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(54) Title: TREATING A VIRAL DISORDER

(57) **Abrégé/Abstract:**

Heterocyclic compounds of formula (I) and methods of treating or preventing an HIV-mediated disorder by administering a compound of formula (I) are described herein.



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(54) Title: TREATING A VIRAL DISORDER

(57) Abstract: Heterocyclic compounds of formula (I) and methods of treating or preventing an HIV-mediated disorder by administering a compound of formula (I) are described herein.

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Treating a Viral Disorder

CLAIM OF PRIORITY

This application claims priority under 35 USC §119(e) to U.S. Patent Application Serial No. 60/540,429, filed on January 29, 2004 and to U.S. Patent Application Serial No. 60/560,484, filed on April 7, 2004, the entire contents of each of which are hereby
5 incorporated by reference.

BACKGROUND

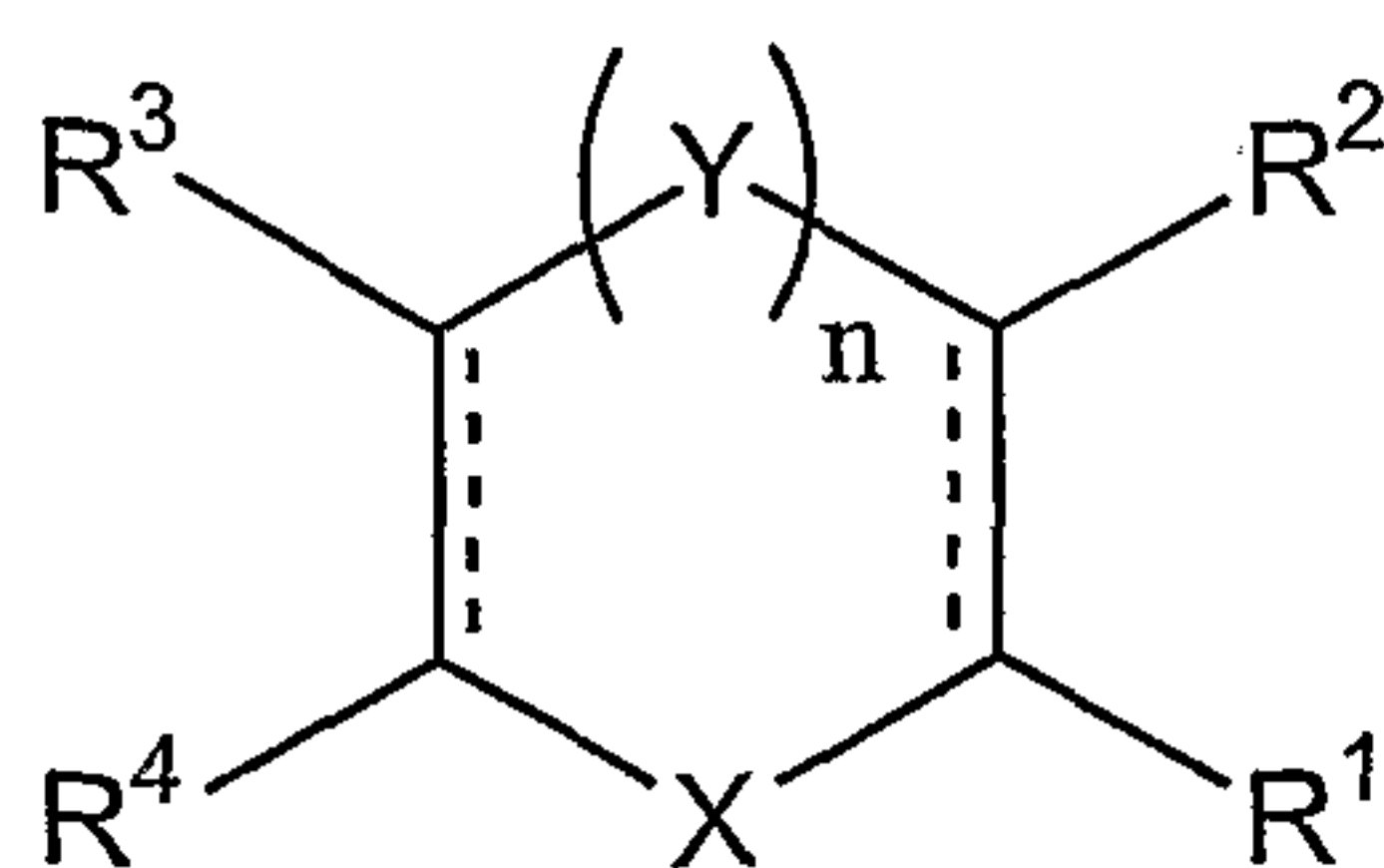
The Sir2 protein is a deacetylase which uses NAD as a cofactor (Imai *et al.*, 2000; Moazed, 2001; Smith *et al.*, 2000; Tanner *et al.*, 2000; Tanny and Moazed, 2001). Unlike other deacetylases, many of which are involved in gene silencing, Sir2 is
10 insensitive to histone deacetylase inhibitors like trichostatin A (TSA) (Imai *et al.*, 2000; Landry *et al.*, 2000a; Smith *et al.*, 2000).

SIRT1 deacetylates the HIV Tat protein and is required for Tat-mediated transactivation of the HIV promoter. (Melanie Ott, Title, Workshop 1, Molecular Mechanisms of HIV Pathogenesis, Keystone Symposia, as printed from
15 <http://www.keystonesymposia.org/Meetings/ViewMeetings.cfm?MeetingID=694> on Jan. 28, 2004.)

SUMMARY

The invention relates to substituted heterocyclic compounds, compositions comprising the compounds, and methods of using the compounds and compound
20 compositions. The compounds and compositions comprising them are useful for treating viral infection or disease or infection or disease symptoms, including AIDS. The compounds can modulate SIRT1 activity. SIRT1 deacetylates the HIV Tat protein and is required for Tat-mediated transactivation of the HIV promoter.

In one aspect, this invention relates to a method for treating or preventing a viral
25 disorder, e.g., an infection or disease, in a subject, e.g., AIDS. The method includes administering to the subject an effective amount of a compound having a formula (I):



(I)

wherein,

5 R^1 and R^2 , together with the carbons to which they are attached, form C₅-C₁₀ cycloalkyl, C₅-C₁₀ heterocyclyl, C₅-C₁₀ cycloalkenyl, C₅-C₁₀ heterocycloalkenyl, C₆-C₁₀ aryl, or C₆-C₁₀ heteroaryl, each of which may be optionally substituted with 1-5 R^5 ; or R^1 is H, S-alkyl, or S-aryl, and R^2 is amidoalkyl wherein the nitrogen is substituted with alkyl, aryl, or arylalkyl, each of which is optionally further substituted with alkyl, halo,
10 hydroxy, or alkoxy;

R^3 and R^4 , together with the carbons to which they are attached, form C₅-C₁₀ cycloalkyl, C₅-C₁₀ heterocyclyl, C₅-C₁₀ cycloalkenyl, C₅-C₁₀ heterocycloalkenyl, C₆-C₁₀ aryl, or C₆-C₁₀ heteroaryl, each of which may be optionally substituted with 1-5 R^6 ;

each of R^5 and R^6 is, independently, halo, hydroxy, C₁-C₁₀ alkyl, C₁-C₆ haloalkyl,
15 C₁-C₁₀ alkoxy, C₁-C₆ haloalkoxy, C₆-C₁₀ aryl, C₅-C₁₀ heteroaryl, C₇-C₁₂ aralkyl, C₇-C₁₂ heteroaralkyl, C₃-C₈ heterocyclyl, C₂-C₁₂ alkenyl, C₂-C₁₂ alkynyl, C₅-C₁₀ cycloalkenyl, C₅-C₁₀ heterocycloalkenyl, carboxy, carboxylate, cyano, nitro, amino, C₁-C₆ alkyl amino, C₁-C₆ dialkyl amino, mercapto, SO₃H, sulfate, S(O)NH₂, S(O)₂NH₂, phosphate, C₁-C₄ alkylendioxy, oxo, acyl, aminocarbonyl, C₁-C₆ alkyl aminocarbonyl, C₁-C₆ dialkyl
20 aminocarbonyl, C₁-C₁₀ alkoxycarbonyl, C₁-C₁₀ thioalkoxycarbonyl, hydrazinocarbonyl, C₁-C₆ alkyl hydrazinocarbonyl, C₁-C₆ dialkyl hydrazinocarbonyl, hydroxyaminocarbonyl; alkoxyaminocarbonyl; or one of R^5 or R^6 and R^7 form a cyclic moiety containing 4-6 carbons, 1-3 nitrogens, 0-2 oxygens and 0-2 sulfurs, which may be optionally substituted with oxo or C₁-C₆ alkyl;

25 X is NR⁷, O, or S; Y is NR⁷, O or S;

- - - represent optional double bonds;

each of R^7 and $R^{7'}$ is, independently, hydrogen, C_1 - C_6 alkyl, C_7 - C_{12} arylalkyl, C_7 - C_{12} heteroarylalkyl; or R^7 and one of R^5 or R^6 form a cyclic moiety containing 4-6 carbons, 1-3 nitrogens, 0-2 oxygens and 0-2 sulfurs, which may be optionally substituted with oxo or C_1 - C_6 alkyl; and n is 0 or 1.

5 Embodiments can include one or more of the following.

In certain embodiments, n can be 1.

