophys. Res. Commun. 273 (2), 793-798 (2000) |

**[0106]** Of particular note are Class I HDACs. All Class I HDACs appear to be sensitive to inhibition by trichostatin A (TSA). Also of particular note is HDAC8, a protein whose crystal structure Applicants determined and used in conjunction with arriving at the present invention.

**[0107]** HDAC8 is a 377 residue, 42kDa protein localized to the nucleus of a wide array of tissues, as well as several human tumor cell lines. The wild-type form of full length HDAC8 is described in GenBank Accession Number NP 060956; Buggy, J.J., Sideris, M.L., Mak, P., Lorimer, D.D., McIntosh, B. and Clark, J.M., Cloning and characterization of a novel human histone deacetylase, HDAC8, Biochem. J. 350 Pt 1, 199-205 (2000). $Zn^{2+}$ is likely native to the protein and required for HDAC8 activity.

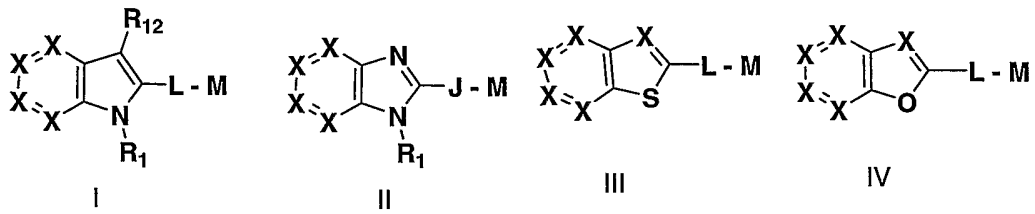
## CRYSTAL STRUCTURE FOR HDAC

**[0108]** Syrrx, Inc. in San Diego, California recently solved the crystal structure for HDAC8. Knowledge of the crystal structure was used to guide the design of the HDAC inhibitors provided herein.

**[0109]** Figure 1 illustrates a ribbon diagram overview of the structure of HDAC8, highlighting the secondary structural elements of the protein. HDAC8 was found to have a single domain structure belonging to the open α/β class of folds. The structure consists of a central 8-stranded parallel β-sheet sandwiched between layers of α-helices. The ligand binding clefts lie almost in the plane of the central β-sheet, and are formed primarily by loops emanating from the carboxy-terminal ends of the β-strands comprising the sheet. There are two large structural extensions, which occur beyond the core of the α/β motif, off the second and last β-strands of the central β-sheet. Residues contained in the extension off the second β-strand form a globular "cap" over the core of the protein, play an important role in defining the shape of the ligand binding pockets, and are involved in a number of key interactions with the bound ligands.

## HDAC INHIBITORS

**[0110]** In one embodiment, a compound is provided comprising a formula selected from the group consisting of:



I II III IV

wherein

each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

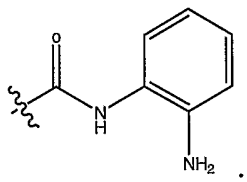
each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion;

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent; and

J is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent, with the proviso that J is not phenyl,

with the proviso that L is a substituent comprising a chain of 1-10 atoms in Formulae I, II and IV when each X is $CR_{12}$ and M is



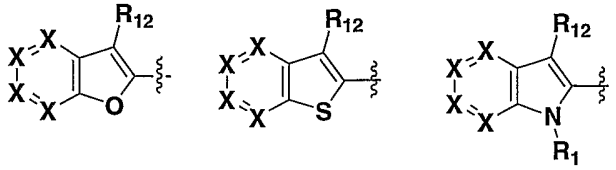
**[0111]** For clarity, it is noted that J in the above embodiment may be any L substituent described herein other than phenyl.

**[0112]** In another embodiment, HDAC inhibitors of the present invention comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



wherein

each X is independently selected from the group consisting of $CR_{12}$ and N;

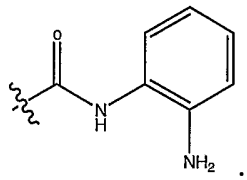
$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent,

with the proviso that L is a substituent comprising a chain of 1-10 atoms when each X is $CR_{12}$ and M is

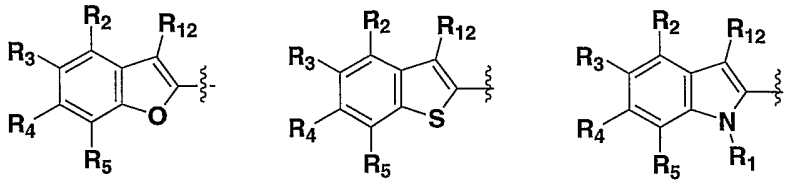


**[0113]** In another embodiment, HDAC inhibitors of the present invention comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

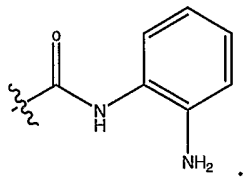
$R_2$, $R_3$, $R_4$ and $R_5$ are each independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent,

with the proviso that L is a substituent comprising a chain of 1-10 atoms when each X is $CR_{12}$ and M is

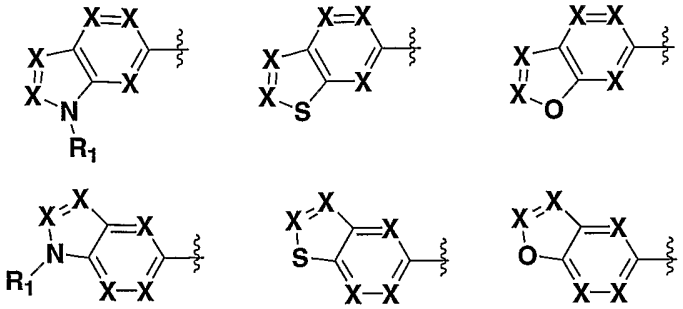


**[0114]** In one embodiment, HDAC inhibitors of the present invention are comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

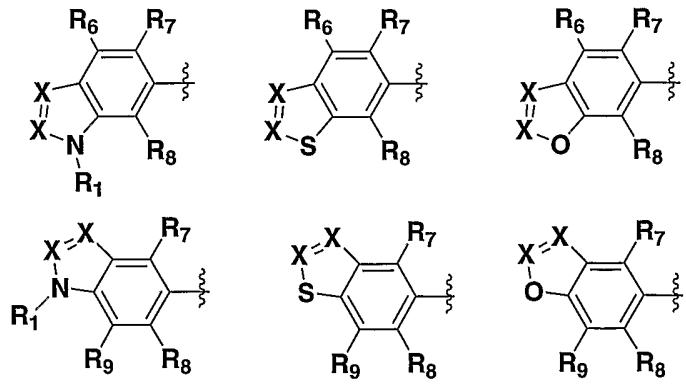
L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0115]** In another embodiment, HDAC inhibitors of the present invention comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_6$, $R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

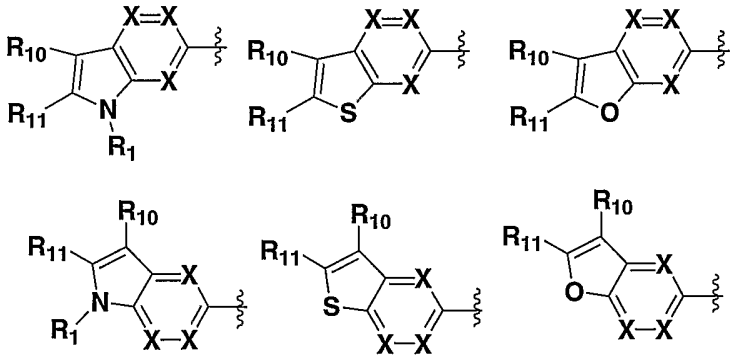
L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0116]** In yet another embodiment, HDAC inhibitors of the present comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_{10}$ and $R_{11}$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

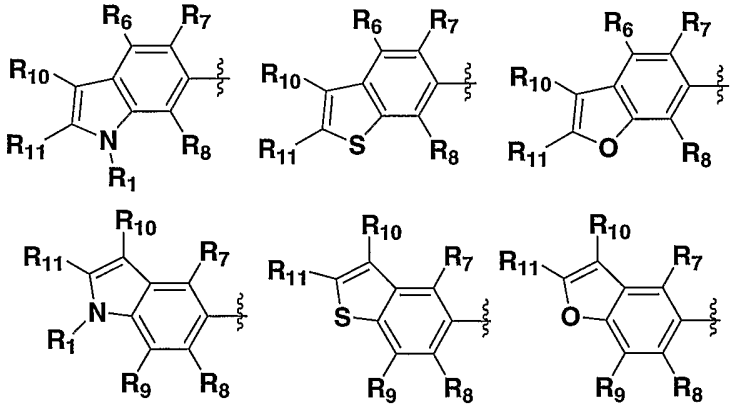
L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0117]** In yet another embodiment, HDAC inhibitors of the present invention comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_6$, $R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{10}$ and $R_{11}$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

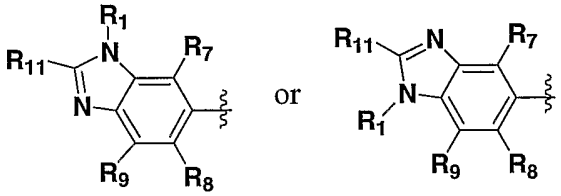
L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0118]** In yet another embodiment, HDAC inhibitors of the present invention comprise the formula

**Z—L—M**

wherein

Z is selected from the group consisting of




$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{11}$ is selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0119]** It is noted that any two adjacent X moieties may optionally each be $CR_{12}$ where the $R_{12}$ substituents are taken together to form a substituted or unsubstituted ring.

**[0120]** In one particular variation, $R_2$ and $R_3$, or $R_3$ and $R_4$, or $R_4$ and $R_5$ are taken together to form a substituted or unsubstituted ring.

**[0121]** In another particular variation, $R_6$ and $R_7$, or $R_8$ and $R_9$ are taken together to form a substituted or unsubstituted ring.

**[0122]** In a particular variation of the above, $R_{10}$ and $R_{11}$ are taken together to form a substituted or unsubstituted ring. According to the above variation, the ring is an aryl or heteroaryl ring.

**[0123]** According to each of the above variation, the Z moiety is a substituted or unsubstituted benzofuran or benzothiophene. In another variation, the Z moiety is a substituted or unsubstituted benzoimidazole, or benzoindole.

**[0124]** In accordance to each of the above variations, $R_1$ is a substituted or unsubstituted N-substituted piperidin-3-yl moiety. In a particular variation, the N-substituted piperidin-3-yl moiety is an N-($C_{1-6}$)alkyl piperidin-3-yl moiety. In accordance to each of the above variations, $R_1$ is selected from the group consisting of ($C_{1-4}$)alkyl, phenyl, 1-piperidin-4-ylmethyl, 2-morpholi-4-yl-ethyl, 2-halo-phenyl, 2-halo-phen($C_{1-4}$)alkyl, 3-halo-phen($C_{1-4}$)alkyl, 2-$CF_3O$-phen($C_{1-4}$)alkyl, 3-$CF_3O$-phen($C_{1-4}$)alkyl, 3-halo-phenyl, 4-halo-phenyl, 2-methoxy-phenyl, 3-methoxy-phenyl, 4-methoxy-phenyl, 4-phenoxy-phenyl, 4-benzyloxyphenyl, 4-pyrazol-1-yl-benzyl, 1-p-tolyl-ethyl, pyrrolidin-3-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl; 2-di($C_{1-4}$)alkylamino-ethyl, 2-di($C_{1-4}$)alkylamino-1-methyl-ethyl, 2-di($C_{1-4}$)alkylamino-ethyl, 2-hydroxy-2-phenyl-ethyl, 2-pyridin-2-yl-ethyl, 2-pyridin-3-yl-ethyl, 2-pyridin-4-yl-ethyl, 2-(1H-indol-3-yl)-ethyl, 3-indolyl($C_{1-4}$)alkyl, 1-indan-2-yl, *R*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *R*-β-($CH_3$)-phen($C_{1-4}$)alkyl, 6-propylsulfanyl, *trans*-4-hydroxy-cyclohexyl, 1-aza-bicyclo[2.2.2]oct-2-yl, 1-($C_{1-4}$)alkyl-piperidin-3-yl, 1-(2,2-difluoro-ethyl)-piperidin-3-yl, (2-di($C_{1-4}$)alkylamino-2-phenyl-ethyl), 1-benzyl-piperidin-3-yl, 1-allyl-piperidin-3-yl, 1-acetyl-piperidin-3-yl, piperidin-3-yl, and phen($C_{1-4}$)alkyl;

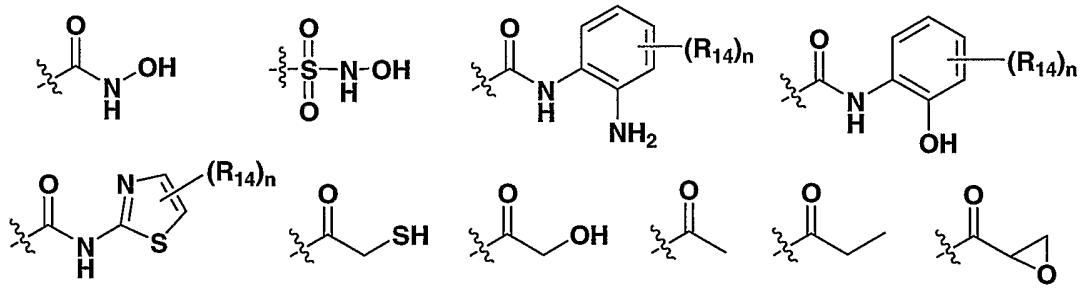
**[0125]** It is further noted that in accordance to each of the above variation, L is O or L may be absent.

**[0126]** In a particular variation, $R_3$ or $R_4$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted, and $R_2$ and $R_5$ are hydrogen.

**[0127]** In another particular variation, $R_6$, $R_7$, $R_8$ and $R_9$ are hydrogen.

**[0128]** In yet another variation for each of the above, Z is a substituted or unsubstituted benzofuran, benzothiophene, benzoimidazole, or benzoindole and M is carboxylic acid hydroxyamide.

**[0129]** In accordance to each of the above variations, M comprises a member selected from the group consisting of trifluoroacetyl (-C(O)-$CF_3$), -NH-P(O)OH-$CH_3$, sulfonamides (-$SO_2NH_2$), hydroxysulfonamides (-$SO_2NHOH$), thiols(-SH), and carbonyl groups having the formula -C(O)-$R_{13}$ wherein $R_{13}$ is hydroxylamino, hydroxyl, amino, alkylamino, or an alkoxy group. In one particular variation, M is selected from the group consisting of:



wherein n is 0, 1, 2, 3, or 4 and each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, ($C_{1-10}$)alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, ($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl, hetero($C_{3-12}$)cycloalkyl, ($C_{9-12}$)bicycloalkyl, hetero($C_{3-12}$)bicycloalkyl, aryl($C_{1-10}$)alkyl, heteroaryl($C_{1-5}$)alkyl, perhalo($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl($C_{1-10}$)alkyl, halo($C_{1-10}$)alkyl, carbonyl($C_{1-3}$)alkyl, thiocarbonyl($C_{1-3}$)alkyl, sulfonyl($C_{1-3}$)alkyl, sulfinyl($C_{1-3}$)alkyl, amino ($C_{1-10}$)alkyl, imino($C_{1-3}$)alkyl, aryl, heteroaryl, ($C_{9-12}$)bicycloaryl, and hetero($C_{4-12}$)bicycloaryl, each substituted or unsubstituted.

**[0130]** In accordance to each of the above variations, M comprises a hydroxamic acid moiety.

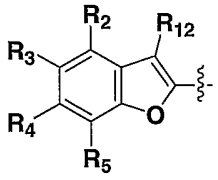
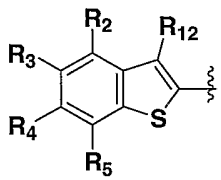
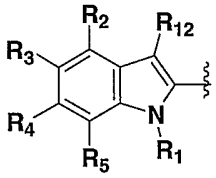
**[0131]** In accordance to each of the above variations, L is E, Z or mixtures of E/Z $-CH_2=CH_2-$.

**[0132]** In another embodiment, HDAC inhibitors of the present invention comprise the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of

wherein

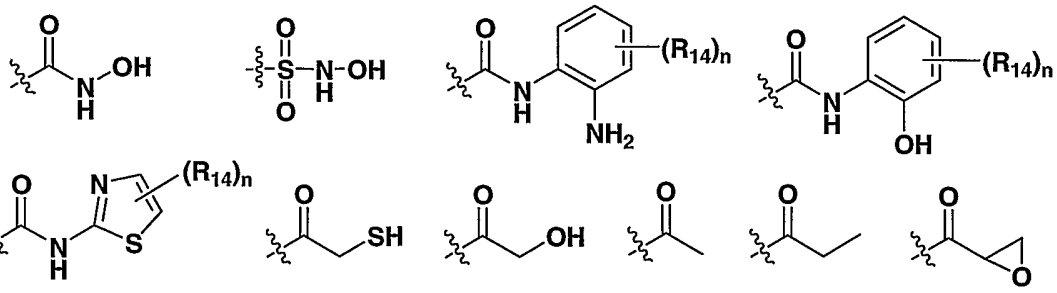
$R_1$ is a substituted or unsubstituted N-substituted piperidin-3-yl moiety;

$R_2$ and $R_5$ are each hydrogen;

$R_3$ and $R_4$ are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

$R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is selected from the group consisting of:



n is 0, 1, 2, 3, or 4;

each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, ($C_{1-10}$)alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, ($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl, hetero($C_{3-12}$)cycloalkyl, ($C_{9-12}$)bicycloalkyl, hetero($C_{3-12}$)bicycloalkyl, aryl($C_{1-10}$)alkyl, heteroaryl($C_{1-5}$)alkyl, perhalo($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl($C_{1-10}$)alkyl, halo($C_{1-10}$)alkyl, carbonyl($C_{1-3}$)alkyl, thiocarbonyl($C_{1-3}$)alkyl, sulfonyl($C_{1-3}$)alkyl, sulfinyl($C_{1-3}$)alkyl, amino ($C_{1-10}$)alkyl, imino($C_{1-3}$)alkyl, aryl, heteroaryl, ($C_{9-12}$)bicycloaryl, and hetero($C_{4-12}$)bicycloaryl, each substituted or unsubstituted; and

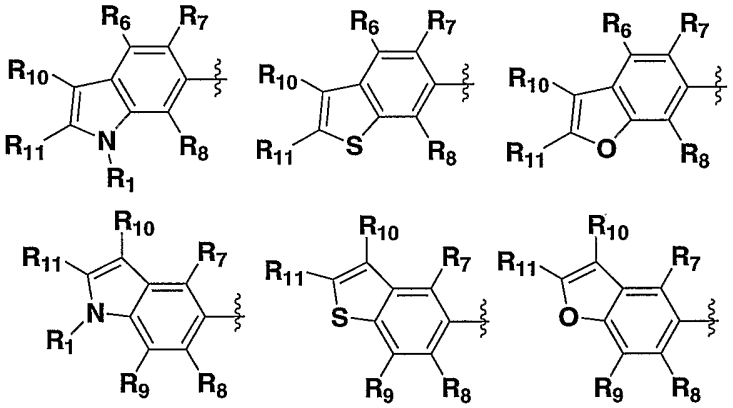
L is O or (E) $-CH_2=CH_2-$.

**[0133]** In another embodiment, HDAC inhibitors of the present invention comprise the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of

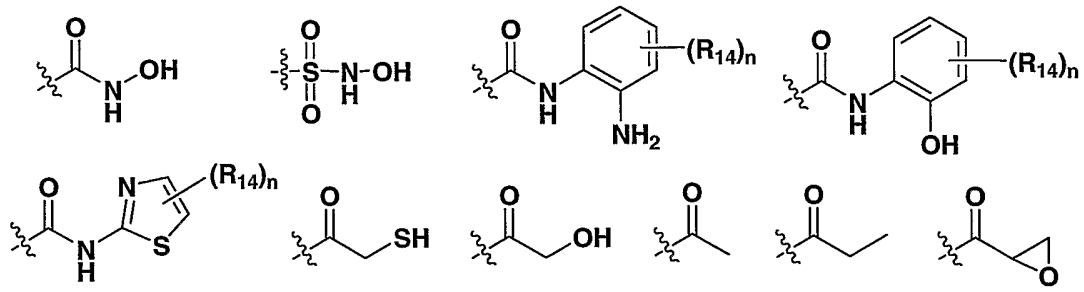


$R_1$ is a substituted or unsubstituted N-substituted piperidin-3-yl moiety;

$R_6$, $R_7$, $R_8$, and $R_9$ are each hydrogen;

$R_{10}$ and $R_{11}$ are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

M is selected from the group consisting of:



n is 0, 1, 2, 3, or 4;

each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, $(C_{1-10})$alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, $(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl, hetero$(C_{3-12})$cycloalkyl, $(C_{9-12})$bicycloalkyl, hetero$(C_{3-12})$bicycloalkyl, aryl$(C_{1-10})$alkyl, heteroaryl$(C_{1-5})$alkyl, perhalo$(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl$(C_{1-10})$alkyl, halo$(C_{1-10})$alkyl, carbonyl$(C_{1-3})$alkyl, thiocarbonyl$(C_{1-3})$alkyl, sulfonyl$(C_{1-3})$alkyl, sulfinyl$(C_{1-3})$alkyl, amino $(C_{1-10})$alkyl, imino$(C_{1-3})$alkyl, aryl, heteroaryl, $(C_{9-12})$bicycloaryl, and hetero$(C_{4-12})$bicycloaryl, each substituted or unsubstituted; and

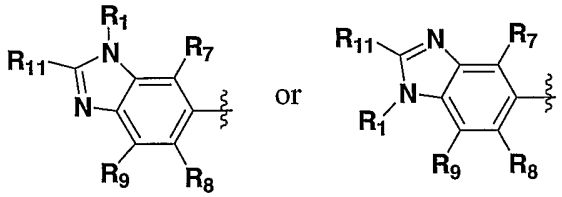
L is O or (E) $-CH_2=CH_2-$.

**[0134]** In another embodiment, HDAC inhibitors of the present invention comprise the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{11}$ is selected from the group consisting of are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

**[0135]** It is noted in regard to each of the above embodiments that a given alkyl, alkoxy, aryloxy, heteroaryloxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, amino, thio, or carbonyl group substituent may optionally be further substituted. As also noted, such two substituents may be taken together to form a ring. Examples of further substituted alkyl groups include, but are not limited to, those selected from the group consisting of haloalkyl, cycloalkyl, aminoalkyl, oxaalkyl, heteroaralkyl, and aralkyl, each of which may optionally be further substituted. Examples of further substituted alkoxy aryloxy, and heteroaryloxy groups include, but are not limited to, those selected from the group consisting of haloalkoxy, haloaryloxy, and haloheteroaryloxy, each of which may optionally be further substituted. Examples of further substituted aminosulfonyl, alkylsulfonyl, arylsulfonyl, and heteroarylsulfonyl groups include, but are not limited to, those selected from the group consisting of alkylaminosulfonyl, arylaminosulfonyl, heteroarylaminosulfonyl, heteroaralkylsulfonyl, and aralkylsulfonyl, each of which may optionally be further substituted. Examples of further substituted amino groups include, but are not limited to, those selected from the group consisting of alkylamino, arylamino, and acylamino, each of which may optionally be further substituted. Examples of further substituted thio groups include, but are not limited to, those selected from the group consisting of alkylthio, arylthio, and heteroarylthio, each of which may optionally be further substituted. Examples of further substituted carbonyl groups include, but are not limited to, acids, acid halides, amides, esters, and ketones. For example, the carbonyl groups may be an alkylcarbonyl, arylcarbonyl, heteroarylcarbonyl, aminocarbonyl, alkoxycarbonyl, aralkoxycarbonyl, or heteroaralkoxycarbonyl, each of which may optionally be further substituted.

**[0136]** It is noted that the preceding lists of examples are not intended to be limiting as other forms of alkyl, alkoxy, aryloxy, heteroaryloxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, amino, and thio groups may also be formed with the addition of other substituents to the base group, some of which are described herein and all of which are intended to fall within the scope of the present invention.

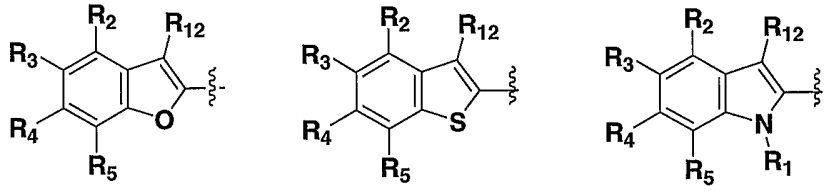
**Substituent $R_1$**

**[0137]** It should be recognized that the compounds described in the above table where the $R_1$ substituent is varied may each be further substituted by replacing one or more of the hydrogens implicitly depicted in the structure with non-hydrogen substituents. Such further substituents may optionally form additional fused rings, as is also taught herein.

**[0138]** In one variation, $R_1$ is a substituted alkyl where the carbon of $R_1$ alpha to the ring atom is a tertiary carbon, i.e., in addition to the bond to the ring atom, the carbon atom has two non-hydrogen substituents. It is believed that substitution of the carbon alpha to the ring atom in this manner may reduce oxidation of that alpha carbon, particularly when the ring atom is nitrogen, thus adding to the stability of the compound.

**Substituents $R_3$ and $R_4$**

**[0139]** The table below provides non-exclusive examples of different compounds having different $R_3$ and $R_4$ substituents.




**$R_3$ and $R_4$ Substituents**

| | |
|---|---|
| toluene-4-sulfonylamino | 5-toluene-3-sulfonylamino |
| p-tolylmethanesulfonylamino | 4-chloro-phenylmethanesulfonylamino |
| 5-propane-1-sulfonylamino | 4-chloro-benzenesulfonylamino |
| thiophene-2-sulfonylamino | 2-naphthalen-1-yl-ethanesulfonylamino |
| naphthalene-1-sulfonylamino | naphthalene-2-sulfonylamino |
| methanesulfonylamino | 4-methoxy-benzenesulfonylamino |

| | |
|---|---|
| cyclohexanecarbonyl-amino | 3-methoxy-propionylamino |
| benzoylamino | 3-methyl-benzoylamino |
| 4-methyl-benzoylamino | 3-methoxy-benzoylamino |
| 4-methoxy-benzoylamino | 3-bromo-benzoylamino |
| 4-bromo-benzoylamino | 3-hydroxy-benzoylamino |
| 3-phenoxy-benzoylamino | 4-phenoxy-benzenesulfonylamino |
| 2,3-dihydro-benz[1,4]dioxine-6-sulfonylamino | 4-methanesulfonyl-benzenesulfonylamino |
| 3-dimethylamino-benzoylamino | 4-dimethylamino-benzoylamino |
| 3-(N-hydroxycarbamimidoyl)-benzoylamino | 4-(N-hydroxycarbamimidoyl)-benzoylamino |
| naphthalene-2-carbonyl)-amino | isonicotinamidyl |
| 3-phenyl-propionylamino | 5-phenylacetylamino |
| 5-methyl-1-phenyl-1H-pyrazole-3-sulfonylamino | 2-phenoxy-pyridine-4-sulfonylamino |
| 5-oxazol-5-yl-thiophene-2-sulfonylamino | 5-pyridin-2-yl-thiophene-2-sulfonylamino |
| 5-oxazol-2-yl-benzesulfonylamino | furan-2-carboxamidyl |
| furan-3-carboxamidyl | benzofuran-2-carboxamidyl |
| 1-methyl-1H-pyrrole-2-carboxyamidyl | 2,6-dimethoxy-nicotinamid-5-carboxamidyl |
| quinoline-2-carboxamidyl | pyrazine-2-carboxamidyl |
| 4-isopropyl-benzoylamino | 2-oxo-2-phenyl-acetylamino |
| 1-methyl-1H-indole-2-carboxamidyl | dimethylaminomethyl, (1H-[1,2,4]triazol-3-ylamino |
| 5-phenylaminomethyl, 2-(1H-indol-3-yl)-ethylamino | (2-hydroxy-ethyl)-[2-(1H-indol-3-yl)-ethyl]-aminomethyl |

**Substituents $R_2$, $R_3$, $R_4$, $R_5$, $R_6$, $R_7$, $R_8$ and $R_9$**

**[0140]** $R_2$, $R_3$, $R_4$, $R_5$, $R_6$, $R_7$, $R_8$ and $R_9$ may each independently be selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl,

alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted.

**[0141]** It is noted that $R_2$ and $R_3$; $R_3$ and $R_4$; and $R_4$ and $R_5$ may each optionally be taken together to form a ring. The ring formed may optionally be a 5 or 6 membered ring. In one variation, the ring formed is an aryl or heteroaryl ring.

**[0142]** It is also noted that $R_6$ and $R_7$; $R_7$ and $R_8$; and $R_8$ and $R_9$ may each optionally be taken together to form a ring. The ring formed may optionally be a 5 or 6 membered ring. In one variation, the ring formed is an aryl or heteroaryl ring.

**Substituent Z**

**[0143]** Figure 2B illustrates particular examples of Z moieties that the compounds of the present invention may comprise. In one particular embodiment, the Z moiety is a substituted or unsubstituted benzimidazole or imidazole.

**[0144]** It is noted that the examples of Z moieties shown in Figure 2B may optionally be further substituted as has been specified herein. For example, the various $R_1$ substituents that may be appended to the ring are not specified in Figure 2B.

**[0145]** Also, it is noted that Figure 2B is intended only to be exemplary and that other Z substituents may be employed in the compounds according to the present invention consistent with the teachings herein.

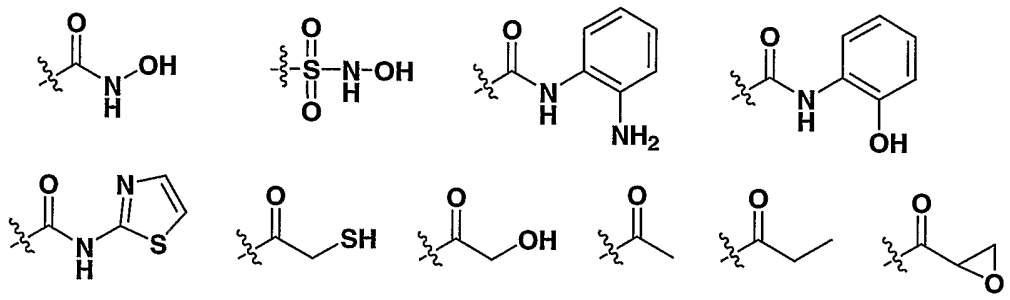
**[0146]** Examples of rings comprising heteroatoms, including 5 and 6 membered aromatic rings comprising heteroatoms are illustrated in Figure 2C. It is noted that the rings shown in Figure 2C are unsubstituted and that further substitutions may optionally be added as has been specified.

**Substituent M**

**[0147]** In regard to each of the above embodiments, substituent M may be a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion, and optionally, more particularly a zinc ion since a zinc ion is known to be present in the catalytic site of histone deacetylases. Hence, the M substituent may facilitate inhibitor binding by complexing with the zinc ion present in the catalytic site of histone deacetylases.

**[0148]** Examples of substituents capable of complexing with a zinc ion that may be used as the M substituent include, but are not limited to trifluoroacetyl (-C(O)-$CF_3$), -NH-

P(O)OH-$CH_3$, sulfonamides (-$SO_2NH_2$), hydroxysulfonamides (-$SO_2NHOH$), thiols(-SH), and carbonyl groups having the formula -C(O)-$R_{13}$ wherein $R_{13}$ is hydroxylamino, hydroxyl, amino, alkylamino, or an alkyloxy group. Particular examples of such substituents include:



**[0149]** In one particular variation, M is a hydroxamic acid (-C(O)-NHOH), also shown above. It is noted that hydroxamic acids, such as trichostatin A, have been shown to be effective inhibitors against histone deacetylases by complexing with the zinc ion present in the catalytic site of histone deacetylases.

**Leader group L**

**[0150]** In regard to each of the above embodiments, the leader group, L, may be any substituent comprising a chain of 0-10 atoms connecting the M substituent to remainder of the compound. The number of atoms in the chain serves to extend the zinc complexing substituent, M, a sufficient distance away from the remainder of the compound so as to allow the zinc complexing substituent to interact with the zinc ion while the remainder of the compound interacts with hydrophobic regions in the binding pocket of the histone deacetylase.

**[0151]** In one embodiment, the leader group, L, is 0 or is absent. In another embodiment, the leader group, L, comprises a chain of 1-10 atoms that extend from the M substituent to remainder of the compound, optionally 3-9 and optionally 4-8 atoms. In one variation, the number of atoms in the chain of atoms extending between the M substituent and the remainder of the compound is 3, 4, 5, 6, 7, 8 or 9 atoms.

**[0152]** It is noted that the chain of atoms of the leader group extending between the M substituent and the remainder of the compound may consist only of carbon atoms. Alternatively, the chain may also comprise non-carbon atoms such as nitrogen, oxygen and sulfur.

**[0153]** It is also noted that the bonds forming the chain of atoms of the leader group extending between the M substituent and the remainder of the compound may be saturated, partially unsaturated, or fully unsaturated. For example, the leader group may comprise as part of the chain of atoms one or more alkene (-CH=CH-) or alkyne (-C≡C-) bonds.

**[0154]** A variety of different moieties may be incorporated into the leader groups of the HDAC inhibitors of the present invention. Examples of such moieties are shown in Figure 2D.

**[0155]** The atoms forming the backbone of the leader group, L, may optionally comprise one or more members of the group consisting of: -$(CH_2)$n-, where n is an integer from 1 to 10; -$CH(CH_3)$-; -$CH(CH_3)CH_2$- and -$CH_2CH(CH_3)$-; -$CH(CH_3)CH_2CH_2$-, -$CH_2CH(CH_3)CH_2$-, and -$CH_2CH_2CH$ $(CH_3)$-; -$CH(CH_3)CH_2CH_2CH_2$-, -$CH_2CH(CH_3)CH_2CH_2$-, -$CH_2CH_2CH(CH_3)CH_2$-, and -$CH_2CH_2CH_2CH(CH_3)$-; -$CH(CH_3)CH_2CH_2CHCH_2$-, -$CH_2CH(CH_3)CH_2CH_2CH_2$-, -$CH_2CH_2CH(CH_3)CH_2CH_2$-, -$CH_2CH_2CH_2CH(CH_3)CH_2$-, and -$CH_2CH_2CH_2CH_2CH(CH_3)$-; -$CH(CH_2CH_3)$-; -$CH(CH_2CH_3)CH_2$- and -$CH_2CH(CH_2CH_3)$-; -$CH(CH_2CH_3)CH_2CH_2$-, -$CH_2CH(CH_2CH_3)CH_2$-, and -$CH_2CH_2CH(CH_2CH_3)$-; -$CH(CH_2CH_3)CH_2CH_2CH_2$-, -$CH_2CH(CH_2CH_3)CH_2CH_2$-, -$CH_2CH_2CH(CH_2CH_3)CH_2$-, and -$CH_2CH_2CH_2CH(CH_2CH_3)$-; -$CH_2CH_2CH(CH_2CH_3)CH_2CH_2$-, -$CH_2CH_2CH_2CH(CH_2CH_3)CH_2$-, and -$CH(CH_2CH_3)CH_2CH_2CH_2CH_2$-, -$CH_2CH(CH_2CH_3)CH_2CH_2CH_2$-, -$CH_2CH_2CH_2CHCH(CH_2CH_3)$; -CH=CH-; -CH=$CHCH_2$- and -$CH_2CH$=CH-; -CH=$CHCH_2$-, -$CH_2CH$=$CHCH_2$-, and -$CH_2CH_2CH$=CH-; -CH=$CHCH_2CH_2CH_2$-, -$CH_2CH$=$CHCH_2CH_2$-, -$CH_2CH_2CH$=$CHCH_2$-, and -$H_2CH_2CH_2CH$=CH-; -CH=$CHCHCH_2CH_2CH_2$-, -$CH_2CH$=$CHCH_2CH_2CH_2$-, -$CH_2CH_2CH$=$CHCH_2CH_2$-, -$CH_2CH_2CH_2CH$=$CHCH_2$-, and -$CH_2CH_2CH_2CHCH$=CH-; -$C(CH_3)$=CH- and -CH=$C(CH_3)$-; -$C(CH_3)$=$CHCH_2$-, -CH=$C(CH_3)CH_2$-, and -CH=$CHCH(CH_3)$-; -$CH(CH_3)CH$=CH-, -$CH_2C(CH_3)$=CH-, and -$CH_2CH$=$C(CH_3)$-; -CH=CHCH=CH-; -CH=CHCH=$CHCH_2$-, -$CH_2CH$=CHCH=CH-, and -CH=$CHCH_2CH$=CH-; -CH=CHCH=$CHCH_2CH_2$-, -CH=$CHCH_2CH$=$CHCH_2$-, and -CH=$CHCH_2CH_2CH$=CH-, -$CH_2CH$=CHCH=$CHCH_2$-, -$CH_2CH$=$CHCH_2CH$=CH-, and -$CH_2CH_2CH$=CHCH=CH-; -$C(CH_3)$=CHCH=CH-, -CH=$C(CH_3)CH$ =CH-, -CH=$CHC(CH_3)$=CH-, and -CH=CHCH=$C(CH_3)$- ; -C≡C-; -C≡$CCH_2$-, -$CH_2C$≡C-; -

C≡CCH($CH_3$)-, and -CH($CH_3$)C≡C-; -C=C$CH_2CH_2$-, -$CH_2$C-C$CH_2$-, and -$CH_2CH_2$C=C-; -C≡CCH($CH_3$)$CH_2$- and -C≡C$CH_2$CH($CH_3$)-; -CH($CH_3$)C=C$CH_2$- and -$CH_2$C≡CCH($CH_3$)-; -CH($CH_3$)$CH_2$C≡C- and -$CH_2$CH($CH_3$)C≡C-; -C≡CCH=CH-, -CH=CHC≡C-, and -C≡CC≡C-; -C≡C$CH_2CH_2CH_2$- and -$CH_2CH_2CH_2$C≡C-; -C≡C$CH_2CH_2CH_2CH_2$- and -$CH_2CH_2CH_2CH_2$C≡C-; -C≡CCH=CHCH=CH-, -CH=CHC≡C-CH=CH-, and -CH=CHCH=CHC≡C-; -C($CH_3$)=CHC≡C-, -CH=C($CH_3$)C≡C-, -C≡CC($CH_3$)=CH-, and -C≡CCH=C($CH_3$). L may also be E, Z or mixtures of E/Z -$CH_2$=$CH_2$-. It is noted that the hydrogen atoms of above possible portions of the leader group may optionally be substituted with further substituents.

**[0156]** It is also noted that the leader group may comprise one or more substituents extending from one or more atoms of the leader group backbone. In one variation, two substituents extending from the atoms extending between the carbon alpha to the leader group and the M substituent to form one or more three, four, five, six, seven, eight or nine membered rings. The atoms of the leader group forming the ring may be separated from each other by 0, 1, 2, 3, or 4 atoms.

**[0157]** The rings may be saturated or partially unsaturated (i.e., comprise one or two double bonds). The rings may also be aromatic, referred to herein as aryl and heteroaryl rings. The rings may optionally be further substituted. These further ring substituents may combine to form additional rings that are fused to the rings forming a portion of the backbone, e.g., bicycloaryl and bicycloheteroaryl.

**[0158]** Examples of cycloalkyl rings that may be formed by one or more leader group backbone atoms include, but are not limited to: cyclopropyl, cyclohexane, cyclopentane, cyclopentene, cyclopentadiene, cyclohexane, cyclohexene, cyclohexadiene, phenyl, cycloheptane, cycloheptene, cycloheptadiene, cyclooctane, cyclooctene, and cyclooctadiene.

**[0159]** Examples of heteroaryl rings that may be formed by one or more leader group backbone atoms include, but are not limited to: furan, thiofuran, pyrrole, isopyrrole, 3-isopyrrole, pyrazole, isoimidazole, triazole, isoxazole, oxazole, thiazole, isothiazole, oxadiazole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, benzofuran, isobenzofuran, benzothiofuran, isobenzothiophene, indole, isobenzazole, quinoline, isoquinoline, cinnoline, quinazoline, naphthyridine, and pyridopyridine.

**[0160]** It is noted that the inhibitors may include one or more chiral centers. The chiral centers may be either the R or S enantiomers, or where there are more than one chiral centers, the compounds are the diastereomers, depending on the substituents.

**[0161]** In a particular embodiment, the inhibitors may be in the form of a pharmaceutically acceptable salt. In another particular embodiment, the inhibitor is present in a mixture of stereoisomers. In one particular variation, there is provided the inhibitor according to any one of the above variation wherein the inhibitor compound comprises a single stereoisomer.

**[0162]** Synthetic scheme for preparing compounds according to these various embodiments are provided in the Examples. Particular examples of HDAC inhibitors according to these embodiments are provided in the examples.

**Salts, Hydrates, and Prodrugs of HDAC Inhibitors**

**[0163]** It should be recognized that the compounds of the present invention may be present and optionally administered in the form of salts, hydrates and prodrugs that are converted in vivo into the compounds of the present invention. For example, it is within the scope of the present invention to convert the compounds of the present invention into and use them in the form of their pharmaceutically acceptable salts derived from various organic and inorganic acids and bases in accordance with procedures well known in the art.

**[0164]** When the compounds of the present invention possess a free base form, the compounds can be prepared as a pharmaceutically acceptable acid addition salt by reacting the free base form of the compound with a pharmaceutically acceptable inorganic or organic acid, e.g., hydrohalides such as hydrochloride, hydrobromide, hydroiodide; other mineral acids and their corresponding salts such as sulfate, nitrate, phosphate, etc ...; and alkyl- and monoarylsulfonates such as ethanesulfonate, toluenesulfonate and benzenesulfonate; and other organic acids and their corresponding salts such as acetate, tartrate, maleate, succinate, citrate, benzoate, salicylate and ascorbate. Further acid addition salts of the present invention include, but are not limited to: adipate, alginate, arginate, aspartate, benzenesulfonate (besylate), bisulfate, bisulfite, bromide, butyrate, camphorate, camphorsulfonate, caprylate, chloride, chlorobenzoate, cyclopentanepropionate, digluconate, dihydrogenphosphate, dinitrobenzoate,

dodecylsulfate, ethanesulfonate, fumarate, galacterate (from mucic acid), galacturonate, glucoheptaoate, gluconate, glutamate, glycerophosphate, hemisuccinate, hemisulfate, heptanoate, hexanoate, hippurate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxyethanesulfonate, iodide, isethionate, iso-butyrate, lactate, lactobionate, malate, malonate, mandelate, metaphosphate, methanesulfonate, methylbenzoate, monohydrogenphosphate, 2-naphthalenesulfonate, nicotinate, nitrate, oxalate, oleate, pamoate, pectinate, persulfate, phenylacetate, 3-phenylpropionate, phosphate, phosphonate and phthalate. It should be recognized that the free acid forms will typically differ from their respective salt forms somewhat in physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free acid forms for the purposes of the present invention.

**[0165]** When the compounds of the present invention possess a free base form, a pharmaceutically acceptable base addition salt can be prepared by reacting the free acid form of the compound with a pharmaceutically acceptable inorganic or organic base. Examples of such bases are alkali metal hydroxides including potassium, sodium and lithium hydroxides; alkaline earth metal hydroxides such as barium and calcium hydroxides; alkali metal alkoxides, e.g. potassium ethanolate and sodium propanolate; and various organic bases such as ammonium hydroxide, piperidine, diethanolamine and N-methylglutamine. Also included are the aluminum salts of the compounds of the present invention. Further base salts of the present invention include, but are not limited to: copper, ferric, ferrous, lithium, magnesium, manganic, manganous, potassium, sodium and zinc salts. Organic base salts include, but are not limited to, salts of primary, secondary and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, e.g., arginine, betaine, caffeine, chloroprocaine, choline, N, N'-dibenzylethylenediamine (benzathine), dicyclohexylamine, diethanolamine, diethylamine, 2-diethylaminoethanol, 2-dimethylaminoethanol, ethanolamine, ethylenediamine, N-ethylmorpholine, N-ethylpiperidine, glucamine, glucosamine, histidine, hydrabamine, iso-propylamine, lidocaine, lysine, meglumine, N-methyl-D-glucamine, morpholine, piperazine, piperidine, polyamine resins, procaine, purines, theobromine, triethanolamine, triethylamine, trimethylamine, tripropylamine and tris-(hydroxymethyl)-methylamine (tromethamine). It should be recognized that the free

base forms will typically differ from their respective salt forms somewhat in physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free base forms for the purposes of the present invention.

**[0166]** Compounds of the present invention, which comprise basic nitrogen-containing groups, may be quaternized with such agents as ($C_{1-4}$) alkyl halides, e.g., methyl, ethyl, iso-propyl and tert-butyl chlorides, bromides and iodides; di ($C_{1-4}$) alkyl sulfates, e.g., dimethyl, diethyl and diamyl sulfates; ($C_{10-18}$) alkyl halides, e.g., decyl, dodecyl, lauryl, myristyl and stearyl chlorides, bromides and iodides; and aryl ($C_{1-4}$) alkyl halides, e.g., benzyl chloride and phenethyl bromide. Such salts permit the preparation of both water-soluble and oil-soluble compounds of the present invention.

**[0167]** *N*-oxides of compounds according to the present invention can be prepared by methods known to those of ordinary skill in the art. For example, *N*-oxides can be prepared by treating an unoxidized form of the compound with an oxidizing agent (e.g., trifluoroperacetic acid, permaleic acid, perbenzoic acid, peracetic acid, *meta*-chloroperoxybenzoic acid, or the like) in a suitable inert organic solvent (e.g., a halogenated hydrocarbon such as dichloromethane) at approximately 0 °C. Alternatively, the *N*-oxides of the compounds can be prepared from the *N*-oxide of an appropriate starting material.

**[0168]** Prodrug derivatives of compounds according to the present invention can be prepared by modifying substituents of compounds of the present invention that are then converted *in vivo* to a different substituent. It is noted that in many instances, the prodrugs themselves also fall within the scope of the range of compounds according to the present invention. For example, prodrugs can be prepared by reacting a compound with a carbamylating agent (e.g., 1,1-acyloxyalkylcarbonochloridate, *para*-nitrophenyl carbonate, or the like) or an acylating agent. Further examples of methods of making prodrugs are described in Saulnier *et al.*(1994), *Bioorganic and Medicinal Chemistry Letters*, Vol. 4, p. 1985.

**[0169]** Protected derivatives of compounds of the present invention can also be made. Examples of techniques applicable to the creation of protecting groups and their removal can be found in T.W. Greene, *Protecting Groups in Organic Synthesis*, 3rd edition, John Wiley & Sons, Inc. 1999.

**[0170]** Compounds of the present invention may also be conveniently prepared, or formed during the process of the invention, as solvates (e.g. hydrates). Hydrates of compounds of the present invention may be conveniently prepared by recrystallization from an aqueous/organic solvent mixture, using organic solvents such as dioxane, tetrahydrofuran or methanol.

**[0171]** A "pharmaceutically acceptable salt", as used herein, is intended to encompass any compound according to the present invention that is utilized in the form of a salt thereof, especially where the salt confers on the compound improved pharmacokinetic properties as compared to the free form of compound or a different salt form of the compound. The pharmaceutically acceptable salt form may also initially confer desirable pharmacokinetic properties on the compound that it did not previously possess, and may even positively affect the pharmacodynamics of the compound with respect to its therapeutic activity in the body. An example of a pharmacokinetic property that may be favorably affected is the manner in which the compound is transported across cell membranes, which in turn may directly and positively affect the absorption, distribution, biotransformation and excretion of the compound. While the route of administration of the pharmaceutical composition is important, and various anatomical, physiological and pathological factors can critically affect bioavailability, the solubility of the compound is usually dependent upon the character of the particular salt form thereof, which it utilized. One of skill in the art will appreciate that an aqueous solution of the compound will provide the most rapid absorption of the compound into the body of a subject being treated, while lipid solutions and suspensions, as well as solid dosage forms, will result in less rapid adsorption of the compound.

**Preparation Of HDAC Inhibitors**

**[0172]** Various methods may be developed for synthesizing compounds according to the present invention. Representative methods for synthesizing these compounds are provided in the Examples. It is noted, however, that the compounds of the present invention may also be synthesized by other synthetic routes that others may devise.

**[0173]** It will be readily recognized that certain compounds according to the present invention have atoms with linkages to other atoms that confer a particular stereochemistry

to the compound (e.g., chiral centers). It is recognized that synthesis of compounds according to the present invention may result in the creation of mixtures of different stereoisomers (enantiomers, diastereomers). Unless a particular stereochemistry is specified, recitation of a compound is intended to encompass all of the different possible stereoisomers.

**[0174]** Various methods for separating mixtures of different stereoisomers are known in the art. For example, a racemic mixture of a compound may be reacted with an optically active resolving agent to form a pair of diastereoisomeric compounds. The diastereomers may then be separated in order to recover the optically pure enantiomers. Dissociable complexes may also be used to resolve enantiomers (e.g., crystalline diastereoisomeric salts). Diastereomers typically have sufficiently distinct physical properties (e.g., melting points, boiling points, solubilities, reactivity, etc.) that they can be readily separated by taking advantage of these dissimilarities. For example, diastereomers can typically be separated by chromatography or by separation/resolution techniques based upon differences in solubility. A more detailed description of techniques that can be used to resolve stereoisomers of compounds from their racemic mixture can be found in Jean Jacques Andre Collet, Samuel H. Wilen, Enantiomers, Racemates and Resolutions, John Wiley & Sons, Inc. (1981).

## Indications For Use Of HDAC Inhibitors

**[0175]** HDAC is believed to contribute to the pathology and/or symptomology of several different diseases such that reduction of the activity of HDAC in a subject through inhibition may be used to therapeutically address these disease states. Examples of various diseases that may be treated using the HDAC inhibitors of the present invention are described herein. It is noted that additional diseases beyond those disclosed herein may be later identified as the biological roles that HDAC play in various pathways becomes more fully understood.

### Undesirable or Uncontrolled Cell Proliferation

**[0176]** One set of indications that HDAC inhibitors of the present invention may be used to treat are those involving undesirable or uncontrolled cell proliferation. Such indications include benign tumors, various types of cancers such as primary tumors and

tumor metastasis, restenosis (e.g. coronary, carotid, and cerebral lesions), abnormal stimulation of endothelial cells (atherosclerosis), insults to body tissue due to surgery, abnormal wound healing, abnormal angiogenesis, diseases that produce fibrosis of tissue, repetitive motion disorders, disorders of tissues that are not highly vascularized, and proliferative responses associated with organ transplants. More specific indications for HDAC inhibitors include, but are not limited to prostate cancer, lung cancer, acute leukemia, multiple myeloma, bladder carcinoma, renal carcinoma, breast carcinoma, colorectal carcinoma, neuroblastoma and melaoma.

**[0177]** In one embodiment, a method is provided for treating diseases associated with undesired and uncontrolled cell proliferation. The method comprises administering to a subject suffering from uncontrolled cell proliferation a therapeutically effective amount of a HDAC inhibitor according to the present invention, such that said uncontrolled cell proliferation is reduced. The particular dosage of the inhibitor to be used will depend on the severity of the disease state, the route of administration, and related factors that can be determined by the attending physician. Generally, acceptable and effective daily doses are amounts sufficient to effectively slow or eliminate uncontrolled cell proliferation.

**[0178]** HDAC inhibitors according to the present invention may also be used in conjunction with other agents to inhibit undesirable and uncontrolled cell proliferation. Examples of other anti-cell proliferation agents that may be used in conjunction with the HDAC inhibitors of the present invention include, but are not limited to, retinoid acid and derivatives thereof, 2-methoxyestradiol, ANGIOSTATIN™ protein, ENDOSTATIN™ protein, suramin, squalamine, tissue inhibitor of metalloproteinase-I, tissue inhibitor of metalloproteinase-2, plasminogen activator inhibitor-1, plasminogen activator inhibitor-2, cartilage-derived inhibitor, paclitaxel, platelet factor 4, protamine sulfate (clupeine), sulfated chitin derivatives (prepared from queen crab shells), sulfated polysaccharide peptidoglycan complex (sp-pg), staurosporine, modulators of matrix metabolism, including for example, proline analogs ((l-azetidine-2-carboxylic acid (LACA), cishydroxyproline, d,l-3,4-dehydroproline, thiaproline), beta.-aminopropionitrile fumarate, 4-propyl-5-(4-pyridinyl)-2(3H)-oxazolone; methotrexate, mitoxantrone, heparin, interferons, 2 macroglobulin-serum, chimp-3, chymostatin, beta-cyclodextrin tetradecasulfate, eponemycin; fumagillin, gold sodium thiomalate, d-penicillamine

(CDPT), beta-1-anticollagenase-serum, alpha-2-antiplasmin, bisantrene, lobenzarit disodium, n-(2-carboxyphenyl-4-chloroanthronilic acid disodium or "CCA", thalidomide; angostatic steroid, carboxyaminoimidazole; metalloproteinase inhibitors such as BB94. Other anti-angiogenesis agents that may be used include antibodies, preferably monoclonal antibodies against these angiogenic growth factors: bFGF, aFGF, FGF-5, VEGF isoforms, VEGF-C, HGF/SF and Ang-1/Ang-2. Ferrara N. and Alitalo, K. "Clinical application of angiogenic growth factors and their inhibitors" (1999) Nature Medicine 5:1359-1364.

**[0179]** Generally, cells in benign tumors retain their differentiated features and do not divide in a completely uncontrolled manner. A benign tumor is usually localized and nonmetastatic. Specific types of benign tumors that can be treated using HDAC inhibitors of the present invention include hemangiomas, hepatocellular adenoma, cavernous haemangioma, focal nodular hyperplasia, acoustic neuromas, neurofibroma, bile duct adenoma, bile duct cystanoma, fibroma, lipomas, leiomyomas, mesotheliomas, teratomas, myxomas, nodular regenerative hyperplasia, trachomas and pyogenic granulomas.

**[0180]** In the case of malignant tumors, cells become undifferentiated, do not respond to the body's growth control signals, and multiply in an uncontrolled manner. Malignant tumors are invasive and capable of spreading to distant sites (metastasizing). Malignant tumors are generally divided into two categories: primary and secondary. Primary tumors arise directly from the tissue in which they are found. Secondary tumors, or metastases, are tumors that originated elsewhere in the body but have now spread to distant organs. Common routes for metastasis are direct growth into adjacent structures, spread through the vascular or lymphatic systems, and tracking along tissue planes and body spaces (peritoneal fluid, cerebrospinal fluid, etc...).

**[0181]** Specific types of cancers or malignant tumors, either primary or secondary, that can be treated using the HDAC inhibitors of the present invention include, but are not limited to, leukemia, breast cancer, skin cancer, bone cancer, prostate cancer, liver cancer, lung cancer, brain cancer, cancer of the larynx, gallbladder, pancreas, rectum, parathyroid, thyroid, adrenal, neural tissue, head and neck, colon, stomach, bronchi, kidneys, basal cell carcinoma, squamous cell carcinoma of both ulcerating and papillary type, metastatic skin carcinoma, osteo sarcoma, Ewing's sarcoma, veticulum cell sarcoma, myeloma, giant cell tumor, small-cell lung tumor, gallstones, islet cell tumor, primary brain tumor, acute and

chronic lymphocytic and granulocytic tumors, hairy-cell tumor, adenoma, hyperplasia, medullary carcinoma, pheochromocytoma, mucosal neuronms, intestinal ganglloneuromas, hyperplastic corneal nerve tumor, marfanoid habitus tumor, Wilm's tumor, seminoma, ovarian tumor, leiomyomater tumor, cervical dysplasia and in situ carcinoma, neuroblastoma, retinoblastoma, soft tissue sarcoma, malignant carcinoid, topical skin lesion, mycosis fungoide, rhabdomyosarcoma, Kaposi's sarcoma, osteogenic and other sarcoma, malignant hypercalcemia, renal cell tumor, polycythermia vera, adenocarcinoma, glioblastoma multiforma, leukemias, lymphomas, malignant melanomas, epidermoid carcinomas, and other carcinomas and sarcomas.

**[0182]** The HDAC inhibitors of the present invention may also be used to treat abnormal cell proliferation due to insults to body tissue during surgery. These insults may arise as a result of a variety of surgical procedures such as joint surgery, bowel surgery, and cheloid scarring. Diseases that produce fibrotic tissue include emphysema. Repetitive motion disorders that may be treated using the present invention include carpal tunnel syndrome. An example of a cell proliferative disorder that may be treated using the invention is a bone tumor.

**[0183]** Proliferative responses associated with organ transplantation that may be treated using HDAC inhibitors of the invention include proliferative responses contributing to potential organ rejections or associated complications. Specifically, these proliferative responses may occur during transplantation of the heart, lung, liver, kidney, and other body organs or organ systems.

**[0184]** Abnormal angiogenesis that may be may be treated using this invention include those abnormal angiogenesis accompanying rheumatoid arthritis, ischemic-reperfusion related brain edema and injury, cortical ischemia, ovarian hyperplasia and hypervascularity, (polycystic ovary syndrome), endometriosis, psoriasis, diabetic retinopaphy, and other ocular angiogenic diseases such as retinopathy of prematurity (retrolental fibroplastic), macular degeneration, corneal graft rejection, neuroscular glaucoma and Oster Webber syndrome.

**[0185]** Examples of diseases associated with uncontrolled angiogenesis that may be treated according to the present invention include, but are not limited to retinal/choroidal neuvascularization and corneal neovascularization. Examples of retinal/choroidal

neuvascularization include, but are not limited to, Bests diseases, myopia, optic pits, Stargarts diseases, Pagets disease, vein occlusion, artery occlusion, sickle cell anemia, sarcoid, syphilis, pseudoxanthoma elasticum carotid abostructive diseases, chronic uveitis/vitritis, mycobacterial infections, Lyme's disease, systemic lupus erythematosus, retinopathy of prematurity, Eales disease, diabetic retinopathy, macular degeneration, Bechets diseases, infections causing a retinitis or chroiditis, presumed ocular histoplasmosis, pars planitis, chronic retinal detachment, hyperviscosity syndromes, toxoplasmosis, trauma and post-laser complications, diseases associated with rubesis (neovascularization of the angle) and diseases caused by the abnormal proliferation of fibrovascular or fibrous tissue including all forms of proliferative vitreoretinopathy. Examples of corneal neuvascularization include, but are not limited to, epidemic keratoconjunctivitis, Vitamin A deficiency, contact lens overwear, atopic keratitis, superior limbic keratitis, pterygium keratitis sicca, sjogrens, acne rosacea, phylectenulosis, diabetic retinopathy, retinopathy of prematurity, corneal graft rejection, Mooren ulcer, Terrien's marginal degeneration, marginal keratolysis, polyarteritis, Wegener sarcoidosis, Scleritis, periphigoid radial keratotomy, neovascular glaucoma and retrolental fibroplasia, syphilis, Mycobacteria infections, lipid degeneration, chemical burns, bacterial ulcers, fungal ulcers, Herpes simplex infections, Herpes zoster infections, protozoan infections and Kaposi sarcoma.

**[0186]** Chronic inflammatory diseases associated with uncontrolled angiogenesis may also be treated using HDAC inhibitors of the present invention. Chronic inflammation depends on continuous formation of capillary sprouts to maintain an influx of inflammatory cells. The influx and presence of the inflammatory cells produce granulomas and thus maintains the chronic inflammatory state. Inhibition of angiogenesis using a HDAC inhibitor alone or in conjunction with other anti-inflammatory agents may prevent the formation of the granulosmas and thus alleviate the disease. Examples of chronic inflammatory diseases include, but are not limited to, inflammatory bowel diseases such as Crohn's disease and ulcerative colitis, psoriasis, sarcoidois, and rhematoid arthritis.

**[0187]** Inflammatory bowel diseases such as Crohn's disease and ulcerative colitis are characterized by chronic inflammation and angiogenesis at various sites in the

gastrointestinal tract. For example, Crohn's disease occurs as a chronic transmural inflammatory disease that most commonly affects the distal ileum and colon but may also occur in any part of the gastrointestinal tract from the mouth to the anus and perianal area. Patients with Crohn's disease generally have chronic diarrhea associated with abdominal pain, fever, anorexia, weight loss and abdominal swelling. Ulcerative colitis is also a chronic, nonspecific, inflammatory and ulcerative disease arising in the colonic mucosa and is characterized by the presence of bloody diarrhea. These inflammatory bowel diseases are generally caused by chronic granulomatous inflammation throughout the gastrointestinal tract, involving new capillary sprouts surrounded by a cylinder of inflammatory cells. Inhibition of angiogenesis by these inhibitors should inhibit the formation of the sprouts and prevent the formation of granulomas. Inflammatory bowel diseases also exhibit extra intestinal manifectations, such as skin lesions. Such lesions are characterized by inflammation and angiogenesis and can occur at many sites other the gastrointestinal tract. Inhibition of angiogenesis by HDAC inhibitors according to the present invention can reduce the influx of inflammatory cells and prevent lesion formation.

**[0188]** Sarcoidois, another chronic inflammatory disease, is characterized as a multisystem granulomatous disorder. The granulomas of this disease can form anywhere in the body. Thus, the symptoms depend on the site of the granulomas and whether the disease is active. The granulomas are created by the angiogenic capillary sprouts providing a constant supply of inflammatory cells. By using HDAC inhibitors according to the present invention to inhibit angionesis, such granulomas formation can be inhibited. Psoriasis, also a chronic and recurrent inflammatory disease, is characterized by papules and plaques of various sizes. Treatment using these inhibitors alone or in conjunction with other anti-inflammatory agents should prevent the formation of new blood vessels necessary to maintain the characteristic lesions and provide the patient relief from the symptoms.

**[0189]** Rheumatoid arthritis (RA) is also a chronic inflammatory disease characterized by non-specific inflammation of the peripheral joints. It is believed that the blood vessels in the synovial lining of the joints undergo angiogenesis. In addition to forming new vascular networks, the endothelial cells release factors and reactive oxygen species that lead to pannus growth and cartilage destruction. The factors involved in angiogenesis may

actively contribute to, and help maintain, the chronically inflamed state of rheumatoid arthritis. Treatment using HDAC inhibitors according to the present invention alone or in conjunction with other anti-RA agents may prevent the formation of new blood vessels necessary to maintain the chronic inflammation and provide the RA patient relief from the symptoms.

**Compositions Comprising HDAC Inhibitors**

**[0190]** A wide variety of compositions and administration methods may be used in conjunction with the HDAC inhibitors of the present invention. Such compositions may include, in addition to the HDAC inhibitors of the present invention, conventional pharmaceutical excipients, and other conventional, pharmaceutically inactive agents. Additionally, the compositions may include active agents in addition to the HDAC inhibitors of the present invention. These additional active agents may include additional compounds according to the invention, or one or more other pharmaceutically active agents.

**[0191]** The compositions may be in gaseous, liquid, semi-liquid or solid form, formulated in a manner suitable for the route of administration to be used. For oral administration, capsules and tablets are typically used. For parenteral administration, reconstitution of a lyophilized powder, prepared as described herein, is typically used.

**[0192]** Compositions comprising HDAC inhibitors of the present invention may be administered or coadministered orally, parenterally, intraperitoneally, intravenously, intraarterially, transdermally, sublingually, intramuscularly, rectally, transbuccally, intranasally, liposomally, via inhalation, vaginally, intraoccularly, via local delivery (for example by catheter or stent), subcutaneously, intraadiposally, intraarticularly, or intrathecally. The compounds and/or compositions according to the invention may also be administered or coadministered in slow release dosage forms.

**[0193]** The HDAC inhibitors and compositions comprising them may be administered or coadministered in any conventional dosage form. Coadministration in the context of this invention is intended to mean the administration of more than one therapeutic agents, one of which includes a HDAC inhibitor, in the course of a coordinated treatment to

achieve an improved clinical outcome. Such coadministration may also be coextensive, that is, occurring during overlapping periods of time.

**[0194]** Solutions or suspensions used for parenteral, intradermal, subcutaneous, or topical application may optionally include one or more of the following components: a sterile diluent, such as water for injection, saline solution, fixed oil, polyethylene glycol, glycerine, propylene glycol or other synthetic solvent; antimicrobial agents, such as benzyl alcohol and methyl parabens; antioxidants, such as ascorbic acid and sodium bisulfite; chelating agents, such as ethylenediaminetetraacetic acid (EDTA); buffers, such as acetates, citrates and phosphates; agents for the adjustment of tonicity such as sodium chloride or dextrose, and agents for adjusting the acidity or alkalinity of the composition, such as alkaline or acidifying agents or buffers like carbonates, bicarbonates, phosphates, hydrochloric acid, and organic acids like acetic and citric acid. Parenteral preparations may optionally be enclosed in ampules, disposable syringes or single or multiple dose vials made of glass, plastic or other suitable material.

**[0195]** When HDAC inhibitors according to the present invention exhibit insufficient solubility, methods for solubilizing the compounds may be used. Such methods are known to those of skill in this art, and include, but are not limited to, using cosolvents, such as dimethylsulfoxide (DMSO), using surfactants, such as TWEEN, or dissolution in aqueous sodium bicarbonate. Derivatives of the compounds, such as prodrugs of the compounds may also be used in formulating effective pharmaceutical compositions.

**[0196]** Upon mixing or adding HDAC inhibitors according to the present invention to a composition, a solution, suspension, emulsion or the like may be formed. The form of the resulting composition will depend upon a number of factors, including the intended mode of administration, and the solubility of the compound in the selected carrier or vehicle. The effective concentration needed to ameliorate the disease being treated may be empirically determined.

**[0197]** Compositions according to the present invention are optionally provided for administration to humans and animals in unit dosage forms, such as tablets, capsules, pills, powders, dry powders for inhalers, granules, sterile parenteral solutions or suspensions, and oral solutions or suspensions, and oil-water emulsions containing suitable quantities of the compounds, particularly the pharmaceutically acceptable salts, preferably the sodium

salts, thereof. The pharmaceutically therapeutically active compounds and derivatives thereof are typically formulated and administered in unit-dosage forms or multiple-dosage forms. Unit-dose forms, as used herein, refers to physically discrete units suitable for human and animal subjects and packaged individually as is known in the art. Each unit-dose contains a predetermined quantity of the therapeutically active compound sufficient to produce the desired therapeutic effect, in association with the required pharmaceutical carrier, vehicle or diluent. Examples of unit-dose forms include ampoules and syringes individually packaged tablet or capsule. Unit-dose forms may be administered in fractions or multiples thereof. A multiple-dose form is a plurality of identical unit-dosage forms packaged in a single container to be administered in segregated unit-dose form. Examples of multiple-dose forms include vials, bottles of tablets or capsules or bottles of pint or gallons. Hence, multiple dose form is a multiple of unit-doses that are not segregated in packaging.

**[0198]** In addition to one or more HDAC inhibitors according to the present invention, the composition may comprise: a diluent such as lactose, sucrose, dicalcium phosphate, or carboxymethylcellulose; a lubricant, such as magnesium stearate, calcium stearate and talc; and a binder such as starch, natural gums, such as gum acaciagelatin, glucose, molasses, polvinylpyrrolidine, celluloses and derivatives thereof, povidone, crospovidones and other such binders known to those of skill in the art. Liquid pharmaceutically administrable compositions can, for example, be prepared by dissolving, dispersing, or otherwise mixing an active compound as defined above and optional pharmaceutical adjuvants in a carrier, such as, for example, water, saline, aqueous dextrose, glycerol, glycols, ethanol, and the like, to form a solution or suspension. If desired, the pharmaceutical composition to be administered may also contain minor amounts of auxiliary substances such as wetting agents, emulsifying agents, or solubilizing agents, pH buffering agents and the like, for example, acetate, sodium citrate, cyclodextrine derivatives, sorbitan monolaurate, triethanolamine sodium acetate, triethanolamine oleate, and other such agents. Actual methods of preparing such dosage forms are known in the art, or will be apparent, to those skilled in this art; for example, see Remington: The Science and Practice of Pharmacy, A. Gennaro, ed., 20th edition, Lippincott, Williams & Wilkins, Philadelphia, PA, 2000. The composition or formulation to be administered will, in any event, contain a sufficient

quantity of a HDAC inhibitor of the present invention to reduce HDAC activity *in vivo*, thereby treating the disease state of the subject.

**[0199]** Dosage forms or compositions may optionally comprise one or more HDAC inhibitors according to the present invention in the range of 0.005% to 100% (weight/weight) with the balance comprising additional substances such as those described herein. For oral administration, a pharmaceutically acceptable composition may optionally comprise any one or more commonly employed excipients, such as, for example pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, talcum, cellulose derivatives, sodium crosscarmellose, glucose, sucrose, magnesium carbonate, sodium saccharin, talcum. Such compositions include solutions, suspensions, tablets, capsules, powders, dry powders for inhalers and sustained release formulations, such as, but not limited to, implants and microencapsulated delivery systems, and biodegradable, biocompatible polymers, such as collagen, ethylene vinyl acetate, polyanhydrides, polyglycolic acid, polyorthoesters, polylactic acid and others. Methods for preparing these formulations are known to those skilled in the art. The compositions may optionally contain 0.01%-100% (weight/weight) of one or more HDAC inhibitors, optionally 0.1-95%, and optionally 1-95%.

**[0200]** Salts, preferably sodium salts, of the HDAC inhibitors may be prepared with carriers that protect the compound against rapid elimination from the body, such as time release formulations or coatings. The formulations may further include other active compounds to obtain desired combinations of properties.

**Formulations For Oral Administration**

**[0201]** Oral pharmaceutical dosage forms may be as a solid, gel or liquid. Examples of solid dosage forms include, but are not limited to tablets, capsules, granules, and bulk powders. More specific examples of oral tablets include compressed, chewable lozenges and tablets that may be enteric-coated, sugar-coated or film-coated. Examples of capsules include hard or soft gelatin capsules. Granules and powders may be provided in non-effervescent or effervescent forms. Each may be combined with other ingredients known to those skilled in the art.

**[0202]** In certain embodiments, HDAC inhibitors according to the present invention are provided as solid dosage forms, preferably capsules or tablets. The tablets, pills, capsules,

troches and the like may optionally contain one or more of the following ingredients, or compounds of a similar nature: a binder; a diluent; a disintegrating agent; a lubricant; a glidant; a sweetening agent; and a flavoring agent.

**[0203]** Examples of binders that may be used include, but are not limited to, microcrystalline cellulose, gum tragacanth, glucose solution, acacia mucilage, gelatin solution, sucrose and starch paste.

**[0204]** Examples of lubricants that may be used include, but are not limited to, talc, starch, magnesium or calcium stearate, lycopodium and stearic acid.

**[0205]** Examples of diluents that may be used include, but are not limited to, lactose, sucrose, starch, kaolin, salt, mannitol and dicalcium phosphate.

**[0206]** Examples of glidants that may be used include, but are not limited to, colloidal silicon dioxide.

**[0207]** Examples of disintegrating agents that may be used include, but are not limited to, crosscarmellose sodium, sodium starch glycolate, alginic acid, corn starch, potato starch, bentonite, methylcellulose, agar and carboxymethylcellulose.

**[0208]** Examples of coloring agents that may be used include, but are not limited to, any of the approved certified water soluble FD and C dyes, mixtures thereof; and water insoluble FD and C dyes suspended on alumina hydrate.

**[0209]** Examples of sweetening agents that may be used include, but are not limited to, sucrose, lactose, mannitol and artificial sweetening agents such as sodium cyclamate and saccharin, and any number of *spray-dried* flavors.

**[0210]** Examples of flavoring agents that may be used include, but are not limited to, natural flavors extracted from plants such as fruits and synthetic blends of compounds that produce a pleasant sensation, such as, but not limited to peppermint and methyl salicylate.

**[0211]** Examples of wetting agents that may be used include, but are not limited to, propylene glycol monostearate, sorbitan monooleate, diethylene glycol monolaurate and polyoxyethylene lauryl ether.

**[0212]** Examples of anti-emetic coatings that may be used include, but are not limited to, fatty acids, fats, waxes, shellac, ammoniated shellac and cellulose acetate phthalates.

**[0213]** Examples of film coatings that may be used include, but are not limited to, hydroxyethylcellulose, sodium carboxymethylcellulose, polyethylene glycol 4000 and cellulose acetate phthalate.

**[0214]** If oral administration is desired, the salt of the compound may optionally be provided in a composition that protects it from the acidic environment of the stomach. For example, the composition can be formulated in an *enteric-coating* that maintains its integrity in the stomach and releases the active compound in the intestine. The composition may also be formulated in combination with an antacid or other such ingredient.

**[0215]** When the dosage unit form is a capsule, it may optionally additionally comprise a liquid carrier such as a fatty oil. In addition, dosage unit forms may optionally additionally comprise various other materials that modify the physical form of the dosage unit, for example, coatings of sugar and other enteric agents.

**[0216]** Compounds according to the present invention may also be administered as a component of an elixir, suspension, syrup, wafer, sprinkle, chewing gum or the like. A syrup may optionally comprise, in addition to the active compounds, sucrose as a sweetening agent and certain preservatives, dyes and colorings and flavors.

**[0217]** The HDAC inhibitors of the present invention may also be mixed with other active materials that do not impair the desired action, or with materials that supplement the desired action, such as antacids, H2 blockers, and diuretics. For example, if a compound is used for treating asthma or hypertension, it may be used with other bronchodilators and antihypertensive agents, respectively.

**[0218]** Examples of pharmaceutically acceptable carriers that may be included in tablets comprising HDAC inhibitors of the present invention include, but are not limited to binders, lubricants, diluents, disintegrating agents, coloring agents, flavoring agents, and wetting agents. Enteric-coated tablets, because of the enteric-coating, resist the action of stomach acid and dissolve or disintegrate in the neutral or alkaline intestines. Sugar-coated tablets may be compressed tablets to which different layers of pharmaceutically acceptable substances are applied. Film-coated tablets may be compressed tablets that have been coated with polymers or other suitable coating. Multiple compressed tablets may be compressed tablets made by more than one compression cycle utilizing the

pharmaceutically acceptable substances previously mentioned. Coloring agents may also be used in tablets. Flavoring and sweetening agents may be used in tablets, and are especially useful in the formation of chewable tablets and lozenges.

**[0219]** Examples of liquid oral dosage forms that may be used include, but are not limited to, aqueous solutions, emulsions, suspensions, solutions and/or suspensions reconstituted from non-effervescent granules and effervescent preparations reconstituted from effervescent granules.

**[0220]** Examples of aqueous solutions that may be used include, but are not limited to, elixirs and syrups. As used herein, elixirs refer to clear, sweetened, hydroalcoholic preparations. Examples of pharmaceutically acceptable carriers that may be used in elixirs include, but are not limited to solvents. Particular examples of solvents that may be used include glycerin, sorbitol, ethyl alcohol and syrup. As used herein, syrups refer to concentrated aqueous solutions of a sugar, for example, sucrose. Syrups may optionally further comprise a preservative.

**[0221]** Emulsions refer to two-phase systems in which one liquid is dispersed in the form of small globules throughout another liquid. Emulsions may optionally be oil-in-water or water-in-oil emulsions. Examples of pharmaceutically acceptable carriers that may be used in emulsions include, but are not limited to non-aqueous liquids, emulsifying agents and preservatives.

**[0222]** Examples of pharmaceutically acceptable substances that may be used in non-effervescent granules, to be reconstituted into a liquid oral dosage form, include diluents, sweeteners and wetting agents.

**[0223]** Examples of pharmaceutically acceptable substances that may be used in effervescent granules, to be reconstituted into a liquid oral dosage form, include organic adds and a source of carbon dioxide.

**[0224]** Coloring and flavoring agents may optionally be used in all of the above dosage forms.

**[0225]** Particular examples of preservatives that may be used include glycerin, methyl and propylparaben, benzoic add, sodium benzoate and alcohol.

**[0226]** Particular examples of non-aqueous liquids that may be used in emulsions include mineral oil and cottonseed oil.

**[0227]** Particular examples of emulsifying agents that may be used include gelatin, acacia, tragacanth, bentonite, and surfactants such as polyoxyethylene sorbitan monooleate.

**[0228]** Particular examples of suspending agents that may be used include sodium carboxymethylcellulose, pectin, tragacanth, Veegum and acacia. Diluents include lactose and sucrose. Sweetening agents include sucrose, syrups, glycerin and artificial sweetening agents such as sodium cyclamate and saccharin.

**[0229]** Particular examples of wetting agents that may be used include propylene glycol monostearate, sorbitan monooleate, diethylene glycol monolaurate and polyoxyethylene lauryl ether.

**[0230]** Particular examples of organic acids that may be used include citric and tartaric acid.

**[0231]** Sources of carbon dioxide that may be used in effervescent compositions include sodium bicarbonate and sodium carbonate. Coloring agents include any of the approved certified water soluble FD and C dyes, and mixtures thereof.

**[0232]** Particular examples of flavoring agents that may be used include natural flavors extracted from plants such fruits, and synthetic blends of compounds that produce a pleasant taste sensation.

**[0233]** For a solid dosage form, the solution or suspension, in for example propylene carbonate, vegetable oils or triglycerides, is preferably encapsulated in a gelatin capsule. Such solutions, and the preparation and encapsulation thereof, are disclosed in U.S. Pat. Nos. 4,328,245; 4,409,239; and 4,410,545. For a liquid dosage form, the solution, eg., for example, in a polyethylene glycol, may be diluted with a sufficient quantity of a pharmaceutically acceptable liquid carrier, e.g. water, to be easily measured for administration.

**[0234]** Alternatively, liquid or semi-solid oral formulations may be prepared by dissolving or dispersing the active compound or salt in vegetable oils, glycols, triglycerides, propylene glycol esters (e.g. propylene carbonate) and other such carriers, and encapsulating these solutions or suspensions in hard or soft gelatin capsule shells. Other useful formulations include those set forth in U.S. Pat. Nos. Re 28,819 and 4,358,603.

**Injectables, Solutions and Emulsions**

**[0235]** The present invention is also directed to compositions designed to administer the HDAC inhibitors of the present invention by parenteral administration, generally characterized by injection, either subcutaneously, intramuscularly or intravenously. Injectables may be prepared in any conventional form, for example as liquid solutions or suspensions, solid forms suitable for solution or suspension in liquid prior to injection, or as emulsions.

**[0236]** Examples of excipients that may be used in conjunction with injectables according to the present invention include, but are not limited to water, saline, dextrose, glycerol or ethanol. The injectable compositions may also optionally comprise minor amounts of non-toxic auxiliary substances such as wetting or emulsifying agents, pH buffering agents, stabilizers, solubility enhancers, and other such agents, such as for example, sodium acetate, sorbitan monolaurate, triethanolamine oleate and cyclodextrins. Implantation of a slow-release or sustained-release system, such that a constant level of dosage is maintained (see, e.g., U.S. Pat. No. 3,710,795) is also contemplated herein. The percentage of active compound contained in such parenteral compositions is highly dependent on the specific nature thereof, as well as the activity of the compound and the needs of the subject.

**[0237]** Parenteral administration of the formulations includes intravenous, subcutaneous and intramuscular administrations. Preparations for parenteral administration include sterile solutions ready for injection, sterile dry soluble products, such as the lyophilized powders described herein, ready to be combined with a solvent just prior to use, including hypodermic tablets, sterile suspensions ready for injection, sterile dry insoluble products ready to be combined with a vehicle just prior to use and sterile emulsions. The solutions may be either aqueous or nonaqueous.

**[0238]** When administered intravenously, examples of suitable carriers include, but are not limited to physiological saline or phosphate buffered saline (PBS), and solutions containing thickening and solubilizing agents, such as glucose, polyethylene glycol, and polypropylene glycol and mixtures thereof.

**[0239]** Example of pharmaceutically acceptable carriers that may optionally be used in parenteral preparations include, but are not limited to aqueous vehicles, nonaqueous

vehicles, antimicrobial agents, isotonic agents, buffers, antioxidants, local anesthetics, suspending and dispersing agents, emulsifying agents, sequestering or chelating agents and other pharmaceutically acceptable substances.

**[0240]** Examples of aqueous vehicles that may optionally be used include Sodium Chloride Injection, Ringers Injection, Isotonic Dextrose Injection, Sterile Water Injection, Dextrose and Lactated Ringers Injection.

**[0241]** Examples of nonaqueous parenteral vehicles that may optionally be used include fixed oils of vegetable origin, cottonseed oil, corn oil, sesame oil and peanut oil.

**[0242]** Antimicrobial agents in bacteriostatic or fungistatic concentrations may be added to parenteral preparations, particularly when the preparations are packaged in multiple-dose containers and thus designed to be stored and multiple aliquots to be removed. Examples of antimicrobial agents that may used include phenols or cresols, mercurials, benzyl alcohol, chlorobutanol, methyl and propyl p-hydroxybenzoic acid esters, thimerosal, benzalkonium chloride and benzethonium chloride.

**[0243]** Examples of isotonic agents that may be used include sodium chloride and dextrose. Examples of buffers that may be used include phosphate and citrate. Examples of antioxidants that may be used include sodium bisulfate. Examples of local anesthetics that may be used include procaine hydrochloride. Examples of suspending and dispersing agents that may be used include sodium carboxymethylcellulose, hydroxypropyl methylcellulose and polyvinylpyrrolidone. Examples of emulsifying agents that may be used include Polysorbate 80 (Tween 80). A sequestering or chelating agent of metal ions include EDTA.

**[0244]** Pharmaceutical carriers may also optionally include ethyl alcohol, polyethylene glycol and propylene glycol for water miscible vehicles and sodium hydroxide, hydrochloric acid, citric acid or lactic acid for pH adjustment.

**[0245]** The concentration of a HDAC inhibitor in the parenteral formulation may be adjusted so that an injection administers a pharmaceutically effective amount sufficient to produce the desired pharmacological effect. The exact concentration of a HDAC inhibitor and/or dosage to be used will ultimately depend on the age, weight and condition of the patient or animal as is known in the art.

**[0246]** Unit-dose parenteral preparations may be packaged in an ampoule, a vial or a syringe with a needle. All preparations for parenteral administration should be sterile, as is known and practiced in the art.

**[0247]** Injectables may be designed for local and systemic administration. Typically a therapeutically effective dosage is formulated to contain a concentration of at least about 0.1% w/w up to about 90% w/w or more, preferably more than 1% w/w of the HDAC inhibitor to the treated tissue(s). The HDAC inhibitor may be administered at once, or may be divided into a number of smaller doses to be administered at intervals of time. It is understood that the precise dosage and duration of treatment will be a function of the location of where the composition is parenterally administered, the carrier and other variables that may be determined empirically using known testing protocols or by extrapolation from *in vivo* or *in vitro* test data. It is to be noted that concentrations and dosage values may also vary with the age of the individual treated. It is to be further understood that for any particular subject, specific dosage regimens may need to be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the formulations. Hence, the concentration ranges set forth herein are intended to be exemplary and are not intended to limit the scope or practice of the claimed formulations.

**[0248]** The HDAC inhibitor may optionally be suspended in micronized or other suitable form or may be derivatized to produce a more soluble active product or to produce a prodrug. The form of the resulting mixture depends upon a number of factors, including the intended mode of administration and the solubility of the compound in the selected carrier or vehicle. The effective concentration is sufficient for ameliorating the symptoms of the disease state and may be empirically determined.

**Lyophilized Powders**

**[0249]** The HDAC inhibitors of the present invention may also be prepared as lyophilized powders, which can be reconstituted for administration as solutions, emulsions and other mixtures. The lyophilized powders may also be formulated as solids or gels.