X can be NR^7 and Y can be $NR^{7'}$. R^7 and $R^{7'}$ can each be, e.g., hydrogen or CH_3 . One of R^7 and $R^{7'}$ can be hydrogen and the other can be CH_3 .

R^1 and R^2 can form C_5 - C_{10} cycloalkenyl.

10 R^1 and R^2 can form C_6 - C_{10} aryl.

R^1 and R^2 can form C_5 - C_{10} cycloalkenyl, which may be substituted with R^5 , and R^3 and R^4 can form C_6 - C_{10} aryl, which may be substituted with R^6 .

In certain embodiments, the cycloalkenyl double bond can be between the carbon attached to R^1 and the carbon attached to R^2 . C_5 - C_{10} cycloalkenyl, e.g., C_6 or C_7 cycloalkenyl, can be substituted with R^5 and C_6 - C_{10} aryl can be substituted with R^6 ;

15 R^6 can be halo (e.g., chloro or bromo), C_1 - C_6 alkyl (e.g., CH_3), C_1 - C_6 haloalkyl (e.g., CF_3) or C_1 - C_6 haloalkoxy (e.g., OCF_3). R^5 can be for example, C_1 - C_6 alkyl substituted with a substituent such as an amino substituent, or aminocarbonyl (for example a substituted aminocarbonyl, substituted with substituents such as an aryl, heteroaryl, cycloalkyl, heterocycloalkyl, aminocarbonyl, alkylaminocarbonyl, alkoxy carbonyl or other substituents. In each instances, the substituents can be further substituted with other substituents.); and

n can be 0.

R^1 and R^2 can form C_5 - C_{10} cycloalkenyl.

25 R^1 and R^2 can form C_6 - C_{10} aryl.

X can be NR^7 , and R^7 can be, e.g., hydrogen or CH_3 .

R^1 and R^2 can form C_5 - C_{10} cycloalkenyl, which may be substituted with R^5 , and R^3 and R^4 can form C_6 - C_{10} aryl, which may be substituted with R^6 .

In certain embodiments, the cycloalkenyl double bond can be between the carbon attached to R^1 and the carbon attached to R^2 . C_5 - C_{10} cycloalkenyl, e.g., C_6 or C_7 cycloalkenyl, can be substituted with R^5 and C_6 - C_{10} aryl can be substituted with R^6 ;

R^6 can be halo (e.g., chloro), C_1 - C_6 alkyl (e.g., CH_3), C_1 - C_6 haloalkyl (e.g., CF_3) or C_1 - C_6 haloalkoxy (e.g., OCF_3). R^5 can be aminocarbonyl; and

n can be 0.

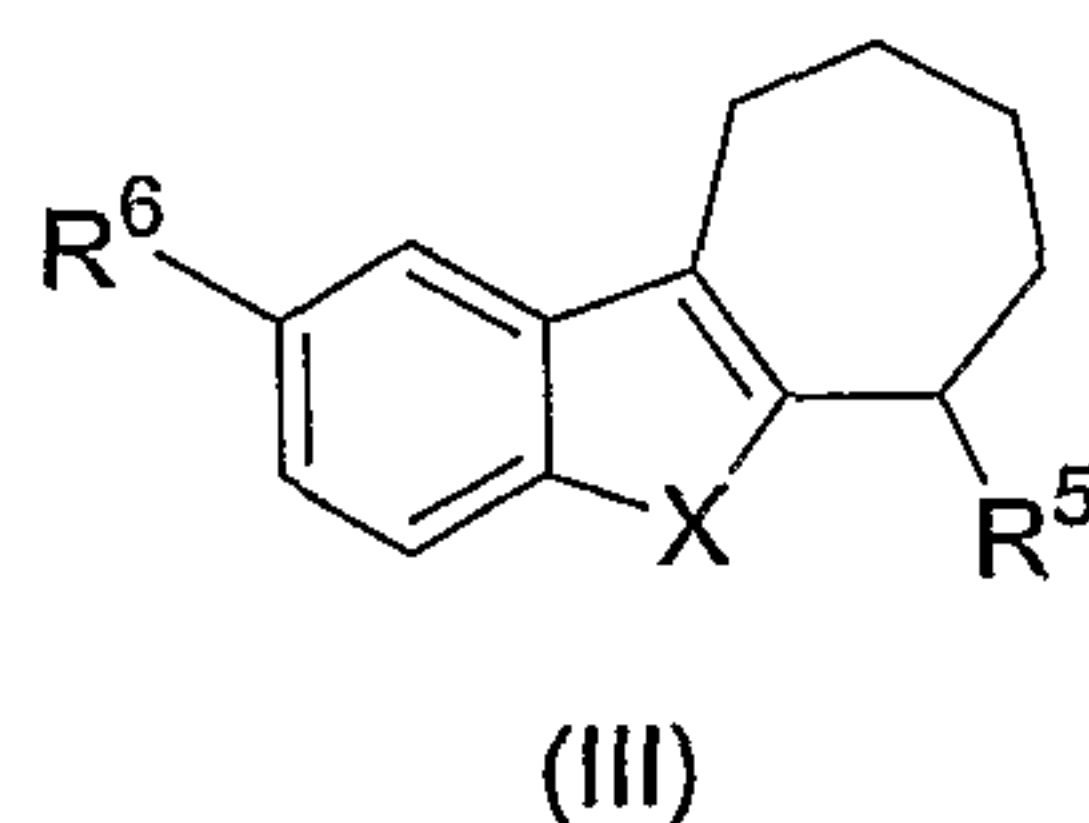
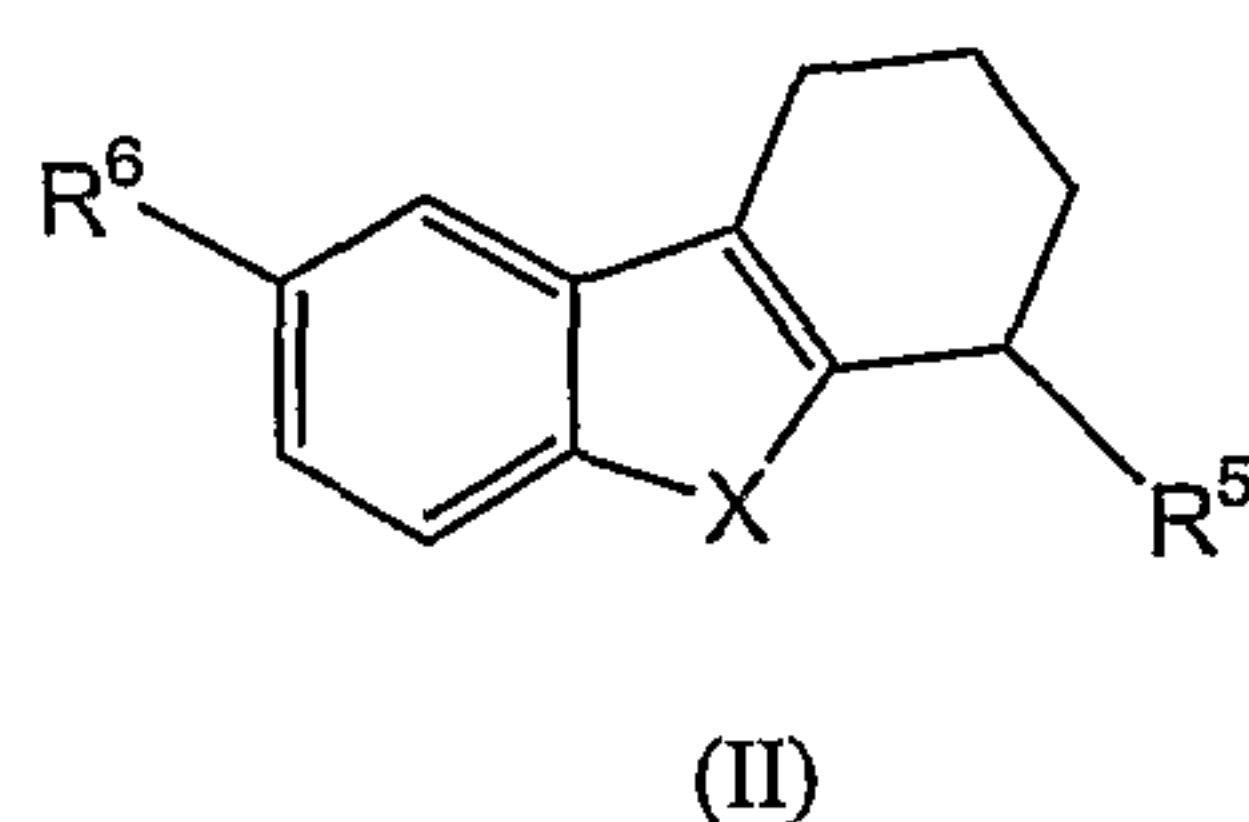
R^1 and R^2 can form C_5 - C_{10} cycloalkenyl.

5 R^1 and R^2 can form C_6 - C_{10} aryl.

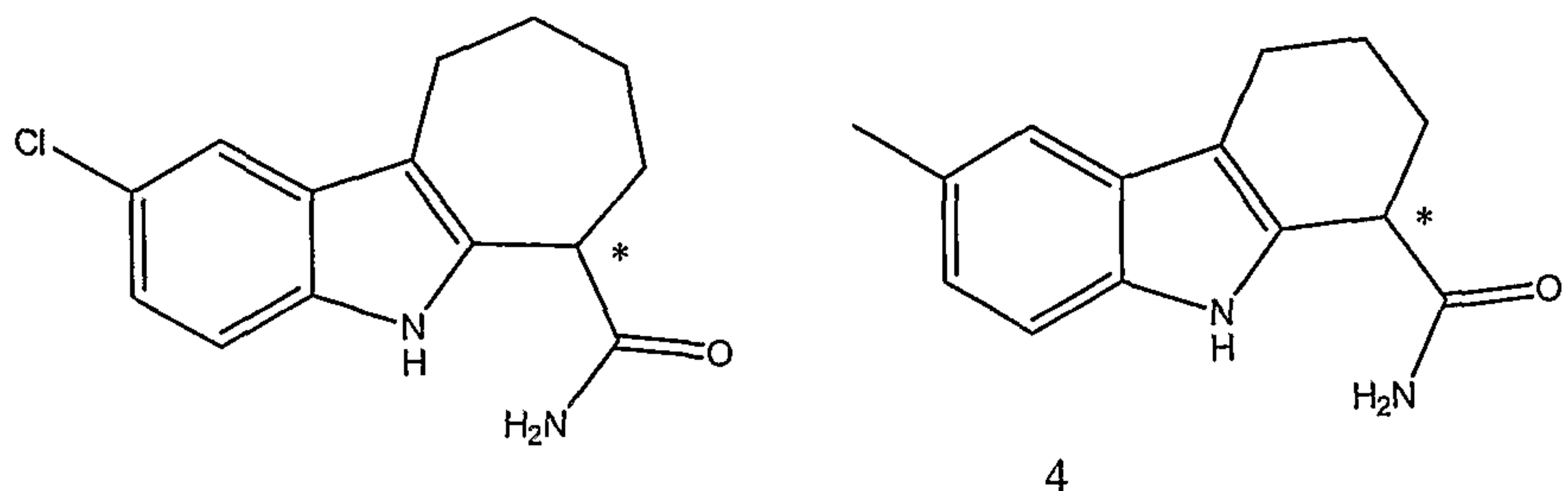
X can be NR^7 , and R^7 can be, e.g., hydrogen or CH_3 .

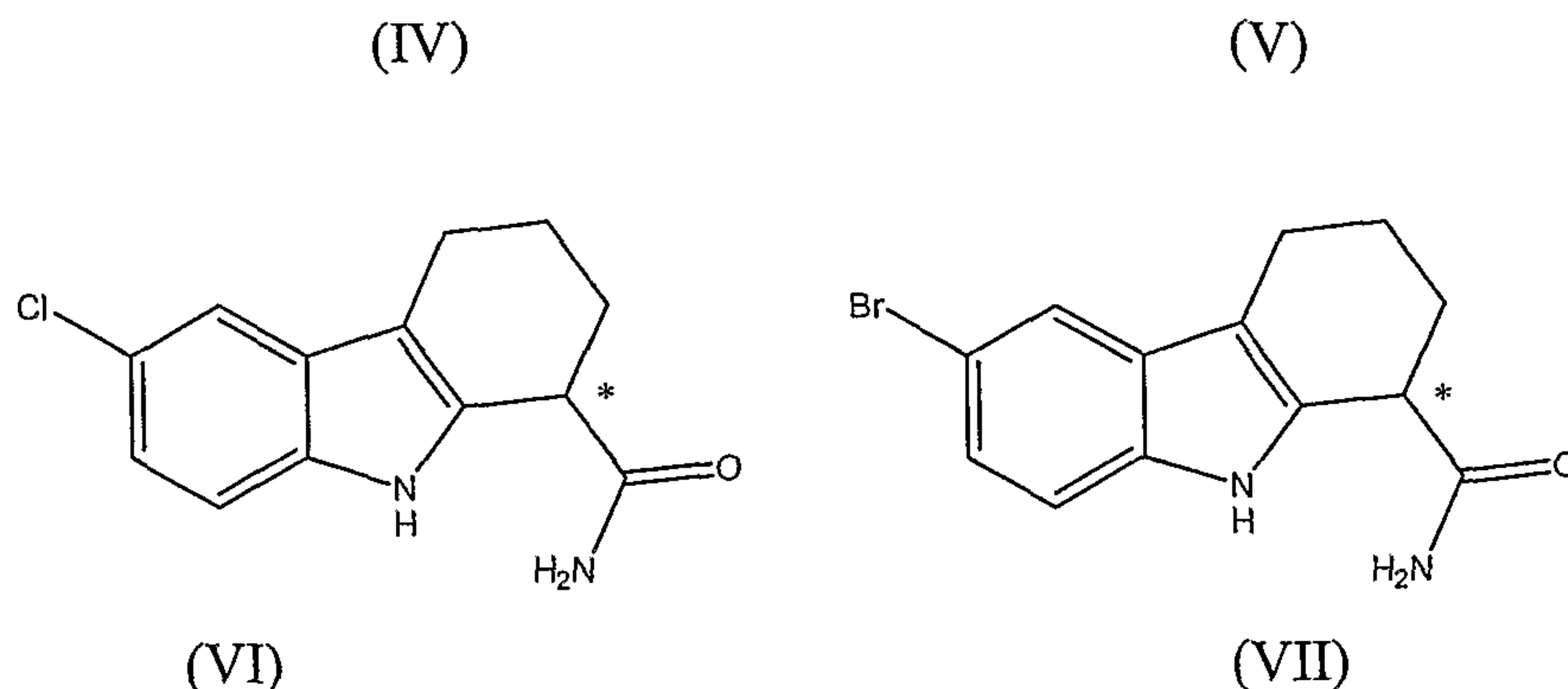
R^1 and R^2 can form C_5 - C_{10} cycloalkenyl, which may be substituted with R^5 , and R^3 and R^4 can form C_6 - C_{10} aryl, which may be substituted with R^6 .

10 In certain embodiments, the cycloalkenyl double bond can be between the carbon attached to R^1 and the carbon attached to R^2 . C_5 - C_{10} cycloalkenyl, e.g., C_6 or C_7 cycloalkenyl, can be substituted with R^5 and C_6 - C_{10} aryl can be substituted with R^6 . These compounds may have formula (II) or formula (III):



20 R^6 can be halo (e.g., chloro or bromo), C_1 - C_6 alkyl (e.g., CH_3), C_1 - C_6 haloalkyl (e.g., CF_3) or C_1 - C_6 haloalkoxy (e.g., OCF_3). R^5 can be aminocarbonyl. The compound
25 may be a compound selected from Figure 1 or compounds (IV), (V), (VI), or (VII).





In one instance, the compound can be a compound of formula (VI) having a high enantiomeric excess of a single isomer, wherein the optical rotation of the predominant isomer is negative, for example, -14.1 ($c=0.33$, DCM) or, for example, $[\alpha]_D^{25} -41.2^\circ$ ($c=0.96$, CH_3OH). In some instances, a compound of formula (IV), (V), or (VII) is administered having a high enantiomeric excess of a single isomer, where the predominant isomer has the same absolute configuration as the negative isomer of the compound of formula (VI) as corresponds to the asterisk carbon shown above.

The compound can preferentially inhibit SIRT1 relative to a non-SIRT1 sirtuin, e.g., at least a 1.5, 2, 5, or 10 fold preference. The compound can have a K_i for SIRT1 that is less than 500, 100, 50, or 40 nM.

In some instances, the compound reduces the activity of a FOXO transcription factor such as FoxO1 or FoxO3.

The amount can be effective to ameliorate at least one symptom of the viral disorder. For example, the disease or disorder can be a retroviral disorder, e.g., a lentiviral disorder, e.g., an HIV-mediated disorder such as AIDS. SIRT1 deacetylates the HIV Tat protein and is required for Tat-mediated transactivation of the HIV promoter. The method can further include administering a molecule of the invention in combination with an additional anti-viral treatment. E.g., a molecule of the invention can be administered in combination with an anti-viral agent, e.g., a protease inhibitor, e.g., a HIV protease inhibitor, a fusion inhibitor, an integrase inhibitor, or a reverse transcriptase inhibitor, (e.g., a nucleotide analog, e.g., AZT, or a non-nucleoside reverse transcriptase inhibitor). The method can include administering the compound more than once, e.g., repeatedly administering the compound. The compound can be administered in one or more boluses or continuously. The compound can be administered from without (e.g., by

injection, ingestion, inhalation, etc), or from within, e.g., by an implanted device. The method can include a regimen that includes increasing or decreasing dosages of the compound.

Administered "in combination with", as used herein, means that two (or more) different treatments are delivered to the subject during the course of the subject's affliction with the disorder, e.g., the two or more treatments are delivered after the subject has been diagnosed with the disorder and before the disorder has been cured or eliminated. In some embodiments, the delivery of one treatment is still occurring when the delivery of the second begins, so that there is overlap. This is sometimes referred to herein as "simultaneous" or "concurrent delivery." In other embodiments, the delivery of one treatment ends before the delivery of the other treatment begins. In some embodiments of either case, the treatment is more effective because of combined administration. For example, the second treatment is more effective, e.g., an equivalent effect is seen with less of the second treatment, or the second treatment reduces symptoms to a greater extent, than would be seen if the second treatment were administered in the absence of the first treatment, or the analogous situation is seen with the first treatment. In some embodiments, delivery is such that the reduction in a symptom, or other parameter related to the disorder is greater than what would be observed with one treatment delivered in the absence of the other. The effect of the two treatments can be partially additive, wholly additive, or greater than additive. The delivery can be such that an effect of the first treatment delivered is still detectable when the second is delivered.

In some embodiments, a molecule of the invention is administered after another (first) anti-viral treatment has been administered to the patient but the first treatment did not achieve an optimal outcome or is no longer achieving an optimal outcome, e.g., the virus has become resistant to the first treatment.