**[0250]** Sterile, lyophilized powder may be prepared by dissolving the sodium salt in a sodium phosphate buffer solution containing dextrose or other suitable excipient. Subsequent sterile filtration of the solution followed by lyophilization under standard

conditions known to those of skill in the art provides the desired formulation. Briefly, the lyophilized powder may optionally be prepared by dissolving dextrose, sorbitol, fructose, corn syrup, xylitol, glycerin, glucose, sucrose or other suitable agent, about 1-20%, preferably about 5 to 15%, in a suitable buffer, such as citrate, sodium or potassium phosphate or other such buffer known to those of skill in the art at, typically, about neutral pH. Then, an HDAC inhibitor is added to the resulting mixture, preferably above room temperature, more preferably at about 30-35 °C, and stirred until it dissolves. The resulting mixture is diluted by adding more buffer to a desired concentration. The resulting mixture is sterile filtered or treated to remove particulates and to insure sterility, and apportioned into vials for lyophilization. Each vial may contain a single dosage or multiple dosages of the HDAC inhibitor.

**Topical Administration**

**[0251]** The HDAC inhibitors of the present invention may also be administered as topical mixtures. Topical mixtures may be used for local and systemic administration. The resulting mixture may be a solution, suspension, emulsions or the like and are formulated as creams, gels, ointments, emulsions, solutions, elixirs, lotions, suspensions, tinctures, pastes, foams, aerosols, irrigations, sprays, suppositories, bandages, dermal patches or any other formulations suitable for topical administration.

**[0252]** The HDAC inhibitors may be formulated as aerosols for topical application, such as by inhalation (see, U.S. Pat. Nos. 4,044,126, 4,414,209, and 4,364,923, which describe aerosols for delivery of a steroid useful for treatment inflammatory diseases, particularly asthma). These formulations for administration to the respiratory tract can be in the form of an aerosol or solution for a nebulizer, or as a microfine powder for insufflation, alone or in combination with an inert carrier such as lactose. In such a case, the particles of the formulation will typically diameters of less than 50 microns, preferably less than 10 microns.

**[0253]** The HDAC inhibitors may also be formulated for local or topical application, such as for topical application to the skin and mucous membranes, such as in the eye, in the form of gels, creams, and lotions and for application to the eye or for intracisternal or intraspinal application. Topical administration is contemplated for transdermal delivery and also for administration to the eyes or mucosa, or for inhalation therapies. Nasal

solutions of the HDAC inhibitor alone or in combination with other pharmaceutically acceptable excipients can also be administered.

**Formulations For Other Routes of Administration**

**[0254]** Depending upon the disease state being treated, other routes of administration, such as topical application, transdermal patches, a rectal administration, may also be used. For example, pharmaceutical dosage forms for rectal administration are rectal suppositories, capsules and tablets for systemic effect. Rectal suppositories are used herein mean solid bodies for insertion into the rectum that melt or soften at body temperature releasing one or more pharmacologically or therapeutically active ingredients. Pharmaceutically acceptable substances utilized in rectal suppositories are bases or vehicles and agents to raise the melting point. Examples of bases include cocoa butter (theobroma oil), glycerin-gelatin, carbowax, (polyoxyethylene glycol) and appropriate mixtures of mono-, di- and triglycerides of fatty acids. Combinations of the various bases may be used. Agents to raise the melting point of suppositories include spermaceti and wax. Rectal suppositories may be prepared either by the compressed method or by molding. The typical weight of a rectal suppository is about 2 to 3 gm. Tablets and capsules for rectal administration may be manufactured using the same pharmaceutically acceptable substance and by the same methods as for formulations for oral administration.

**Examples of Formulations**

**[0255]** The following are particular examples of oral, intravenous and tablet formulations that may optionally be used with compounds of the present invention. It is noted that these formulations may be varied depending on the particular compound being used and the indication for which the formulation is going to be used.

ORAL FORMULATION

| | |
|---|---|
| Compound of the Present Invention | 10-100 mg |
| Citric Acid Monohydrate | 105 mg |
| Sodium Hydroxide | 18 mg |
| Flavoring | |
| Water | q.s. to 100 mL |

INTRAVENOUS FORMULATION

| | |
|---|---|
| Compound of the Present Invention | 0.1-10 mg |
| Dextrose Monohydrate | q.s. to make isotonic |
| Citric Acid Monohydrate | 1.05 mg |
| Sodium Hydroxide | 0.18 mg |
| Water for Injection | q.s. to 1.0 mL |

TABLET FORMULATION

| | |
|---|---|
| Compound of the Present Invention | 1% |
| Microcrystalline Cellulose | 73% |
| Stearic Acid | 25% |
| Colloidal Silica | 1%. |

**Kits Comprising HDAC Inhibitors**

**[0256]** The invention is also directed to kits and other articles of manufacture for treating diseases associated with HDAC. It is noted that diseases are intended to cover all conditions for which the HDAC possesses activity that contributes to the pathology and/or symptomology of the condition.

**[0257]** In one embodiment, a kit is provided that comprises a composition comprising at least one HDAC inhibitor of the present invention in combination with instructions. The instructions may indicate the disease state for which the composition is to be administered, storage information, dosing information and/or instructions regarding how to administer the composition. The kit may also comprise packaging materials. The packaging material may comprise a container for housing the composition. The kit may also optionally comprise additional components, such as syringes for administration of the composition. The kit may comprise the composition in single or multiple dose forms.

**[0258]** In another embodiment, an article of manufacture is provided that comprises a composition comprising at least one HDAC inhibitor of the present invention in combination with packaging materials. The packaging material may comprise a container for housing the composition. The container may optionally comprise a label indicating the disease state for which the composition is to be administered, storage information, dosing

information and/or instructions regarding how to administer the composition. The kit may also optionally comprise additional components, such as syringes for administration of the composition. The kit may comprise the composition in single or multiple dose forms.

**[0259]** It is noted that the packaging material used in kits and articles of manufacture according to the present invention may form a plurality of divided containers such as a divided bottle or a divided foil packet. The container can be in any conventional shape or form as known in the art which is made of a pharmaceutically acceptable material, for example a paper or cardboard box, a glass or plastic bottle or jar, a re-sealable bag (for example, to hold a "refill" of tablets for placement into a different container), or a blister pack with individual doses for pressing out of the pack according to a therapeutic schedule. The container that is employed will depend on the exact dosage form involved, for example a conventional cardboard box would not generally be used to hold a liquid suspension. It is feasible that more than one container can be used together in a single package to market a single dosage form. For example, tablets may be contained in a bottle that is in turn contained within a box. Typically the kit includes directions for the administration of the separate components. The kit form is particularly advantageous when the separate components are preferably administered in different dosage forms (e.g., oral, topical, transdermal and parenteral), are administered at different dosage intervals, or when titration of the individual components of the combination is desired by the prescribing physician.

**[0260]** One particular example of a kit according to the present invention is a so-called blister pack. Blister packs are well known in the packaging industry and are being widely used for the packaging of pharmaceutical unit dosage forms (tablets, capsules, and the like). Blister packs generally consist of a sheet of relatively stiff material covered with a foil of a preferably transparent plastic material. During the packaging process recesses are formed in the plastic foil. The recesses have the size and shape of individual tablets or capsules to be packed or may have the size and shape to accommodate multiple tablets and/or capsules to be packed. Next, the tablets or capsules are placed in the recesses accordingly and the sheet of relatively stiff material is sealed against the plastic foil at the face of the foil which is opposite from the direction in which the recesses were formed. As a result, the tablets or capsules are individually sealed or collectively sealed, as desired, in

the recesses between the plastic foil and the sheet. Preferably the strength of the sheet is such that the tablets or capsules can be removed from the blister pack by manually applying pressure on the recesses whereby an opening is formed in the sheet at the place of the recess. The tablet or capsule can then be removed via said opening.

**[0261]** Another specific embodiment of a kit is a dispenser designed to dispense the daily doses one at a time in the order of their intended use. Preferably, the dispenser is equipped with a memory-aid, so as to further facilitate compliance with the regimen. An example of such a memory-aid is a mechanical counter that indicates the number of daily doses that has been dispensed. Another example of such a memory-aid is a battery-powered micro-chip memory coupled with a liquid crystal readout, or audible reminder signal which, for example, reads out the date that the last daily dose has been taken and/or reminds one when the next dose is to be taken.

**Combination Therapy**

**[0262]** A wide variety therapeutic agents may have a therapeutic additive or synergistic effect with HDAC inhibitors according to the present invention. Such therapeutic agents may additively or synergistically combine with the HDAC inhibitors to inhibit undesirable cell growth, such as inappropriate cell growth resulting in undesirable benign conditions or tumor growth.

**[0263]** In one embodiment, a method is provided for treating a cell proliferative disease state comprising treating cells with a compound according to the present invention in combination with an anti-proliferative agent, wherein the cells are treated with the compound according to the present invention before, at the same time, and/or after the cells are treated with the anti-proliferative agent, referred to herein as combination therapy. It is noted that treatment of one agent before another is referred to herein as sequential therapy, even if the agents are also administered together. It is noted that combination therapy is intended to cover when agents are administered before or after each other (sequential therapy) as well as when the agents are administered at the same time.

**[0264]** Examples of therapeutic agents that may be used in combination with HDAC inhibitors include, but are not limited to, anticancer agents, alkylating agents, antibiotic agents, antimetabolic agents, hormonal agents, plant-derived agents, and biologic agents.

**[0265]** Alkylating agents are polyfunctional compounds that have the ability to substitute alkyl groups for hydrogen ions. Examples of alkylating agents include, but are not limited to, bischloroethylamines (nitrogen mustards, e.g. chlorambucil, cyclophosphamide, ifosfamide, mechlorethamine, melphalan, uracil mustard), aziridines (e.g. thiotepa), alkyl alkone sulfonates (e.g. busulfan), nitrosoureas (e.g. carmustine, lomustine, streptozocin), nonclassic alkylating agents (altretamine, dacarbazine, and procarbazine), platinum compounds (carboplastin and cisplatin). These compounds react with phosphate, amino, hydroxyl, sulfihydryl, carboxyl, and imidazole groups. Under physiological conditions, these drugs ionize and produce positively charged ion that attach to susceptible nucleic acids and proteins, leading to cell cycle arrest and/or cell death. Combination therapy including a HDAC inhibitor and an alkylating agent may have therapeutic synergistic effects on cancer and reduce sides affects associated with these chemotherapeutic agents.

**[0266]** Antibiotic agents are a group of drugs that produced in a manner similar to antibiotics as a modification of natural products. Examples of antibiotic agents include, but are not limited to, anthracyclines (e.g. doxorubicin, daunorubicin, epirubicin, idarubicin and anthracenedione), mitomycin C, bleomycin, dactinomycin, plicatomycin. These antibiotic agents interferes with cell growth by targeting different cellular components. For example, anthracyclines are generally believed to interfere with the action of DNA topoisomerase II in the regions of transcriptionally active DNA, which leads to DNA strand scissions. Bleomycin is generally believed to chelate iron and forms an activated complex, which then binds to bases of DNA, causing strand scissions and cell death. Combination therapy including a HDAC inhibitor and an antibiotic agent may have therapeutic synergistic effects on cancer and reduce sides affects associated with these chemotherapeutic agents.

**[0267]** Antimetabolic agents are a group of drugs that interfere with metabolic processes vital to the physiology and proliferation of cancer cells. Actively proliferating cancer cells require continuous synthesis of large quantities of nucleic acids, proteins, lipids, and other vital cellular constituents. Many of the antimetabolites inhibit the synthesis of purine or pyrimidine nucleosides or inhibit the enzymes of DNA replication. Some antimetabolites also interfere with the synthesis of ribonucleosides and RNA and/or

amino acid metabolism and protein synthesis as well. By interfering with the synthesis of vital cellular constituents, antimetabolites can delay or arrest the growth of cancer cells. Examples of antimetabolic agents include, but are not limited to, fluorouracil (5-FU), floxuridine (5-FUdR), methotrexate, leucovorin, hydroxyurea, thioguanine (6-TG), mercaptopurine (6-MP), cytarabine, pentostatin, fludarabine phosphate, cladribine (2-CDA), asparaginase, and gemcitabine. Combination therapy including a HDAC inhibitor and a antimetabolic agent may have therapeutic synergistic effects on cancer and reduce sides affects associated with these chemotherapeutic agents.

**[0268]** Hormonal agents are a group of drug that regulate the growth and development of their target organs. Most of the hormonal agents are sex steroids and their derivatives and analogs thereof, such as estrogens, androgens, and progestins. These hormonal agents may serve as antagonists of receptors for the sex steroids to down regulate receptor expression and transcription of vital genes. Examples of such hormonal agents are synthetic estrogens (e.g. diethylstibestrol), antiestrogens (e.g. tamoxifen, toremifene, fluoxymesterol and raloxifene), antiandrogens (bicalutamide, nilutamide, flutamide), aromatase inhibitors (e.g., aminoglutethimide, anastrozole and tetrazole), ketoconazole, goserelin acetate, leuprolide, megestrol acetate and mifepristone. Combination therapy including a HDAC inhibitor and a hormonal agent may have therapeutic synergistic effects on cancer and reduce sides affects associated with these chemotherapeutic agents.

**[0269]** Plant-derived agents are a group of drugs that are derived from plants or modified based on the molecular structure of the agents. Examples of plant-derived agents include, but are not limited to, vinca alkaloids (e.g., vincristine, vinblastine, vindesine, vinzolidine and vinorelbine), podophyllotoxins (e.g., etoposide (VP-16) and teniposide (VM-26)), taxanes (e.g., paclitaxel and docetaxel). These plant-derived agents generally act as antimitotic agents that bind to tubulin and inhibit mitosis. Podophyllotoxins such as etoposide are believed to interfere with DNA synthesis by interacting with topoisomerase II, leading to DNA strand scission. Combination therapy including a HDAC inhibitor and a plant-derived agent may have therapeutic synergistic effects on cancer and reduce sides affects associated with these chemotherapeutic agents.

**[0270]** Biologic agents are a group of biomolecules that elicit cancer/tumor regression when used alone or in combination with chemotherapy and/or radiotherapy. Examples of

biologic agents include, but are not limited to, immuno-modulating proteins such as cytokines, monoclonal antibodies against tumor antigens, tumor suppressor genes, and cancer vaccines. Combination therapy including a HDAC inhibitor and a biologic agent may have therapeutic synergistic effects on cancer, enhance the patient's immune responses to tumorigenic signals, and reduce potential sides affects associated with this chemotherapeutic agent.

**[0271]** Cytokines possess profound immunomodulatory activity. Some cytokines such as interleukin-2 (IL-2, aldesleukin) and interferon have demonstrated antitumor activity and have been approved for the treatment of patients with metastatic renal cell carcinoma and metastatic malignant melanoma. IL-2 is a T-cell growth factor that is central to T-cell-mediated immune responses. The selective antitumor effects of IL-2 on some patients are believed to be the result of a cell-mediated immune response that discriminate between self and nonself. Examples of interleukins that may be used in conjunction with HDAC inhibitor include, but are not limited to, interleukin 2 (IL-2), and interleukin 4 (IL-4), interleukin 12 (IL-12).

**[0272]** Interferon include more than 23 related subtypes with overlapping activities, all of the IFN subtypes within the scope of the present invention. IFN has demonstrated activity against many solid and hematologic malignancies, the later appearing to be particularly sensitive.

**[0273]** Other cytokines that may be used in conjunction with a HDAC inhibitor include those cytokines that exert profound effects on hematopoiesis and immune functions. Examples of such cytokines include, but are not limited to erythropoietin, granulocyte-CSF (filgrastin), and granulocyte, macrophage-CSF (sargramostim). These cytokines may be used in conjunction with a HDAC inhibitor to reduce chemotherapy-induced myelopoietic toxicity.

**[0274]** Other immuno-modulating agents other than cytokines may also be used in conjunction with a HDAC inhibitor to inhibit abnormal cell growth. Examples of such immuno-modulating agents include, but are not limited to bacillus Calmette-Guerin, levamisole, and octreotide, a long-acting octapeptide that mimics the effects of the naturally occurring hormone somatostatin.

**[0275]** Monoclonal antibodies against tumor antigens are antibodies elicited against antigens expressed by tumors, preferably tumor-specific antigens. For example, monoclonal antibody HERCEPTIN® (Trastruzumab) is raised against human epidermal growth factor receptor2 (HER2) that is overexpressed in some breast tumors including metastatic breast cancer. Overexpression of HER2 protein is associated with more aggressive disease and poorer prognosis in the clinic. HERCEPTIN® is used as a single agent for the treatment of patients with metastatic breast cancer whose tumors over express the HER2 protein. Combination therapy including HDAC inhibitor and HERCEPTIN® may have therapeutic synergistic effects on tumors, especially on metastatic cancers.

**[0276]** Another example of monoclonal antibodies against tumor antigens is RITUXAN® (Rituximab) that is raised against CD20 on lymphoma cells and selectively deplete normal and malignant $CD20^+$ pre-B and mature B cells. RITUXAN® is used as single agent for the treatment of patients with relapsed or refractory low-grade or follicular, CD20+, B cell non-Hodgkin's lymphoma. Combination therapy including HDAC inhibitor and RITUXAN® may have therapeutic synergistic effects not only on lymphoma, but also on other forms or types of malignant tumors.

**[0277]** Tumor suppressor genes are genes that function to inhibit the cell growth and division cycles, thus preventing the development of neoplasia. Mutations in tumor suppressor genes cause the cell to ignore one or more of the components of the network of inhibitory signals, overcoming the cell cycle check points and resulting in a higher rate of controlled cell growth—cancer. Examples of the tumor suppressor genes include, but are not limited to, *DPC-4, NF-1, NF-2, RB, p53, WT1, BRCA1* and *BRCA2.*

**[0278]** *DPC-4* is involved in pancreatic cancer and participates in a cytoplasmic pathway that inhibits cell division. *NF-1* codes for a protein that inhibits Ras, a cytoplasmic inhibitory protein. *NF-1* is involved in neurofibroma and pheochromocytomas of the nervous system and myeloid leukemia. *NF-2* encodes a nuclear protein that is involved in meningioma, schwanoma, and ependymoma of the nervous system. *RB* codes for the pRB protein, a nuclear protein that is a major inhibitor of cell cycle. *RB* is involved in retinoblastoma as well as bone, bladder, small cell lung and breast cancer. *P53* codes for p53 protein that regulates cell division and can induce apoptosis. Mutation and/or inaction of p53 is found in a wide ranges of cancers. *WT1* is

involved in Wilms tumor of the kidneys. *BRCA1* is involved in breast and ovarian cancer, and *BRCA2* is involved in breast cancer. The tumor suppressor gene can be transferred into the tumor cells where it exerts its tumor suppressing functions. Combination therapy including a HDAC inhibitor and a tumor suppressor may have therapeutic synergistic effects on patients suffering from various forms of cancers.

**[0279]** Cancer vaccines are a group of agents that induce the body's specific immune response to tumors. Most of cancer vaccines under research and development and clinical trials are tumor-associated antigens (TAAs). TAA are structures (i.e. proteins, enzymes or carbohydrates) which are present on tumor cells and relatively absent or diminished on normal cells. By virtue of being fairly unique to the tumor cell, TAAs provide targets for the immune system to recognize and cause their destruction. Example of TAAs include, but are not limited to gangliosides (GM2), prostate specific antigen (PSA), alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA) (produced by colon cancers and other adenocarcinomas, e.g. breast, lung, gastric, and pancreas cancer s), melanoma associated antigens (MART-1, gp100, MAGE 1,3 tyrosinase), papillomavirus E6 and E7 fragments, whole cells or portions/lysates of antologous tumor cells and allogeneic tumor cells.

**[0280]** An adjuvant may be used to augment the immune response to TAAs. Examples of adjuvants include, but are not limited to, bacillus Calmette-Guerin (BCG), endotoxin lipopolysaccharides, keyhole limpet hemocyanin (GKLH), interleukin-2 (IL-2), granulocyte-macrophage colony-stimulating factor (GM-CSF) and cytoxan, a chemotherapeutic agent which is believe to reduce tumor-induced suppression when given in low doses.

**HDAC Activity Assay**

**[0281]** Compounds according to the present invention may be screened for activity against one or more HDACs. Provided in this example are assays for activity against HDAC1, HDAC2, HDAC6 and HDAC8.

**[0282]** Purified HDAC1, HDAC2, HDAC6, and HDAC8 may be obtained as follows.

**[0283]** For HDAC1, DNA encoding residues 1-482 of the full-length sequence of the human enzyme may be amplified by PCR and cloned into the BamHI/XbaI sites of pFastbac (Invitrogen), which incorporates a 6-histidine tag at the N-terminus. SEQ. I.D.

No. 1 corresponds to residues 1-482 with the N-terminal 6-histidine tag and SEQ. I.D. No. 2 is the DNA sequence that was used to encode SEQ. I.D. No. 1.

**[0284]** For HDAC2, DNA encoding residues 1-488 of the full-length sequence of the human enzyme may be amplified by PCR and cloned into the BamHI/SmaI sites of pFastbac (Invitrogen), which incorporates a 6-histidine tag at the C-terminus. SEQ. I.D. No. 3 corresponds to residues 1-488 with the C-terminal 6-histidine tag and SEQ. I.D. No. 4 is the DNA sequence that was used to encode SEQ. I.D. No. 3.

**[0285]** For HDAC6, DNA encoding residues 73-845 of the human enzyme may be amplified by PCR and cloned into the SmaI site of pFastbac (Invitrogen), which incorporates a 6xHistidine tag at the C-terminus. SEQ. I.D. No. 5 corresponds to residues 73-845 with the C-terminal 6-histidine tag and SEQ. I.D. No. 6 is the DNA sequence that was used to encode SEQ. I.D. No. 5.

**[0286]** For HDAC8, DNA encoding residues 1-377 corresponding to the entire sequence of the human enzyme may be amplified by PCR and cloned into the BamHI/SmaI sites of pFastbac (Invitrogen), which incorporates a 6-histidine tag at the N-terminus. SEQ. I.D. No. 7 corresponds to residues 1-377 with the N-terminal 6-histidine tag and SEQ. I.D. No. 8 is the DNA sequence that was used to encode SEQ. I.D. No. 7.

**[0287]** Recombinant baculovirus incorporating the HDAC constructs may be generated by transposition using the Bac-to-Bac system (Invitrogen). High-titer viral stocks may be generated by infection of *Spodoptera frugiperda* Sf9 cells; the expression of recombinant protein may be carried out by infection of *Spodoptera frugiperda* Sf9 or *Trichoplusia ni* Hi5 cells (Invitrogen) in 10L Wave Bioreactors (Wave Biotech).

**[0288]** Recombinant protein may be isolated from cellular extracts by passage over ProBond resin (Invitrogen). HDAC1 and HDAC6 may then be treated with TEV protease for the removal of the N-terminal 6XHistidine affinity tag (residual uncleaved protein may be removed through a second passage over Probond Resin). Partially purified extracts of all HDACs may then be further purified by high pressure liquid chromatography over a BioSep S3000 gel filtration resin. The purity of HDAC proteins may be determined on denaturing SDS-PAGE gel. Purified HDACs may then be concentrated to a final concentration of 4.0 mg/ml for HDAC1, 10 mg/ml for HDAC2, 4.0 mg/ml for HDAC6, and 3 mg/ml for HDAC8. The proteins may be either stored at –78 °C in a buffer

containing 25mM TRIS-HCl pH 7.6, 150mM NaCl, 0.1mM EDTA and 0.25 mM TCEP or at –20 °C in the presence of glycerol (final concentration of glycerol at 50%)

**[0289]** The inhibitory properties of compounds relative to HDAC1, HDAC2, HDAC6 and HDAC8 may be determined using a white or black 384-well-plate format under the following reaction conditions: 25 mM Tris pH 8.0, 100 mM NaCl, 50 mM KCl, 0.1 mM EDTA, 0.01% Brij35, 0.1 mM TCEP. 50 uM tBoc-Lys(Ac)-AMC, 2% DMSO. Reaction product may be determined quantitatively by fluorescence intensity using a Fluorescence plate reader (Molecular Devices Gemini) with an excitation wavelength at 370 nm and emission at 480 nm (for white plates) or 465 nm (for black plates).

**[0290]** The assay reaction may be initiated as follows: 5 ul of 150 uM tBoc-Lys(Ac)AMC was added to each well of the plate, followed by the addition of 5 ul of inhibitor (2 fold serial dilutions for 11 data points for each inhibitor) containing 6% DMSO. 5 ul of either HDAC1, HDAC2, HDAC6 or HDAC8 solution may be added to initiate the reaction (final enzyme concentrations were 2.5 nM for HDAC1, 1 nM for HDAC2, 2.5 nM for HDAC6 and 10 nM for HDAC8). The reaction mixture may then be incubated at room temperature for 60 min, and quenched and developed by addition of 5 ul of 10 mM phenanthroline and 4 mg/ml trypsin (final concentration of phenanthroline is 2.5 mM, and trypsin is 1 mg/ml). Fluorescence intensities of the resulting reaction mixtures may be measured after a 30 minute incubation at room temperature.

**[0291]** IC50 values may be calculated by non-linear curve fitting of the compound concentrations and fluorescence intensities to the standard IC50 equation. As a reference point for this assay, suberanilohydroxamic acid (SAHA) showed an IC50 of 63 nM for HDAC1, 69 nM for HDAC2, 108 nM for HDAC6 and 242 nM for HDAC8.

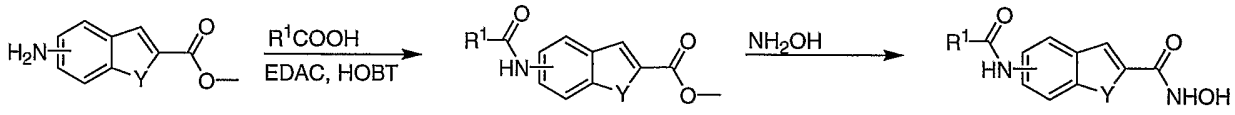
**[0292]** The Section below provides examples of HDAC inhibitors that were assayed according to the above assays and found to have better than 1000 nM activity against HDAC-1, HDAC-2, HDAC-6, and HDAC-8.

## EXAMPLES

### Synthetic Schemes For HDAC Inhibitors

**[0293]** HDAC inhibitors according to the present invention may be synthesized according to a variety of reaction schemes. Some illustrative schemes are provided herein in the examples. Other reaction schemes could be readily devised by those skilled in the art.

**Scheme 1:**




1: 5-$NH_2$, Y = O
2: 5-$NH_2$, Y = S
3: 6-$NH_2$, Y = S

4

5

**Synthesis of 5-amino-benzofuran-2-carboxylic acid methyl ester (1).**

**[0294]** 5-Amino-benzofuran-2-carboxylic acid methyl ester was synthesized as previously described in J. Med. Chem., 43(8), 2000, 1541-1549.

**Synthesis of 5-amino-benzo[b]thiophene-2-carboxylic acid methyl ester (2).**

**[0295]** 5-Amino-benzo[b]thiophene-2-carboxylic acid methyl ester was synthesized as previously described in Bioorg. Med. Chem Lett.,10(5), 2002, 1611-1618.

**Synthesis of 6-amino-benzo[b]thiophene-2-carboxylic acid methyl ester (3).**

**[0296]** 6-Amino-benzo[b]thiophene-2-carboxylic acid methyl ester was synthesized as previously described in J. Chem Soc., Perkin Trans 1, 17, 1975, 1686-1690.

**General procedure for the synthesis 5-substituted-amido-benzofuran-2-carboxylic acid methyl esters, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid methyl esters, and 6-substituted-amido-benzo[b]thiophene-2-carboxylic acid methyl esters (4).**

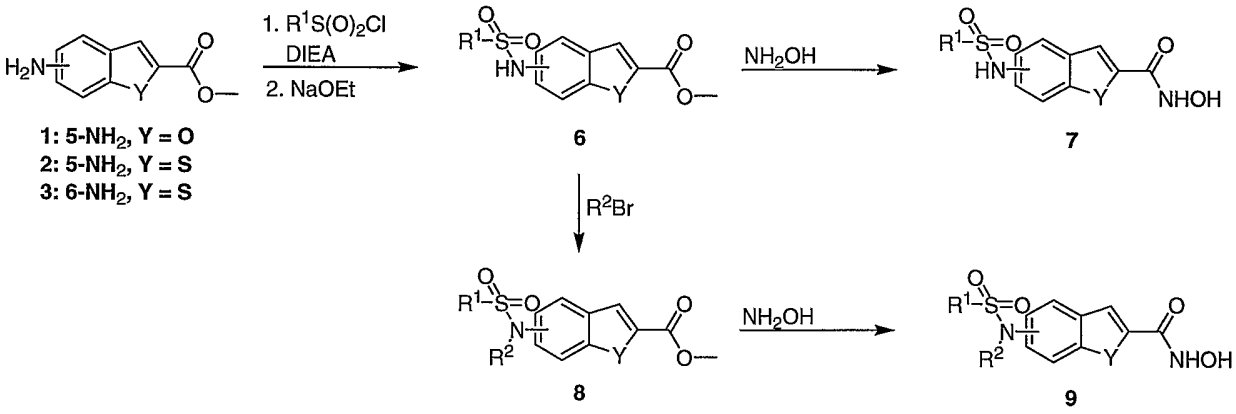
**[0297]** To a solution of 5-amino-benzofuran-2-carboxylic acid methyl ester (**1**, 0.30 mmol), 5-amino-benzo[b]thiophene-2-carboxylic acid methyl ester (**2**, 0.30 mmol) or 6-

amino-benzo[b]thiophene-2-carboxylic acid methyl ester (**3**, 0.30 mmol) in DMF (1.0 mL) was added HOBt (0.91 mmol), EDCI (0.91mmol), the appropriately substituted carboxylic acid (46 mg, mmol), and DIEA (2.1 mmol). The reaction was stirred at ambient temperature for 18 hrs and was then poured into $H_2O$ (5 mL), extracted with EtOAc, washed with brine, dried over $MgSO_4$ and concentrated to dryness. The resulting material was evaporated onto silica gel and purified via flash chromatography to provide the desired 5-substituted-amido-benzofuran-2-carboxylic acid methyl ester, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid methyl ester, or 6-substituted-amido-benzo[b]thiophene-2-carboxylic acid methyl ester (4).

**General procedure for the synthesis of 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamides, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides, and 6-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides (5).**

**[0298]** To a solution of the appropriate 5-substituted-amido-benzofuran-2-carboxylic acid methyl ester or 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid methyl ester (**3**) in DMF (1.0 mL) was added $NH_2OH$ (50% in $H_2O$; 1.0 mL). The reaction was stirred at ambient temperature for 24 hrs and, without further work-up, purified by preparative LCMS to provide the desired 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamide, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamide, or 6-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamide (5).

**Scheme 2:**




**General procedure for the synthesis of 5-substituted-sulfonylamino-benzofuran-2-carboxylic acid methyl esters, 5-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl esters, and 6-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl esters (6).**

**[0299]** To a solution of 5-amino-benzofuran-2-carboxylic acid methyl ester (**1**, 1.36 mmol), 5-amino-benzo[b]thiophene-2-carboxylic acid methyl ester (2, 1.36 mmol), or 6-amino-benzo[b]thiophene-2-carboxylic acid methyl ester (3, 1.36 mmol) in DCM (4.0 mL) was added the appropriately substituted sulfonyl chloride (2.72 mmol) and triethylamine (3.4 mmol). The reaction mixture was allowed to stir for 4 hours at ambient temperature and then poured into saturated sodium bicarbonate solution. The mixture was extracted with DCM and the organic layer was then rinsed with brine, dried over $Mg_2SO_4$, and concentrated. The crude material was then redissolved in DCM/MeOH (1:3, 5.0 mL) and treated with NaOEt (6.8 mmol). The mixture was heated for 1 hr at 60 °C, cooled to ambient temperature, and then treated with 1N HCl. The mixture was concentrated under reduced pressure and extracted with DCM. The organic layer was washed with brine, dried over $Mg_2SO_4$, and concentrated. The resulting material was purified via flash chromatography to provide the desired 5-substituted-sulfonylamino-benzofuran-2-carboxylic acid methyl ester, 5-substitutedsulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl ester, or 6-substitutedsulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl ester (6).

**General procedure for the synthesis of 5-substituted-sulfonylamino-benzofuran-2-carboxylic acid hydroxyamides, 5-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamides, and 6-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamides (7).**

**[0300]** The procedure for the synthesis of 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamides, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides, and 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides (**5**) was used to provide the desired 5-substituted-sulfonylamino-benzofuran-2-carboxylic acid hydroxyamide, 5-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide, or 6-substituted-sulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide (7).

**General procedure for the synthesis of 5-(substituted-sulfonyl-N-alkylated-amino)-benzofuran-2-carboxylic acid methyl esters, 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid methyl esters, and 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid methyl esters (8).**

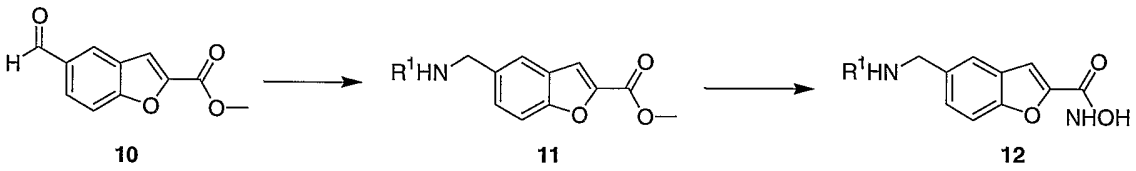
**[0301]** To a solution of the appropriate 5-substituted-sulfonylamino-benzofuran-2-carboxylic acid methyl ester, 5-substitutedsulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl ester, or 6-substitutedsulfonylamino-benzo[b]thiophene-2-carboxylic acid methyl ester (**6**, 0.65 mmol) in DMF (3.3 mL) was added the appropriately substituted alkyl bromide (0.707 mmol) and $K_2CO_3$ (1.36 mmol). The reaction mixture was allowed to stir for two hours at 25-100 °C and then poured into water. The mixture was extracted with EtOAc, washed with brine, dried over $Na_2SO_4$, concentrated, and purified via flash chromatography to provide the desired 5-(substituted-sulfonyl-N-alkylated-amino)-benzofuran-2-carboxylic acid methyl esters, 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid methyl esters, and 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid methyl esters (8).

**General procedure for the synthesis of 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamides (9).**

**[0302]** The procedure for the synthesis of 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamides, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid

hydroxyamides, and 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides (**5**) was used to provide the desired 5-(substituted-sulfonyl-N-alkylated-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamides (9).

**Scheme 3:**




10 11 12

**Synthesis of 5-formyl-benzofuran-2-carboxylic acid methyl ester (10).**

**[0303]** 5-formyl-benzofuran-2-carboxylic acid methyl ester (**10**) was synthesized as previously described in WO19990312.

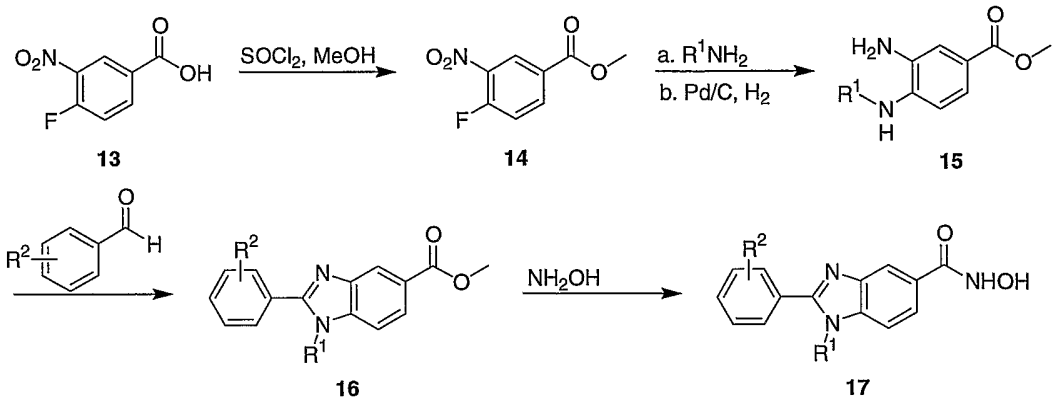
**General procedure for the synthesis of 5-{(substituted-amino)-methyl}-benzofuran-2-carboxylic acid methyl esters (11).**

**[0304]** To a solution of 5-formyl-benzofuran-2-carboxylic acid methyl ester (**10**, 2.45 mmol) and the appropriately substituted amine (4.90 mmol) in DCM (50.0 mL) was added $NaBH(OAc)_3$ (4.89 mmol). The reaction mixture was allowed to stir at ambient temperature for 18 hours. The reaction was poured into 10% $K_2CO_3$ and extracted with ethyl acetate. The organic layer was washed with brine, dried with $Na_2SO_4$, and concentrated. The resulting material was purified via flash chromatography to provide the desired 5-{(substituted-amino)-methyl}-benzofuran-2-carboxylic acid methyl ester (11).

**General procedure for the synthesis of 5-{(substituted-amino)-methyl}-benzofuran-2-carboxylic acid hydroxyamides (12).**

**[0305]** The procedure for the synthesis of 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamides and 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides (**4**) was used to provide the desired 5-{(substituted-amino)-methyl}-benzofuran-2-carboxylic acid hydroxyamide (**12**).

**Scheme 4:**




**Synthesis of 4-fluoro-3-nitro-benzoic acid methyl ester (14).**

**[0306]** To a suspension of 4-fluoro-3-nitro benzoic acid (13, 5.94 mmol) in MeOH (20 mL) was added thionyl chloride (17.82 mmol) drop-wise at –78 °C. The reaction was stirred for 18 hrs as it was allowed to warm to ambient temperature. The resulting solution was concentrated to dryness. The resulting material was dissolved in MeOH and concentrated to dryness (3x) to provide the desired 4-fluoro-3-nitro-benzoic acid methyl ester (14).

**General procedure for the synthesis of 3-amino-(4-substituted-amino)-benzoic acid methyl esters (15).**

**[0307]** To a solution of 4-fluoro-3-nitro-benzoic acid methyl ester (14, 1.00 mmol) and the appropriately substituted amine (1.00 mmol) in DMF (2.0 mL) was added DIEA (2.01 mmol). The reaction was heated at 50-100 °C for 24-48 hrs and then cooled to ambient temperature. The resulting mixture was poured into $H_2O$, extracted with EtOAc, washed with brine, and dried over $MgSO_4$. The organic layer was evaporated to dryness and the resulting 3-nitro-(4-substituted-amino)-benzoic acid methyl ester was used without any further purification. The appropriate 3-nitro-(4-substituted-amino)-benzoic acid methyl ester was then dissolved in EtOH (5.0 mL). This solution was poured into a vessel containing 10% Pd/C (catalytic) and the reaction was stirred in the presence of $H_2$ (g) at atmospheric pressure for 24 hrs. The reaction was the filtered through Celite and the resulting solution of 3-amino-(4-substituted-amino)-benzoic acid methyl ester (15) was used without further purification.

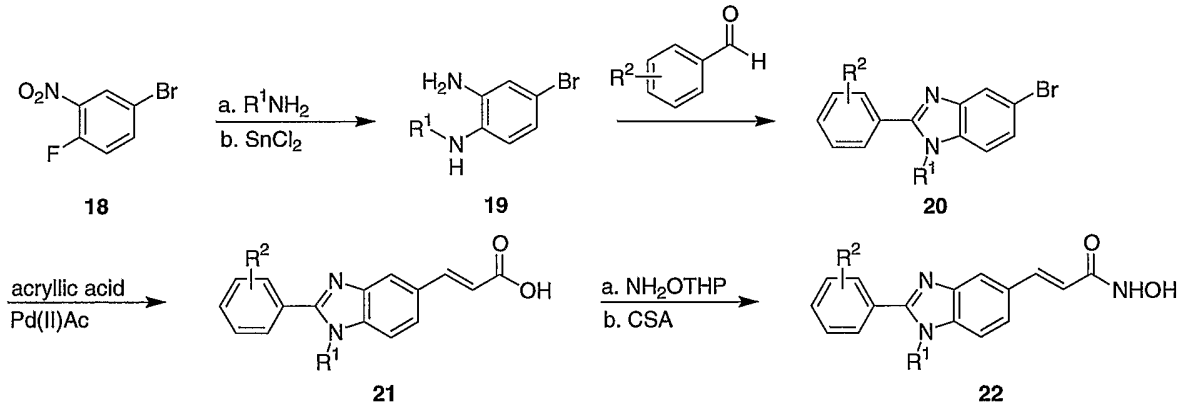
**General procedure for the synthesis of $N^1$-alkylated-2-substituted-1H-benzoimidazole-5-carboxylic acid methyl esters (16).**

**[0308]** To a solution of 3-amino-(4-substituted-amino)-benzoic acid methyl ester (**15**, 1.0 mmol) in EtOH (5.0 mL) was added the appropriately substituted aldehyde (1.2 mmol). The pH was adjusted to 5 with AcOH and the reaction was refluxed for 24-48 hrs. The reaction was cooled, evaporated to dryness and purified via flash chromatography to provide the desired $N^1$-alkylated-2-substituted-1H-benzoimidazole-5-carboxylic acid methyl ester (16).

**General procedure for the synthesis of $N^1$-alkylated-2-substituted-1H-benzoimidazole-5-carboxylic acid hydroxyamides (17).**

**[0309]** The procedure for the synthesis of 5-substituted-amido-benzofuran-2-carboxylic acid hydroxyamides, 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides, and 5-substituted-amido-benzo[b]thiophene-2-carboxylic acid hydroxyamides (**5**) was used to provide the desired $N^1$-alkylated-2-substituted-1H-benzoimidazole-5-carboxylic acid hydroxyamide (17).