The method can include administering the compound locally.

The amount can be effective to increase acetylation of a sirtuin substrate (e.g., a viral sirtuin substrate such as tat or a tat-like transactivator, or a cellular sirtuin substrate that participates in the viral lifecycle) in at least some cells of the subject.

The subject can be a mammal, e.g., a human.

The subject can be identified as being in need of such treatment or prevention.

The method further can include identifying a subject in need of such treatment, e.g., by evaluating sirtuin activity in a cell of the subject, evaluating nucleotide identity in a nucleic acid of the subject that encodes a sirtuin, evaluating the subject for a virus (e.g., HIV) or a virally infected cell or neoplastic cells whose growth properties are altered by a viral infection, evaluating the genetic composition or expression of genes in a cell of the subject, e.g., a virally infected cell.

The method further can include identifying a subject in need of such treatment, e.g., by evaluating by parameter such as sirtuin activity, HIV level, the level of a selected T cell or other cell surface marker, the presence of an additional infectious agent (e.g., TB) in the subject, determining if the value determined for the parameter has a predetermined relationship with a reference value, e.g., the subject's T cell count is below a threshold level, and administering the treatment to the patient.

The method can further include monitoring the subject, e.g., imaging the subject, evaluating the subject, evaluating sirtuin activity in a cell of the subject, evaluating the subject for side effects, e.g., renal function.

In another aspect, this invention relates to a method of inhibiting sirtuin-mediated deacetylation of a substrate. The method includes contacting a sirtuin with a compound of formula (I). The inhibiting can occur *in vitro*, in cell-free medium, in cell culture, or in an organism, e.g., a mammal, preferably a human.

In a further aspect, this invention relates to a method for evaluating a plurality of compounds, the method includes: a) providing library of compound that comprises a plurality of compounds, each having a formula (I); and b) for each of a plurality of compounds from the library, i) contacting the compound to a sirtuin test protein that comprises a functional deacetylase domain of a sirtuin; and ii) evaluating interaction between the compound and the sirtuin test protein in the presence of the compound.

Embodiments can include one or more of the following.

In one embodiment, evaluating the interaction between the compound and the sirtuin test protein includes evaluating enzymatic activity of the sirtuin test protein, e.g., with respect to a substrate, e.g., a viral sirtuin substrate such as tat or a tat-like transactivator, or a cellular sirtuin substrate that participates in the viral lifecycle.

In one embodiment, evaluating the interaction between the compound and the sirtuin test protein includes evaluating a binding interaction between the compound and the sirtuin test protein

The method can further include selecting, based on results of the evaluating, a compound that modulates deacetylase activity for a substrate. The substrate can be an acetylated lysine amino acid, an acetylated viral sirtuin substrate such as tat or a tat-like transactivator, or a cellular sirtuin substrate that participates in the viral lifecycle or an acetylated peptide thereof, or other known sirtuin substrates.

The method may also further include selecting, based on results of the evaluating, a compound that modulates sirtuin deacetylase activity of a substrate.

The method may also further include selecting, based on results of the evaluating, a compound that modulates the sirtuin.

In one aspect, this invention relates to a conjugate that includes: a targeting agent and a compound, wherein the targeting agent and the compound are covalently linked, and the compound has a formula (I).

Embodiments can include one or more of the following. The targeting agent can be an antibody, e.g., specific for a cell surface protein of a virally infected cell, e.g., a viral receptor (e.g., CD4) or a viral antigen. The targeting agent can be a synthetic peptide. The targeting agent can be a domain of a naturally occurring protein.

In another aspect, this invention relates to a kit which includes: a compound described herein, and instructions for use for treating a disease described herein. The kit may further include a printed material comprising a rendering of the structure of the name of the compound.

In one aspect, this invention relates to a database, which includes a plurality of records, each record having: a) information about or identifying a compound that has a structure described herein, e.g., a structure of formula (I); and b) information about a parameter of a patient, the parameter relating to a viral disorder or a patient parameter, e.g., viral load, white blood cell count, weight, etc.

In one aspect, this invention relates to a method of evaluating a compound, the method includes: providing a first compound that has a structure of formula (I), or a data record having information about the structure; providing a second compound that has a

structure of formula (I) or not having formula (I), or a data record having information about the structure; evaluating a first compound and the second compound, e.g., *in vivo*, *in vitro*, or *in silico*; and comparing the ability of a second compound to interact, e.g., inhibit a sirtuin, e.g., SIRT1, with a first compound, thereby evaluating ability of the second compound to interact with SIRT1.

In other aspects, the invention relates to a composition comprising a compound of any of the formulae herein, and a pharmaceutically acceptable carrier. The composition may contain an additional therapeutic agent (for example one, two, three, or more additional agents), e.g., an anti-viral agent, e.g., a protease inhibitor, e.g., a HIV protease inhibitor, a fusion inhibitor, an integrase inhibitor, and/or a reverse transcriptase inhibitor, (e.g., a nucleotide analog, e.g., AZT, or a non-nucleoside reverse transcriptase inhibitor). Also within the scope of this invention is the use of such a composition for the manufacture of a medicament for anti-viral use.

In another aspect, the invention is a method for treating or preventing a viral disease, e.g., HIV, in a subject. The method includes administering a SIRT1 antagonist described herein, e.g., having a structure of formula (I).

In another aspect, the invention includes a method for treating or preventing a tat or tat mediated disease or disorder. The method includes administering a compound described herein, e.g., a compound of formula (I).

In one embodiment, the method includes administering a SIRT1 antagonist in combination with one or more therapeutic agents, e.g., a therapeutic agent or agent for treating a viral disorder, e.g., a viral disorder described herein. The additional agents may be administered in a single composition with the SIRT1 antagonist or may be administered separately, for example in separate formulations such as separate pills.

When administered in separate formulations, the agents can be administered at the same time, or at different times. Exemplary additional agents include a protease inhibitor, e.g., a HIV protease inhibitor, a fusion inhibitor, an integrase inhibitor, or a reverse transcriptase inhibitor, (e.g., a nucleotide analog, e.g., AZT, or a non-nucleoside reverse transcriptase inhibitor). Specific examples include saquinavir, ritonavir, indinavir, nelfinavir, saquinavir, amprenavir, lopinavir, emtricitabine, tenofovir disoproxil fumarate,

and combinations thereof, e.g., a fixed-dose combination of emtricitabine and tenofovir disoproxil fumarate.

The SIRT1 antagonist and the therapeutic agents can be administered simultaneously or sequentially.

5 Also within the scope of this invention is a packaged product. The packaged product includes a container, one of the aforementioned compounds in the container, and a legend (e.g., a label or insert) associated with the container and indicating administration of the compound for treating a disorder described herein, diseases, or disease symptoms, including any of those delineated herein.

10 The subject can be a mammal, preferably a human. The subject can also be a non-human subject, e.g., an animal model or a cat. In certain embodiments the method can further include identifying a subject. Identifying a subject in need of such treatment can be in the judgment of a subject or a health care professional and can be subjective (e.g., opinion) or objective (e.g., measurable by a test or diagnostic method).

15 The term "mammal" includes organisms, which include mice, rats, cows, sheep, pigs, rabbits, goats, and horses, monkeys, dogs, cats, and preferably humans.

The term "treating" or "treated" refers to administering a compound described herein to a subject with the purpose to cure, heal, alleviate, relieve, alter, remedy, ameliorate, improve, or affect a disease, e.g., an infection, the symptoms of the disease or
20 the predisposition toward the disease.

An effective amount of the compound described above may range from about 0.1 mg/Kg to about 500 mg/Kg, alternatively from about 1 to about 50 mg/Kg, or 0.1 mg/Kg to 18 mg/Kg. Effective doses will also vary depending on route of administration, as well as the possibility of co-usage with other agents.

25 The term "halo" or "halogen" refers to any radical of fluorine, chlorine, bromine or iodine.

The term "alkyl" refers to a hydrocarbon chain that may be a straight chain or branched chain, containing the indicated number of carbon atoms. For example, C₁-C₁₂ alkyl indicates that the group may have from 1 to 12 (inclusive) carbon atoms in it. The
30 term "haloalkyl" refers to an alkyl in which one or more hydrogen atoms are replaced by halo, and includes alkyl moieties in which all hydrogens have been replaced by halo (e.g.,

perfluoroalkyl). The terms "arylalkyl" or "aralkyl" refer to an alkyl moiety in which an alkyl hydrogen atom is replaced by an aryl group. Aralkyl includes groups in which more than one hydrogen atom has been replaced by an aryl group. Examples of "arylalkyl" or "aralkyl" include benzyl, 2-phenylethyl, 3-phenylpropyl, 9-fluorenyl, benzhydryl, and trityl groups.

The term "alkylene" refers to a divalent alkyl, e.g., -CH₂-, -CH₂CH₂-, and -CH₂CH₂CH₂-.

The term "alkenyl" refers to a straight or branched hydrocarbon chain containing 2-12 carbon atoms and having one or more double bonds. Examples of alkenyl groups include, but are not limited to, allyl, propenyl, 2-butenyl, 3-hexenyl and 3-octenyl groups. One of the double bond carbons may optionally be the point of attachment of the alkenyl substituent. The term "alkynyl" refers to a straight or branched hydrocarbon chain containing 2-12 carbon atoms and characterized in having one or more triple bonds. Examples of alkynyl groups include, but are not limited to, ethynyl, propargyl, and 3-hexynyl. One of the triple bond carbons may optionally be the point of attachment of the alkynyl substituent.