**Scheme 5:**




**General procedure for the synthesis of 4-bromo-$N^1$-substituted-benzene-1,2-diamines (19).**

**[0310]** To a solution of 4-bromo-1-fluoro-2-nitro-benzene (**18**, 1.00 mmol) and the appropriately substituted amine (1.00 mmol) in DMF (2.0 mL) was added DIEA (2.01

mmol). The reaction was heated at 50-100 °C for 24-48 hrs and then cooled to ambient temperature. The resulting mixture was poured into $H_2O$, extracted with EtOAc, washed with brine, and dried over $MgSO_4$. The organic layer was evaporated to dryness and the resulting (4-Bromo-2-nitro-phenyl)-$N^1$-substituted-amine was used without any further purification. To a solution of the appropriate (4-Bromo-2-nitro-phenyl)-$N^1$-substituted-amine (1.77 mmol) in EtOAc (7.0 mL) was added $SnCl_2$ 5.31 mmol). The reaction was stirred at ambient temperature for 24 hrs. The reaction was poured into saturated $NaHCO_3$, diluted with EtOAc, and filtered through Celite. The phases were separated, and the organic layer was washed with brine, dried over $MgSO_4$, and evaporated to dryness to provide the desired 4-bromo-$N^1$-substituted-benzene-1,2-diamines (19) which was used without further purification.

**General procedure for the synthesis of 5-bromo-$N^1$-alkylated-2-substituted-1H-benzoimidazoles (20).**

**[0311]** To the appropriate 4-bromo-$N^1$-substituted-benzene-1,2-diamine (**19**, 1.77 mmol) was in EtOH (5.0 mL) was added the appropriately substituted aldehyde (2.12 mmol). The pH was adjusted to 5 with AcOH and the mixture was refluxed for 24-48 hrs. The reaction was cooled, evaporated to dryness and purified via flash chromatography to provide the desired 5-bromo-$N^1$-alkylated-2-substituted-1H-benzoimidazoles (20).

**General procedure for the synthesis of 3-($N^1$-alkylated-2-substituted-1H-benzoimidazol-5-yl)-acrylic acids (21).**

**[0312]** To a solution of the appropriate 5-bromo-$N^1$-alkylated-2-substituted-1H-benzoimidazoles (20, 1.03 mmol), Pd(II)Ac (0.05 mmol), and P(*o*-tolyl)$_3$ (0.10 mmol) in DMF (1.0 mL) was added acrylic acid (1.54 mmol) and $Et_3N$ (2.06 mmol). The reaction mixture was heated at 100 °C for 1h. The reaction mixture was then concentrated directly onto silica gel and purified via flash chromatography to provide the desired 3-($N^1$-alkylated-2-substituted-1H-benzoimidazol-5-yl)-acrylic acid (21).

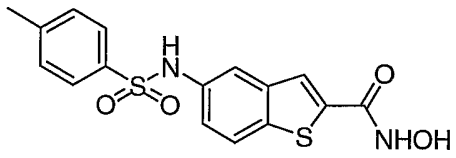
**General procedure for the synthesis of 3-( $N^1$-alkylated-2-substituted-1H-benzoimidazol-5-yl)-N-hydroxy-acrylamides (22).**

**[0313]** To a solution of the appropriate 3-($N^1$-alkylated-2-substituted-1H-benzoimidazol-5-yl)-acrylic acid (21, 0.25 mmol), and HOBt (0.38 mmol) in DMF (5.0 mL) was added EDCI (0.38mmol), *O*-(tetrahydro-pyran-2-yl)-hydroxylamine (0.38 mmol), and DIEA (0.75 mmol). The reaction was stirred at ambient temperature for 18 hrs. The resulting mixture was poured into $H_2O$, extracted with EtOAc, washed with brine, and dried over $MgSO_4$. The organic layer was evaporated to dryness and the resulting material was reconstituted in MeOH (2 mL). CSA (0.28 mmol) was added to the solution. The reaction was stirred for 2 hr at ambient temperature and, without further work-up, purified by preparative LCMS to yield the desired 3-( $N^1$-alkylated-2-substituted-1H-benzoimidazol-5-yl)-N-hydroxy-acrylamides (22).

**Examples of Inhibitors According to the Present Invention**

**[0314]** Provided in this example are particular compounds that have been found to have HDAC8 activity based on the assay provided in Example 2. It is noted that these compounds may also have activity relative to other HDACs. It is also noted that these compounds are intended to illustrate various HDAC inhibitors according to the present invention and the present invention is not intended to be limited to these compounds:

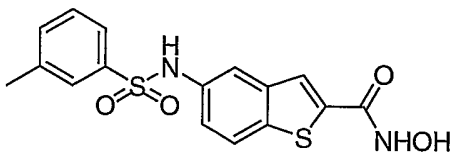
COMPOUND 1




5-(Toluene-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0315]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.23 (s, 3H), 7.10 (dd, 1H), 7.24 (d, 2H), 7.51 (s, 1H), 7.56 (d, 2H), 7.72 (s, 1H), 7.79 (d, 1H), 9.21 (s, 1H), 10.26 (s, 1H), 11.41 (s, 1H). ESI-MS: *m/z* 363.2 $(M + H)^+$.

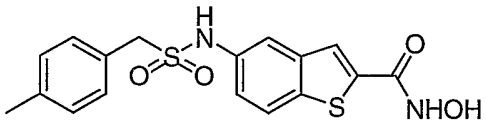
COMPOUND 2



5-(Toluene-3-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0316]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.30 (s, 3H), 7.16 (dd, 1H), 7.39 (d, 2 H), 7.55 (m, 3H), 7.78 (s, 1H), 7.85 (d, 1H), 9.21 (s, 1H), 10.35 (s, 1H), 11.40 (s, 1H). ESI-MS: *m/z* 363.2 $(M + H)^+$.

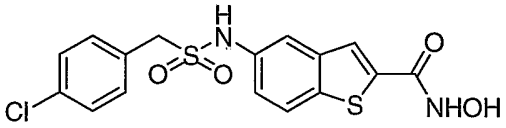
COMPOUND 3




5-p-Tolylmethanesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0317]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.26 (s, 3H), 4.42 (s, 2H), 7.12 (s, 4H), 7.24 (dd, 1H), 7.67 (s, 1H), 7.84 (s, 1H), 7.93 (d, 1H), 9.29 (s, 1H), 9.89 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 377.2 $(M + H)^+$.

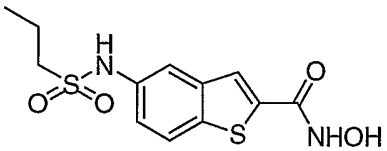
COMPOUND 4




5-(4-Chloro-phenylmethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0318]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 4.52 (s, 2H), 7.26 (m, 3H), 7.40 (d, 2H), 7.70 (s, 1H), 7.85 (s, 1H), 7.96 (d, 1H), 9.29 (s, 1H), 9.94 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 397.0 $(M + H)^+$.

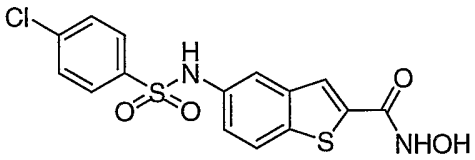
COMPOUND 5




5-(Propane-1-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0319]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 0.91 (t, 3H), 1.68 (m, 2H), 3.06 (t, 2H), 7.28 (d, 1H), 7.71 (s, 1H), 7.85 (s, 1H), 7.95 (d, 1H), 9.29 (s, 1H), 9.89 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 315.1 $(M + H)^+$.

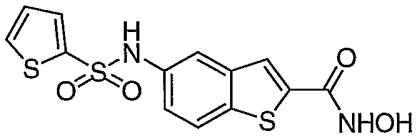
COMPOUND 6



5-(4-Chloro-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0320]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.20 (dd, 1 H), 7.65 (m, 3 H), 7.78 (d, 2 H), 7.85 (s, 1 H), 7.93 (d, 1 H), 9.33 (s, 1 H), 10.51 (s, 1 H), 11.47 (s, 1 H). ESI-MS: *m/z* 383.0 $(M + H)^+$.

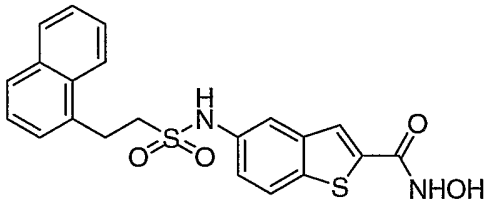
COMPOUND 7



5-(Thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0321]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.08 (m, 1H), 7.19 (dd, 1H), 7.52 (dd, 1H), 7.64 (s, 1H), 7.82 (s, 1H), 7.85 (dd, 1H), 7.91 (s, 1H), 9.30 (s, 1H), 10.53 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 355.0 $(M + H)^+$.

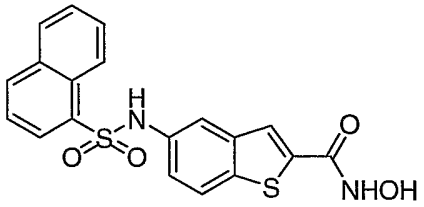
COMPOUND 8



5-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0322]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.42 (m, 4H), 7.22 (t, 1H), 7.41 (m, 4H), 7.57 (d, 1H), 7.78 (m, 2H), 7.87 (m, 2H), 8.02 (d, 1H), 9.30 (s, 1H), 10.20 (s, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 427.1 $(M + H)^+$.

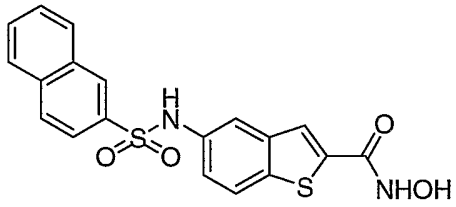
COMPOUND 9



5-(Naphthalene-1-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0323]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.06 (dd, 1H), 7.49 (s, 1H), 7.57 (t, 1H), 7.65 (t, 1H), 7.74 (m, 3H), 8.04 (d, 1H), 8.19 (m, 2H), 8.74 (d, 1H), 9.26 (s, 1H), 10.83 (s, 1H), 11.38 (s, 1H). ESI-MS: *m/z* 399.1 $(M + H)^+$.

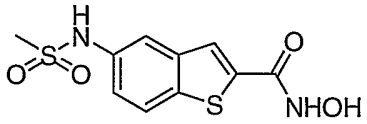
COMPOUND 10



5-(Naphthalene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0324]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.17 (dd, 1H), 7.64 (m, 3H), 7.76 (m, 2H), 7.83 (d, 1H), 7.96 (d, 1H), 8.07 (m, 2H), 8.43 (s, 1H), 9.27 (s, 1H), 10.54 (s, 1H), 11.39 (s, 1H). ESI-MS: *m/z* 399.1 $(M + H)^+$.

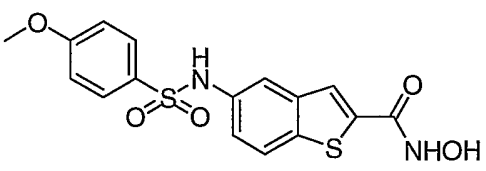
COMPOUND 11



5-Methanesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0325]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.98 (s, 3H), 7.28 (dd, 1H), 7.71 (s, 1H), 7.85 (s, 1H), 7.96 (d, 1H), 9.30 (s, 1H), 9.84 (s, 1H), 11.47 (s, 1H). ESI-MS: *m/z* 287.1 $(M + H)^+$.

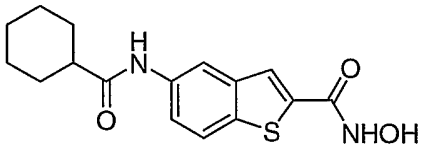
COMPOUND 12



5-(4-Methoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0326]** $^1$H NMR (400 MHz, $CDCl_3$): δ ppm 3.74 (s, 3H), 7.01 (d, 2H), 7.15 (dd, 1H), 7.57 (s, 1H), 7.66 (d, 2H), 7.78 (s, 1H), 7.85 (d, 1H), 9.29 (s, 1H), 10.27 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 378.1 $(M + H)^+$.

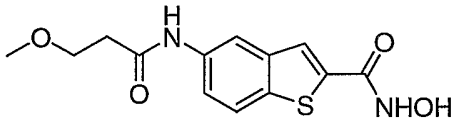
COMPOUND 13



5-(Cyclohexanecarbonyl-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0327]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 1.24 (m, 2H), 1.41 (m, 2H), 1.65 (d, 1H), 1.78 (m, 5H), 2.34 (m, 1H), 7.50 (m, 1H), 7.82 (s, 1H), 7.87 (d, 1H), 8.32 (m, 1H), 9.25 (s, 1H), 9.94 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 319.1 $(M + H)^+$.

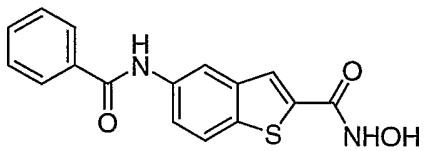
COMPOUND 14



5-(3-Methoxy-propionylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0328]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.56 (t, 2H), 3.24 (s, 3H), 3.62 (t, 2H), 7.50 (dd, 1H), 7.82 (s, 1H), 7.87 (d, 1H), 8.32 (m, 1H), 9.10 (s, 1H), 10.09 (s, 1H), 11.43 (s, 1H). ESI-MS: *m/z* 295.1 $(M + H)^+$.

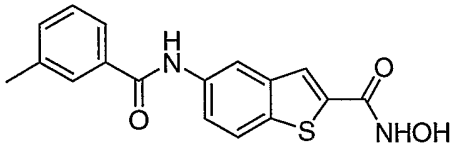
COMPOUND 15



5-Benzoylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0329]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.57 (m, 3H), 7.76 (dd, 1H), 7.90 (s, 1H), 7.97 (m, 3H), 8.43 (s, 1H), 9.27 (s, 1H), 10.40 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 313.1 $(M + H)^+$.

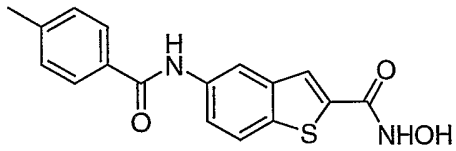
COMPOUND 16



5-(3-Methyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0330]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.39 (s, 3H), 7.41 (m, 2H), 7.76 (m, 3H), 7.89 (s, 1H), 7.96 (d, 1H), 8.43 (m, 1H), 9.27 (s, 1H), 10.35 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 327.1 $(M + H)^+$.

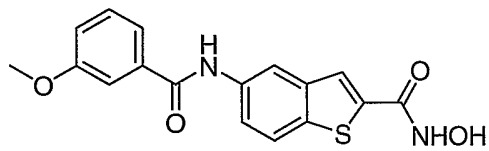
COMPOUND 17



5-(4-Methyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0331]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.36 (s, 3H), 7.34 (d, 2H), 7.75 (dd, 1H), 7.89 (m, 3H), 7.96 (d, 1H), 8.43 (m, 1H), 9.27 (s, 1H), 10.31 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 327.1 $(M + H)^+$.

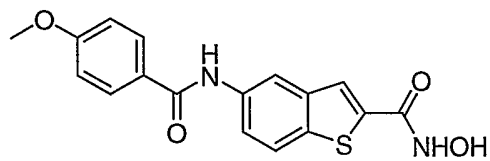
COMPOUND 18



5-(3-Methoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0332]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.83 (s, 3H), 7.16 (dd, 1H), 7.47 (t, 2H), 7.50 (s, 1H), 7.56 (d, 1H), 7.75 (dd, 1H), 7.89 (s, 1H), 7.97 (d, 1H), 8.42 (d, 1H), 9.27 (s, 1H), 10.36 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 343.1 $(M + H)^+$.

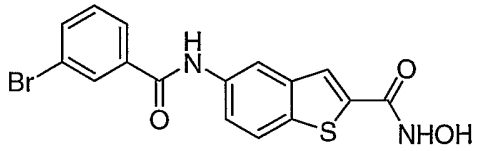
COMPOUND 19



5-(4-Methoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0333]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.82 (s, 3H), 7.06 (d, 2H), 7.75 (dd, 1H), 7.88 (s, 1H), 7.97 (m, 3H), 8.42 (d, 1H), 9.27 (s, 1H), 10.23 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 343.1 $(M + H)^+$.

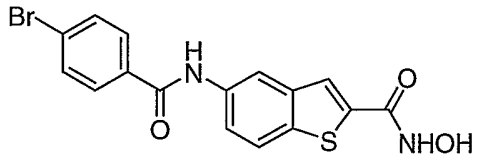
COMPOUND 20




5-(3-Bromo-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0334]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.51 (t, 1H), 7.72 (m, 1H), 7.80 (m, 2H), 7.90 (s, 1 H), 7.98 (m, 2H), 8.16 (t, 1H), 8.41 (d, 1H), 9.28 (s, 1H), 10.49 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 391.0 $(M + H)^+$.

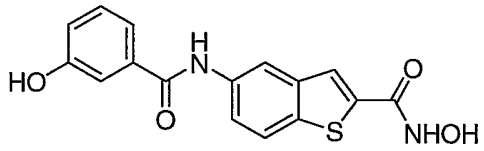
COMPOUND 21




5-(4-Bromo-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0335]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.74 (m, 3H), 7.94 (m, 4H), 8.42 (d, 1H), 9.28 (s, 1H), 10.47 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 391.0 $(M + H)^+$.

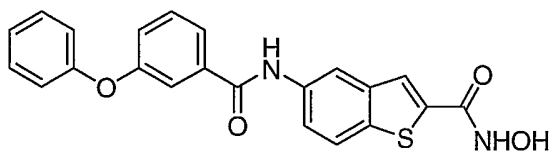
COMPOUND 22




5-(3-Hydroxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0336]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 6.98 (dd, 1H), 7.32 (m, 2H), 7.41 (d, 1H), 7.76 (dd, 1H), 7.90 (s, 1H), 7.97 (d, 1H), 8.44 (d, 1H), 9.29 (s, 1H), 9.76 (s, 1H), 10.32 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 329.1 $(M + H)^+$.

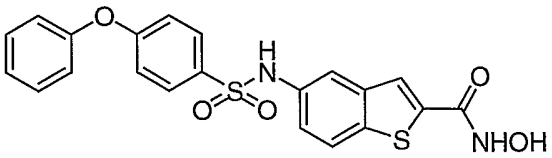
COMPOUND 23




5-(3-Phenoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0337]** $^1$H NMR (400 MHz, $CDCl_3$): δ ppm 7.06 (d, 2H), 7.20 (m, 2H), 7.42 (t, 2H), 7.56 (m, 2H), 7.73 (m, 2H), 7.88 (s, 1H), 7.96 (d, 1H), 8.40 (d, 1H), 9.27 (s, 1H), 10.40 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 405.1 $(M + H)^+$.

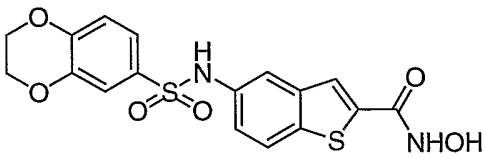
COMPOUND 24



5-(4-Phenoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0338]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.02 (d, 2H), 7.05 (d, 2H), 7.15 (dd, 1H), 7.23 (t, 1H), 7.42 (t, 2H), 7.59 (s, 1H), 7.73 (d, 2H), 7.79 (s, 1H), 7.87 (d, 1H), 9.27 (s, 1H), 10.34 (s, 1H), 11.41 (s, 1H). ESI-MS: *m/z* 441.1 $(M + H)^+$.

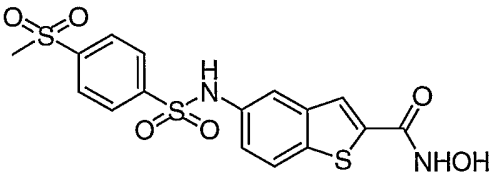
COMPOUND 25



5-(2,3-Dihydro-benzo[1,4]dioxine-6-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0339]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 4.23 (m, 4H), 6.95 (d, 1H), 7.18 (m, 3H), 7.58 (s, 1H), 7.79 (s, 1H), 7.86 (d, 1H), 9.27 (s, 1H), 10.28 (s, 1H), 11.41 (s, 1H). ESI-MS: *m/z* 407.1 $(M + H)^+$.

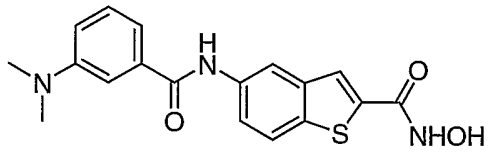
COMPOUND 26



5-(4-Methanesulfonyl-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0340]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.06 (s, 3 H), 6.98 (dd, 1H), 7.44 (s, 1H), 7.62 (s, 1H), 7.71 (d, 1H), 7.80 (d, 2H), 7.89 (d, 2H), 9.09 (s, 1H), 10.47 (s, 1H), 11.24 (s, 1H). ESI-MS: *m/z* 427.0 $(M + H)^+$.

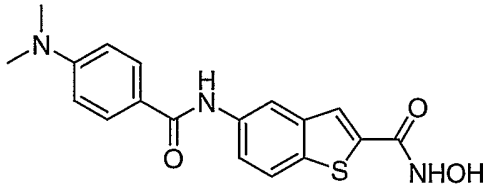
COMPOUND 27



5-(3-Dimethylamino-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0341]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.99 (s, 6H), 7.03 (m, 1H), 7.36 (m, 3H), 7.76 (m, 1H), 7.93 (d, 2H), 8.43 (d, 1H), 10.33 (s, 1H), 11.40 (s, 1H). ESI-MS: *m/z* 356.1 $(M + H)^+$.

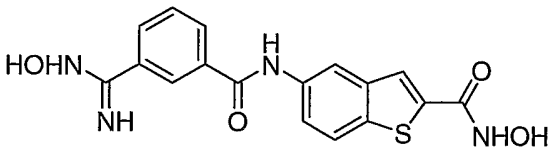
COMPOUND 28



5-(4-Dimethylamino-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0342]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.98 (s, 6H), 6.76 (d, 2H), 7.76 (dd, 1H), 7.90 (m, 3H), 8.41 (d, 1H), 10.01 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 356.1 $(M + H)^+$.

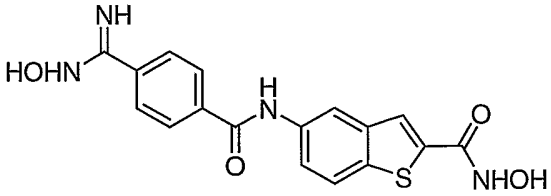
COMPOUND 29



5-[3-(N-Hydroxycarbamimidoyl)-benzoylamino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0343]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.73 (m, 2H), 7.90 (m, 2H), 7.99 (d, 1H), 8.21 (d, 1H), 8.28 (s, 1H), 8.42 (d, 1H), 9.50 (s, 1H), 10.55 (s, 1H), 11.03 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 371.1 $(M + H)^+$.

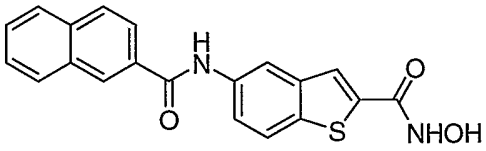
COMPOUND 30



5-[4-(N-Hydroxycarbamimidoyl)-benzoylamino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0344]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.76 (s, 2H), 7.87 (s, 2H), 7.99 (s, 2H), 8.10 (s,1H), 8.43 (s, 1H), 9.55 (s, 1H), 10.55 (s, 1H), 10.92 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 371.1 $(M + H)^+$.

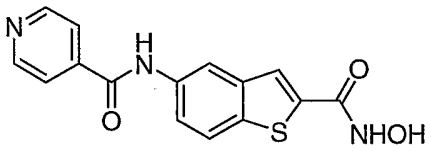
COMPOUND 31



5-[(Naphthalene-2-carbonyl)-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0345]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.63 (m, 2H), 7.81 (d, 1H), 7.93 (s, 1H), 8.05 (m, 5H), 8.49 (d, 1H), 8.59 (s, 1H), 9.28 (s, 1H), 10.59 (s, 1H), 11.47 (s, 1H). ESI-MS: *m/z* 363.1 $(M + H)^+$.

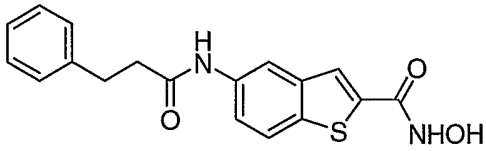
COMPOUND 32



N-(2-Hydroxycarbamoyl-benzo[b]thiophen-5-yl)-isonicotinamide.

**[0346]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.74 (dd, 1H), 7.91 (m, 3H), 7.99 (d, 1H), 8.42 (d, 1H), 8.81 (d, 2H), 9.40 (s, 1H), 10.67 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 314.2 $(M + H)^+$.

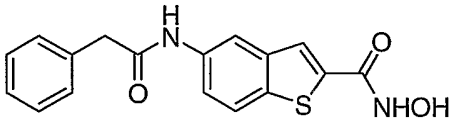
COMPOUND 33



5-(3-Phenyl-propionylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0347]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.64 (t, 2H), 2.92 (t, 2H), 7.17 (m, 1H), 7.26 (m, 4H), 7.47 (sdd, 1H), 7.82 (s, 1H), 7.90 (d, 1H), 8.28 (d, 1H), 9.26 (s, 1H), 10.06 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 341.1 $(M + H)^+$.

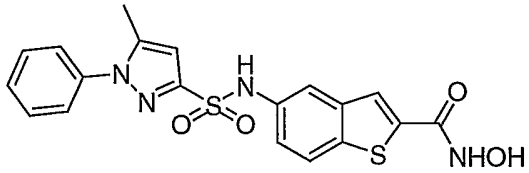
COMPOUND 34



5-Phenylacetylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0348]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.66 (s, 2H), 7.24 (m, 1H), 7.33 (m, 4H), 7.52 (dd,1 H), 7.83 (s, 1H), 7.91 (d, 1H), 8.29 (d, 1H), 9.26 (s, 1H), 10.33 (s, 1H), 11.43 (s, 1H). ESI-MS: *m/z* 327.1 $(M + H)^+$.

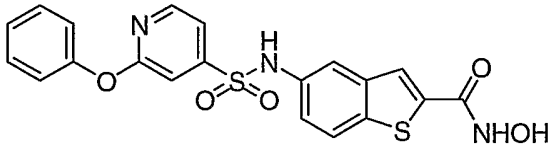
COMPOUND 35



5-(5-Methyl-1-phenyl-1H-pyrazole-3-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0349]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 2.31 (s, 3H), 7.22 (m, 1H), 7.41-7.55 (band, 5H), 7.65 (s, 1H), 7.84 (s, 1H), 7.91 (m, 2H), 9.27 (s, 1H), 10.34 (s, 1H), 11.43 (s, 1H). ESI-MS: *m/z* 429.1 $(M + H)^+$.

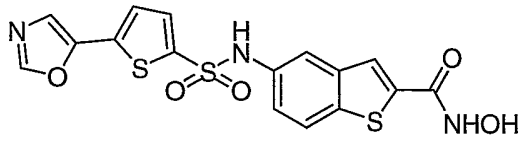
COMPOUND 36



5-(2-Phenoxy-pyridine-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0350]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.15 (m, 4H), 7.24 (d, 1H), 7.40 (t, 2H), 7.63 (s 1H), 7.81 (s, 1H), 7.90 (d, 1H), 8.10 (dd, 1H), 8.44 (s, 1H), 9.28 (s, 1H), 10.53 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 442.1 $(M + H)^+$.

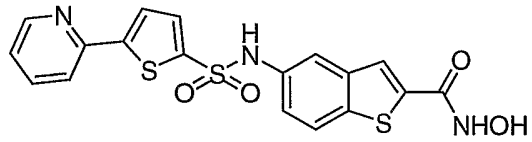
COMPOUND 37



5-(5-Oxazol-5-yl-thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0351]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.22 (dd, 1H), 7.42 (d, 1H), 7.55 (d, 1H), 7.67 (m, 2H), 7.83 (s, 1H), 7.92 (sd, 1H), 8.47 (s, 1H), 9.28 (s, 1H), 10.70 (s, 1H), 11.43 (s, 1H). ESI-MS: *m/z* 422.0 $(M + H)^+$.

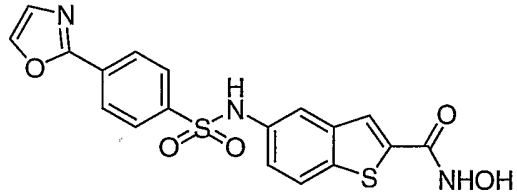
COMPOUND 38



5-(5-Pyridin-2-yl-thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0352]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.23 (dd, 1H), 7.33 (m, 1H), 7.53 (d, 1H), 7.68 (s, 1H), 7.74 (d, 1H), 7.85 (m, 2H), 7.94 (m, 2H), 8.51 (d, 1H), 9.28 (s, 1H), 10.62 (s, 2H), 11.41 (s, 1H). ESI-MS: *m/z* 432.1 $(M + H)^+$.

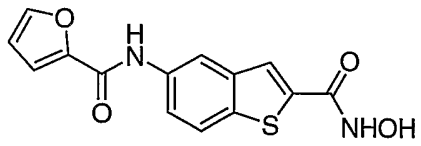
COMPOUND 39



5-(4-Oxazol-2-yl-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0353]** $^1$H NMR (400 MHz, $CDCl_3$): δ ppm 7.16 (dd, 1H), 7.62 (s, 1H), 7.78-7.88 (band, 7H), 8.50 (s, 1H), 9.27 (s, 1H), 10.45 (s, 1H), 11.40 (s, 1H). ESI-MS: *m/z* 416.1 $(M + H)^+$.

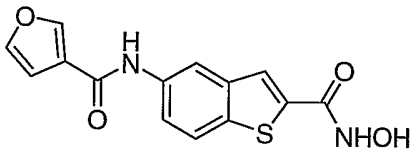
COMPOUND 40



Furan-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0354]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 6.71 (dd, 1H), 7.36 (d, 1H), 7.74 (dd, 1H), 7.88 (s, 1H), 7.95 (m, 2H), 8.39 (d, 1H), 9.28 (s, 1H), 10.33 (s, 1H), 11.45 (s, 1H). ESI-MS: *m/z* 303.1 $(M + H)^+$.

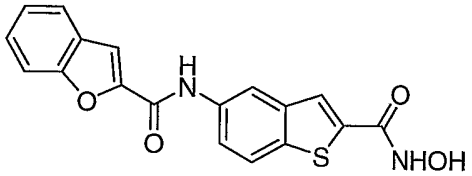
COMPOUND 41



Furan-3-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0355]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.00 (d, 1H), 7.69 (dd, 1H), 7.80 (m, 1H), 7.88 (s, 1H), 7.96 (d, 1H), 8.36 (d, 2H), 9.27 (s, 1H), 10.06 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 303.1 $(M + H)^+$.

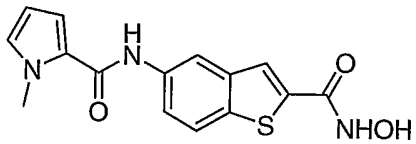
COMPOUND 42



Benzofuran-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0356]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.37 (t, 1H), 7.51 (t, 1H), 7.73 (d, 1H), 7.81 (m, 3H), 7.91 (s, 1H), 7.99 (d, 1H), 8.45 (d, 1H), 9.29 (s, 1H), 10.69 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 353.1 $(M + H)^+$.

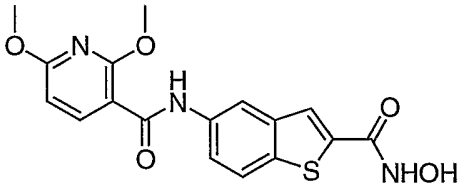
COMPOUND 43



1-Methyl-1H-pyrrole-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0357]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.89 (s, 3H), 6.11 (m, 1H), 7.05 (m, 2H), 7.71 (dd, 1H), 7.85 (s, 1H), 7.95 (s, 1H), 8.36 (d, 1H), 9.29 (s, 1H), 9.91 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 316.1 $(M + H)^+$.

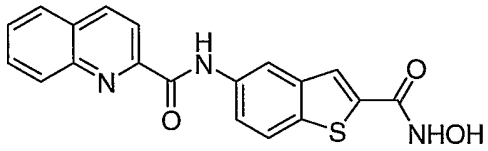
COMPOUND 44



N-(2-Hydroxycarbamoyl-benzo[b]thiophen-5-yl)-2,6-dimethoxy-nicotinamide.

**[0358]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 3.93 (s, 3H), 4.07 (s, 3H), 6.54 (d, 1H), 7.67 (d, 1H), 7.87 (s, 1H), 7.95 (d, 1H), 8.14 (d, 1H), 8.42 (s, 1H), 9.28 (s, 1H), 10.04 (s, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 374.1 $(M + H)^+$.

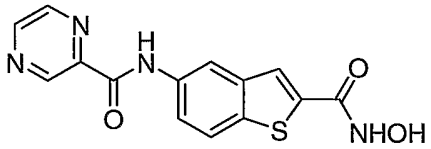
COMPOUND 45



Quinoline-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0359]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.77 (t, 1H), 7.90-8.05 (band, 4H), 8.12 (d, 1H), 8.26 (m, 2H), 8.60 (s, 1H), 8.66 (d, 1H), 9.29 (s, 1H), 10.92 (s, 1H), 11.49 (s, 1H). ESI-MS: *m/z* 364.1 $(M + H)^+$.

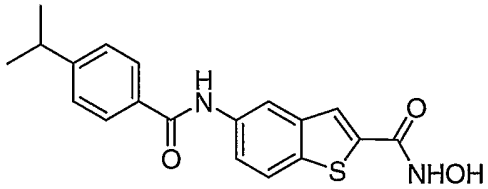
COMPOUND 46



Pyrazine-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0360]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.91 (m, 2H), 8.00 (d, 1H), 8.55 (s, 1H), 8.82 (m, 1H), 8.93 (d, 1H), 9.29 (d, 1H), 10.91 (s, 1H), 11.47 (s, 1H). ESI-MS: *m/z* 315.1 $(M + H)^+$.

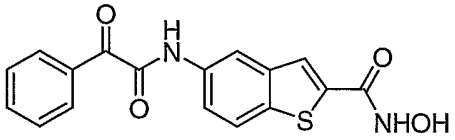
COMPOUND 47



5-(4-Isopropyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0361]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 1.23 (s, 6H), 2.97 (s, 1H), 7.40 (d, 2H), 7.74 (dd, 1H), 7.89 (m, 3H), 7.97 (d, 1H), 8.44 (s, dH), 9.28 (s, 1H), 10.31 (s, 1H), 11.46 (s, 1H). ESI-MS: *m/z* 355.1 $(M + H)^+$.

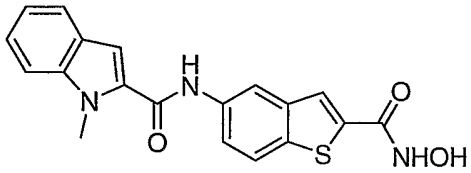
COMPOUND 48




5-(2-Oxo-2-phenyl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0362]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 7.62 (t, 2H), 7.67 (dd, 1H), 7.76 (t, 1H), 7.91 (s, 1H), 8.02 (d, 1H), 8.10 (m, 2H), 8.43 (d, 1H), 9.31 (s, 1H), 11.14 (s, 1H), 11.49 (s, 1H). ESI-MS: *m/z* 341.1 $(M + H)^+$.

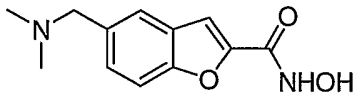
COMPOUND 49




1-Methyl-1H-indole-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide.

**[0363]** $^1$H NMR (400 MHz, DMSO-*d6*): δ ppm 4.02 (s, 3H), 7.13 (t, 1H), 7.30 (t, 2H), 7.35 (s, 1H), 7.57 (d, 1H), 7.69 (d, 1H), 7.76 (dd, 1H), 7.91 (s, 1H), 7.99 (d, 1H), 8.44 (d, 1H), 9.29 (s, 1H), 10.47 (s, 1H), 11.47 (s, 1H). ESI-MS: *m/z* 366.1 $(M + H)^+$.

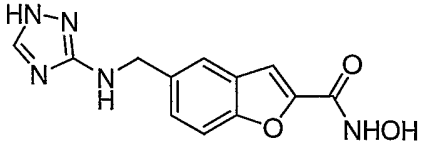
COMPOUND 50




5-Dimethylaminomethyl-benzofuran-2-carboxylic acid hydroxyamide.

**[0364]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 2.78 (s, 6H), 4.42 (d, 2H), 7.58 (d, 1H), 7.61 (s, 1H), 7.79 (d, 1H), 7.92 (s, 1H), 9.39 (s, 1H), 11.55(s, 1H). ESI-MS: *m/z* 235.1 $(M + H)^+$.

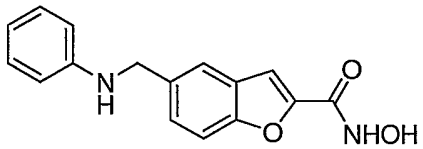
COMPOUND 51



5-[(1H-[1,2,4]Triazol-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0365]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.48 (s, 2H), 7.41 (dd, 1H), 7.45 (s, 1H), 7.59 (d, 1H), 7.69 (s, 1H), 8.14 (s, 1H), 8.36 (s, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 274.0 $(M + H)^+$.

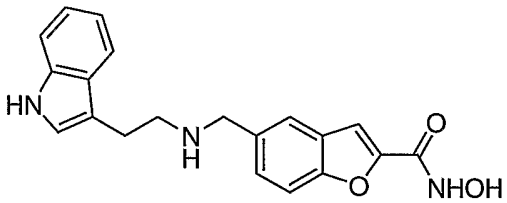
COMPOUND 52



5-Phenylaminomethyl-benzofuran-2-carboxylic acid hydroxyamide.

**[0366]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.14 (s, 2H), 6.35 (t, 1H), 6.43 (d, 2H), 6.85 (t, 2H), 7.25 (s, 1H), 7.25 (dd, 1H), 7.38 (d, 1H), 7.50 (s, 1H), 11.30 (s, 1H). ESI-MS: *m/z* 283.1 $(M + H)^+$.

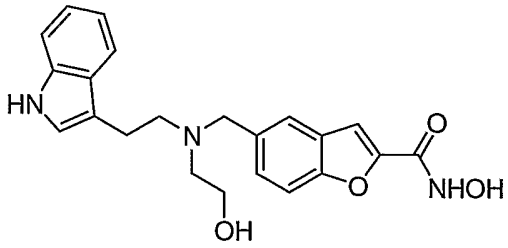
COMPOUND 53



5-{[2-(1H-Indol-3-yl)-ethylamino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide.

**[0367]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.09 (d, 2H), 3.22 (s, 2H), 4.34 (s, 2H), 7.00 (t, 1H), 7.11 (t, 1H), 7.23 (s, 1H), 7.37 (d, 1H), 7.56 (m, 2H), 7.73 (d, 1H), 7.91 (s, 1H), 9.11 (s, 2H), 11.00 (s, 1H). ESI-MS: *m/z* 350.1 $(M + H)^+$.

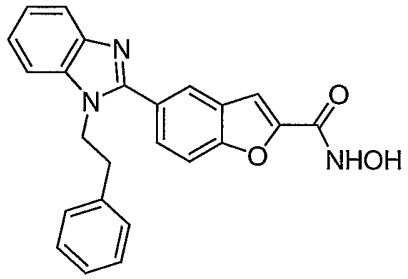
COMPOUND 54




5-({(2-Hydroxy-ethyl)-[2-(1H-indol-3-yl)-ethyl]-amino}-methyl)-benzofuran-2-carboxylic acid hydroxyamide.

**[0368]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 2.95-3.18 (band, 6H), 3.58 (m, 2H), 4.41 (s, 2H), 6.72 (t, 1H), 6.85 (t, 1H), 6.98 (d, 1H), 7.12 (d, 1H), 7.22 (d, 1H), 7.34 (s, 1H), 7.43 (dd, 1H), 7.53 (d, 1H), 7.77 (s, 1H), 9.50 (s, 1H), 10.73 (s, 1H). ESI-MS: *m/z* 394.1 $(M + H)^+$.

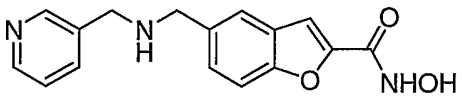
COMPOUND 55




5-(1-Phenethyl-1H-benzoimidazol-2-yl)-benzofuran-2-carboxylic acid hydroxyamide.

**[0369]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.10 (t, 2H), 4.71 (t, 2H), 6.91 (d, 2H), 7.18 (m, 3H), 7.58 (m, 2H), 7.64 (s, 1H), 7.69 (dd, 1H), 7.99 (m, 3H), 8.06 (d, 1H), 11.72 (s, 1H). ESI-MS: *m/z* 398.1 $(M + H)^+$.

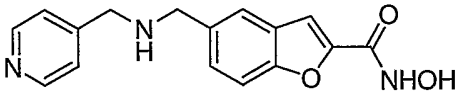
COMPOUND 56




5-{[(Pyridin-3-ylmethyl)-amino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide.

**[0370]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.60 (s, 4H), 7.55 (s, 1H), 7.58 (dd, 1H), 7.71 (m, 2H), 7.89 (s, 1H), 8.17 (dd, 1H), 8.73 (dd, 1H), 8.79 (d, 1H), 9.58 (s, 1H), 11.60 (s, 1H). ESI-MS: *m/z* 298.0 $(M + H)^+$.

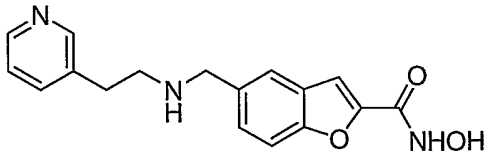
COMPOUND 57



5-{[(Pyridin-4-ylmethyl)-amino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide.

**[0371]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.38 (s, 4H), 7.56 (s, 1H), 7.58 (dd, 1H), 7.72 (m, 3H), 7.90 (d, 1H), 8.76 (d, 2H), 9.73 (s, 1H), 11.59 (s, 1H). ESI-MS: *m/z* 298.0 $(M + H)^+$.

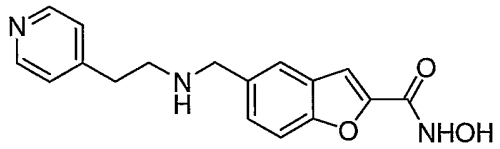
COMPOUND 58



5-[(2-Pyridin-3-yl-ethylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0372]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.07 (t, 2H), 3.24-3.33 (band, 2H), 7.55 (s, 1H), 7.57 (dd, 1H), 7.66 (dd, 1H), 7.73 (d, 1H), 7.89 (s, 1H), 8.04 (d, 1H), 8.65 (d, 2H), 9.05 (s, 2H), 11.57 (s, 1H). ESI-MS: *m/z* 312.1 $(M + H)^+$.

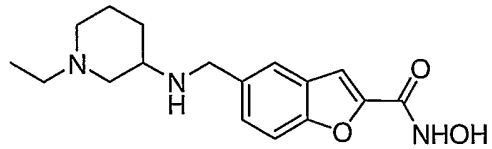
COMPOUND 59



5-[(2-Pyridin-4-yl-ethylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0373]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.10 (t, 2H), 3.31 (m, 2H), 4.31 (t, 2H), 7.58 (m, 4H), 7.74 (d, 1H), 7.88 (s, 1H), 8.69 (d, 2H), 9.00 (s, 1H), 11.58 (s, 1H). ESI-MS: *m/z* 312.1 $(M + H)^+$.

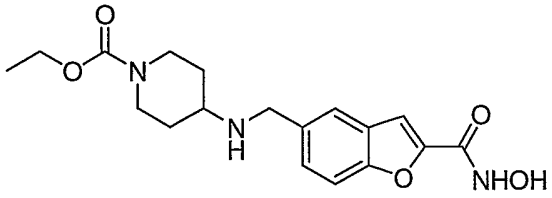
COMPOUND 60



5-[(1-Ethyl-piperidin-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0374]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 1.63 (m, 2H), 2.02 (d, 1H), 2.28 (d, 1H), 2.90 (m, 2H), 3.21 (m, 2H), 3.48 (m, 2H), 4.37 (s, 2H), 7.56 (s, 1H), 7.59 (dd, 1H), 7.74 (d, 1H), 7.92 (s, 1H), 9.49 (s, 1H), 11.56 (s, 1H). ESI-MS: *m/z* 318.1 $(M + H)^+$.

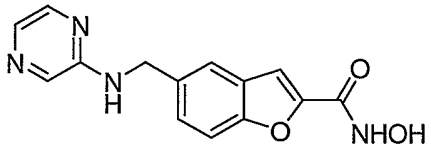
COMPOUND 61




4-[(2-Hydroxycarbamoyl-benzofuran-5-ylmethyl)-amino]-piperidine-1-carboxylic acid ethyl ester.

**[0375]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 1.46 (m, 2H), 2.11 (d, 2H), 3.31 (m, 1H), 4.03 (m, 6H), 4.30 (t, 2H), 7.58 (m, 2H), 7.74 (d, 1H), 7.91 (s, 1H), 8.91 (s, 1H), 11.56 (s, 1H). ESI-MS: *m/z* 362.1 $(M + H)^+$.

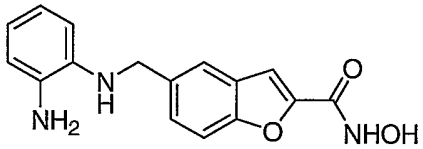
COMPOUND 62




5-(Pyrazin-2-ylaminomethyl)-benzofuran-2-carboxylic acid hydroxyamide.

**[0376]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.55 (s, 2H), 7.43 (dd, 1H), 7.45 (s, 1H), 7.59 (d, 1H), 7.67 (d, 2H), 7.69 (s, 1H), 7.93 (m, 1H), 8.00 (d, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 285.0 $(M + H)^+$.

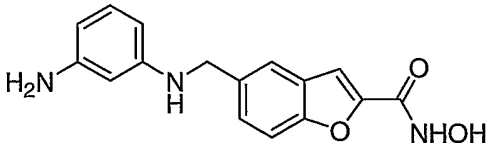
COMPOUND 63




5-[(2-Amino-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0377]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.44 (s, 2H), 6.66 (m, 2H), 7.01 (t, 1H), 7.11 (d, 1H), 7.45 (s, 1H), 7.50 (dd, 1H), 7.62 (d, 1H), 7.77 (s, 1H), 9.29 (s, 1H), 11.52 (s, 1H). ESI-MS: *m/z* 298.0 $(M + H)^+$.

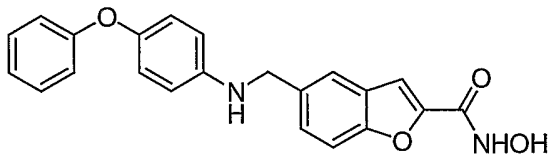
COMPOUND 64



5-[(3-Amino-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0378]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.34 (s, 2H), 6.44 (dd, 1H), 6.49 (d, 1H), 6.62 (dd, 1H), 7.13 (t, 1H), 7.45 (m, 2H), 7.60 (d, 1H), 7.69 (s, 1H), 9.63 (s, 1H), 11.51 (s, 1H). ESI-MS: *m/z* 298.1 $(M + H)^+$.

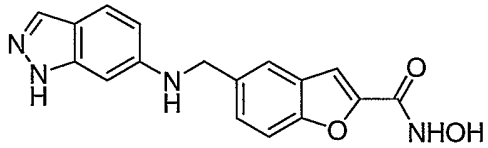
COMPOUND 65



5-[(4-Phenoxy-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0379]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.35 (s, 2H), 6.68 (d, 2H), 6.83 (t, 4H), 7.00 (t, 1H), 7.29 (t, 2H), 7.48 (m, 2H), 7.61 (d, 1H), 7.74 (s, 1H), 11.55 (s, 1H). ESI-MS: *m/z* 375.0 $(M + H)^+$.

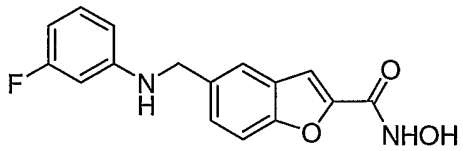
COMPOUND 66



5-[(1H-Indazol-6-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0380]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.44(s, 2H), 6.33 (s, 1H), 6.65 (dd, 1H), 7.41 (d, 1H), 7.45 (s, 1H), 7.47 (dd, 1H), 7.60 (d, 1H), 7.75 (d, 2H), 11.55 (s, 1H). ESI-MS: *m/z* 323.0 $(M + H)^+$.

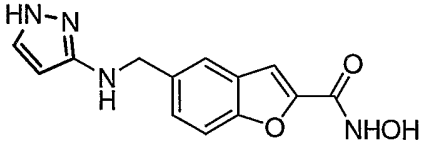
COMPOUND 67



5-[(3-Fluoro-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0381]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.44 (s, 2H), 6.26 (td, 1H), 6.34 (dd, 1H), 6.43 (dd, 1H), 7.03 (m, 1H), 7.45 (m, 2H), 7.59 (d, 1H), 7.70 (s, 1H), 11.55 (s, 1H). ESI-MS: *m/z* 301.0 $(M + H)^+$.

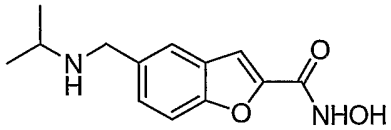
COMPOUND 68




5-[(1H-Pyrazol-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide.

**[0382]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 4.44 (s, 2H), 5.76 (d, 1H), 7.44 (dd, 1H), 7.47 (s, 1H), 7.61 (d, 1H), 7.72 (s, 1H), 7.79 (s, 1H), 11.55 (s, 1H). ESI-MS: *m/z* 273.0 $(M + H)^+$.

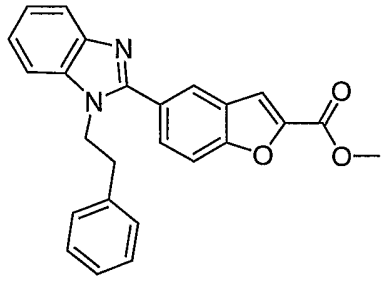
COMPOUND 69




5-(Isopropylamino-methyl)-benzofuran-2-carboxylic acid hydroxyamide.

**[0383]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 1.29 (d, 6H), 3.34 (m, 1H), 4.25 (m, 2H), 7.57 (m, 2H), 7.74 (d, 1H), 7.90 (s, 1H), 8.66 (s, 1H), 11.55 (s, 1H). ESI-MS: *m/z* 249.0 $(M + H)^+$.

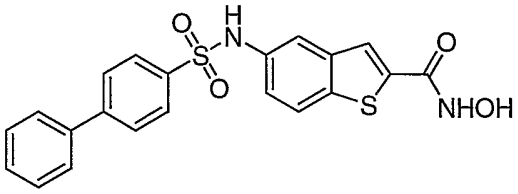
COMPOUND 70




5-(1-Phenethyl-1H-benzoimidazol-2-yl)-benzofuran-2-carboxylic acid methyl ester.

**[0384]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.00 (t, 2H), 3.93 (s, 3H), 4.54 (t, 2H), 6.87 (dd, 2H), 7.12 (m, 3H), 7.29 (m, 2H), 7.68 (m, 2H), 7.73 (d, 1H), 7.85 (m, 3H). ESI-MS: *m/z* 397.1 $(M + H)^+$.

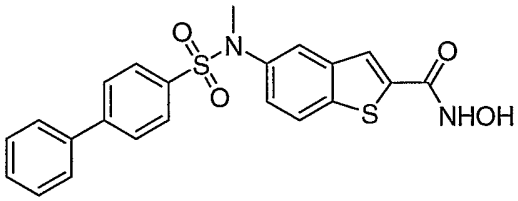
COMPOUND 71



5-(Biphenyl-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0385]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 7.22 (dd, 1H), 7.41 (dt, 1H), 7.47 (dt, 2H), 7.63 (s, 1H), 7.67 (s, 1H), 7.69 (m, 1H), 7.80 (s, 1H), 7.82 (s, 4H), 7.89 (d, 1H), 9.26 (s, 1H), 10.54 (s, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 425.0 $(M + H)^+$.

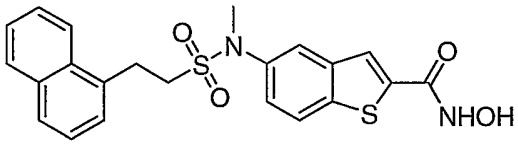
COMPOUND 72



5-[(Biphenyl-4-sulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0386]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.24 (s, 3H), 7.23 (dd, 1H), 7.45 (dt, 1H), 7.52 (dt, 2H), 7.59 (d, 2H), 7.71 (s, 1H), 7.75 (dd, 2H), 7.85 (s, 1H), 7.89 (dd, 2H), 8.01 (d, 1H), 9.27 (s, 1H), 11.58 (s, 1H). ESI-MS: *m/z* 439.0 $(M + H)^+$.

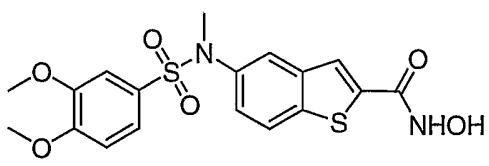
COMPOUND 73



5-[Methyl-(2-naphthalen-1-yl-ethanesulfonyl)-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0387]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.37(s, 3H), 3.47 (m, 4H), 7.44 (m, 2H), 7.52 (m, 2H), 7.57 (dd, 1H), 7.82 (d, 1H), 7.88 (m, 2H), 7.94 (dd, 1H), 8.02 (s, 1H), 8.05 (d, 1H), 9.29 (s, 1H), 11.61 (s, 1H). ESI-MS: *m/z* 441.0 $(M + H)^+$.

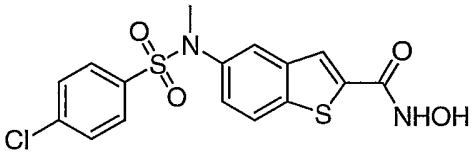
COMPOUND 74



5-[(3,4-Dimethoxy-benzenesulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0388]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.16 (s, 3H), 3.59 (s, 3H), 3.82 (s, 3H), 6.82 (s, 1H), 7.11 (s, 2H), 7.20 (dd, 1H), 7.66 (s, 1H), 7.85 (s, 1H), 7.99 (d, 1H), 9.29 (s, 1H), 11.52 (s, 1H). ESI-MS: *m/z* 422.9 $(M + H)^+$.

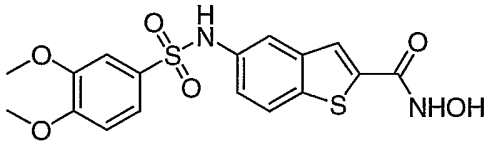
COMPOUND 75




5-[(4-Chloro-benzenesulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0389]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.20 (s, 3H), 7.19 (dd, 1H), 7.52 (dd, 2H), 7.66 (dd, 2H), 7.69 (s, 1H), 7.86 (s, 1H), 8.00 (d, 1H), 9.32 (s, 1H), 11.52 (s, 1H). ESI-MS: *m/z* 396.9 $(M + H)^+$.

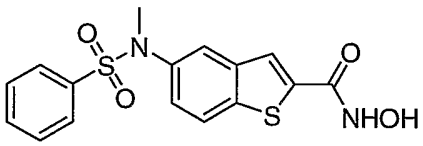
COMPOUND 76




5-(3,4-Dimethoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0390]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.74 (d, 6H), 7.01 (d, 1H), 7.18 (dd, 1H), 7.28 (m, 2H), 7.59 (s, 1H), 7.79 (s, 1H), 7.87 (d, 1H), 10.17 (s, 1H), 11.40 (s, 1H). ESI-MS: *m/z* 409.0 $(M + H)^+$.

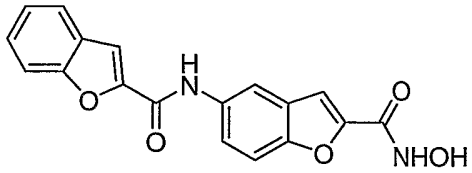
COMPOUND 77




5-(Benzenesulfonyl-methyl-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0391]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.11 (s, 3H), 7.15 (dd, 1H), 7.52 (m, 2H), 7.58 (m, 2H), 7.64 (s, 1H), 7.71 (m, 1H), 7.84 (s, 1H), 7.97 (d, 1H), 9.30 (s, 1H), 11.48 (s, 1H). ESI-MS: *m/z* 363.0 $(M + H)^+$.

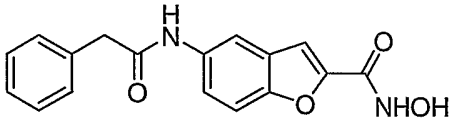
COMPOUND 78



5-[(Benzofuran-2-carbonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0392]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.38 (dt, 1H), 7.51 (dt, 1H), 7.52 (s, 1H), 7.65 (d, 1H), 7.74 (dd, 1H), 7.78 (dd, 1H), 7.78 (d, 1H), 7.84 (d, 1H), 8.52 (d, 1H), 9.54 (s, 1H), 10.28 (s, 1H), 11.52 (s, 1H). ESI-MS: *m/z* 337.0 $(M + H)^+$.

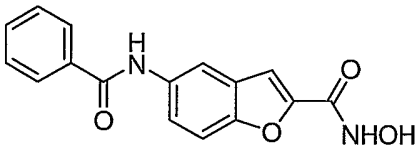
COMPOUND 79



5-Phenylacetylamino-benzofuran-2-carboxylic acid hydroxyamide.

**[0393]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.65 (s, 2H), 7.25 (m, 1H), 7.34 (m, 4H), 7.45 (s, 1H), 7.51 (dd, 1H), 7.57 (d, 1H), 8.11 (d, 1H), 9.25 (s, 1H), 10.27 (s, 1H), 11.47 (s, 1H). ESI-MS: *m/z* 311.0 $(M + H)^+$.

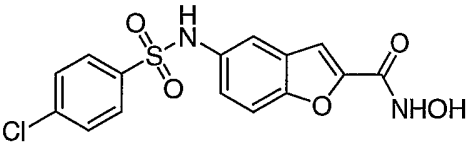
COMPOUND 80



5-Benzoylamino-benzofuran-2-carboxylic acid hydroxyamide.

**[0394]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.53 (m, 3H), 7.61 (m, 2H), 7.72 (dd, 1H), 7.97 (m, 2H), 8.26 (d, 1H), 9.28 (s, 1H), 10.35 (s, 1H), 11.50 (s, 1H). ESI-MS: *m/z* 297.0 $(M + H)^+$.

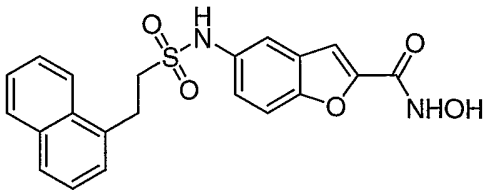
COMPOUND 81



5-(4-Chloro-benzenesulfonylamino)-benzofuran-2-carboxylic acid hydroxyamide.

**[0395]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.12 (dd, 1H), 7.42 (s, 1H), 7.44 (d, 1H), 7.53 (d, 1H), 7.60 (dd, 2H), 7.69 (dd, 2H), 9.28 (s, 1H), 10.33 (s, 1H), 11.49 (s, 1H). ESI-MS: *m/z* 366.9 $(M + H)^+$.

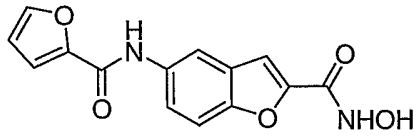
COMPOUND 82



5-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzofuran-2-carboxylic acid hydroxyamide.

**[0396]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.43 (m, 4H), 7.32 (dt, 1H), 7.41 (m, 3H), 7.48 (m, 2H), 7.64 (s, 1H), 7.66 (s, 1H), 7.68 (d, 1H), 7.79 (t, 1H), 7.90 (d, 1H), 9.29 (s, 1H), 10.06 (s, 1H), 11.53 (s, 1H). ESI-MS: *m/z* 411.0 $(M + H)^+$.

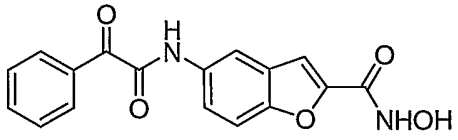
COMPOUND 83



5-[(Furan-2-carbonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0397]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 6.71 (m, 1H), 7.34 (dd, 1H), 7.49 (s, 1H), 7.61 (d, 1H), 7.72 (dd, 1H), 7.95 (d, 1H), 8.20 (d, 1H), 9.37 (s, 1H), 10.28 (s, 1H), 11.50 (s, 1H). ESI-MS: *m/z* 287.0 $(M + H)^+$.

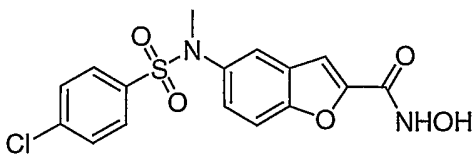
COMPOUND 84



5-(2-Oxo-2-phenyl-acetylamino)-benzofuran-2-carboxylic acid hydroxyamide.

**[0398]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.53 (s, 1H), 7.63 (t, 2H), 7.66 (s, 2H), 7.77 (dt, 1H), 8.07 (dd, 2H), 8.26 (s, 1H), 9.30 (s, 1H), 11.07 (s, 1H), 11.55 (s, 1H). ESI-MS: *m/z* 325.0 $(M + H)^+$.

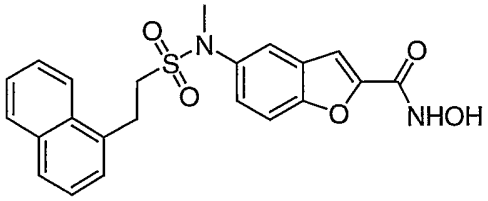
COMPOUND 85



5-[(4-Chloro-benzenesulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0399]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.19 (s, 3H), 7.16 (dd, 1H), 7.45 (s, 1H), 7.50 (m, 3H), 7.62 (d, 1H), 7.66 (dd, 2H), 9.32 (s, 1H), 11.56 (s, 1H). ESI-MS: *m/z* 380.9 $(M + H)^+$.

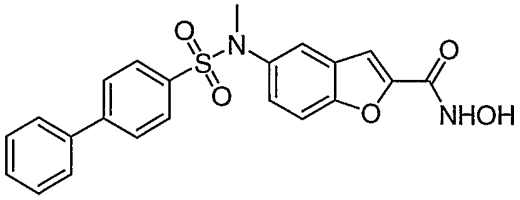
COMPOUND 86



5-[Methyl-(2-naphthalen-1-yl-ethanesulfonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0400]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.34 (s, 3H), 3.46 (m, 4H), 7.46 (m, 3H), 7.53 (m, 3H), 7.66 (d, 1H), 7.83 (d, 1H), 7.86 (d, 1H), 7.92 (m, 2H), 9.32 (s, 1H), 11.56 (s, 1H). ESI-MS: *m/z* 425.0 $(M + H)^+$.

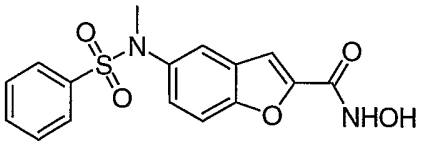
COMPOUND 87



5-[(Biphenyl-4-sulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0401]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.23 (s, 3H), 7.20 (dd, 1H), 7.45 (m, 2H), 7.51 (m, 3H), 7.57 (d, 2H), 7.62 (d, 1H), 7.76 (d, 2H), 7.89 (d, 2H), 9.32 (s, 1H), 11.56 (s, 1H). ESI-MS: *m/z* 423.0 $(M + H)^+$.

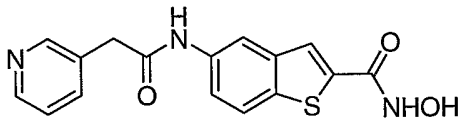
COMPOUND 88



5-(Benzenesulfonyl-methyl-amino)-benzofuran-2-carboxylic acid hydroxyamide.

**[0402]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.26 (s, 3H), 7.13 (dd, 1H), 7.43 (s, 1H), 7.46 (d, 1H), 7.49 (d, 1H), 7.51 (s, 1H), 7.58 (m, 3H), 7.71 (dt, 1H), 9.40 (s, 1H), 11.53 (s, 1H). ESI-MS: *m/z* 347.0 $(M + H)^+$.

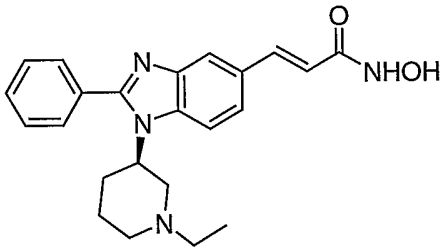
COMPOUND 89



5-(2-Pyridin-3-yl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0403]** $^1$H NMR (400 MHz, DMSO-*d6*): δ 3.91 (s, 2H), 7.53 (dd, 1H), 7.71 (t, 1H), 7.84 (s, 1H), 7.95 (d, 1H), 8.15 (d, 1H), 8.28 (s, 1H), 8.65 (dd, 1H), 8.72 (s, 1H), 9.28 (s, 1H), 10.46 (s, 1H), 11.43 (s, 1H). ESI-MS: *m/z* 328.0 $(M + H)^+$.

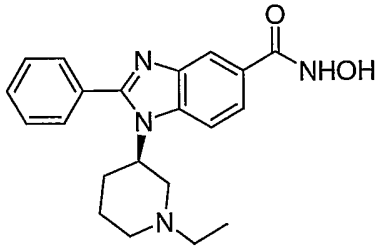
COMPOUND 90



(R)-3-[1-(1-Ethyl-piperidin-3-yl)-2-phenyl-1H-benzoimidazol-5-yl]-N-hydroxy-acrylamide.

**[0404]** $^1$H NMR (400MHz, DMSO-*d6*): δ 0.94-0.98 (t, 3H), 1.50 (m, 1H), 1.78 (d, 1H), 2.05 (m, 2H), 2.24-2.39 (m, 3H), 2.75 (t, 1H), 2.84 (d, 1H), 2.99 (d, 1H), 4.40 (m, 1H), 6.46-6.50 (d, 1H), 7.49 (d, 2H), 7.58-7.91 (band, 7H). ESI-MS: *m/z* 390.2 $(M + H)^+$.

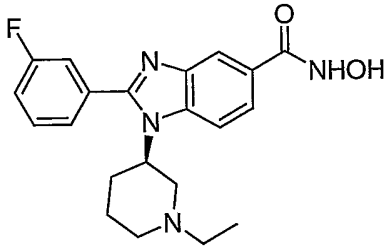
COMPOUND 91



(R)-1-(1-Ethyl-piperidin-3-yl)-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0405]** $^1$H NMR (400MHz, DMSO-*d6*): δ 0.94-0.98 (t, 3H), 1.49 (m, 1H), 1.78 (d, 1H), 1.97-2.07 (m, 2H), 2.24-2.41 (m, 3H), 2.71 (m, 1H), 2.84 (d, 1H), 2.99 (d, 1H), 4.38 (m, 1H), 7.62-7.73 (band, 6H), 7.92 (t, 1H), 8.08 (d, 1H). ESI-MS: *m/z* 364.2 $(M + H)^+$.

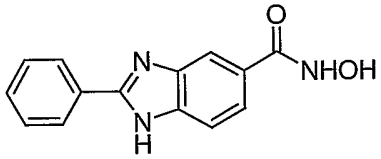
COMPOUND 92



(R)-1-(1-Ethyl-piperidin-3-yl)-2-(3-fluoro-phenyl)-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0406]** $^1$H NMR (400MHz, DMSO-*d*6): δ 0.94-0.99 (m, 3H), 1.48 (m, 1H), 1.78 (m, 1H), 1.97-2.10 (m, 2H), 2.23-2.41 (m, 3H), 2.73 (m, 1H), 2.83 (d, 1H), 3.03 (d, 1H), 4.34 (m, 1H), 7.45-7.55 (band, 3H), 7.65-7.74 (m, 2H), 7.91 (t, 1H), 8.09 (d, 1H). ESI-MS: *m/z* 382.2 $(M + H)^+$.

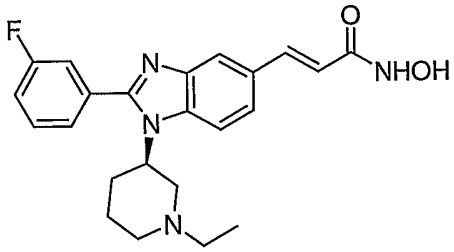
COMPOUND 93



2-Phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0407]** $^1$H NMR (400MHz, DMSO-*d*6): δ 7.61-7.78 (band, 6H), 8.05 (d, 1H), 8.18 (m, 2H). ESI-MS: *m/z* 253.1 $(M + H)^+$.

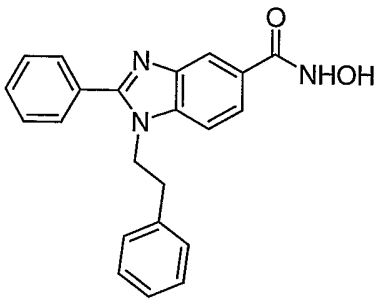
COMPOUND 94



(R)-3-[1-(1-Ethyl-piperidin-3-yl)-2-(3-fluoro-phenyl)-1H-benzoimidazol-5-yl]-N-hydroxy-acrylamide.

**[0408]** $^1$H NMR (400MHz, DMSO-*d*6): δ 0.96-0.99 (t, 3H), 1.48 (m, 1H), 1.78 (d, 1H), 1.99-2.09 (m, 2H), 2.22-2.40 (m, 3H), 2.69 (m, 1H), 2.84 (d, 1H), 3.04 (d, 1H), 4.36 (m, 1H), 6.46 (d, 1H), 7.45-7.69 (band, 6H), 7.89 (m, 2H). ESI-MS: *m/z* 408.2 $(M + H)^+$.

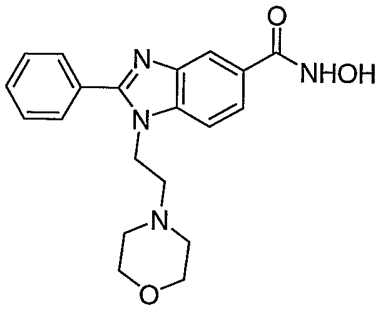
COMPOUND 95



1-Phenethyl-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0409]** $^1$H NMR (400MHz, DMSO-*d*6): δ 2.99 (t, 2H), 4.54 (t, 2H), 6.90 (m, 2H), 7.15 (m, 3H), 7.55 (m, 5H), 7.76 (q, 2H), 8.11 (s, 1H). ESI-MS: *m/z* 357.1 $(M + H)^+$.

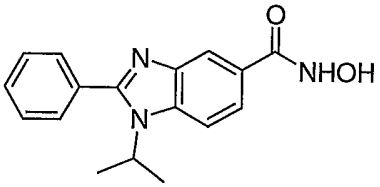
COMPOUND 96



1-(2-Morpholin-4-yl-ethyl)-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0410]** $^1$H NMR (400MHz, DMSO-*d*6): δ 3.22 (br s, 3H), 3.52-3.87 (range, 4H), 4.23-4.74 (range, 5H), 7.64 (m, 3H), 7.82 (m, 4H), 8.16 (s, 1H). ESI-MS: *m/z* 366.2 $(M + H)^+$.

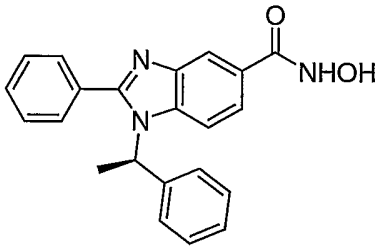
COMPOUND 97



1-Isopropyl-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0411]** $^1$H NMR (400MHz, DMSO-*d*6): δ 1.62-1.69 (m, 6H), 4.72-4.78 (m, 1H), 7.66-7.82 (range, 6H), 8.02 (m, 1H), 8.15 (m, 1H). ESI-MS: *m/z* 295.1 $(M + H)^+$.

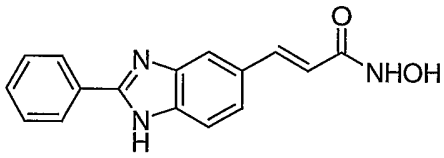
COMPOUND 98



(R)-2-Phenyl-1-(1-phenyl-ethyl)-1H-benzoimidazole-5-carboxylic acid hydroxyamide.

**[0412]** $^1$H NMR (400MHz, DMSO-*d*6): δ 1.99 (d, 3H), 5.85 (m, 1H), 7.20-7.42 (range, 6H), 7.54-7.75 (range, 6H), 8.11 (s, 1H). ESI-MS: *m/z* 357.2 $(M + H)^+$.

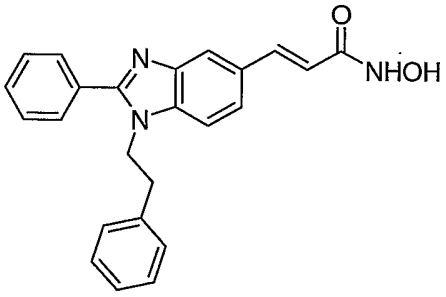
COMPOUND 99



N-Hydroxy-3-(2-phenyl-1H-benzoimidazol-5-yl)-acrylamide.

**[0413]** $^1$H NMR (400MHz, DMSO-*d*6): δ 6.45 (d, 1H), 7.45-7.62 (range, 6H), 7.77 (br s, 1H), 8.18 (d, 2H). ESI-MS: *m/z* 279.1 $(M + H)^+$.

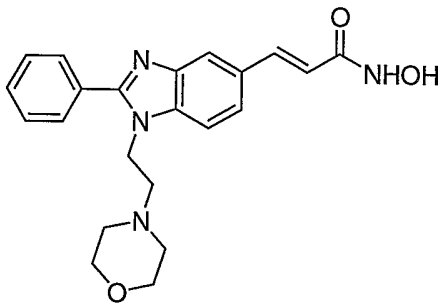
COMPOUND 100



N-Hydroxy-3-(1-phenethyl-2-phenyl-1H-benzoimidazol-5-yl)-acrylamide.

**[0414]** $^1$H NMR (400MHz, DMSO-*d*6): δ 2.96 (t, 2H), 4.54 (t, 2H), 6.43 (d, 1H), 6.91 (m, 2H), 7.15 (m, 3H), 7.51-7.74 (range, 8H), 7.87 (s, 1H). ESI-MS: *m/z* 383.2 $(M + H)^+$.

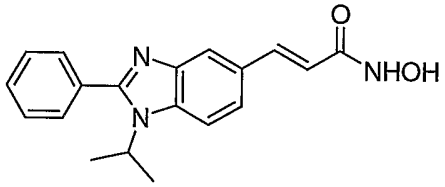
COMPOUND 101



N-Hydroxy-3-[1-(2-morpholin-4-yl-ethyl)-2-phenyl-1H-benzoimidazol-5-yl]-acrylamide.

**[0415]** $^1$H NMR (400MHz, DMSO-*d*6): δ 2.16 (m, 4H), 2.56 (t, 2H), 3.30 (m, 4H), 4.42 (t, 2H), 6.46 (d, 1H), 7.52-7.63 (m, 6H), 7.70 (d, 1H), 7.82-7.88 (m, 3H). ESI-MS: *m/z* 392.2 $(M + H)^+$.

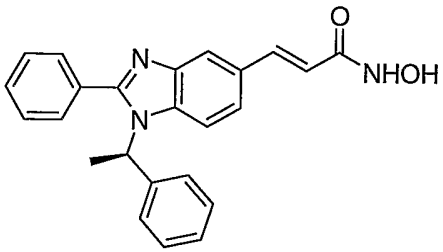
COMPOUND 102



N-Hydroxy-3-(1-isopropyl-2-phenyl-1H-benzoimidazol-5-yl)-acrylamide.

**[0416]** $^1$H NMR (400MHz, DMSO-*d*6): δ 1.59 (d, 6H), 4.68-4.75 (m, 1H), 6.46 (d, 1H), 7.48-7.68 (range, 7H), 7.81 (d, 2H). ESI-MS: *m/z* 321.2 $(M + H)^+$.

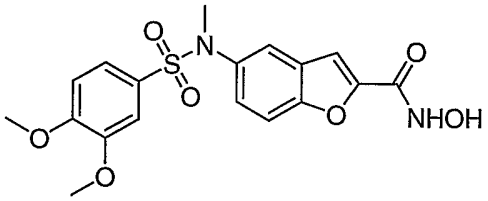
COMPOUND 103



(R)-N-Hydroxy-3-[2-phenyl-1-(1-phenyl-ethyl)-1H-benzoimidazol-5-yl]-acrylamide.

**[0417]** $^1$H NMR (400MHz, DMSO-*d*6): δ 1.98 (d, 3H), 5.81 (m, 1H), 6.40 (d, 1H), 7.16-7.37 (range, 7H), 7.53-7.61 (range, 4H), 7.71 (m, 2H), 7.89 (s, 1H). ESI-MS: *m/z* 383.2 $(M + H)^+$.

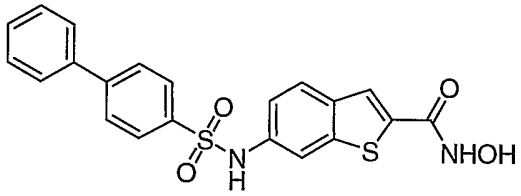
COMPOUND 104



5-[(3,4-Dimethoxy-benzenesulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide.

**[0418]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.14 (s, 3H), 3.61 (s, 3H), 3.83 (s, 3H), 6.80 (s, 1H), 7.11 (s, 2H), 7.17 (dd, 1H), 7.46 (s, 1H), 7.49 (d, 1H), 7.61 (d, 1H), 9.22 (s, 1H), 11.51 (s, 1H). ESI-MS: *m/z* 407.0 $(M + H)^+$.

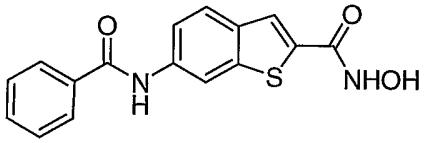
COMPOUND 105



6-(Biphenyl-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0419]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.19 (dd, 1H), 7.40 (t, 1H), 7.46 (t, 2H), 7.65 (s, 1H), 7.68 (d, 1H), 7.72 (s, 1H), 7.77 (m, 2H), 7.83 (m, 4H), 9.22 (s, 1H), 10.63 (s, 1H), 11.38 (s, 1H). ESI-MS: *m/z* 426.0 $(M + H)^+$.

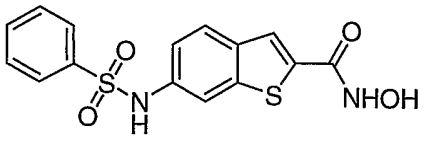
COMPOUND 106



6-Benzoylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0420]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.53 (t, 2H), 7.59 (t, 1H), 7.72 (dd, 1H), 7.85 (s, 1H), 7.88 (d, 1H), 7.97 (dd, 2H), 8.55 (s, 1H), 9.22 (s, 1H), 10.48 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 313.0 $(M + H)^+$.

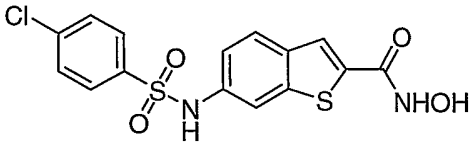
COMPOUND 107



6-Benzenesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0421]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.14 (dd, 1H), 7.52 (t, 2H), 7.58 (t, 1H), 7.66 (s, 1H), 7.76 (m, 4H), 9.22 (s, 1H), 10.54 (s, 1H), 11.38 (s, 1H). ESI-MS: *m/z* 349.0 $(M + H)^+$.

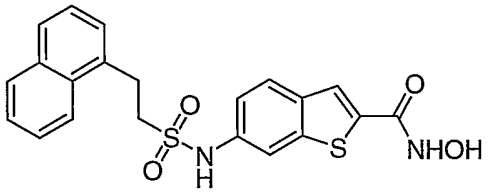
COMPOUND 108




6-(4-Chloro-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0422]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.13 (dd, 1H), 7.59 (dd, 2H), 7.68 (s, 1H), 7.77 (m, 4H), 9.23 (s, 1H), 10.61 (s, 1H), 11.40 (s, 1H). ESI-MS: *m/z* 385.0 $(M + H)^+$.

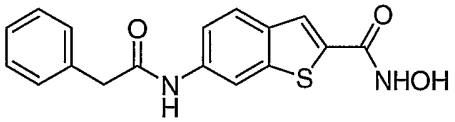
COMPOUND 109




6-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0423]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.46 (dd. 4H), 7.23 (t, 1H), 7.38 (m, 3H), 7.43 (t, 1H), 7.62 (d, 1H), 7.77 (d, 1H), 7.88 (m, 4H), 9.23 (s, 1H), 10.32 (s, 1H), 11.41 (s, 1H). ESI-MS: *m/z* 427.0 $(M + H)^+$.

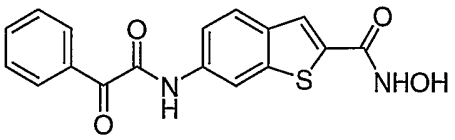
COMPOUND 110




6-Phenylacetylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0424]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.67(s, 2H), 7.24 (m, 1H), 7.33 (m, 4H), 7.47 (d, 1H), 7.81 (s, 1H), 7.83 (d, 1H), 8.39 (s, 1H), 9.21 (s, 1H), 10.41 (s, 1H), 11.38 (s, 1H). ESI-MS: *m/z* 327.0 $(M + H)^+$.

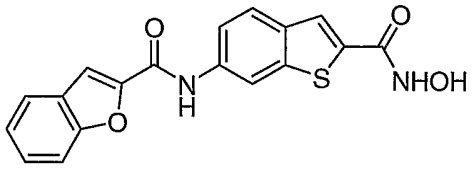
COMPOUND 111



6-(2-Oxo-2-phenyl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0425]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.63 (m, 3H), 7.76 (t, 1H), 7.87 (s, 1H), 7.93 (d, 1H), 8.06 (d, 2H), 8.52 (s, 1H), 9.25 (s, 1H), 11.19 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 341.0 $(M + H)^+$.

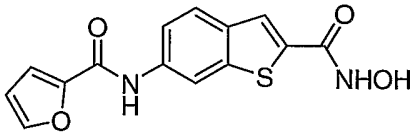
COMPOUND 112




Benzofuran-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-6-yl)-amide.

**[0426]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 7.37 (t, 1H), 7.51 (t, 1H), 7.72 (d, 1H), 7.85 (m, 5H), 8.55 (s, 1H), 9.24 (s, 1H), 10.76 (s, 1H), 11.44 (s, 1H). ESI-MS: *m/z* 353.0 $(M + H)^+$.

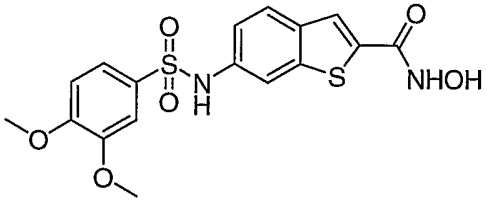
COMPOUND 113




Furan-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-6-yl)-amide.

**[0427]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 6.72 (s, 1H), 7.37 (s, 1H), 7.62 (d, 1H), 7.87 (m, 2H), 7.95 (s, 1H), 8.48 (s, 1H), 9.33 (s, 1H), 10.40 (s, 1H), 11.42 (s, 1H). ESI-MS: *m/z* 303.0 $(M + H)^+$.