The terms "alkylamino" and "dialkylamino" refer to -NH(alkyl) and -NH(alkyl)₂ radicals respectively. The term "aralkylamino" refers to a -NH(aralkyl) radical. The term alkylaminoalkyl refers to a (alkyl)NH-alkyl- radical; the term dialkylaminoalkyl refers to a (alkyl)₂N-alkyl- radical. The term "alkoxy" refers to an -O-alkyl radical. The term "mercapto" refers to an SH radical. The term "thioalkoxy" refers to an -S-alkyl radical. The term thioaryloxy refers to an -S-aryl radical.

The term "aryl" refers to an aromatic monocyclic, bicyclic, or tricyclic hydrocarbon ring system, wherein any ring atom capable of substitution can be substituted (e.g., by one or more substituents). Examples of aryl moieties include, but are not limited to, phenyl, naphthyl, and anthracenyl.

The term "cycloalkyl" as employed herein includes saturated cyclic, bicyclic, tricyclic, or polycyclic hydrocarbon groups having 3 to 12 carbons. Any ring atom can be substituted (e.g., by one or more substituents). The cycloalkyl groups can contain fused rings. Fused rings are rings that share a common carbon atom. Examples of cycloalkyl

moieties include, but are not limited to, cyclopropyl, cyclohexyl, methylcyclohexyl, adamantyl, and norbornyl.

The term "heterocyclyl" refers to a nonaromatic 3-10 membered monocyclic, 8-12 membered bicyclic, or 11-14 membered tricyclic ring system having 1-3 heteroatoms if monocyclic, 1-6 heteroatoms if bicyclic, or 1-9 heteroatoms if tricyclic, said heteroatoms selected from O, N, or S (e.g., carbon atoms and 1-3, 1-6, or 1-9 heteroatoms of N, O, or S if monocyclic, bicyclic, or tricyclic, respectively). The heteroatom may optionally be the point of attachment of the heterocyclyl substituent. Any ring atom can be substituted (e.g., by one or more substituents). The heterocyclyl groups can contain fused rings. Fused rings are rings that share a common carbon atom. Examples of heterocyclyl include, but are not limited to, tetrahydrofuranyl, tetrahydropyranyl, piperidinyl, morpholino, pyrrolinyl, pyrimidinyl, quinolinyl, and pyrrolidinyl.

The term "cycloalkenyl" refers to partially unsaturated, nonaromatic, cyclic, bicyclic, tricyclic, or polycyclic hydrocarbon groups having 5 to 12 carbons, preferably 5 to 8 carbons. The unsaturated carbon may optionally be the point of attachment of the cycloalkenyl substituent. Any ring atom can be substituted (e.g., by one or more substituents). The cycloalkenyl groups can contain fused rings. Fused rings are rings that share a common carbon atom. Examples of cycloalkenyl moieties include, but are not limited to, cyclohexenyl, cyclohexadienyl, or norbornenyl.

The term "heterocycloalkenyl" refers to a partially saturated, nonaromatic 5-10 membered monocyclic, 8-12 membered bicyclic, or 11-14 membered tricyclic ring system having 1-3 heteroatoms if monocyclic, 1-6 heteroatoms if bicyclic, or 1-9 heteroatoms if tricyclic, said heteroatoms selected from O, N, or S (e.g., carbon atoms and 1-3, 1-6, or 1-9 heteroatoms of N, O, or S if monocyclic, bicyclic, or tricyclic, respectively). The unsaturated carbon or the heteroatom may optionally be the point of attachment of the heterocycloalkenyl substituent. Any ring atom can be substituted (e.g., by one or more substituents). The heterocycloalkenyl groups can contain fused rings. Fused rings are rings that share a common carbon atom. Examples of heterocycloalkenyl include but are not limited to tetrahydropyridyl and dihydropyranyl.

The term "heteroaryl" refers to an aromatic 5-8 membered monocyclic, 8-12 membered bicyclic, or 11-14 membered tricyclic ring system having 1-3 heteroatoms if

monocyclic, 1-6 heteroatoms if bicyclic, or 1-9 heteroatoms if tricyclic, said heteroatoms selected from O, N, or S (e.g., carbon atoms and 1-3, 1-6, or 1-9 heteroatoms of N, O, or S if monocyclic, bicyclic, or tricyclic, respectively). Any ring atom can be substituted (e.g., by one or more substituents).

5 The term “oxo” refers to an oxygen atom, which forms a carbonyl when attached to carbon, an N-oxide when attached to nitrogen, and a sulfoxide or sulfone when attached to sulfur.

 The term “acyl” refers to an alkylcarbonyl, cycloalkylcarbonyl, arylcarbonyl, heterocyclylcarbonyl, or heteroarylcarbonyl substituent, any of which may be further substituted (e.g., by one or more substituents).

 The terms “aminocarbonyl,” alkoxycarbonyl,” hydrazinocarbonyl, and hydroxyaminocarbonyl refer to the radicals $-C(O)NH_2$, $-C(O)O(alkyl)$, $-C(O)NH_2NH_2$, and $-C(O)NH_2NH_2$, respectively.

 The term “amindo” refers to a $-NHC(O)-$ radical, wherein N is the point of attachment.

 The term “substituents” refers to a group “substituted” on an alkyl, cycloalkyl, alkenyl, alkynyl, heterocyclyl, heterocycloalkenyl, cycloalkenyl, aryl, or heteroaryl group at any atom of that group. Any atom can be substituted. Suitable substituents include, without limitation, alkyl (e.g., C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12 straight or branched chain alkyl), cycloalkyl, haloalkyl (e.g., perfluoroalkyl such as CF_3), aryl, heteroaryl, aralkyl, heteroaralkyl, heterocyclyl, alkenyl, alkynyl, cycloalkenyl, heterocycloalkenyl, alkoxy, haloalkoxy (e.g., perfluoroalkoxy such as OCF_3), halo, hydroxy, carboxy, carboxylate, cyano, nitro, amino, alkyl amino, SO_3H , sulfate, phosphate, methylenedioxy ($-O-CH_2-O-$ wherein oxygens are attached to vicinal atoms), ethylenedioxy, oxo, thioxo (e.g., $C=S$), imino (alkyl, aryl, aralkyl), $S(O)_n$ alkyl (where n is 0-2), $S(O)_n$ aryl (where n is 0-2), $S(O)_n$ heteroaryl (where n is 0-2), $S(O)_n$ heterocyclyl (where n is 0-2), amine (mono-, di-, alkyl, cycloalkyl, aralkyl, heteroaralkyl, aryl, heteroaryl, and combinations thereof), ester (alkyl, aralkyl, heteroaralkyl, aryl, heteroaryl), amide (mono-, di-, alkyl, aralkyl, heteroaralkyl, aryl, heteroaryl, and combinations thereof), sulfonamide (mono-, di-, alkyl, aralkyl, heteroaralkyl, and combinations thereof). In one aspect, the substituents on a group are independently any

one single, or any subset of the aforementioned substituents. In another aspect, a substituent may itself be substituted with any one of the above substituents.

A “retroviral disorder” refers to a disorder caused at least in part by a retrovirus. In one embodiment, the retrovirus can be integrated in a cell, e.g., as a latent or newly integrated virus. In the case of latent virus, in one example, a subject having the disorder may not have a detectable viral load. In another example, the subject has a detectable, e.g., substantial, viral load.

A “lentiviral disorder” refers to a disorder caused at least in part by a lentivirus. Lentiviruses typically are infectious viruses that have 4 main genes coding for the virion proteins in the order: 5′-*gag-pro-pol-env*-3′. There may be additional genes depending on the virus (e.g., for HIV-1: *vif*, *vpr*, *vpu*, *tat*, *rev*, *nef*) whose products are involved in regulation of synthesis and processing virus RNA and other replicative functions. For some lentiviruses, the LRT is about 600nt long, of which the U3 region is 450, the R sequence 100 and the U5 region some 70 nt long. Exemplary Lentiviruses include primate lentiviruses (e.g., SIV, HIV-1, HIV-2), equine lentiviruses (e.g., equine infectious anemia virus), bovine lentiviruses (e.g., bovine immunodeficiency virus), feline lentiviruses (e.g., feline immunodeficiency virus (Petuluma)), and ovine/caprine lentiviruses (e.g., arthritis encephalitis virus; 61.0.6.4.002 visna/maedi virus (strain 1514)).

In another embodiment, the retrovirus is in the form of infectious particles. For example, a subject having the disorder may have a detectable (e.g., a significant) viral load.

An exemplary “retroviral disorder” is an HIV-related disorder. An “HIV-related disorder” refers to any disorder caused at least in part by an HIV-related retrovirus, including HIV-1, HIV-2, FLV, HTLV-1, HTLV-2, and SIV. See, e.g., Coffin (1992) *Curr Top Microbiol Immunol.* 1992;176:143-64 Such disorders include AIDS and AIDS-related complex (ARC), and a variety of disorders that arise as a consequence of HIV infection, e.g., Kaposi’s sarcoma, non-Hodgkin’s lymphomas, central nervous system non-Hodgkin’s lymphomas, and rare tumors (e.g., intracranial tumors such as glioblastomas, anaplastic astrocytomas, and subependymomas), opportunistic infections (e.g., Histoplasmosis, CMV (Cytomegalovirus), Cryptosporidiosis, Cryptococcal

Meningitis, Dementia and Central Nervous System Problems, Hepatitis and HIV, Hepatitis C and HIV, HPV, KS (Kaposi's Sarcoma), Lymphoma, MAC (Mycobacterium Avium Complex), Molluscum, PCP (Pneumocystis Carinii Pneumonia), PML (Progressive Multifocal Leukoencephalopathy), Shingles (Herpes Zoster), TB (Tuberculosis), Thrush (Candidiasis), Toxoplasmosis), fatigue, anemia, cachexia, and AIDS wasting.

A "viral neoplastic disorder" is a disease or disorder characterized by cells that have the capacity for autonomous growth or replication due to a virus, e.g., a viral infection. As a result the cells are in an abnormal state or condition characterized by proliferative cell growth.

Methods and compositions disclosed herein can be used to treat any viral disorder which is dependent on the state of acetylation of a protein, e.g., a viral or cellular protein involved in propagation of the virus, e.g., a viral transcription factor. Exemplary viral disorders include retroviral and lentiviral disorders.

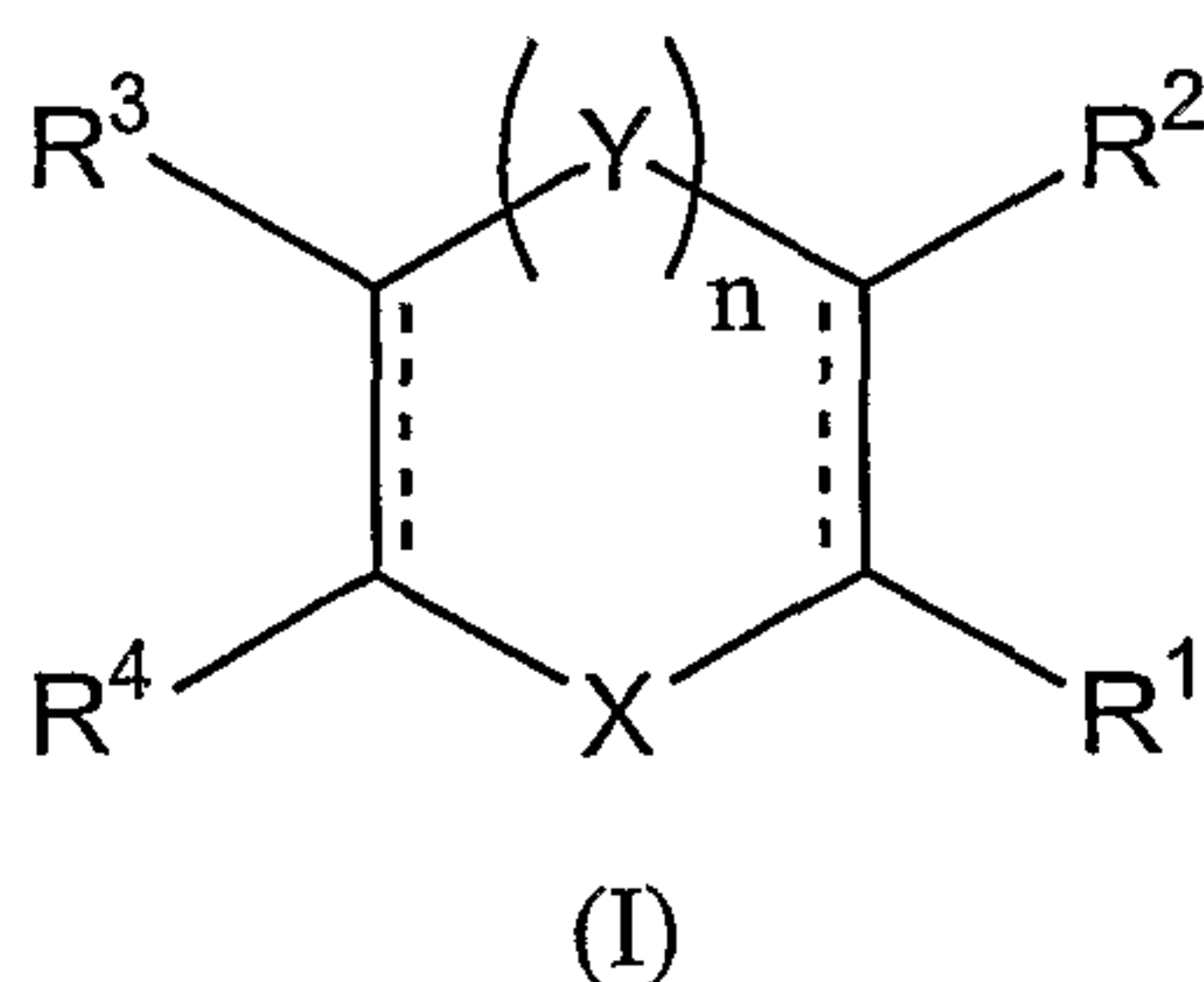
The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

All references cited herein, whether in print, electronic, computer readable storage media or other form, are expressly incorporated by reference in their entirety, including but not limited to, abstracts, articles, journals, publications, texts, treatises, internet web sites, databases, patents, patent applications and patent publications. This application also incorporates by reference a U.S. application, titled "ANTI-VIRAL THERAPEUTICS," filed 31 January 2005, naming DiStefano et al, and assigned attorney docket number 13407-054001.

DETAILED DESCRIPTION

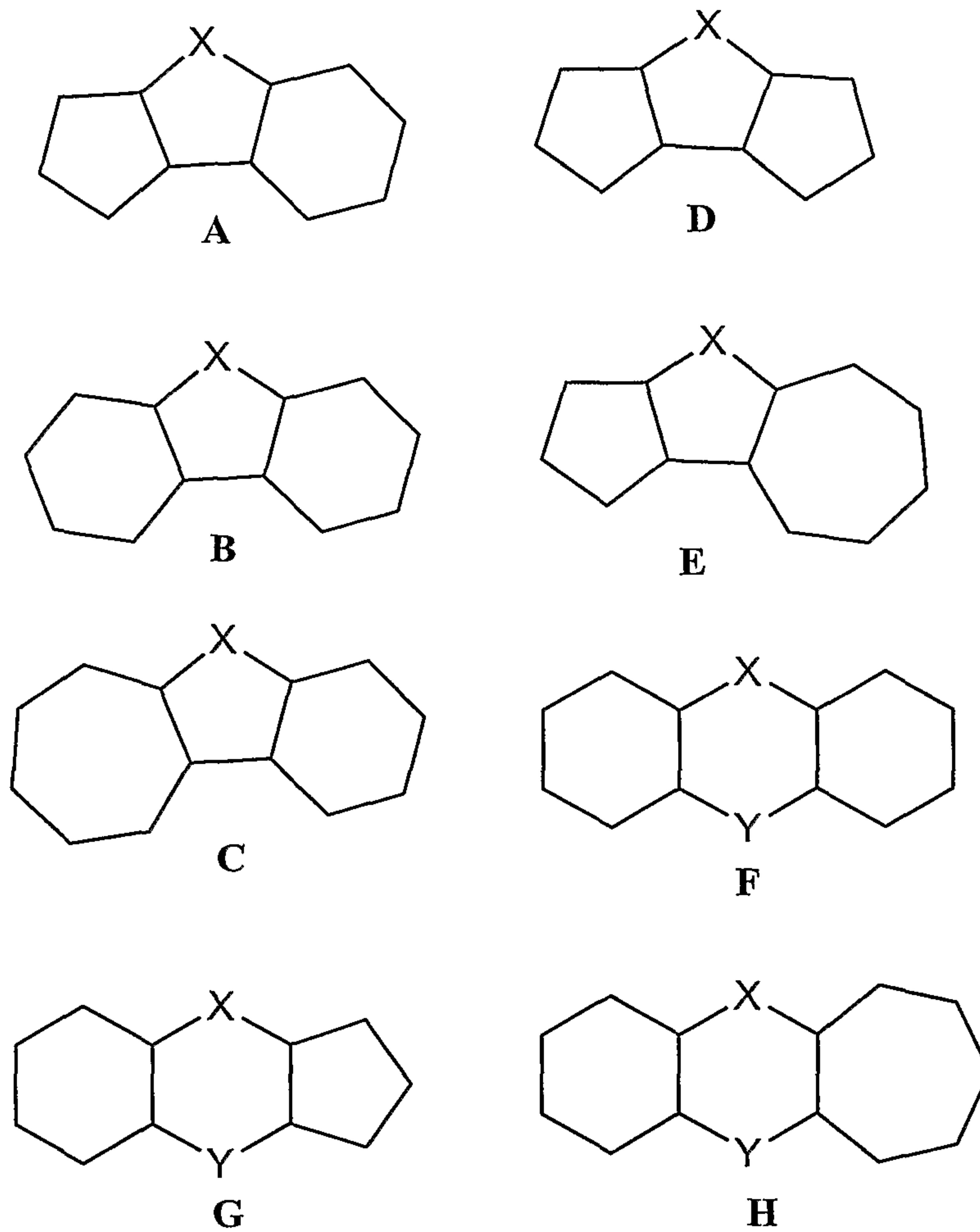
Structure of Compounds

Compounds that can be used in practicing the invention have a general formula (I) and contain a substituted pentacyclic or hexacyclic core containing one or two, respectively, oxygen, nitrogen, or sulfur atoms as a constituent atom of the ring, e.g., X and Y in formula (I) below.