COMPOUND 114




6-(3,4-Dimethoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

**[0428]** $^1$H NMR (400 MHz, DMSO-*d*6): δ 3.71 (s, 3H), 3.75 (s, 3H), 7.01 (d, 1H), 7.16 (dd, 1H), 7.27 (s, 1H), 7.33 (d, 1H), 7.69 (s, 1H), 7.75 (d, 1H), 7.77 (s, 1H), 9.22 (s, 1H), 10.35 (s, 1H), 11.39 (s, 1H). ESI-MS: *m/z* 409.0 $(M + H)^+$.

**[0429]** As used herein the symbols and conventions used in these processes, schemes and examples are consistent with those used in the contemporary scientific literature, for example, the Journal of the American Chemical Society or the Journal of Biological Chemistry. Standard single-letter or thee-letter abbreviations are generally used to designate amino acid residues, which are assumed to be in the L-configuration unless otherwise noted. Unless otherwise noted, all starting materials were obtained from commercial suppliers and used without further purification. Specifically, the following abbreviations may be used in the examples and throughout the specification:

| | |
|---|---|
| g (grams); | mg (milligrams); |
| L (liters); | mL (milliliters); |
| μL (microliters); | psi (pounds per square inch); |
| M (molar); | mM (millimolar); |
| i.v. (intravenous); | Hz (Hertz); |
| MHz (megahertz); | mol (moles); |
| mmol (millimoles); | RT (ambient temperature); |
| min (minutes);h (hours); | |
| mp (melting point); | TLC (thin layer chromatography); |
| Tr (retention time); | RP (reverse phase); |
| MeOH (methanol); | i-PrOH (isopropanol); |
| TEA (triethylamine); | TFA (trifluoroacetic acid); |
| TFAA (trifluoroacetic anhydride); | THF (tetrahydrofuran); |
| DMSO (dimethylsulfoxide); | EtOAc (ethyl acetate); |
| DME (1,2-dimethoxyethane); | DCM (dichloromethane); |
| DCE (dichloroethane); | DMF (N,N-dimethylformamide); |
| DMPU (N,N'-dimethylpropyleneurea); | CDI (1,1-carbonyldiimidazole); |
| IBCF (isobutyl chloroformate); | HOAc (acetic acid); |
| HOSu (N-hydroxysuccinimide); | HOBT (1-hydroxybenzotriazole); |
| Et2O (diethyl ether); | EDCI (ethylcarbodiimide hydrochloride); |

| | |
|---|---|
| BOC (tert-butyloxycarbonyl); | FMOC (9-fluorenylmethoxycarbonyl); |
| DCC (dicyclohexylcarbodiimide); | CBZ (benzyloxycarbonyl); |
| Ac (acetyl); | atm (atmosphere); |
| TMSE (2-(trimethylsilyl)ethyl); | TMS (trimethylsilyl); |
| TIPS (triisopropylsilyl); | TBS (t-butyldimethylsilyl); |
| DMAP (4-dimethylaminopyridine); | Me (methyl); |
| OMe (methoxy); | Et (ethyl); |
| Et (ethyl); | tBu (tert-butyl); |

HPLC (high pressure liquid chromatography);

BOP (bis(2-oxo-3-oxazolidinyl)phosphinic chloride);

TBAF (tetra-n-butylammonium fluoride);

mCPBA (meta-chloroperbenzoic acid.

**[0430]** All references to ether or $Et_2O$ are to diethyl ether; brine refers to a saturated aqueous solution of NaCl. Unless otherwise indicated, all temperatures are expressed in °C (degrees Centigrade). All reactions conducted under an inert atmosphere at RT unless otherwise noted.

**[0431]** $^1H$ NMR spectra were recorded on a Bruker Avance 400. Chemical shifts are expressed in parts per million (ppm). Coupling constants are in units of hertz (Hz). Splitting patterns describe apparent multiplicities and are designated as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad).

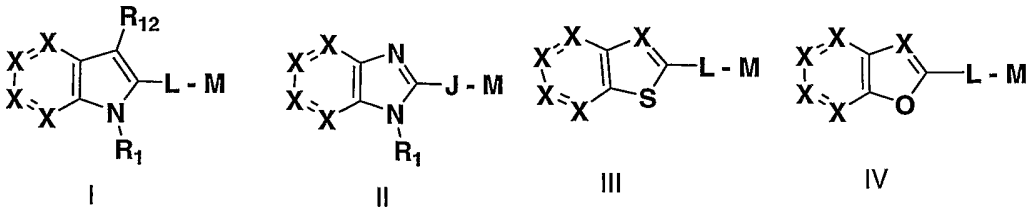
**[0432]** Low-resolution mass spectra (MS) and compound purity data were acquired on a Waters ZQ LC/MS single quadrupole system equipped with electrospray ionization (ESI) source, UV detector (220 and 254 nm), and evaporative light scattering detector (ELSD). Thin-layer chromatography was performed on 0.25 mm E. Merck silica gel plates (60F-254), visualized with UV light, 5% ethanolic phosphomolybdic acid, Ninhydrin or p-anisaldehyde solution. Flash column chromatography was performed on silica gel (230-400 mesh, Merck).

**[0433]** It will be apparent to those skilled in the art that various modifications and variations can be made to the compounds, compositions, kits, and methods of the present invention without departing from the spirit or scope of the invention. Thus, it is intended

that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A compound comprising a formula selected from the group consisting of:




I II III IV

wherein

each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

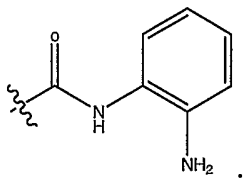
each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion;

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent; and

J is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent, with the proviso that J is not phenyl,

with the proviso that L is a substituent comprising a chain of 1-10 atoms in Formulae I, II and IV when each X is $CR_{12}$ and M is




.

2. The compound according Claim 1, wherein two adjacent X moieties are $CR_{12}$ where the $R_{12}$ groups are taken together to form a substituted or unsubstituted ring.

3. The compound according Claim 2, wherein the ring is an aryl or heteroaryl ring.

4. The compound according to Claim 1, wherein the Z moiety is a substituted or unsubstituted benzofuran or benzothiophene.

5. The compound according to Claim 1, wherein the Z moiety is a substituted or unsubstituted benzoimidazole, or benzoindole.

6. The compound according to Claim 1, wherein $R_1$ is a substituted or unsubstituted N-substituted piperidin-3-yl moiety.

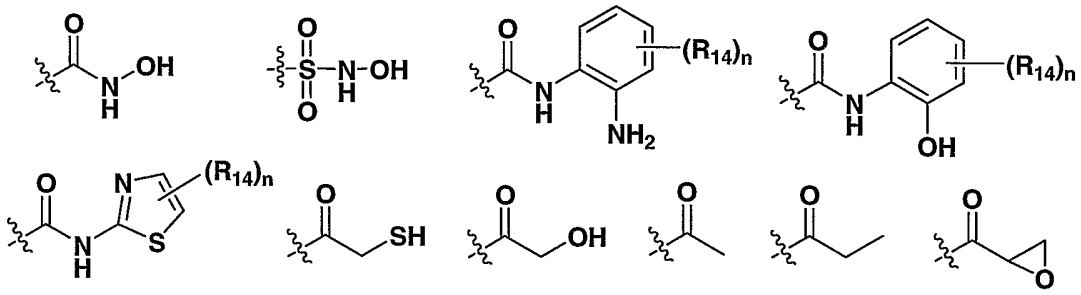
7. The compound according to Claim 6, wherein the N-substituted piperidin-3-yl moiety is an N-($C_{1-6}$)alkyl piperidin-3-yl moiety.

8. The compound according to Claim 1, wherein L is O or absent.

9. The compound according to Claim 1, wherein Z is a substituted or unsubstituted benzofuran, benzothiophene, benzoimidazole, or benzoindole and M is carboxylic acid hydroxyamide.

10. The compound according to Claim 1, wherein M comprises a member selected from the group consisting of trifluoroacetyl, -NH-P(O)OH-$CH_3$, sulfonamides, hydroxysulfonamides, thiols, and carbonyl groups having the formula -C(O)-$R_{13}$ wherein $R_{13}$ is hydroxylamino, hydroxyl, amino, alkylamino, or an alkoxy group.

11. The compound according to Claim 1, wherein M is selected from the group consisting of:



wherein n is 0, 1, 2, 3, or 4; and

each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, $(C_{1-10})$alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, $(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl, hetero$(C_{3-12})$cycloalkyl, $(C_{9-12})$bicycloalkyl, hetero$(C_{3-12})$bicycloalkyl, aryl$(C_{1-10})$alkyl, heteroaryl$(C_{1-5})$alkyl, perhalo$(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl$(C_{1-10})$alkyl, halo$(C_{1-10})$alkyl, carbonyl$(C_{1-3})$alkyl, thiocarbonyl$(C_{1-3})$alkyl, sulfonyl$(C_{1-3})$alkyl, sulfinyl$(C_{1-3})$alkyl, amino $(C_{1-10})$alkyl, imino$(C_{1-3})$alkyl, aryl, heteroaryl, $(C_{9-12})$bicycloaryl, and hetero$(C_{4-12})$bicycloaryl, each substituted or unsubstituted.

12. The compound according to Claim 1, wherein M comprises a hydroxamic acid moiety.

13. The compound according to Claim 1, wherein L is E, Z or mixtures of E/Z $-CH_2=CH_2-$.

14. The compound according to Claim 1, wherein the compound is in the form of a pharmaceutically acceptable salt.

15. The compound according to Claim 1, wherein the compound is present in a mixture of stereoisomers.

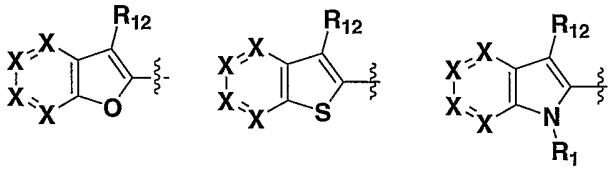
16. The compound according to Claim 1, wherein the compound comprises a single stereoisomer.

17. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

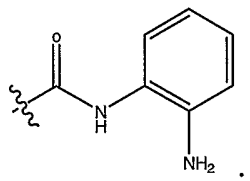
$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent,

with the proviso that L is a substituent comprising a chain of 1-10 atoms when each X is $CR_{12}$ and M is

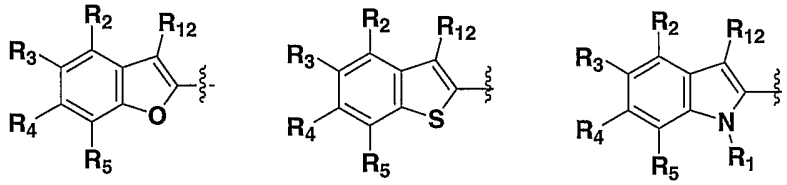


18. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



wherein

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

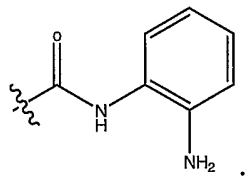
$R_2$, $R_3$, $R_4$ and $R_5$ are each independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent,

with the proviso that L is a substituent comprising a chain of 1-10 atoms when each X is $CR_{12}$ and M is




19. The compound according to Claim 18, wherein $R_2$ and $R_3$, or $R_3$ and $R_4$, or $R_4$ and $R_5$ are taken together to form a substituted or unsubstituted ring.

20. The compound according to Claim 19, wherein the ring is an aryl or heteroaryl ring.

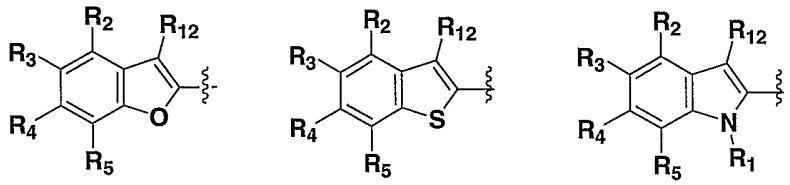
21. The compound according to Claim 18, wherein $R_3$ or $R_4$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted, and $R_2$ and $R_5$ are hydrogen.

22. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



wherein

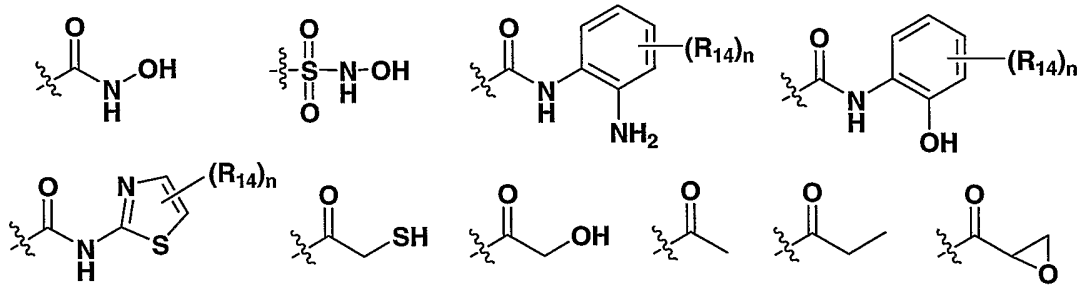
$R_1$ is selected from the group consisting of ($C_{1-4}$)alkyl, phenyl, 1-piperidin-4-ylmethyl, 2-morpholi-4-yl-ethyl, 2-halo-phenyl, 2-halo-phen($C_{1-4}$)alkyl, 3-halo-phen($C_{1-4}$)alkyl, 2-$CF_3O$-phen($C_{1-4}$)alkyl, 3-$CF_3O$-phen($C_{1-4}$)alkyl, 3-halo-phenyl, 4-halo-phenyl, 2-methoxy-phenyl, 3-methoxy-phenyl, 4-methoxy-phenyl, 4-phenoxy-phenyl, 4-benzyloxyphenyl, 4-pyrazol-1-yl-benzyl, 1-p-tolyl-ethyl, pyrrolidin-3-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl; 2-di($C_{1-4}$)alkylamino-ethyl, 2-di($C_{1-4}$)alkylamino-1-methyl-ethyl, 2-di($C_{1-4}$)alkylamino-ethyl, 2-hydroxy-2-phenyl-ethyl, 2-pyridin-2-yl-ethyl, 2-pyridin-3-yl-ethyl, 2-pyridin-4-yl-ethyl, 2-(1H-indol-3-yl)-ethyl, 3-indolyl($C_{1-4}$)alkyl, 1-indan-2-yl, *R*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *R*-β-($CH_3$)-phen($C_{1-4}$)alkyl, 6-propylsulfanyl, *trans*-4-hydroxy-cyclohexyl, 1-aza-bicyclo[2.2.2]oct-2-yl, 1-($C_{1-4}$)alkyl-piperidin-3-yl, 1-(2,2-difluoro-ethyl)-piperidin-3-yl, (2-di($C_{1-4}$)alkylamino-2-phenyl-ethyl), 1-benzyl-piperidin-3-yl, 1-allyl-piperidin-3-yl, 1-acetyl-piperidin-3-yl, piperidin-3-yl, and phen($C_{1-4}$)alkyl;

$R_2$ and $R_5$ are each hydrogen;

$R_3$ and $R_4$ are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

$R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is selected from the group consisting of:



wherein n is 0, 1, 2, 3, or 4; and each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, $(C_{1-10})$alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, $(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl, hetero$(C_{3-12})$cycloalkyl, $(C_{9-12})$bicycloalkyl, hetero$(C_{3-12})$bicycloalkyl, aryl$(C_{1-10})$alkyl, heteroaryl$(C_{1-5})$alkyl, perhalo$(C_{1-10})$alkyl, $(C_{3-12})$cycloalkyl$(C_{1-10})$alkyl, halo$(C_{1-10})$alkyl, carbonyl$(C_{1-3})$alkyl, thiocarbonyl$(C_{1-3})$alkyl, sulfonyl$(C_{1-3})$alkyl, sulfinyl$(C_{1-3})$alkyl, amino $(C_{1-10})$alkyl, imino$(C_{1-3})$alkyl, aryl, heteroaryl, $(C_{9-12})$bicycloaryl, and hetero$(C_{4-12})$bicycloaryl, each substituted or unsubstituted; and

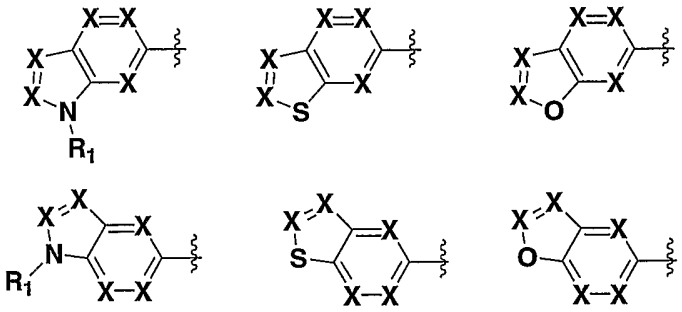
L is O or (E) $-CH_2=CH_2-$.

23. A compound comprising the formula:

**Z——L——M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

24. The compound according to Claim 23, wherein two adjacent X moieties are $CR_{12}$ where the $R_{12}$ groups are taken together to form a substituted or unsubstituted ring.

25. The compound according to Claim 24, wherein the ring is an aryl or heteroaryl ring.

26. The compound according to Claim 23, wherein the Z moiety is a substituted or unsubstituted benzofuran or benzothiophene.

27. The compound according to Claim 23, wherein the Z moiety is a substituted or unsubstituted benzoimidazole, or benzoindole.

28. The compound according to Claim 23, wherein $R_1$ is a substituted or unsubstituted N-substituted piperidin-3-yl moiety.

29. The compound according to Claim 28, wherein the N-substituted piperidin-3-yl moiety is an N-($C_{1-6}$)alkyl piperidin-3-yl moiety.

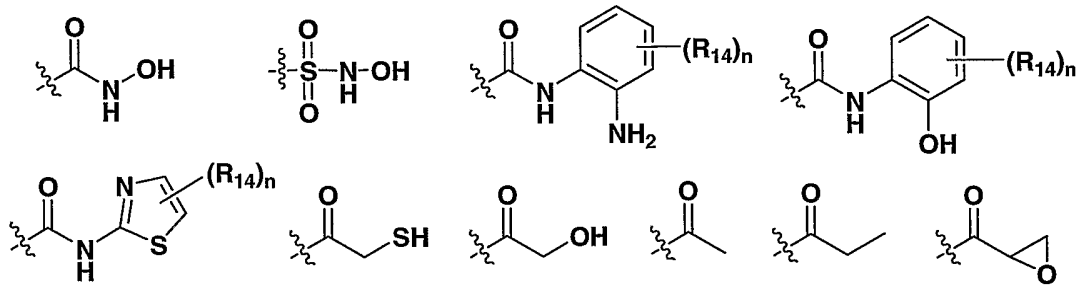
30. The compound according to Claim 23, wherein L is O or absent.

31. The compound according to Claim 23, wherein Z is a substituted or unsubstituted benzofuran, benzothiophene, benzoimidazole, or benzoindole and M is carboxylic acid hydroxyamide.

32. The compound according to Claim 23, wherein M comprises a member selected from the group consisting of trifluoroacetyl, -NH-P(O)OH-$CH_3$, sulfonamides,

hydroxysulfonamides, thiols, and carbonyl groups having the formula -C(O)-$R_{13}$ wherein $R_{13}$ is hydroxylamino, hydroxyl, amino, alkylamino, or an alkoxy group.

33. The compound according to Claim 23, wherein M is selected from the group consisting of:



wherein n is 0, 1, 2, 3, or 4; and

each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, ($C_{1-10}$)alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, ($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl, hetero($C_{3-12}$)cycloalkyl, ($C_{9-12}$)bicycloalkyl, hetero($C_{3-12}$)bicycloalkyl, aryl($C_{1-10}$)alkyl, heteroaryl($C_{1-5}$)alkyl, perhalo($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl($C_{1-10}$)alkyl, halo($C_{1-10}$)alkyl, carbonyl($C_{1-3}$)alkyl, thiocarbonyl($C_{1-3}$)alkyl, sulfonyl($C_{1-3}$)alkyl, sulfinyl($C_{1-3}$)alkyl, amino ($C_{1-10}$)alkyl, imino($C_{1-3}$)alkyl, aryl, heteroaryl, ($C_{9-12}$)bicycloaryl, and hetero($C_{4-12}$)bicycloaryl, each substituted or unsubstituted.

34. The compound according to Claim 23, wherein M comprises a hydroxamic acid moiety.

35. The compound according to Claim 23, wherein L is E, Z or mixtures of E/Z -$CH_2$=$CH_2$-.

36. The compound according to Claim 23, wherein the compound is in the form of a pharmaceutically acceptable salt.

37. The compound according to Claim 23, wherein the compound is present in a mixture of stereoisomers.

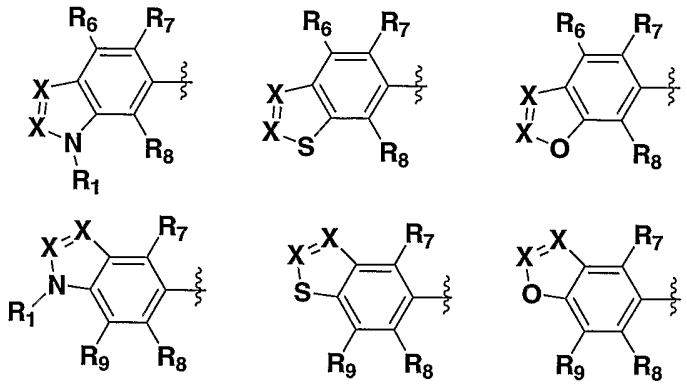
38. The compound according to Claim 23, wherein the compound comprises a single stereoisomer.

39. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_6$, $R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

40. The compound according to Claim 39, wherein $R_6$ and $R_7$, or $R_8$ and $R_9$ are taken together to form a substituted or unsubstituted ring.

41. The compound according to Claim 40, wherein the ring is an aryl or heteroaryl ring.

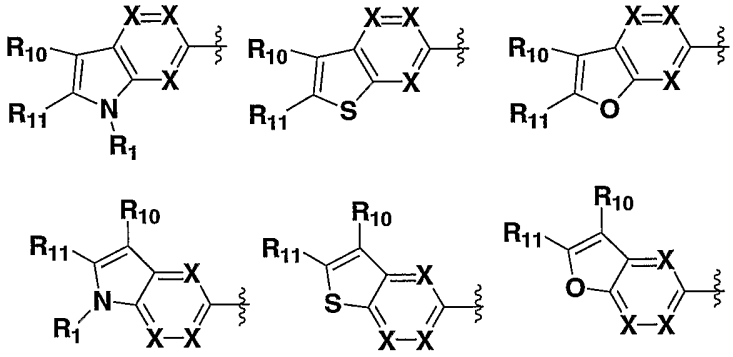
42. The compound according to Claim 39, wherein $R_6$, $R_7$, $R_8$ and $R_9$ are hydrogen.

43. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



each X is independently selected from the group consisting of $CR_{12}$ and N;

$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_{10}$ and $R_{11}$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

each $R_{12}$ is independently selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

44. The compound according to Claim 43, wherein $R_{10}$ and $R_{11}$ are taken together to form a substituted or unsubstituted ring.

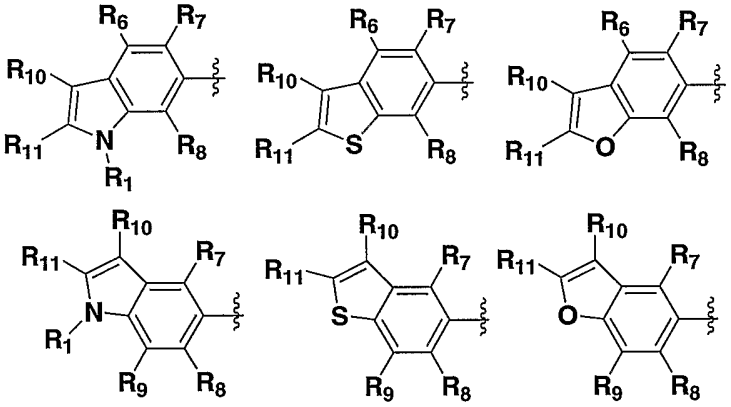
45. The compound according to Claim 44, wherein the ring is an aryl or heteroaryl ring.

46. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_6$, $R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{10}$ and $R_{11}$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl,

aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

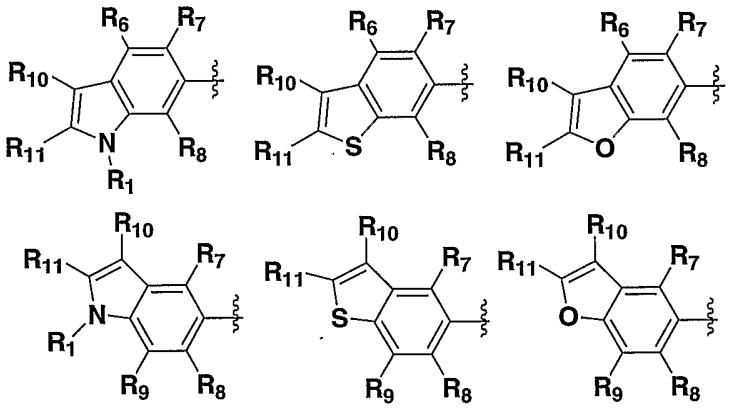
47. The compound according to Claim 46, wherein $R_6$ and $R_7$, or $R_8$ and $R_9$ are taken together to form a substituted or unsubstituted ring.

48. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



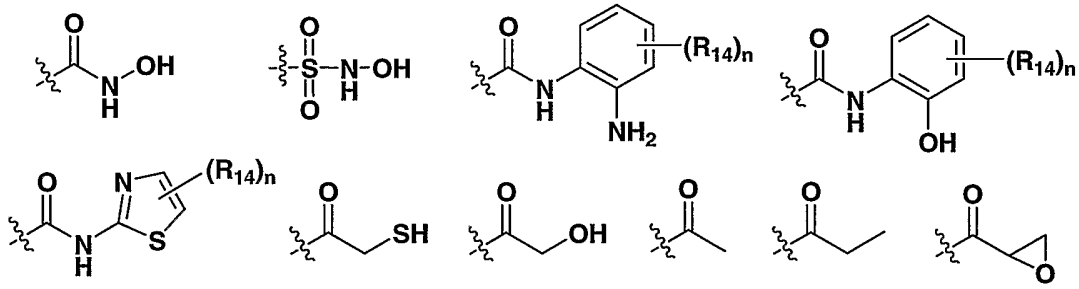
$R_1$ is selected from the group consisting of ($C_{1-4}$)alkyl, phenyl, 1-piperidin-4-ylmethyl, 2-morpholi-4-yl-ethyl, 2-halo-phenyl, 2-halo-phen($C_{1-4}$)alkyl, 3-halo-phen($C_{1-4}$)alkyl, 2-$CF_3O$-phen($C_{1-4}$)alkyl, 3-$CF_3O$-phen($C_{1-4}$)alkyl, 3-halo-phenyl, 4-halo-phenyl, 2-methoxy-phenyl, 3-methoxy-phenyl, 4-methoxy-phenyl, 4-phenoxy-phenyl, 4-benzyloxyphenyl, 4-pyrazol-1-yl-benzyl, 1-p-tolyl-ethyl, pyrrolidin-3-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl, 1-($C_{1-4}$)alkyl-pyrrolidin-2-yl; 2-di($C_{1-4}$)alkylamino-ethyl, 2-di($C_{1-4}$)alkylamino-1-methyl-ethyl, 2-di($C_{1-4}$)alkylamino-ethyl, 2-hydroxy-2-phenyl-ethyl, 2-pyridin-2-yl-ethyl, 2-pyridin-3-yl-ethyl, 2-pyridin-4-yl-ethyl, 2-(1H-indol-3-yl)-ethyl, 3-indolyl($C_{1-4}$)alkyl, 1-indan-2-yl, *R*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *S*-α-($HOCH_2$)-phen($C_{1-4}$)alkyl, *R*-β-($CH_3$)-phen($C_{1-4}$)alkyl, 6-propylsulfanyl, *trans*-4-hydroxy-cyclohexyl, 1-aza-bicyclo[2.2.2]oct-2-yl, 1-($C_{1-}$

$_4$)alkyl-piperidin-3-yl, 1-(2,2-difluoro-ethyl)-piperidin-3-yl, (2-di($C_{1-4}$)alkylamino-2-phenyl-ethyl), 1-benzyl-piperidin-3-yl, 1-allyl-piperidin-3-yl, 1-acetyl-piperidin-3-yl, piperidin-3-yl, and phen($C_{1-4}$)alkyl;

$R_6$, $R_7$, $R_8$, and $R_9$ are each hydrogen;

$R_{10}$ and $R_{11}$ are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

M is selected from the group consisting of:



n is 0, 1, 2, 3, or 4;

each $R_{14}$ is individually selected from the group consisting of hydrogen, nitro, cyano, thio, hydroxy, alkoxy, aryloxy, heteroaryloxy, carbonyl, amino, ($C_{1-10}$)alkylamino, sulfonamido, imino, sulfonyl, sulfinyl, ($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl, hetero($C_{3-12}$)cycloalkyl, ($C_{9-12}$)bicycloalkyl, hetero($C_{3-12}$)bicycloalkyl, aryl($C_{1-10}$)alkyl, heteroaryl($C_{1-5}$)alkyl, perhalo($C_{1-10}$)alkyl, ($C_{3-12}$)cycloalkyl($C_{1-10}$)alkyl, halo($C_{1-10}$)alkyl, carbonyl($C_{1-3}$)alkyl, thiocarbonyl($C_{1-3}$)alkyl, sulfonyl($C_{1-3}$)alkyl, sulfinyl($C_{1-3}$)alkyl, amino ($C_{1-10}$)alkyl, imino($C_{1-3}$)alkyl, aryl, heteroaryl, ($C_{9-12}$)bicycloaryl, and hetero($C_{4-12}$)bicycloaryl, each substituted or unsubstituted; and

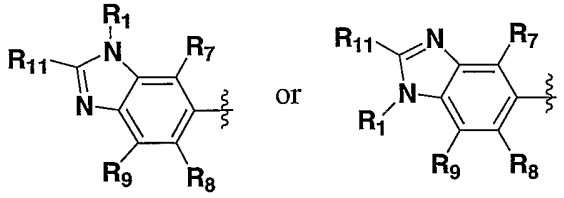
L is O or (E) -$CH_2$=$CH_2$-.

49. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{11}$ is selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

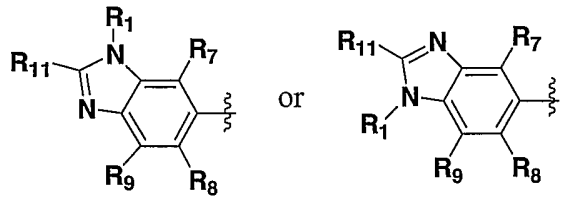
50. The compound according to Claim 49, wherein $R_6$ and $R_7$, or $R_8$ and $R_9$ are taken together to form a substituted or unsubstituted ring.

51. A compound comprising the formula:

**Z—L—M**

wherein

Z is selected from the group consisting of



$R_1$ is selected from the group consisting of hydrogen, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, and a carbonyl group, each substituted or unsubstituted;

$R_7$, $R_8$ and $R_9$ are each selected from the group consisting of hydrogen, halo, alkyl, alkoxy, aryl, heteroaryl, aminosulfonyl, alkylsulfonyl, arylsulfonyl, heteroarylsulfonyl, aryloxy, heteroaryloxy, arylalkyl, heteroarylalkyl, amino, thio, cyano, nitro, and a carbonyl group, each substituted or unsubstituted;

$R_{11}$ is selected from the group consisting of are independently selected from the group consisting of alkyl, aryl, heteroaryl, alkyl-sulfonylamino, aryl-sulfonylamino, heteroaryl-sulfonylamino, alkylcarboxamido, arylcarboxamido, heteroarylcarboxamido, alkylamino, and aminoalkyl, each substituted or unsubstituted;

M is a substituent capable of complexing with a histone deacetylase catalytic site and/or a metal ion; and

L is a substituent comprising a chain of 0-10 atoms connecting the M substituent to the Z substituent.

52. A compound selected from the group consisting of:

5-(Toluene-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Toluene-3-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-p-Tolylmethanesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Chloro-phenylmethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Propane-1-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Chloro-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Naphthalene-1-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Naphthalene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-Methanesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Methoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Cyclohexanecarbonyl-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Methoxy-propionylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-Benzoylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Methyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Methyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Methoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Methoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Bromo-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Bromo-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Hydroxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Phenoxy-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Phenoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(2,3-Dihydro-benzo[1,4]dioxine-6-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Methanesulfonyl-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3-Dimethylamino-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Dimethylamino-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[3-(N-Hydroxycarbamimidoyl)-benzoylamino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[4-(N-Hydroxycarbamimidoyl)-benzoylamino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[(Naphthalene-2-carbonyl)-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

N-(2-Hydroxycarbamoyl-benzo[b]thiophen-5-yl)-isonicotinamide;

5-(3-Phenyl-propionylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-Phenylacetylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(5-Methyl-1-phenyl-1H-pyrazole-3-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(2-Phenoxy-pyridine-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(5-Oxazol-5-yl-thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(5-Pyridin-2-yl-thiophene-2-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(4-Oxazol-2-yl-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

Furan-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

Furan-3-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

Benzofuran-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

1-Methyl-1H-pyrrole-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

N-(2-Hydroxycarbamoyl-benzo[b]thiophen-5-yl)-2,6-dimethoxy-nicotinamide;

Quinoline-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

Pyrazine-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

5-(4-Isopropyl-benzoylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(2-Oxo-2-phenyl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

1-Methyl-1H-indole-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-5-yl)-amide;

5-Dimethylaminomethyl-benzofuran-2-carboxylic acid hydroxyamide;

5-[(1H-[1,2,4]Triazol-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-Phenylaminomethyl-benzofuran-2-carboxylic acid hydroxyamide;

5-{[2-(1H-Indol-3-yl)-ethylamino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide;

5-({(2-Hydroxy-ethyl)-[2-(1H-indol-3-yl)-ethyl]-amino}-methyl)-benzofuran-2-carboxylic acid hydroxyamide;

5-(1-Phenethyl-1H-benzoimidazol-2-yl)-benzofuran-2-carboxylic acid hydroxyamide;

5-{[(Pyridin-3-ylmethyl)-amino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide;

5-{[(Pyridin-4-ylmethyl)-amino]-methyl}-benzofuran-2-carboxylic acid hydroxyamide;

5-[(2-Pyridin-3-yl-ethylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(2-Pyridin-4-yl-ethylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(1-Ethyl-piperidin-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

4-[(2-Hydroxycarbamoyl-benzofuran-5-ylmethyl)-amino]-piperidine-1-carboxylic acid ethyl ester;

5-(Pyrazin-2-ylaminomethyl)-benzofuran-2-carboxylic acid hydroxyamide;

5-[(2-Amino-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(3-Amino-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(4-Phenoxy-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(1H-Indazol-6-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(3-Fluoro-phenylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(1H-Pyrazol-3-ylamino)-methyl]-benzofuran-2-carboxylic acid hydroxyamide;

5-(Isopropylamino-methyl)-benzofuran-2-carboxylic acid hydroxyamide;

5-(1-Phenethyl-1H-benzoimidazol-2-yl)-benzofuran-2-carboxylic acid methyl ester;

5-(Biphenyl-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[(Biphenyl-4-sulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[Methyl-(2-naphthalen-1-yl-ethanesulfonyl)-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[(3,4-Dimethoxy-benzenesulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[(4-Chloro-benzenesulfonyl)-methyl-amino]-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(3,4-Dimethoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-(Benzenesulfonyl-methyl-amino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

5-[(Benzofuran-2-carbonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide;

5-Phenylacetylamino-benzofuran-2-carboxylic acid hydroxyamide;

5-Benzoylamino-benzofuran-2-carboxylic acid hydroxyamide;

5-(4-Chloro-benzenesulfonylamino)-benzofuran-2-carboxylic acid hydroxyamide;

5-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzofuran-2-carboxylic acid hydroxyamide;

5-[(Furan-2-carbonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide;

5-(2-Oxo-2-phenyl-acetylamino)-benzofuran-2-carboxylic acid hydroxyamide;

5-[(4-Chloro-benzenesulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide;

5-[Methyl-(2-naphthalen-1-yl-ethanesulfonyl)-amino]-benzofuran-2-carboxylic acid hydroxyamide;

5-[(Biphenyl-4-sulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide;

5-(Benzenesulfonyl-methyl-amino)-benzofuran-2-carboxylic acid hydroxyamide;

5-(2-Pyridin-3-yl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

(R)-3-[1-(1-Ethyl-piperidin-3-yl)-2-phenyl-1H-benzoimidazol-5-yl]-N-hydroxy-acrylamide;

(R)-1-(1-Ethyl-piperidin-3-yl)-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

(R)-1-(1-Ethyl-piperidin-3-yl)-2-(3-fluoro-phenyl)-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

2-Phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

(R)-3-[1-(1-Ethyl-piperidin-3-yl)-2-(3-fluoro-phenyl)-1H-benzoimidazol-5-yl]-N-hydroxy-acrylamide;

1-Phenethyl-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

1-(2-Morpholin-4-yl-ethyl)-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

1-Isopropyl-2-phenyl-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

(R)-2-Phenyl-1-(1-phenyl-ethyl)-1H-benzoimidazole-5-carboxylic acid hydroxyamide;

N-Hydroxy-3-(2-phenyl-1H-benzoimidazol-5-yl)-acrylamide;

N-Hydroxy-3-(1-phenethyl-2-phenyl-1H-benzoimidazol-5-yl)-acrylamide;

N-Hydroxy-3-[1-(2-morpholin-4-yl-ethyl)-2-phenyl-1H-benzoimidazol-5-yl]-acrylamide;

N-Hydroxy-3-(1-isopropyl-2-phenyl-1H-benzoimidazol-5-yl)-acrylamide;

(R)-N-Hydroxy-3-[2-phenyl-1-(1-phenyl-ethyl)-1H-benzoimidazol-5-yl]-acrylamide;

5-[(3,4-Dimethoxy-benzenesulfonyl)-methyl-amino]-benzofuran-2-carboxylic acid hydroxyamide;

6-(Biphenyl-4-sulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-Benzoylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-Benzenesulfonylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-(4-Chloro-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-(2-Naphthalen-1-yl-ethanesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-Phenylacetylamino-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

6-(2-Oxo-2-phenyl-acetylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide;

Benzofuran-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-6-yl)-amide;

Furan-2-carboxylic acid (2-hydroxycarbamoyl-benzo[b]thiophen-6-yl)-amide; and

6-(3,4-Dimethoxy-benzenesulfonylamino)-benzo[b]thiophene-2-carboxylic acid hydroxyamide.

53. A pharmaceutical composition comprising as an active ingredient a compound according to Claim 1.

54. The pharmaceutical composition of Claim 53, wherein the composition is a solid formulation adapted for oral administration.

55. The pharmaceutical composition of Claim 53, wherein the composition is a liquid formulation adapted for oral administration.

56. The pharmaceutical composition of Claim 53, wherein the composition is a tablet.

57. The pharmaceutical composition of Claim 53, wherein the composition is a liquid formulation adapted for parenteral administration.

58. The pharmaceutical composition comprising a compound according to Claim 1, wherein the composition is adapted for administration by a route selected from the group consisting of orally, parenterally, intraperitoneally, intravenously, intraarterially, transdermally, sublingually, intramuscularly, rectally, transbuccally, intranasally, liposomally, via inhalation, vaginally, intraoccularly, via local delivery, subcutaneously, intraadiposally, intraarticularly, and intrathecally.

59. A kit comprising:

a compound according to Claim 1; and

instructions which comprise one or more forms of information selected from the group consisting of indicating a disease state for which the compound is to be administered, storage information for the compound, dosing information and instructions regarding how to administer the compound.

60. The kit of Claim 59, wherein the kit comprises the compound in a multiple dose form.

61. An article of manufacture comprising:

a compound according to Claim 1; and

packaging materials.

62. The article of manufacture of Claim 61, wherein the packaging material comprises a container for housing the compound.

63. The article of manufacture of Claim 62, wherein the container comprises a label indicating one or more members of the group consisting of a disease state for which the compound is to be administered, storage information, dosing information and/or instructions regarding how to administer the composition.

64. The article of manufacture of Claim 61, wherein the article of manufacture comprises the compound in a multiple dose form.

65. A method of inhibiting histone deacetylase comprising:

contacting histone deacetylase with a compound according to Claim 1.

66. A method of inhibiting histone deacetylase comprising:

causing a compound according to Claim 1 to be present in a subject in order to inhibit histone deacetylase *in vivo*.

67. A method of inhibiting histone deacetylase comprising:

administering a first compound to a subject that is converted *in vivo* to a second compound wherein the second compound inhibits histone deacetylase *in vivo*, the second compound being a compound according to Claim 1.

68. A therapeutic method comprising:

administering a compound according to Claim 1 to a subject.

69. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

causing a compound according to Claim 1 to be present in a subject in a therapeutically effective amount for the disease state.

70. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

administering a first compound to a subject that is converted *in vivo* to a second compound according to Claim 1, wherein the second compound is present in a subject in a therapeutically effective amount for the disease state.

71. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

administering a compound according to Claim 1, wherein the compound is present in the subject in a therapeutically effective amount for the disease state.

72. A method for treating cancer comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a composition according to Claim 1.

73. The method of claim 72, wherein the cancer is selected from the group consisting of squamous cell carcinoma, astrocytoma, Kaposi's sarcoma, glioblastoma, non small-cell lung cancer, bladder cancer, head and neck cancer, melanoma, ovarian cancer, prostate cancer, breast cancer, small-cell lung cancer, glioma, colorectal cancer, genitourinary cancer and gastrointestinal cancer.

74. A method for treating inflammation, inflammatory bowel disease, psoriasis, or transplant rejection, comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a compound according to Claim 1.

75. A method for treating arthritis comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a compound according to Claim 1.

76. A pharmaceutical composition comprising as an active ingredient a compound according to Claim 23.

77. The pharmaceutical composition of Claim 76, wherein the composition is a solid formulation adapted for oral administration.

78. The pharmaceutical composition of Claim 76, wherein the composition is a liquid formulation adapted for oral administration.

79. The pharmaceutical composition of Claim 76, wherein the composition is a tablet.

80. The pharmaceutical composition of Claim 76, wherein the composition is a liquid formulation adapted for parenteral administration.

81. The pharmaceutical composition comprising a compound according to Claim 23, wherein the composition is adapted for administration by a route selected from the group consisting of orally, parenterally, intraperitoneally, intravenously, intraarterially, transdermally, sublingually, intramuscularly, rectally, transbuccally, intranasally, liposomally, via inhalation, vaginally, intraoccularly, via local delivery, subcutaneously, intraadiposally, intraarticularly, and intrathecally.

82. A kit comprising:

a compound according to Claim 23; and

instructions which comprise one or more forms of information selected from the group consisting of indicating a disease state for which the compound is to be administered, storage information for the compound, dosing information and instructions regarding how to administer the compound.

83. The kit of Claim 82, wherein the kit comprises the compound in a multiple dose form.

84. An article of manufacture comprising:

a compound according to Claim 23; and

packaging materials.

85. The article of manufacture of Claim 84, wherein the packaging material comprises a container for housing the compound.

86. The article of manufacture of Claim 85, wherein the container comprises a label indicating one or more members of the group consisting of a disease state for which the compound is to be administered, storage information, dosing information and/or instructions regarding how to administer the composition.

87. The article of manufacture of Claim 84, wherein the article of manufacture comprises the compound in a multiple dose form.

88. A method of inhibiting histone deacetylase comprising:

contacting histone deacetylase with a compound according to Claim 23.

89. A method of inhibiting histone deacetylase comprising:

causing a compound according to Claim 23 to be present in a subject in order to inhibit histone deacetylase *in vivo*.

90. A method of inhibiting histone deacetylase comprising:

administering a first compound to a subject that is converted *in vivo* to a second compound wherein the second compound inhibits histone deacetylase *in vivo*, the second compound being a compound according to Claim 23.

91. A therapeutic method comprising:

administering a compound according to Claim 23 to a subject.

92. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

causing a compound according to Claim 23 to be present in a subject in a therapeutically effective amount for the disease state.

93. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

administering a first compound to a subject that is converted *in vivo* to a second compound according to Claim 23, wherein the second compound is present in a subject in a therapeutically effective amount for the disease state.

94. A method of treating a disease state for which histone deacetylase possesses activity that contributes to the pathology and/or symptomology of the disease state, the method comprising:

administering a compound according to Claim 23, wherein the compound is present in the subject in a therapeutically effective amount for the disease state.

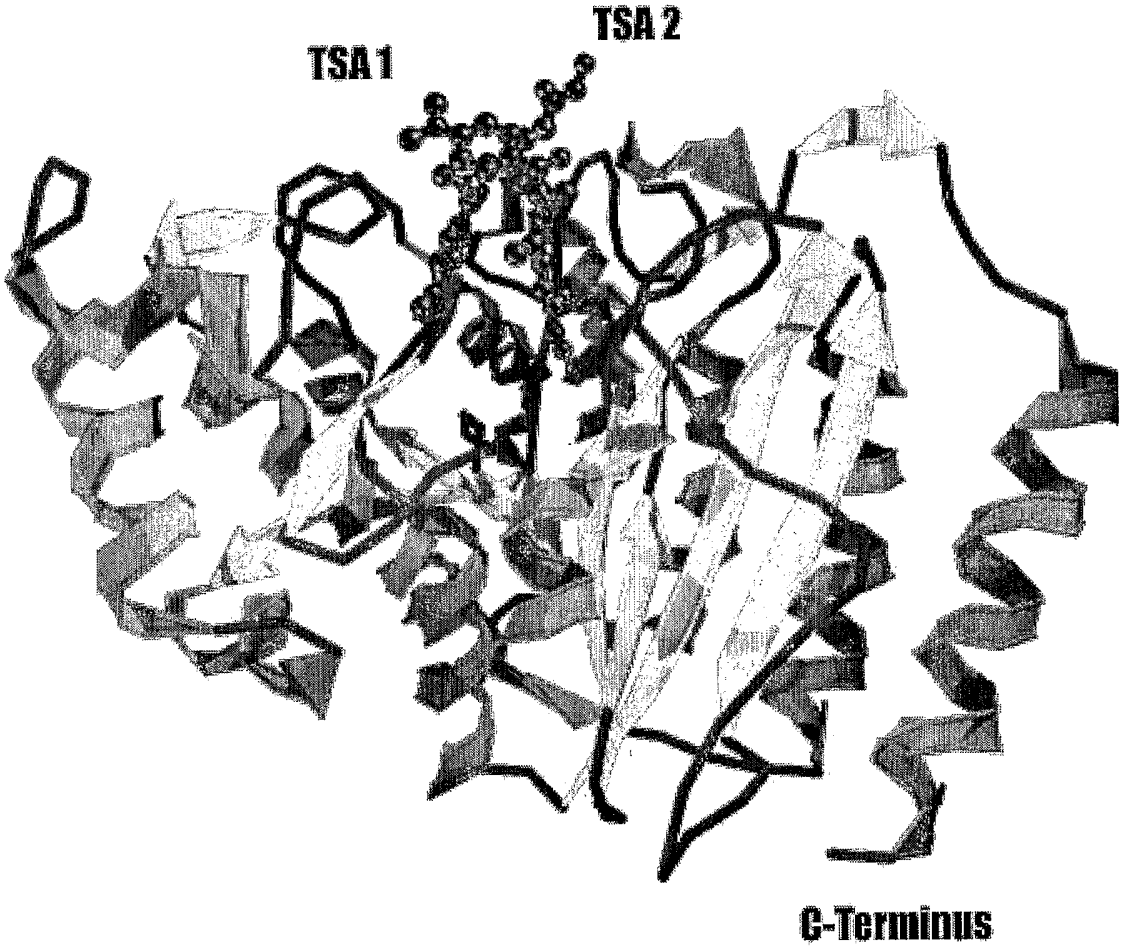
95. A method for treating cancer comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a composition according to Claim 23.

96. The method of claim 95, wherein the cancer is selected from the group consisting of squamous cell carcinoma, astrocytoma, Kaposi's sarcoma, glioblastoma, non small-cell lung cancer, bladder cancer, head and neck cancer, melanoma, ovarian cancer, prostate cancer, breast cancer, small-cell lung cancer, glioma, colorectal cancer, genitourinary cancer and gastrointestinal cancer.

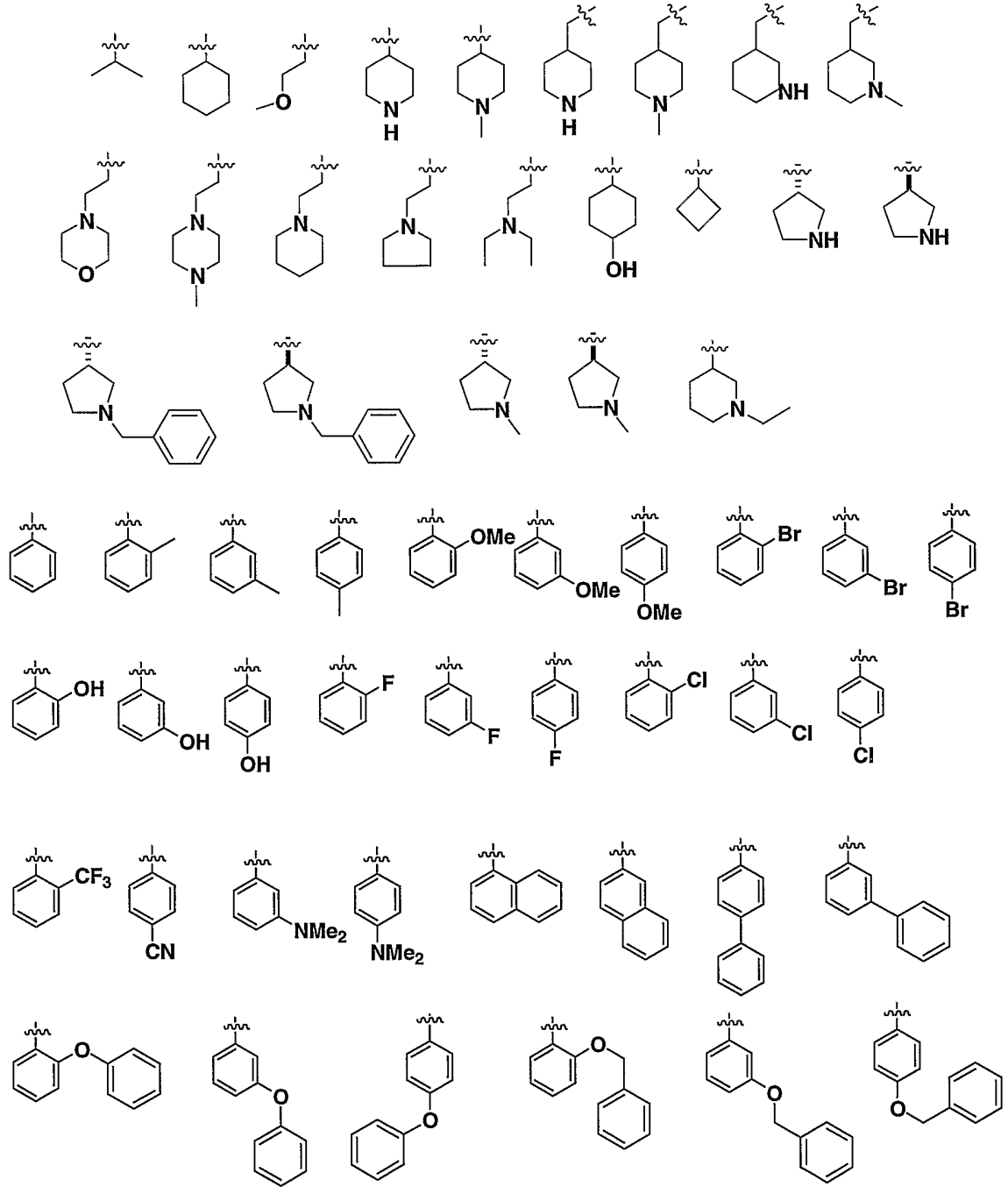
97. A method for treating inflammation, inflammatory bowel disease, psoriasis, or transplant rejection, comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a compound according to Claim 23.

98. A method for treating arthritis comprising administration to a mammalian species in need thereof of a therapeutically effective amount of a compound according to Claim 23.

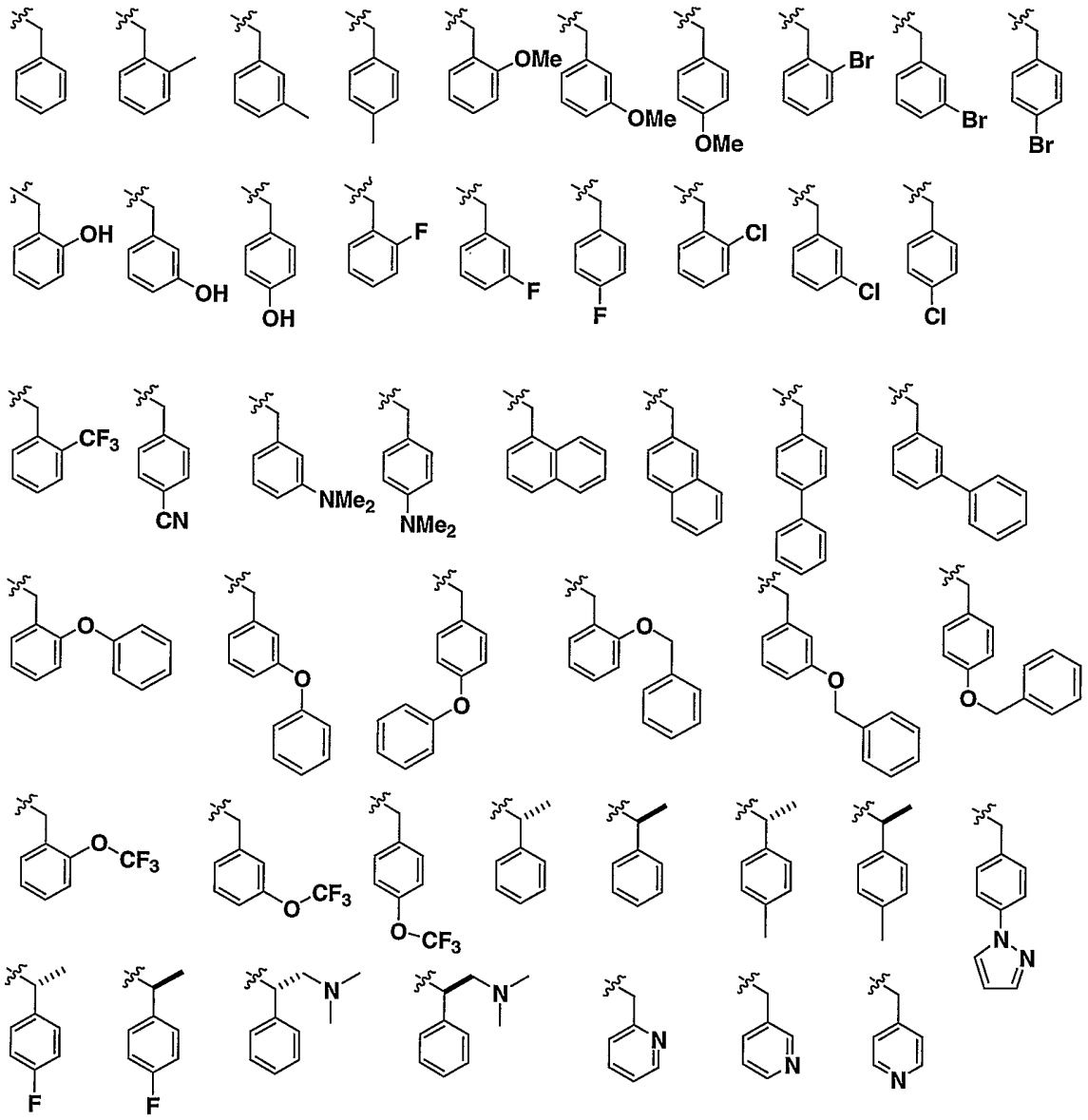
# FIGURE 1



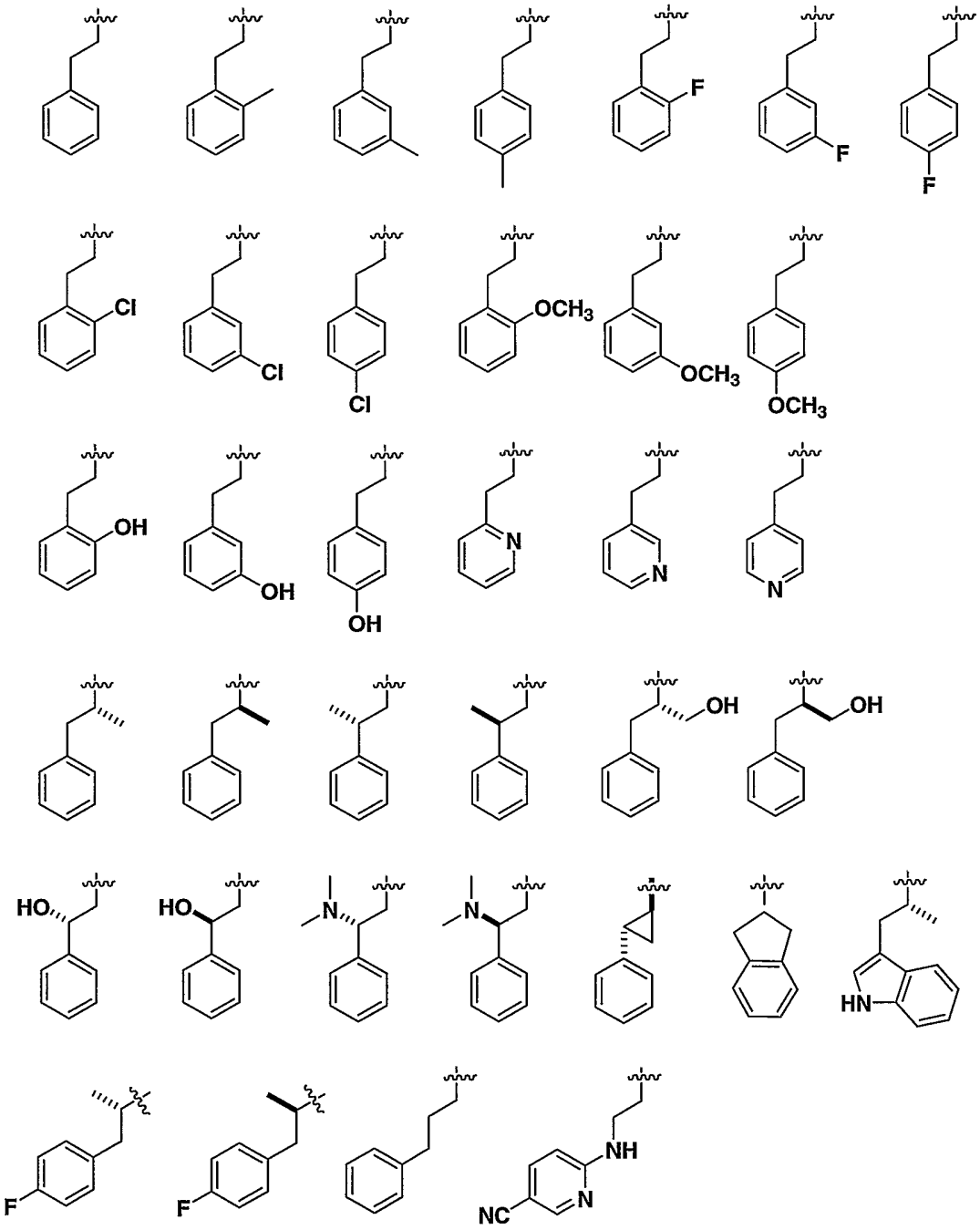
# FIGURE 2A


O
N
H
N
N
H
N
NH
N
N
O
N
N
N
N
OH
NH
NH
N
N
N
N
N
OMe
OMe
OMe
Br
Br
Br
OH
OH
OH
F
F
F
Cl
Cl
Cl
CF3
CN
NMe2
NMe2
O
O
O
O
O
O

# FIGURE 2A (cont.)



# FIGURE 2A (cont.)



# FIGURE 2A (cont.)

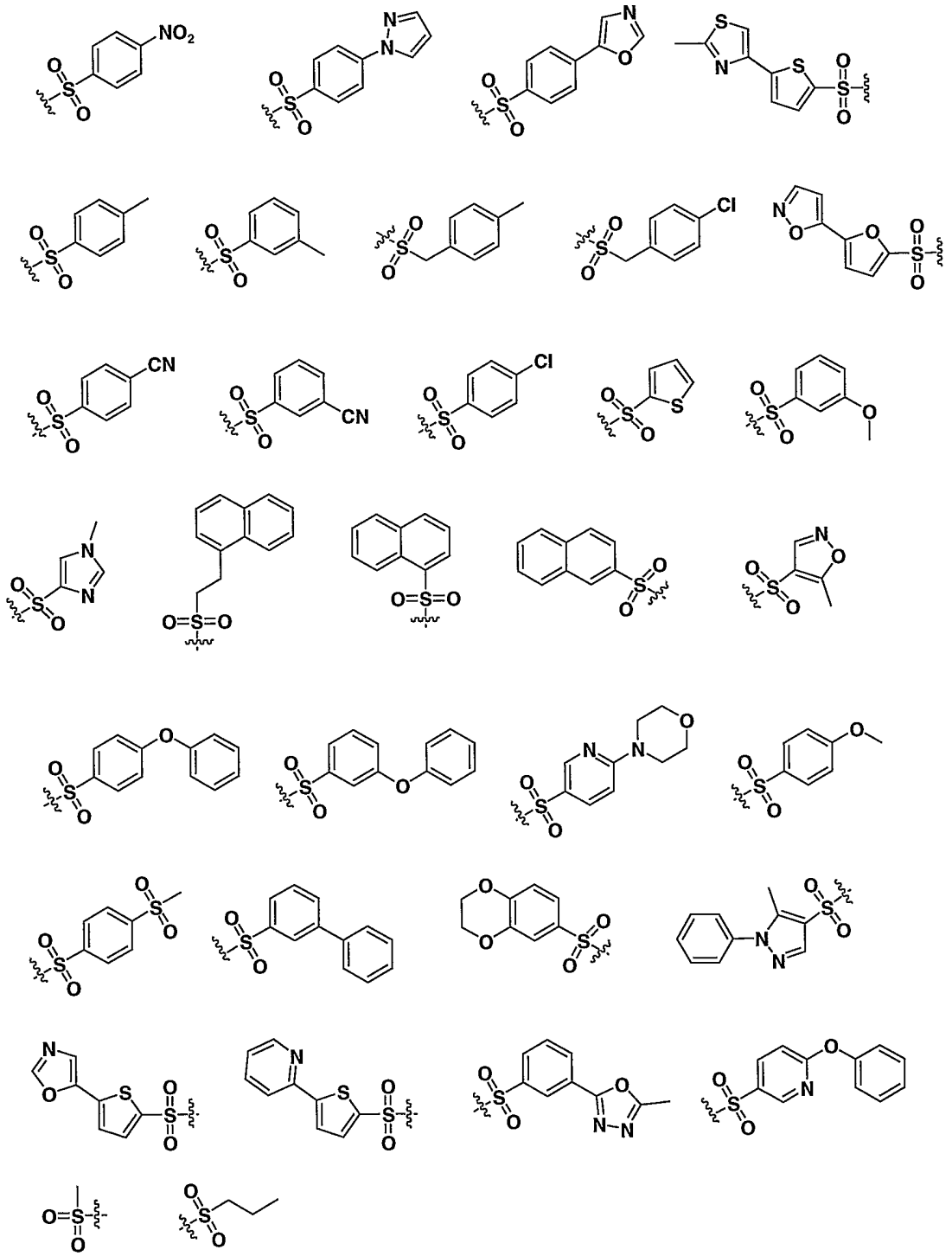
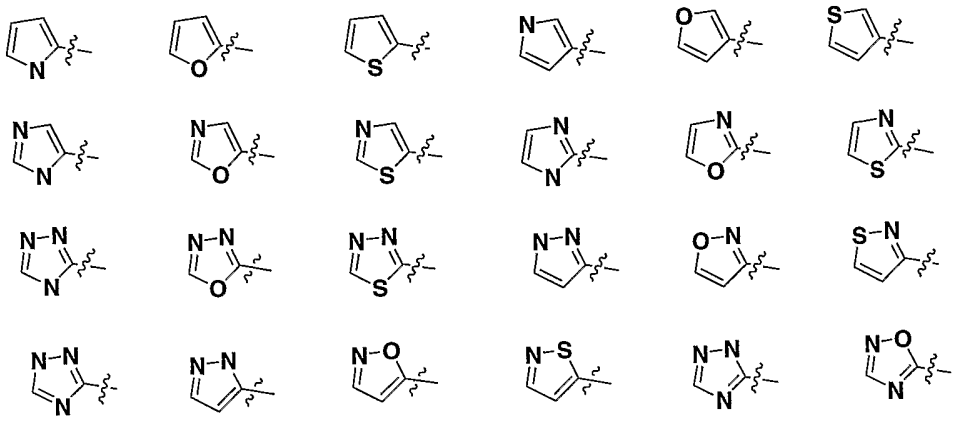
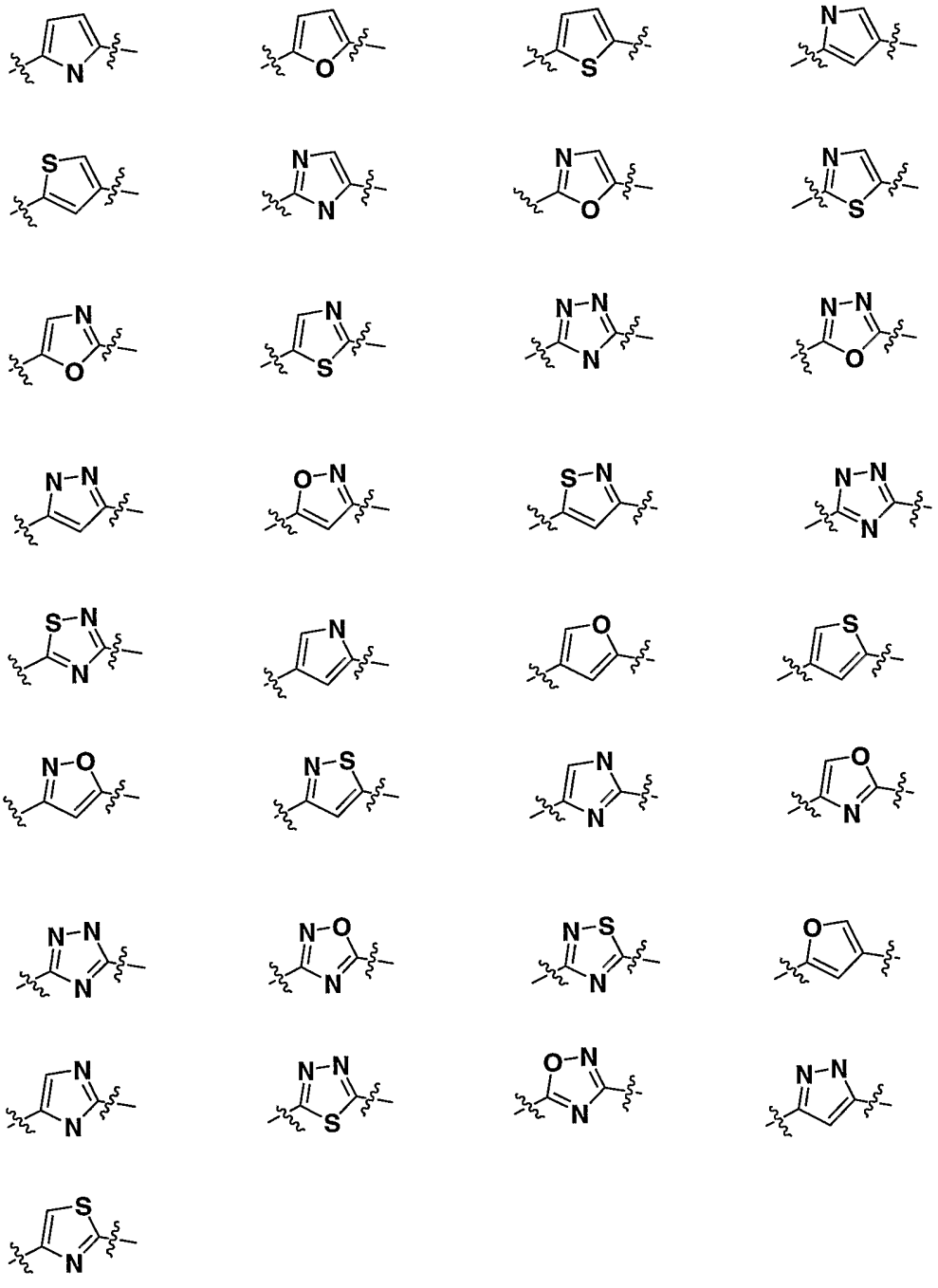


**FIGURE 2B**



# FIGURE 2C



# FIGURE 2C (cont.)

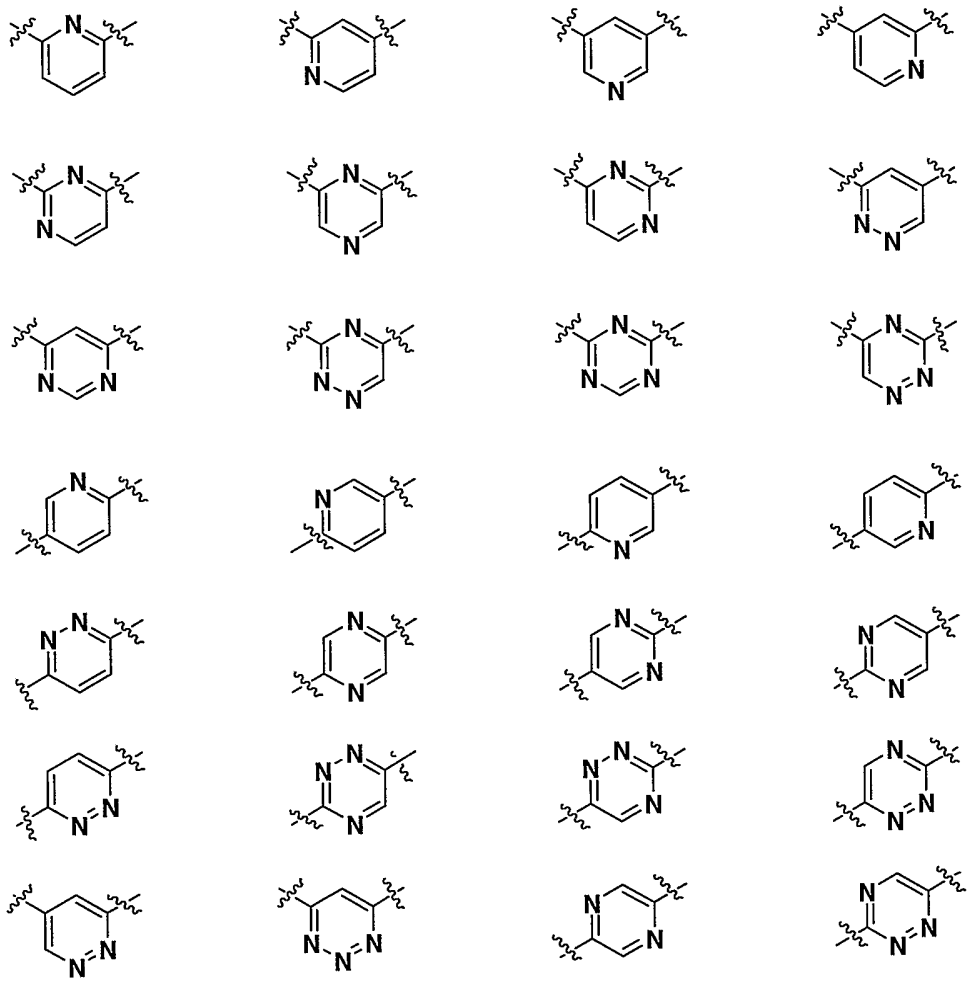
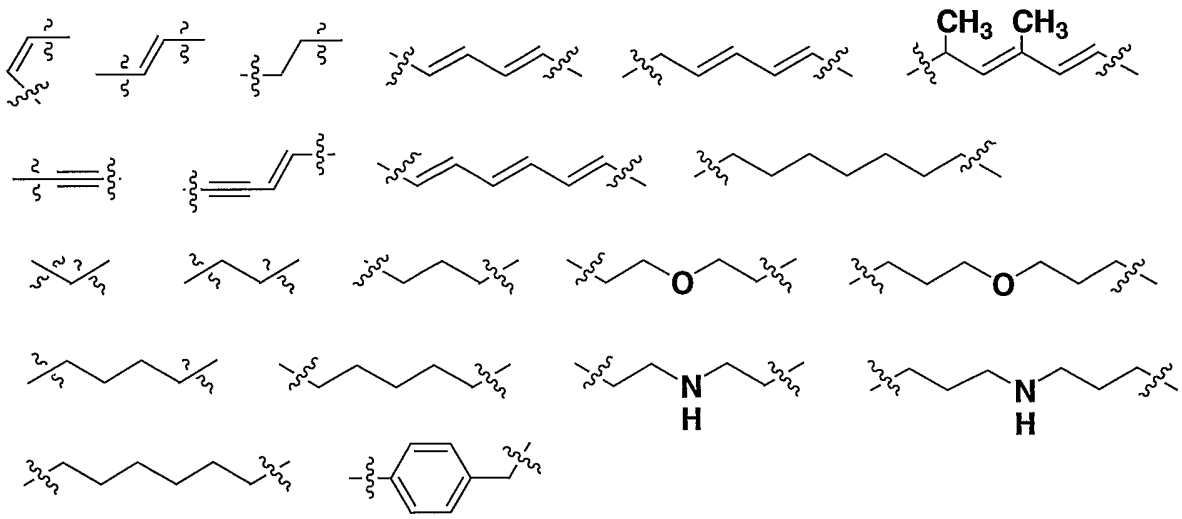


**FIGURE 2D**



## FIGURE 3

SEQ. ID No. 1

MSYYHHHHHHDYDIPTTENLYFQGAMEPGGSMAQTQGTRRKVCYYYDGDVGNYYYGQGHP
MKPHRIRMTHNLLLNYGLYRKMEIYRPHKANAEEMTKYHSDDYIKFLRSIRPDNMSEYSK
QMQRFNVGEDCPVFDGLFEFCQLSTGGSVASAVKLNKQQTDIAVNWAGGLHHAKKSEASG
FCYVNDIVLAILELLKYHQRVLYIDIDIHHGDGVEEAFYTTDRVMTVSFHKYGEYFPGTG
DLRDIGAGKGKYYAVNYPLRDGIDDESYEAIFKPVMSKVMEMFQPSAVVLQCGSDSLSGD
RLGCFNLTIKGHAKCVEFVKSFNLPMLMLGGGGYTIRNVARCWTYETAVALDTEIPNELP
YNDYFEYFGPDFKLHISPSNMTNQNTNEYLEKIKQRLFENLRMLPHAPGVQMQAIPEDAI
PEESGDEDEDDPDKRISICSSDKRIACEEEFSDSEEEGEGGRKNSSNFKKAKRVKTEDEK
EKDPEEKKEVTEEEKTKEEKPEAKGVKEEVKLA

## FIGURE 4

SEQ. ID No. 2

ATGTCGTACTACCATCACCATCACCATCACGATTACGATATCCCAACGACCGAAAACCTG
TATTTTCAGGGCGCCATGGAACCCGGGGGATCCATGGCGCAGACGCAGGGCACCCGGAGG
AAAGTCTGTTACTACTACGACGGGGATGTTGGAAATTACTATTATGGACAAGGCCACCCA
ATGAAGCCTCACCGAATCCGCATGACTCATAATTTGCTGCTCAACTATGGTCTCTACCGA
AAAATGGAAATCTATCGCCCTCACAAAGCCAATGCTGAGGAGATGACCAAGTACCACAGC
GATGACTACATTAAATTCTTGCGCTCCATCCGTCCAGATAACATGTCGGAGTACAGCAAG
CAGATGCAGAGATTCAACGTTGGTGAGGACTGTCCAGTATTCGATGGCCTGTTTGAGTTC
TGTCAGTTGTCTACTGGTGGTTCTGTGGCAAGTGCTGTGAAACTTAATAAGCAGCAGACG
GACATCGCTGTGAATTGGGCTGGGGGCCTGCACCATGCAAAGAAGTCCGAGGCATCTGGC
TTCTGTTACGTCAATGATATCGTCTTGGCCATCCTGGAACTGCTAAAGTATCACCAGAGG
GTGCTGTACATTGACATTGATATTCACCATGGTGACGGCGTGGAAGAGGCCTTCTACACC
ACGGACCGGGTCATGACTGTGTCCTTTCATAAGTATGGAGAGTACTTCCCAGGAACTGGG
GACCTACGGGATATCGGGGCTGGCAAAGGCAAGTATTATGCTGTTAACTACCCGCTCCGA
GACGGGATTGATGACGAGTCCTATGAGGCCATTTTCAAGCCGGTCATGTCCAAAGTAATG
GAGATGTTCCAGCCTAGTGCGGTGGTCTTACAGTGTGGCTCAGACTCCCTATCTGGGGAT
CGGTTAGGTTGCTTCAATCTAACTATCAAAGGACACGCCAAGTGTGTGGAATTTGTCAAG
AGCTTTAACCTGCCTATGCTGATGCTGGGAGGCGGTGGTTACACCATTCGTAACGTTGCC
CGGTGCTGGACATATGAGACAGCTGTGGCCCTGGATACGGAGATCCCTAATGAGCTTCCA
TACAATGACTACTTTGAATACTTTGGACCAGATTTCAAGCTCCACATCAGTCCTTCCAAT
ATGACTAACCAGAACACGAATGAGTACCTGGAGAAGATCAAACAGCGACTGTTTGAGAAC
CTTAGAATGCTGCCGCACGCACCTGGGGTCCAAATGCAGGCGATTCCTGAGGACGCCATC
CCTGAGGAGAGTGGCGATGAGGACGAAGACGACCCTGACAAGCGCATCTCGATCTGCTCC
TCTGACAAACGAATTGCCTGTGAGGAAGAGTTCTCCGATTCTGAAGAGGAGGGAGAGGGG
GGCCGCAAGAACTCTTCCAACTTCAAAAAAGCCAAGAGAGTCAAAACAGAGGATGAAAAA
GAGAAAGACCCAGAGGAGAAGAAAGAAGTCACCGAAGAGGAGAAAACCAAGGAGGAGAAG
CCAGAAGCCAAAGGGGTCAAGGAGGAGGTCAAGTTGGCCTGA

## FIGURE 5

SEQ. ID No. 3

MGSMAYSQGGGKKKVCYYYDGDIGNYYYGQGHPMKPHRIRMTHNLLLNYGLYRKMEIYRP
HKATAEEMTKYHSDEYIKFLRSIRPDNMSEYSKQMQRFNVGEDCPVFDGLFEFCQLSTGG
SVAGAVKLNRQQTDMAVNWAGGLHHAKKSEASGFCYVNDIVLAILELLKYHQRVLYIDID
IHHGDGVEEAFYTTDRVMTVSFHKYGEYFPGTGDLRDIGAGKGKYYAVNFPMRDGIDDES
YGQIFKPIISKVMEMYQPSAVVLQCGADSLSGDRLGCFNLTVKGHAKCVEVVKTFNLPLL
MLGGGGYTIRNVARCWTYETAVALDCEIPNELPYNDYFEYFGPDFKLHISPSNMTNQNTP
EYMEKIKQRLFENLRMLPHAPGVQMQAIPEDAVHEDSGDEDGEDPDKRISIRASDKRIAC
DEEFSDSEDEGEGGRRNVADHKKGAKKARIEEDKKETEDKKTDVKEEDKSKDNSGEKTDT
KGTKSEQLSNPGHHHHHH

## FIGURE 6

SEQ. ID No. 4

ATGGGATCCATGGCGTACAGTCAAGGAGGCGGCAAAAAAAAAGTCTGCTACTACTACGAC
GGTGATATTGGAAATTATTATTATGGACAGGGTCATCCCATGAAGCCTCATAGAATCCGC
ATGACCCATAACTTGCTGTTAAATTATGGCTTATACAGAAAAATGGAAATATATAGGCCC
CATAAAGCCACTGCCGAAGAAATGACAAAATATCACAGTGATGAGTATATCAAATTTCTA
CGGTCAATAAGACCAGATAACATGTCTGAGTATAGTAAGCAGATGCAGAGATTTAATGTT
GGAGAAGATTGTCCAGTGTTTGATGGACTCTTTGAGTTTTGTCAGCTCTCAACTGGCGGT
TCAGTTGCTGGAGCTGTGAAGTTAAACCGACAACAGACTGATATGGCTGTTAATTGGGCT
GGAGGATTACATCATGCTAAGAAATCAGAAGCATCAGGATTCTGTTACGTTAATGATATT
GTGCTTGCCATCCTTGAATTACTAAAGTATCATCAGAGAGTCTTATATATTGATATAGAT
ATTCATCATGGTGATGGTGTTGAAGAAGCTTTTTATACAACAGATCGTGTAATGACGGTA
TCATTCCATAAATATGGGGAATACTTTCCTGGCACAGGAGACTTGAGGGATATTGGTGCT
GGAAAAGGCAAATACTATGCTGTCAATTTTCCAATGAGAGATGGTATAGATGATGAGTCA
TATGGGCAGATATTTAAGCCTATTATCTCAAAGGTGATGGAGATGTATCAACCTAGTGCT
GTGGTATTACAGTGTGGTGCAGACTCATTATCTGGTGATAGACTGGGTTGTTTCAATCTA
ACAGTCAAAGGTCATGCTAAATGTGTAGAAGTTGTAAAAACTTTTAACTTACCATTACTG
ATGCTTGGAGGAGGTGGCTACACAATCCGTAATGTTGCTCGATGTTGGACATATGAGACT
GCAGTTGCCCTTGATTGTGAGATTCCCAATGAGTTGCCATATAATGATTACTTTGAGTAT
TTTGGACCAGACTTCAAACTGCATATTAGTCCTTCAAACATGACAAACCAGAACACTCCA
GAATATATGGAAAAGATAAAACAGCGTTTGTTTGAAAATTTGCGCATGTTACCTCATGCA
CCTGGTGTCCAGATGCAAGCTATTCCAGAAGATGCTGTTCATGAAGACAGTGGAGATGAA
GATGGAGAAGATCCAGACAAGAGAATTTCTATTCGAGCATCAGACAAGCGGATAGCTTGT
GATGAAGAATTCTCAGATTCTGAGGATGAAGGAGAAGGAGGTCGAAGAAATGTGGCTGAT
CATAAGAAAGGAGCAAAGAAAGCTAGAATTGAAGAAGATAAGAAAGAAACAGAGGACAAA
AAAACAGACGTTAAGGAAGAAGATAAATCCAAGGACAACAGTGGTGAAAAAACAGATACC
AAAGGAACCAAATCAGAACAGCTCAGCAACCCCGGGCATCACCATCACCATCACTAA