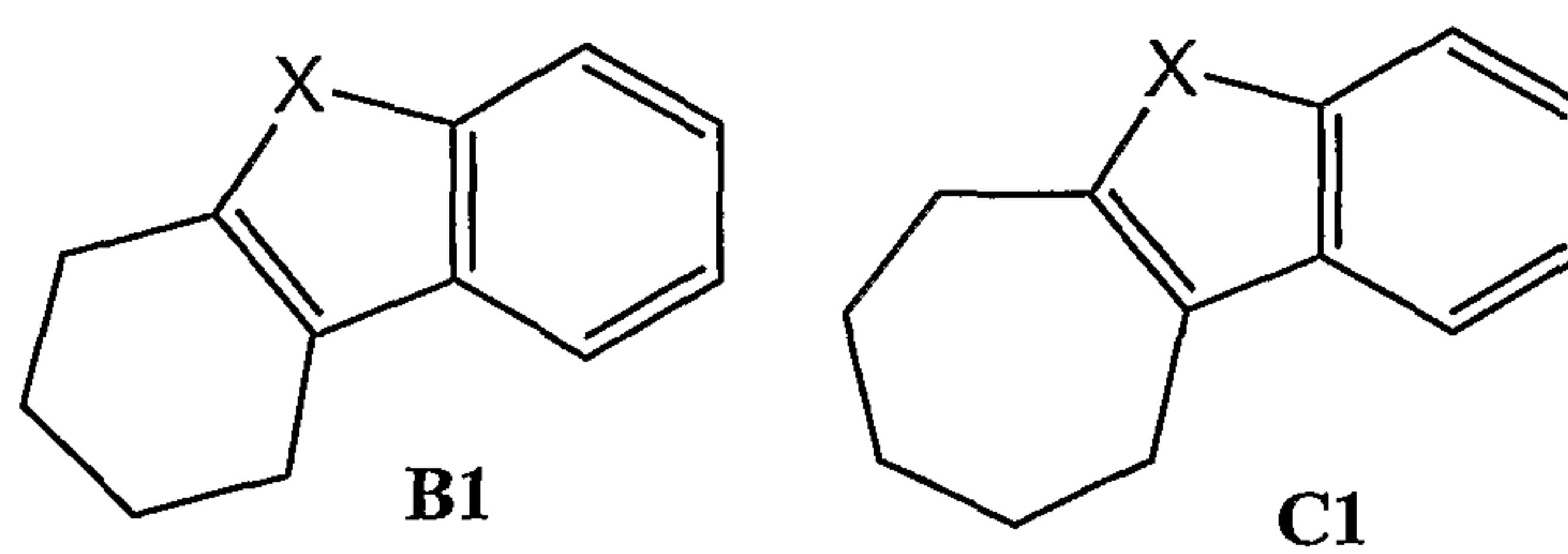


Any ring carbon atom can be substituted. For example, R^1 , R^2 , R^3 , and R^4 may include without limitation substituted or unsubstituted alkyl, cycloalkyl, alkenyl, alkynyl, heterocyclyl, heterocycloalkenyl, cycloalkenyl, aryl, heteroaryl, etc. The pentacyclic or hexacyclic core may be saturated, i.e. containing no double bonds, or partially or fully saturated, i.e. one or two double bonds respectively. When $n=0$, "X" may be oxygen, sulfur, or nitrogen, e.g., NR^7 . The substituent R^7 can be without limitation hydrogen, alkyl, e.g., C1, C2, C3, C4 alkyl, SO_2 (aryl), acyl, or the ring nitrogen may form part of a carbamate, or urea group. When $n=1$, X can be NR^7 , O, or S; and Y can be NR^7 , O or S. X and Y can be any combination of heteroatoms, e.g., N,N, N,O, N, S, etc.

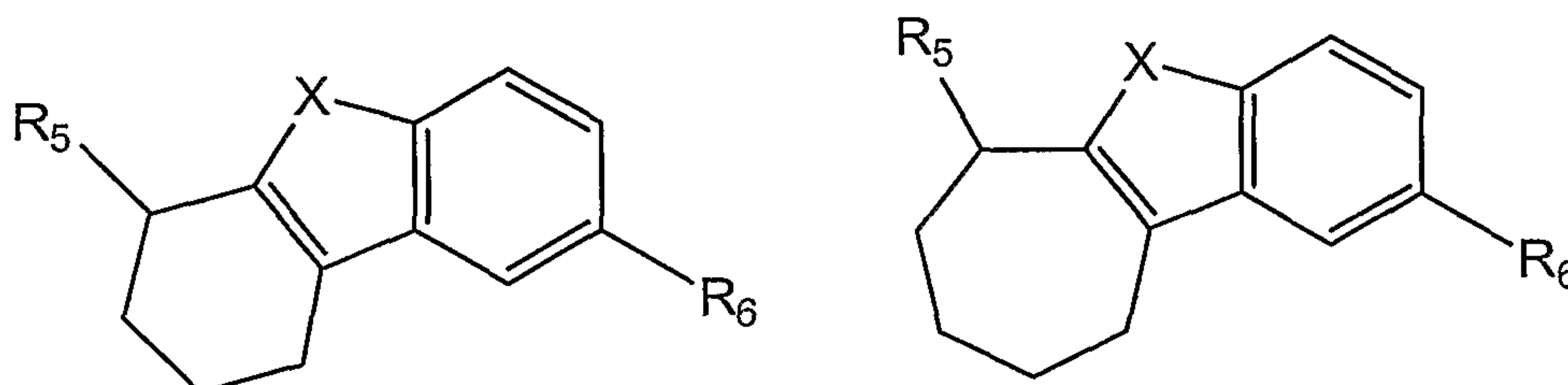
A preferred subset of compounds of formula (I) includes those having one, or preferably, two rings that are fused to the pentacyclic or hexacyclic core, e.g., R^1 and R^2 , together with the carbons to which they are attached, and/or R^3 and R^4 , together with the carbons to which they are attached, can form, e.g., C₅-C₁₀ cycloalkyl (e.g., C5, C6, or C7), C₅-C₁₀ heterocyclyl (e.g., C5, C6, or C7), C₅-C₁₀ cycloalkenyl (e.g., C5, C6, or C7), C₅-C₁₀ heterocycloalkenyl (e.g., C5, C6, or C7), C₆-C₁₀ aryl (e.g., C6, C8 or C10), or C₆-C₁₀ heteroaryl (e.g., C5 or C6). Fused ring combinations may include without limitation one or more of the following:



Preferred combinations include **B**, e.g. having C₆ aryl and C₆ cycloalkenyl (**B1**), and **C**,
5 e.g. having C₆ aryl and C₇ cycloalkenyl (**C1**):



Each of these fused ring systems may be optionally substituted with substituents, which may include without limitation halo, hydroxy, C₁-C₁₀ alkyl (C₁,C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀), C₁-C₆ haloalkyl (C₁,C₂,C₃,C₄,C₅,C₆), C₁-C₁₀ alkoxy (C₁,C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀), C₁-C₆ haloalkoxy (C₁,C₂,C₃,C₄,C₅,C₆), C₆-C₁₀ aryl (C₆,C₇,C₈,C₉,C₁₀), C₅-C₁₀ heteroaryl (C₅,C₆,C₇,C₈,C₉,C₁₀), C₇-C₁₂ aralkyl (C₇,C₈,C₉,C₁₀,C₁₁,C₁₂), C₇-C₁₂ heteroaralkyl (C₇,C₈,C₉,C₁₀,C₁₁,C₁₂), C₃-C₈ heterocyclyl (C₃,C₄,C₅,C₆,C₇,C₈), C₂-C₁₂ alkenyl (C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀,C₁₁,C₁₂), C₂-C₁₂ alkynyl (C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀,C₁₁,C₁₂), C₅-C₁₀ cycloalkenyl (C₅,C₆,C₇,C₈,C₉,C₁₀), C₅-C₁₀ heterocycloalkenyl (C₅,C₆,C₇,C₈,C₉,C₁₀), carboxy, carboxylate, cyano, nitro, amino, C₁-C₆ alkyl amino (C₁,C₂,C₃,C₄,C₅,C₆), C₁-C₆ dialkyl amino (C₁,C₂,C₃,C₄,C₅,C₆), mercapto, SO₃H, sulfate, S(O)NH₂, S(O)₂NH₂, phosphate, C₁-C₄ alkylenedioxy (C₁,C₂,C₃,C₄), oxo, acyl, aminocarbonyl, C₁-C₆ alkyl aminocarbonyl (C₁,C₂,C₃,C₄,C₅,C₆), C₁-C₆ dialkyl aminocarbonyl (C₁,C₂,C₃,C₄,C₅,C₆), C₁-C₁₀ alkoxycarbonyl (C₁,C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀), C₁-C₁₀ thioalkoxycarbonyl (C₁,C₂,C₃,C₄,C₅,C₆,C₇,C₈,C₉,C₁₀), hydrazinocarbonyl, C₁-C₆ alkyl hydrazinocarbonyl (C₁,C₂,C₃,C₄,C₅,C₆), C₁-C₆ dialkyl hydrazinocarbonyl (C₁,C₂,C₃,C₄,C₅,C₆), hydroxyaminocarbonyl, etc. Preferred substituents include halo (e.g., fluoro, chloro, bromo), C₁-C₁₀ alkyl (e.g., C₁, C₂, C₃, C₄, C₅, C₆, C₇, C₈, C₉, C₁₀), C₁-C₆ haloalkyl (e.g., C₁, C₂, C₃, C₄, C₅, C₆, e.g., CF₃), C₁-C₆ haloalkoxyl (e.g., C₁, C₂, C₃, C₄, C₅, C₆, e.g., OCF₃), or aminocarbonyl. The substitution pattern on the two fused rings may be selected as desired, e.g., one ring may be substituted and the other is not, or both rings may be substituted with 1-5 substituents (1,2,3,4,5 substituents). The number of substituents on each ring may be the same or different. Preferred substitution patterns are shown below:



In certain embodiments, when n is 0 and X is NR^7 , the nitrogen substituent R^7 can form a cyclic structure with one of the fused rings containing, e.g., 4-6 carbons, 1-3
 5 nitrogens, 0-2 oxygens and 0-2 sulfurs. This cyclic structure may optionally be substituted with oxo or C_1 - C_6 alkyl.