## FIGURE 7

**SEQ. ID No. 5**

MPGMDLNLEAEALAGTGLVLDEQLNEFHCLWDDSFPEGPERLHAIKEQLIQEGLLDRCVS
FQARFAEKEELMLVHSLEYIDLMETTQYMNEGELRVLADTYDSVYLHPNSYSCACLASGS
VLRLVDAVLGAEIRNGMAIIRPPGHHAQHSLMDGYCMFNHVAVAARYAQQKHRIRRVLIV
DWDVHHGQGTQFTFDQDPSVLYFSIHRYEQGRFWPHLKASNWSTTGFGQGQGYTINVPWN
QVGMRDADYIAAFLHVLLPVALEFQPQLVLVAAGFDALQGDPKGEMAATPAGFAQLTHLL
MGLAGGKLILSLEGGYNLRALAEGVSASLHTLLGDPCPMLESPGAPCRSAQASVSCALEA
LEPFWEVLVRSTETVERDNMEEDNVEESEEEGPWEPPVLPILTWPVLQSRTGLVYDQNMM
NHCNLWDSHHPEVPQRILRIMCRLEELGLAGRCLTLTPRPATEAELLTCHSAEYVGHLRA
TEKMKTRELHRESSNFDSIYICPSTFACAQLATGAACRLVEAVLSGEVLNGAAVVRPPGH
HAEQDAACGFCFFNSVAVAARHAQTISGHALRILIVDWDVHHGNGTQHMFEDDPSVLYVS
LHRYDHGTFFPMGDEGASSQIGRAAGTGFTVNVAWNGPRMGDADYLAAWHRLVLPIAYEF
NPELVLVSAGFDAARGDPLGGCQVSPEGYAHLTHLLMGLASGRIILILEGGYNLTSISES
MAACTRSLLGDPPPLLTLPRPPLSGALASITETIQVHRRYWRSLRVMKVEDREGPGHHHH
HH

## FIGURE 9

**SEQ. ID No. 7**

MHHHHHHPMEEPEEPADSGQSLVPVYIYSPEYVSMCDSLAKIPKRASMVHSLIEAYALHK
QMRIVKPKVASMEEMAAFHTDAYLQHLQKVSQEGDDDHPDSIEYGLGYDCPATEGIFDYA
AAIGGATITAAQCLIDGMCKVAINWSGGWHHAKKDEASGFCYLNDAVLGILRLRRKFERI
LYVDLDLHHGDGVEDAFSFTSKVMTVSLHKFSPGFFPGTGDVSDVGLGKGRYYSVNVPIQ
DGIQDEKYYQICESVLKEVYQAFNPKAVVLQLGADTIAGDPMCSFNMTPVGIGKCLKYIL
QWQLATLILGGGGYNLANTARCWTYLTGVILGKTLSSEIPDHEFFTAYGPDYVLEITPSC
RPDRNEPHRIQQILNYIKGNLKHVV

# FIGURE 8

**SEQ. ID No. 6**

ATGCCCGGGATGGATCTGAACCTTGAGGCTGAAGCACTGGCTGGCACTGGCTTGGTGTTG
GATGAGCAGTTAAATGAATTCCATTGCCTCTGGGATGACAGCTTCCCGGAAGGCCCTGAG
CGGCTCCATGCCATCAAGGAGCAACTGATCCAGGAGGGCCTCCTAGATCGCTGCGTGTCC
TTTCAGGCCCGGTTTGCTGAAAAGGAAGAGCTGATGTTGGTTCACAGCCTAGAATATATT
GATCTGATGGAAACAACCCAGTACATGAATGAGGGAGAACTCCGTGTCCTAGCAGACACC
TACGACTCAGTTTATCTGCATCCGAACTCATACTCCTGTGCCTGCCTGGCCTCAGGCTCT
GTCCTCAGGCTGGTGGATGCGGTCCTGGGGGCTGAGATCCGGAATGGCATGGCCATCATT
AGGCCTCCTGGACATCACGCCCAGCACAGTCTTATGGATGGCTATTGCATGTTCAACCAC
GTGGCTGTGGCAGCCCGCTATGCTCAACAGAAACACCGCATCCGGAGGGTCCTTATCGTA
GATTGGGATGTGCACCACGGTCAAGGAACACAGTTCACCTTCGACCAGGACCCCAGTGTC
CTCTATTTCTCCATCCACCGCTACGAGCAGGGTAGGTTCTGGCCCCACCTGAAGGCCTCT
AACTGGTCCACCACAGGTTTCGGCCAAGGCCAAGGATATACCATCAATGTGCCTTGGAAC
CAGGTGGGGATGCGGGATGCTGACTACATTGCTGCTTTCCTGCACGTCCTGCTGCCAGTC
GCCCTCGAGTTCCAGCCTCAGCTGGTCCTGGTGGCTGCTGGATTTGATGCCCTGCAAGGG
GACCCCAAGGGTGAGATGGCCGCCACTCCGGCAGGGTTCGCCCAGCTAACCCACCTGCTC
ATGGGTCTGGCAGGAGGCAAGCTGATCCTGTCTCTGGAGGGTGGCTACAACCTCCGCGCC
CTGGCTGAAGGCGTCAGTGCTTCGCTCCACACCCTTCTGGGAGACCCTTGCCCCATGCTG
GAGTCACCTGGTGCCCCCTGCCGGAGTGCCCAGGCTTCAGTTTCCTGTGCTCTGGAAGCC
CTTGAGCCCTTCTGGGAGGTTCTTGTGAGATCAACTGAGACCGTGGAGAGGGACAACATG
GAGGAGGACAATGTAGAGGAGAGCGAGGAGGAAGGACCCTGGGAGCCCCCTGTGCTCCCA
ATCCTGACATGGCCAGTGCTACAGTCTCGCACAGGGCTGGTCTATGACCAAAATATGATG
AATCACTGCAACTTGTGGGACAGCCACCACCCTGAGGTACCCCAGCGCATCTTGCGGATC
ATGTGCCGTCTGGAGGAGCTGGGCCTTGCCGGGCGCTGCCTCACCCTGACACCGCGCCCT
GCCACAGAGGCTGAGCTGCTCACCTGTCACAGTGCTGAGTACGTGGGTCATCTCCGGGCC
ACAGAGAAAATGAAAACCCGGGAGCTGCACCGTGAGAGTTCCAACTTTGACTCCATCTAT
ATCTGCCCCAGTACCTTCGCCTGTGCACAGCTTGCCACTGGCGCTGCCTGCCGCCTGGTG
GAGGCTGTGCTCTCAGGAGAGGTTCTGAATGGTGCTGCTGTGGTGCGTCCCCCAGGACAC
CACGCAGAGCAGGATGCAGCTTGCGGTTTTTGCTTTTTCAACTCTGTGGCTGTGGCTGCT
CGCCATGCCCAGACTATCAGTGGGCATGCCCTACGGATCCTGATTGTGGATTGGGATGTC
CACCACGGTAATGGAACTCAGCACATGTTTGAGGATGACCCCAGTGTGCTATATGTGTCC
CTGCACCGCTATGATCATGGCACCTTCTTCCCCATGGGGGATGAGGGTGCCAGCAGCCAG
ATCGGCCGGGCTGCGGGCACAGGCTTCACCGTCAACGTGGCATGGAACGGGCCCCGCATG
GGTGATGCTGACTACCTAGCTGCCTGGCATCGCCTGGTGCTTCCCATTGCCTACGAGTTT
AACCCAGAACTGGTGCTGGTCTCAGCTGGCTTTGATGCTGCACGGGGGGATCCGCTGGGG
GGCTGCCAGGTGTCACCTGAGGGTTATGCCCACCTCACCCACCTGCTGATGGGCCTTGCC
AGTGGCCGCATTATCCTTATCCTAGAGGGTGGCTATAACCTGACATCCATCTCAGAGTCC
ATGGCTGCCTGCACTCGCTCCCTCCTTGGAGACCCACCACCCCTGCTGACCCTGCCACGG
CCCCCACTATCAGGGGCCCTGGCCTCAATCACTGAGACCATCCAAGTCCATCGCAGATAC
TGGCGCAGCTTACGGGTCATGAAGGTAGAAGACAGAGAAGGACCCGGGCATCACCATCAC
CATCACTAA

# FIGURE 10

**SEQ. ID No. 8**

ATGCACCATCACCATCACCATCCCATGGAGGAGCCGGAGGAACCGGCGGACAGTGGGCAG
TCGCTGGTCCCGGTTTATATCTATAGTCCCGAGTATGTCAGTATGTGTGACTCCCTGGCC
AAGATCCCCAAACGGGCCAGTATGGTGCATTCTTTGATTGAAGCATATGCACTGCATAAG
CAGATGAGGATAGTTAAGCCTAAAGTGGCCTCCATGGAGGAGATGGCCGCCTTCCACACT
GATGCTTATCTGCAGCATCTCCAGAAGGTCAGCCAAGAGGGCGATGATGATCATCCGGAC
TCCATAGAATATGGGCTAGGTTATGACTGCCCAGCCACTGAAGGGATATTTGACTATGCA
GCAGCTATAGGAGGGGCTACGATCACAGCTGCCCAATGCCTGATTGACGGAATGTGCAAA
GTAGCAATTAACTGGTCTGGAGGGTGGCATCATGCAAAGAAAGATGAAGCATCTGGTTTT
TGTTATCTCAATGATGCTGTCCTGGGAATATTACGATTGCGACGGAAATTTGAGCGTATT
CTCTACGTGGATTTGGATCTGCACCATGGAGATGGTGTAGAAGACGCATTCAGTTTCACC
TCCAAAGTCATGACCGTGTCCCTGCACAAATTCTCCCCAGGATTTTTCCCAGGAACAGGT
GACGTGTCTGATGTTGGCCTAGGGAAGGGACGGTACTACAGTGTAAATGTGCCCATTCAG
GATGGCATACAAGATGAAAAATATTACCAGATCTGTGAAAGTGTACTAAAGGAAGTATAC
CAAGCCTTTAATCCCAAAGCAGTGGTCTTACAGCTGGGAGCTGACACAATAGCTGGGGAT
CCCATGTGCTCCTTTAACATGACTCCAGTGGGAATTGGCAAGTGTCTTAAGTACATCCTT
CAATGGCAGTTGGCAACACTCATTTTGGGAGGAGGAGGCTATAACCTTGCCAACACGGCT
CGATGCTGGACATACTTGACCGGGGTCATCCTAGGGAAAACACTATCCTCTGAGATCCCA
GATCATGAGTTTTTCACAGCATATGGTCCTGATTATGTGCTGGAAATCACGCCAAGCTGC
CGGCCAGACCGCAATGAGCCCCACCGAATCCAACAAATCCTCAACTACATCAAAGGGAAT
CTGAAGCATGTGGTCTAG

HDAC5006-PCT SEQ LISTING.ST25
SEQUENCE LISTING

<110> Syrrx, Inc.

<120> HISTONE DEACETYLASE INHIBITORS

<130> HDAC5006-PCT

<150> US 60/531,371
<151> 2003-12-19

<160> 8

<170> PatentIn version 3.1

<210> 1
<211> 513
<212> PRT
<213> Homo sapiens

<220>
<221> misc_feature
<223> Amino acid sequence for residues 1-482 of HDAC1 and a 6-histidine tag at the N-terminus

<400> 1

Met Ser Tyr Tyr His His His His His His Asp Tyr Asp Ile Pro Thr
1 5 10 15

Thr Glu Asn Leu Tyr Phe Gln Gly Ala Met Glu Pro Gly Gly Ser Met
20 25 30

Ala Gln Thr Gln Gly Thr Arg Arg Lys Val Cys Tyr Tyr Tyr Asp Gly
35 40 45

Asp Val Gly Asn Tyr Tyr Tyr Gly Gln Gly His Pro Met Lys Pro His
50 55 60

Arg Ile Arg Met Thr His Asn Leu Leu Leu Asn Tyr Gly Leu Tyr Arg
65 70 75 80

Lys Met Glu Ile Tyr Arg Pro His Lys Ala Asn Ala Glu Glu Met Thr
85 90 95

Lys Tyr His Ser Asp Asp Tyr Ile Lys Phe Leu Arg Ser Ile Arg Pro
100 105 110

Asp Asn Met Ser Glu Tyr Ser Lys Gln Met Gln Arg Phe Asn Val Gly
115 120 125

Glu Asp Cys Pro Val Phe Asp Gly Leu Phe Glu Phe Cys Gln Leu Ser
130 135 140

Thr Gly Gly Ser Val Ala Ser Ala Val Lys Leu Asn Lys Gln Gln Thr
145 150 155 160

Asp Ile Ala Val Asn Trp Ala Gly Gly Leu His His Ala Lys Lys Ser
165 170 175

Glu Ala Ser Gly Phe Cys Tyr Val Asn Asp Ile Val Leu Ala Ile Leu
180 185 190

Glu Leu Leu Lys Tyr His Gln Arg Val Leu Tyr Ile Asp Ile Asp Ile
195 200 205

His His Gly Asp Gly Val Glu Glu Ala Phe Tyr Thr Thr Asp Arg Val
210 215 220

Met Thr Val Ser Phe His Lys Tyr Gly Glu Tyr Phe Pro Gly Thr Gly
225 230 235 240

Asp Leu Arg Asp Ile Gly Ala Gly Lys Gly Lys Tyr Tyr Ala Val Asn
245 250 255

Tyr Pro Leu Arg Asp Gly Ile Asp Asp Glu Ser Tyr Glu Ala Ile Phe
260 265 270

Lys Pro Val Met Ser Lys Val Met Glu Met Phe Gln Pro Ser Ala Val
275 280 285

Val Leu Gln Cys Gly Ser Asp Ser Leu Ser Gly Asp Arg Leu Gly Cys
290 295 300

Phe Asn Leu Thr Ile Lys Gly His Ala Lys Cys Val Glu Phe Val Lys
305 310 315 320

Ser Phe Asn Leu Pro Met Leu Met Leu Gly Gly Gly Gly Tyr Thr Ile
325 330 335

Arg Asn Val Ala Arg Cys Trp Thr Tyr Glu Thr Ala Val Ala Leu Asp
340 345 350

Thr Glu Ile Pro Asn Glu Leu Pro Tyr Asn Asp Tyr Phe Glu Tyr Phe
355 360 365

Gly Pro Asp Phe Lys Leu His Ile Ser Pro Ser Asn Met Thr Asn Gln
370 375 380

Asn Thr Asn Glu Tyr Leu Glu Lys Ile Lys Gln Arg Leu Phe Glu Asn
385 390 395 400

Leu Arg Met Leu Pro His Ala Pro Gly Val Gln Met Gln Ala Ile Pro
405 410 415

Glu Asp Ala Ile Pro Glu Glu Ser Gly Asp Glu Asp Glu Asp Asp Pro
420 425 430

Asp Lys Arg Ile Ser Ile Cys Ser Ser Asp Lys Arg Ile Ala Cys Glu
435 440 445

Glu Glu Phe Ser Asp Ser Glu Glu Glu Gly Glu Gly Gly Arg Lys Asn
450 455 460

Ser Ser Asn Phe Lys Lys Ala Lys Arg Val Lys Thr Glu Asp Glu Lys
465 470 475 480

Glu Lys Asp Pro Glu Glu Lys Lys Glu Val Thr Glu Glu Glu Lys Thr
485 490 495

Lys Glu Glu Lys Pro Glu Ala Lys Gly Val Lys Glu Glu Val Lys Leu
500 505 510

Ala

<210> 2
<211> 1542
<212> DNA
<213> Homo sapiens

<220>
<221> misc_feature
<223> DNA sequence used to encode residues 1-482 of HDAC1 and a 6-histidine tag at the N-terminus

<400> 2
atgtcgtact accatcacca tcaccatcac gattacgata tcccaacgac cgaaaacctg 60

tattttcagg gcgccatgga acccggggga tccatggcgc agacgcaggg cacccggagg 120

aaagtctgtt actactacga cggggatgtt ggaaattact attatggaca aggccaccca 180

atgaagcctc accgaatccg catgactcat aatttgctgc tcaactatgg tctctaccga 240

aaaatggaaa tctatcgccc tcacaaagcc aatgctgagg agatgaccaa gtaccacagc 300

gatgactaca ttaaattctt gcgctccatc cgtccagata acatgtcgga gtacagcaag 360

cagatgcaga gattcaacgt tggtgaggac tgtccagtat tcgatggcct gtttgagttc 420

tgtcagttgt ctactggtgg ttctgtggca agtgctgtga aacttaataa gcagcagacg 480

gacatcgctg tgaattgggc tgggggcctg caccatgcaa agaagtccga ggcatctggc 540

ttctgttacg tcaatgatat cgtcttggcc atcctggaac tgctaaagta tcaccagagg 600

gtgctgtaca ttgacattga tattcaccat ggtgacggcg tggaagaggc cttctacacc 660

acggaccggg tcatgactgt gtcctttcat aagtatggag agtacttccc aggaactggg 720

gacctacggg atatcggggc tggcaaaggc aagtattatg ctgttaacta cccgctccga 780

gacgggattg atgacgagtc ctatgaggcc attttcaagc cggtcatgtc caaagtaatg 840

gagatgttcc agcctagtgc ggtggtctta cagtgtggct cagactccct atctggggat 900

cggttaggtt gcttcaatct aactatcaaa ggacacgcca agtgtgtgga atttgtcaag 960

agctttaacc tgcctatgct gatgctggga ggcggtggtt acaccattcg taacgttgcc 1020

cggtgctgga catatgagac agctgtggcc ctggatacgg agatccctaa tgagcttcca 1080

tacaatgact actttgaata ctttggacca gatttcaagc tccacatcag tccttccaat 1140

atgactaacc agaacacgaa tgagtacctg gagaagatca aacagcgact gtttgagaac 1200

cttagaatgc tgccgcacgc acctggggtc caaatgcagg cgattcctga ggacgccatc 1260

cctgaggaga gtggcgatga ggacgaagac gaccctgaca agcgcatctc gatctgctcc 1320

tctgacaaac gaattgcctg tgaggaagag ttctccgatt ctgaagagga gggagagggg 1380

ggccgcaaga actcttccaa cttcaaaaaa gccaagagag tcaaaacaga ggatgaaaaa 1440

gagaaagacc cagaggagaa gaaagaagtc accgaagagg agaaaaccaa ggaggagaag 1500

ccagaagcca aaggggtcaa ggaggaggtc aagttggcct ga 1542

<210> 3
<211> 498
<212> PRT
<213> Homo sapiens

<220>
<221> misc_feature
<223> Amino acid sequence for residues 1-488 of HDAC2 and a 6-histidine tag at the C-terminus

<400> 3

Met Gly Ser Met Ala Tyr Ser Gln Gly Gly Gly Lys Lys Lys Val Cys
1 5 10 15

Tyr Tyr Tyr Asp Gly Asp Ile Gly Asn Tyr Tyr Tyr Gly Gln Gly His
20 25 30

Pro Met Lys Pro His Arg Ile Arg Met Thr His Asn Leu Leu Leu Asn
35 40 45

Tyr Gly Leu Tyr Arg Lys Met Glu Ile Tyr Arg Pro His Lys Ala Thr
50 55 60

Ala Glu Glu Met Thr Lys Tyr His Ser Asp Glu Tyr Ile Lys Phe Leu
65 70 75 80

Arg Ser Ile Arg Pro Asp Asn Met Ser Glu Tyr Ser Lys Gln Met Gln
85 90 95

Arg Phe Asn Val Gly Glu Asp Cys Pro Val Phe Asp Gly Leu Phe Glu
100 105 110

Phe Cys Gln Leu Ser Thr Gly Gly Ser Val Ala Gly Ala Val Lys Leu
115 120 125

Asn Arg Gln Gln Thr Asp Met Ala Val Asn Trp Ala Gly Gly Leu His
130 135 140

His Ala Lys Lys Ser Glu Ala Ser Gly Phe Cys Tyr Val Asn Asp Ile
145 150 155 160

Val Leu Ala Ile Leu Glu Leu Leu Lys Tyr His Gln Arg Val Leu Tyr
165 170 175

Ile Asp Ile Asp Ile His His Gly Asp Gly Val Glu Glu Ala Phe Tyr
180 185 190

Thr Thr Asp Arg Val Met Thr Val Ser Phe His Lys Tyr Gly Glu Tyr
195 200 205

Phe Pro Gly Thr Gly Asp Leu Arg Asp Ile Gly Ala Gly Lys Gly Lys
210 215 220

Tyr Tyr Ala Val Asn Phe Pro Met Arg Asp Gly Ile Asp Asp Glu Ser
225 230 235 240

Tyr Gly Gln Ile Phe Lys Pro Ile Ile Ser Lys Val Met Glu Met Tyr
245 250 255

Gln Pro Ser Ala Val Val Leu Gln Cys Gly Ala Asp Ser Leu Ser Gly
260 265 270

Asp Arg Leu Gly Cys Phe Asn Leu Thr Val Lys Gly His Ala Lys Cys
275 280 285

Val Glu Val Val Lys Thr Phe Asn Leu Pro Leu Leu Met Leu Gly Gly
290 295 300

Gly Gly Tyr Thr Ile Arg Asn Val Ala Arg Cys Trp Thr Tyr Glu Thr
305 310 315 320

Ala Val Ala Leu Asp Cys Glu Ile Pro Asn Glu Leu Pro Tyr Asn Asp
325 330 335

Tyr Phe Glu Tyr Phe Gly Pro Asp Phe Lys Leu His Ile Ser Pro Ser
340 345 350

Asn Met Thr Asn Gln Asn Thr Pro Glu Tyr Met Glu Lys Ile Lys Gln
355 360 365

Arg Leu Phe Glu Asn Leu Arg Met Leu Pro His Ala Pro Gly Val Gln
370 375 380

Met Gln Ala Ile Pro Glu Asp Ala Val His Glu Asp Ser Gly Asp Glu
385 390 395 400

Asp Gly Glu Asp Pro Asp Lys Arg Ile Ser Ile Arg Ala Ser Asp Lys
405 410 415

Arg Ile Ala Cys Asp Glu Glu Phe Ser Asp Ser Glu Asp Glu Gly Glu
420 425 430

Gly Gly Arg Arg Asn Val Ala Asp His Lys Lys Gly Ala Lys Lys Ala
435 440 445

Arg Ile Glu Glu Asp Lys Lys Glu Thr Glu Asp Lys Lys Thr Asp Val
450 455 460

Lys Glu Glu Asp Lys Ser Lys Asp Asn Ser Gly Glu Lys Thr Asp Thr
465 470 475 480

Lys Gly Thr Lys Ser Glu Gln Leu Ser Asn Pro Gly His His His His
485 490 495

His His

<210> 4
<211> 1497
<212> DNA
<213> Homo sapiens

<220>
<221> misc_feature
<223> DNA sequence used to encode residues 1-488 of HDAC2 and a 6-histidine tag at the C-terminus

<400> 4
atgggatcca tggcgtacag tcaaggaggc ggcaaaaaaa aagtctgcta ctactacgac 60

ggtgatattg gaaattatta ttatggacag ggtcatccca tgaagcctca tagaatccgc 120

atgacccata acttgctgtt aaattatggc ttatacagaa aaatggaaat atataggccc 180

cataaagcca ctgccgaaga aatgacaaaa tatcacagtg atgagtatat caaatttcta 240

cggtcaataa gaccagataa catgtctgag tatagtaagc agatgcagag atttaatgtt 300

ggagaagatt gtccagtgtt tgatggactc tttgagtttt gtcagctctc aactggcggt 360

tcagttgctg gagctgtgaa gttaaaccga caacagactg atatggctgt taattgggct 420

ggaggattac atcatgctaa gaaatcagaa gcatcaggat tctgttacgt taatgatatt 480

gtgcttgcca tccttgaatt actaaagtat catcagagag tcttatatat tgatatagat 540

attcatcatg gtgatggtgt tgaagaagct ttttatacaa cagatcgtgt aatgacggta 600

tcattccata aatatgggga atactttcct ggcacaggag acttgaggga tattggtgct 660

ggaaaaggca aatactatgc tgtcaatttt ccaatgagag atggtataga tgatgagtca 720

tatgggcaga tatttaagcc tattatctca aaggtgatgg agatgtatca acctagtgct 780

gtggtattac agtgtggtgc agactcatta tctggtgata gactgggttg tttcaatcta 840

acagtcaaag gtcatgctaa atgtgtagaa gttgtaaaaa cttttaactt accattactg 900

atgcttggag gaggtggcta cacaatccgt aatgttgctc gatgttggac atatgagact 960

gcagttgccc ttgattgtga gattcccaat gagttgccat ataatgatta ctttgagtat 1020

tttggaccag acttcaaact gcatattagt ccttcaaaca tgacaaacca gaacactcca 1080

gaatatatgg aaaagataaa acagcgtttg tttgaaaatt tgcgcatgtt acctcatgca 1140

cctggtgtcc agatgcaagc tattccagaa gatgctgttc atgaagacag tggagatgaa 1200

gatggagaag atccagacaa gagaatttct attcgagcat cagacaagcg gatagcttgt 1260

gatgaagaat tctcagattc tgaggatgaa ggagaaggag gtcgaagaaa tgtggctgat 1320

cataagaaag gagcaaagaa agctagaatt gaagaagata agaaagaaac agaggacaaa 1380

aaaacagacg ttaaggaaga agataaatcc aaggacaaca gtggtgaaaa aacagatacc 1440

aaaggaacca aatcagaaca gctcagcaac cccgggcatc accatcacca tcactaa 1497

<210> 5
<211> 782
<212> PRT
<213> Homo sapiens

<220>
<221> misc_feature
<223> Amino acid sequence for residues 73-845 of HDAC6 and a 6-histidine tag at the C-terminus

<400> 5

Met Pro Gly Met Asp Leu Asn Leu Glu Ala Glu Ala Leu Ala Gly Thr
1 5 10 15

Gly Leu Val Leu Asp Glu Gln Leu Asn Glu Phe His Cys Leu Trp Asp
20 25 30

Asp Ser Phe Pro Glu Gly Pro Glu Arg Leu His Ala Ile Lys Glu Gln
35 40 45

Leu Ile Gln Glu Gly Leu Leu Asp Arg Cys Val Ser Phe Gln Ala Arg
50 55 60

Phe Ala Glu Lys Glu Glu Leu Met Leu Val His Ser Leu Glu Tyr Ile
65 70 75 80

Asp Leu Met Glu Thr Thr Gln Tyr Met Asn Glu Gly Glu Leu Arg Val
85 90 95

Leu Ala Asp Thr Tyr Asp Ser Val Tyr Leu His Pro Asn Ser Tyr Ser
100 105 110

Cys Ala Cys Leu Ala Ser Gly Ser Val Leu Arg Leu Val Asp Ala Val
115 120 125

Leu Gly Ala Glu Ile Arg Asn Gly Met Ala Ile Ile Arg Pro Pro Gly
130 135 140

His His Ala Gln His Ser Leu Met Asp Gly Tyr Cys Met Phe Asn His
145 150 155 160

Val Ala Val Ala Ala Arg Tyr Ala Gln Gln Lys His Arg Ile Arg Arg
165 170 175

Val Leu Ile Val Asp Trp Asp Val His His Gly Gln Gly Thr Gln Phe
180 185 190

Thr Phe Asp Gln Asp Pro Ser Val Leu Tyr Phe Ser Ile His Arg Tyr
195 200 205

Glu Gln Gly Arg Phe Trp Pro His Leu Lys Ala Ser Asn Trp Ser Thr
210 215 220

Thr Gly Phe Gly Gln Gly Gln Gly Tyr Thr Ile Asn Val Pro Trp Asn
225 230 235 240

Gln Val Gly Met Arg Asp Ala Asp Tyr Ile Ala Ala Phe Leu His Val
245 250 255

Leu Leu Pro Val Ala Leu Glu Phe Gln Pro Gln Leu Val Leu Val Ala
260 265 270

Ala Gly Phe Asp Ala Leu Gln Gly Asp Pro Lys Gly Glu Met Ala Ala
275 280 285

Thr Pro Ala Gly Phe Ala Gln Leu Thr His Leu Leu Met Gly Leu Ala
290 295 300

Gly Gly Lys Leu Ile Leu Ser Leu Glu Gly Gly Tyr Asn Leu Arg Ala
305 310 315 320

Leu Ala Glu Gly Val Ser Ala Ser Leu His Thr Leu Leu Gly Asp Pro
325 330 335

Cys Pro Met Leu Glu Ser Pro Gly Ala Pro Cys Arg Ser Ala Gln Ala
340 345 350

Ser Val Ser Cys Ala Leu Glu Ala Leu Glu Pro Phe Trp Glu Val Leu
355 360 365

Val Arg Ser Thr Glu Thr Val Glu Arg Asp Asn Met Glu Glu Asp Asn
370 375 380

Val Glu Glu Ser Glu Glu Glu Gly Pro Trp Glu Pro Pro Val Leu Pro
385 390 395 400

Ile Leu Thr Trp Pro Val Leu Gln Ser Arg Thr Gly Leu Val Tyr Asp
405 410 415

Gln Asn Met Met Asn His Cys Asn Leu Trp Asp Ser His His Pro Glu
420 425 430

Val Pro Gln Arg Ile Leu Arg Ile Met Cys Arg Leu Glu Glu Leu Gly
435 440 445

Leu Ala Gly Arg Cys Leu Thr Leu Thr Pro Arg Pro Ala Thr Glu Ala
450 455 460

Glu Leu Leu Thr Cys His Ser Ala Glu Tyr Val Gly His Leu Arg Ala
465 470 475 480

Thr Glu Lys Met Lys Thr Arg Glu Leu His Arg Glu Ser Ser Asn Phe
485 490 495

Asp Ser Ile Tyr Ile Cys Pro Ser Thr Phe Ala Cys Ala Gln Leu Ala
500 505 510

Thr Gly Ala Ala Cys Arg Leu Val Glu Ala Val Leu Ser Gly Glu Val
515 520 525

Leu Asn Gly Ala Ala Val Val Arg Pro Pro Gly His His Ala Glu Gln
530 535 540

Asp Ala Ala Cys Gly Phe Cys Phe Phe Asn Ser Val Ala Val Ala Ala
545 550 555 560

Arg His Ala Gln Thr Ile Ser Gly His Ala Leu Arg Ile Leu Ile Val
565 570 575

Asp Trp Asp Val His His Gly Asn Gly Thr Gln His Met Phe Glu Asp
580 585 590

Asp Pro Ser Val Leu Tyr Val Ser Leu His Arg Tyr Asp His Gly Thr
595 600 605

Phe Phe Pro Met Gly Asp Glu Gly Ala Ser Ser Gln Ile Gly Arg Ala
610 615 620

Ala Gly Thr Gly Phe Thr Val Asn Val Ala Trp Asn Gly Pro Arg Met
625 630 635 640

Gly Asp Ala Asp Tyr Leu Ala Ala Trp His Arg Leu Val Leu Pro Ile
645 650 655

Ala Tyr Glu Phe Asn Pro Glu Leu Val Leu Val Ser Ala Gly Phe Asp
660 665 670

Ala Ala Arg Gly Asp Pro Leu Gly Gly Cys Gln Val Ser Pro Glu Gly
675 680 685

Tyr Ala His Leu Thr His Leu Leu Met Gly Leu Ala Ser Gly Arg Ile
690 695 700

Ile Leu Ile Leu Glu Gly Gly Tyr Asn Leu Thr Ser Ile Ser Glu Ser
705 710 715 720

Met Ala Ala Cys Thr Arg Ser Leu Leu Gly Asp Pro Pro Pro Leu Leu
725 730 735

Thr Leu Pro Arg Pro Pro Leu Ser Gly Ala Leu Ala Ser Ile Thr Glu
740 745 750

Thr Ile Gln Val His Arg Arg Tyr Trp Arg Ser Leu Arg Val Met Lys
755 760 765

Val Glu Asp Arg Glu Gly Pro Gly His His His His His His
770 775 780

<210> 6
<211> 2349
<212> DNA
<213> Homo sapiens

<220>
<221> misc_feature
<223> DNA sequence used to encode residues 73-845 of HDAC6 and a 6-histidine tag at the C-terminus

<400> 6
atgcccggga tggatctgaa ccttgaggct gaagcactgg ctggcactgg cttggtgttg 60

gatgagcagt taaatgaatt ccattgcctc tgggatgaca gcttcccgga aggccctgag 120

cggctccatg ccatcaagga gcaactgatc caggagggcc tcctagatcg ctgcgtgtcc 180

tttcaggccc ggtttgctga aaaggaagag ctgatgttgg ttcacagcct agaatatatt 240

gatctgatgg aaacaaccca gtacatgaat gagggagaac tccgtgtcct agcagacacc 300

tacgactcag tttatctgca tccgaactca tactcctgtg cctgcctggc ctcaggctct 360

gtcctcaggc tggtggatgc ggtcctgggg gctgagatcc ggaatggcat ggccatcatt 420

aggcctcctg gacatcacgc ccagcacagt cttatggatg gctattgcat gttcaaccac 480

gtggctgtgg cagcccgcta tgctcaacag aaacaccgca tccggagggt ccttatcgta 540

gattgggatg tgcaccacgg tcaaggaaca cagttcacct tcgaccagga ccccagtgtc 600

ctctatttct ccatccaccg ctacgagcag ggtaggttct ggccccacct gaaggcctct 660

aactggtcca ccacaggttt cggccaaggc caaggatata ccatcaatgt gccttggaac 720

caggtgggga tgcgggatgc tgactacatt gctgctttcc tgcacgtcct gctgccagtc 780

gccctcgagt tccagcctca gctggtcctg gtggctgctg gatttgatgc cctgcaaggg 840

gaccccaagg gtgagatggc cgccactccg gcagggttcg cccagctaac ccacctgctc 900

atgggtctgg caggaggcaa gctgatcctg tctctggagg gtggctacaa cctccgcgcc 960

ctggctgaag gcgtcagtgc ttcgctccac acccttctgg gagacccttg ccccatgctg 1020

gagtcacctg gtgccccctg ccggagtgcc caggcttcag tttcctgtgc tctggaagcc 1080

cttgagccct tctgggaggt tcttgtgaga tcaactgaga ccgtggagag ggacaacatg 1140

gaggaggaca atgtagagga gagcgaggag gaaggaccct gggagccccc tgtgctccca 1200

atcctgacat ggccagtgct acagtctcgc acagggctgg tctatgacca aaatatgatg 1260

aatcactgca acttgtggga cagccaccac cctgaggtac cccagcgcat cttgcggatc 1320

atgtgccgtc tggaggagct gggccttgcc gggcgctgcc tcaccctgac accgcgccct 1380

gccacagagg ctgagctgct cacctgtcac agtgctgagt acgtgggtca tctccgggcc 1440

acagagaaaa tgaaaacccg ggagctgcac cgtgagagtt ccaactttga ctccatctat 1500

atctgcccca gtaccttcgc ctgtgcacag cttgccactg gcgctgcctg ccgcctggtg 1560

gaggctgtgc tctcaggaga ggttctgaat ggtgctgctg tggtgcgtcc cccaggacac 1620

cacgcagagc aggatgcagc ttgcggtttt tgctttttca actctgtggc tgtggctgct 1680

cgccatgccc agactatcag tgggcatgcc ctacggatcc tgattgtgga ttgggatgtc 1740

caccacggta atggaactca gcacatgttt gaggatgacc ccagtgtgct atatgtgtcc 1800

ctgcaccgct atgatcatgg caccttcttc cccatggggg atgagggtgc cagcagccag 1860

atcggccggg ctgcgggcac aggcttcacc gtcaacgtgg catggaacgg gccccgcatg 1920

ggtgatgctg actacctagc tgcctggcat cgcctggtgc ttcccattgc ctacgagttt 1980

aacccagaac tggtgctggt ctcagctggc tttgatgctg cacgggggga tccgctgggg 2040

ggctgccagg tgtcacctga gggttatgcc cacctcaccc acctgctgat gggccttgcc 2100

agtggccgca ttatccttat cctagagggt ggctataacc tgacatccat ctcagagtcc 2160

atggctgcct gcactcgctc cctccttgga gacccaccac ccctgctgac cctgccacgg 2220

cccccactat caggggccct ggcctcaatc actgagacca tccaagtcca tcgcagatac 2280

tggcgcagct tacgggtcat gaaggtagaa gacagagaag gacccgggca tcaccatcac 2340

catcactaa 2349

<210> 7
<211> 385
<212> PRT
<213> Homo sapiens

<220>
<221> misc_feature
<223> Amno acid sequence for residues 1-377 of HDAC8 and a 6-histidine tag at the N-terminus

<400> 7

Met His His His His His His Pro Met Glu Glu Pro Glu Glu Pro Ala
1 5 10 15

```
Asp Ser Gly Gln Ser Leu Val Pro Val Tyr Ile Tyr Ser Pro Glu Tyr
            20                  25                  30

Val Ser Met Cys Asp Ser Leu Ala Lys Ile Pro Lys Arg Ala Ser Met
        35                  40                  45

Val His Ser Leu Ile Glu Ala Tyr Ala Leu His Lys Gln Met Arg Ile
    50                  55                  60

Val Lys Pro Lys Val Ala Ser Met Glu Glu Met Ala Ala Phe His Thr
65                  70                  75                  80

Asp Ala Tyr Leu Gln His Leu Gln Lys Val Ser Gln Glu Gly Asp Asp
                85                  90                  95

Asp His Pro Asp Ser Ile Glu Tyr Gly Leu Gly Tyr Asp Cys Pro Ala
            100                 105                 110

Thr Glu Gly Ile Phe Asp Tyr Ala Ala Ala Ile Gly Gly Ala Thr Ile
        115                 120                 125

Thr Ala Ala Gln Cys Leu Ile Asp Gly Met Cys Lys Val Ala Ile Asn
    130                 135                 140

Trp Ser Gly Gly Trp His His Ala Lys Lys Asp Glu Ala Ser Gly Phe
145                 150                 155                 160

Cys Tyr Leu Asn Asp Ala Val Leu Gly Ile Leu Arg Leu Arg Arg Lys
                165                 170                 175

Phe Glu Arg Ile Leu Tyr Val Asp Leu Asp Leu His His Gly Asp Gly
            180                 185                 190

Val Glu Asp Ala Phe Ser Phe Thr Ser Lys Val Met Thr Val Ser Leu
        195                 200                 205

His Lys Phe Ser Pro Gly Phe Phe Pro Gly Thr Gly Asp Val Ser Asp
    210                 215                 220

Val Gly Leu Gly Lys Gly Arg Tyr Tyr Ser Val Asn Val Pro Ile Gln
225                 230                 235                 240

Asp Gly Ile Gln Asp Glu Lys Tyr Tyr Gln Ile Cys Glu Ser Val Leu
                245                 250                 255

Lys Glu Val Tyr Gln Ala Phe Asn Pro Lys Ala Val Val Leu Gln Leu
            260                 265                 270

Gly Ala Asp Thr Ile Ala Gly Asp Pro Met Cys Ser Phe Asn Met Thr
        275                 280                 285
```

Pro Val Gly Ile Gly Lys Cys Leu Lys Tyr Ile Leu Gln Trp Gln Leu
290 295 300

Ala Thr Leu Ile Leu Gly Gly Gly Gly Tyr Asn Leu Ala Asn Thr Ala
305 310 315 320

Arg Cys Trp Thr Tyr Leu Thr Gly Val Ile Leu Gly Lys Thr Leu Ser
325 330 335

Ser Glu Ile Pro Asp His Glu Phe Phe Thr Ala Tyr Gly Pro Asp Tyr
340 345 350

Val Leu Glu Ile Thr Pro Ser Cys Arg Pro Asp Arg Asn Glu Pro His
355 360 365

Arg Ile Gln Gln Ile Leu Asn Tyr Ile Lys Gly Asn Leu Lys His Val
370 375 380

Val
385

<210> 8
<211> 1158
<212> DNA
<213> Homo sapiens

<220>
<221> misc_feature
<223> DNA sequence used to encode residues 1-377 of HDAC8 and a 6-histidine tag at the N-terminus

<400> 8
atgcaccatc accatcacca tcccatggag gagccggagg aaccggcgga cagtgggcag 60

tcgctggtcc cggtttatat ctatagtccc gagtatgtca gtatgtgtga ctccctggcc 120

aagatcccca aacgggccag tatggtgcat tctttgattg aagcatatgc actgcataag 180

cagatgagga tagttaagcc taaagtggcc tccatggagg agatggccgc cttccacact 240

gatgcttatc tgcagcatct ccagaaggtc agccaagagg gcgatgatga tcatccggac 300

tccatagaat atgggctagg ttatgactgc ccagccactg aagggatatt tgactatgca 360

gcagctatag gaggggctac gatcacagct gcccaatgcc tgattgacgg aatgtgcaaa 420

gtagcaatta actggtctgg agggtggcat catgcaaaga aagatgaagc atctggtttt 480

tgttatctca atgatgctgt cctgggaata ttacgattgc gacggaaatt tgagcgtatt 540

ctctacgtgg atttggatct gcaccatgga gatggtgtag aagacgcatt cagtttcacc 600

tccaaagtca tgaccgtgtc cctgcacaaa ttctccccag gatttttccc aggaacaggt 660

gacgtgtctg atgttggcct agggaaggga cggtactaca gtgtaaatgt gcccattcag 720

gatggcatac aagatgaaaa atattaccag atctgtgaaa gtgtactaaa ggaagtatac 780

caagccttta atcccaaagc agtggtctta cagctgggag ctgacacaat agctggggat 840

cccatgtgct cctttaacat gactccagtg ggaattggca agtgtcttaa gtacatcctt 900

caatggcagt tggcaacact cattttggga ggaggaggct ataaccttgc caacacggct 960

cgatgctgga catacttgac cggggtcatc ctagggaaaa cactatcctc tgagatccca 1020

gatcatgagt ttttcacagc atatggtcct gattatgtgc tggaaatcac gccaagctgc 1080

cggccagacc gcaatgagcc ccaccgaatc caacaaatcc tcaactacat caaagggaat 1140

ctgaagcatg tggtctag 1158