Combinations of substituents and variables envisioned by this invention are only those that result in the formation of stable compounds. The term "stable", as used herein, refers to compounds which possess stability sufficient to allow manufacture and which
 10 maintains the integrity of the compound for a sufficient period of time to be useful for the purposes detailed herein (e.g., therapeutic or prophylactic administration to a subject).

Exemplary compounds include those depicted in Table 1 below:

Table 1: Exemplary compounds

Compound number	Chemical name	Ave. SirT1 p53-382 IC50 (μ M)
1	7-Chloro-1,2,3,4-tetrahydro-cyclopenta[b]indole-3-carboxylic acid amide	A
2	2,3,4,9-Tetrahydro-1H-b-carboline-3-carboxylic acid amide	C
3	6-Bromo-2,3,4,9-tetrahydro-1H-carbazole-2-carboxylic acid amide	B

4	6-Methyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	A
5	2,3,4,9-Tetrahydro-1H-carbazole-1-carboxylic acid amide	B
6	2-Chloro-5,6,7,8,9,10-hexahydro-cyclohepta[b]indole-6-carboxylic acid amide	A
7	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid hydroxyamide	C
8	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	A
9	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-2-carboxylic acid amide	C

10	1,2,3,4-Tetrahydro-cyclopenta[b]indole-3-carboxylic acid amide	B
11	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid (5-chloro-pyridin-2-yl)-amide	B
12	1,6-Dimethyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	C
13	6-Trifluoromethoxy-2,3,4,9-tetrahydro-1H-carbazole-2- carboxylic acid amide	C
14	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid diethylamide	D
15	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid carbamoylmethyl-amide	D

16	8-Carbamoyl-6,7,8,9-tetrahydro-5H-carbazole-1-carboxylic acid	D
17	6-Methyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid	D
18	8-Carbamoyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
19	[(6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carbonyl)-amino]-acetic acid ethyl ester	D
20	9-Benzyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	D
21	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid methyl ester	D

22	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid	D
23	C-(6-Methyl-2,3,4,9-tetrahydro-1H-carbazol-1-yl)-methylanine	D
24	6,9-Dimethyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	D
25	7-Methyl-1,2,3,4-tetrahydro-cyclopenta[b]indole-3-carboxylic acid amide	D
26	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethylamide	D
27	2-(1-Benzyl-3-methylsulfanyl-1H-indol-2-yl)-N-p-tolyl-acetamide	D

28	N-Benzyl-2-(1-methyl-3-phenylsulfanyl-1H-indol-2-yl)-acetamide	D
29	N-(4-Chloro-phenyl)-2-(1-methyl-3-phenylsulfanyl-1H-indol-2-yl)-acetamide	D
30	N-(3-Hydroxy-propyl)-2-(1-methyl-3-phenylsulfanyl-1H-indol-2-yl)-acetamide	D
31	2-(1-Benzyl-3-phenylsulfanyl-1H-indol-2-yl)-N-(3-hydroxy-propyl)-acetamide	D
32	2-(1-Benzyl-3-methylsulfanyl-1H-indol-2-yl)-N-(4-methoxy-phenyl)-acetamide	D
33	2-(1-Benzyl-1H-indol-2-yl)-N-(4-methoxy-phenyl)-acetamide	D

34	2-(1-Methyl-3-methylsulfanyl-1H-indol-2-yl)-N-p-tolyl-acetamide	D
35	2-(1-Benzyl-3-methylsulfanyl-1H-indol-2-yl)-N-(2-chloro-phenyl)-acetamide	D
36	2-(1,5-Dimethyl-3-methylsulfanyl-1H-indol-2-yl)-N-(2-hydroxy-ethyl)-acetamide	D
37	(6-Chloro-2,3,4,9-tetrahydro-1H-carbazol-1-yl)-[4-(furan-2-carbonyl)-piperazin-1-yl]-methanone	D
38	2-(1-Benzyl-1H-indol-2-yl)-N-(2-chloro-phenyl)-acetamide	D
39	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D

40	6-Chloro-9-methyl-2,3,4,9-tetrahydro-1H-carbazole-4-carboxylic acid ethyl ester	D
41	5,7-Dichloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
42	7-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
43	5,7-Dichloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid	D
44	6-Chloro-9-methyl-2,3,4,9-tetrahydro-1H-carbazole-4-carboxylic acid	D
45	6-Chloro-9-methyl-2,3,4,9-tetrahydro-1H-carbazole-4-carboxylic acid amide	D

46	6-Morpholin-4-yl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
47	6-Morpholin-4-yl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	D
48	6-Bromo-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
49	6-Fluoro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid ethyl ester	D
50	3-Carbamoyl-1,3,4,9-tetrahydro-b-carboline-2-carboxylic acid tert-butyl ester	D
51	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid (1-phenyl-ethyl)-amide	D

52	6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid (1-phenyl-ethyl)-amide	D
53	7,8-Difluoro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide	D

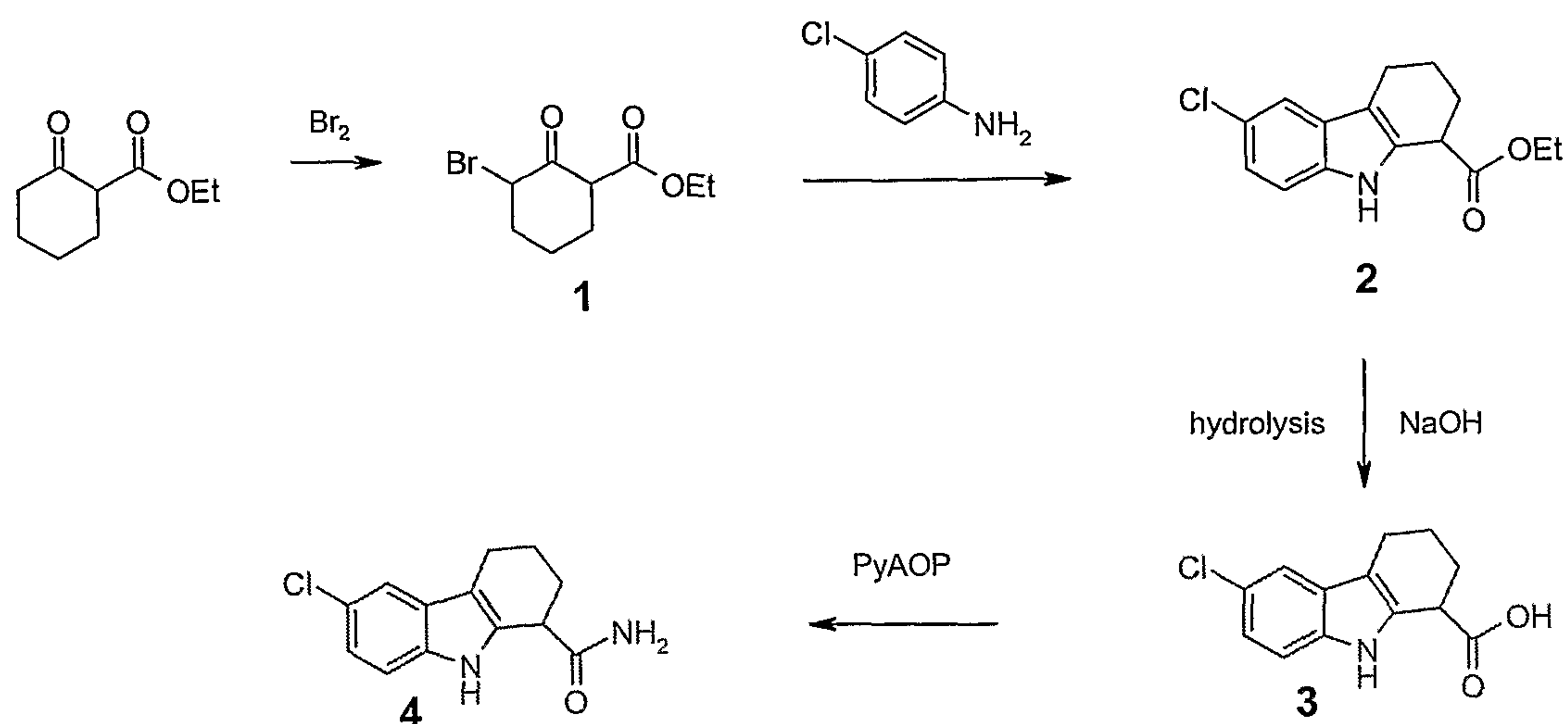
* Compounds having activity designated with an A have an IC_{50} of less than 1.0 μM . Compounds having activity designated with a B have an IC_{50} between 1.0 μM and 10.0 μM . Compounds having activity designated with a C have an IC_{50} greater than 10.0 μM . Compounds designated with a D were not tested in this assay.

Compounds that can be useful in practicing this invention can be identified through both *in vitro* (cell and non-cell based) and *in vivo* methods. A description of these methods is described in the Examples.

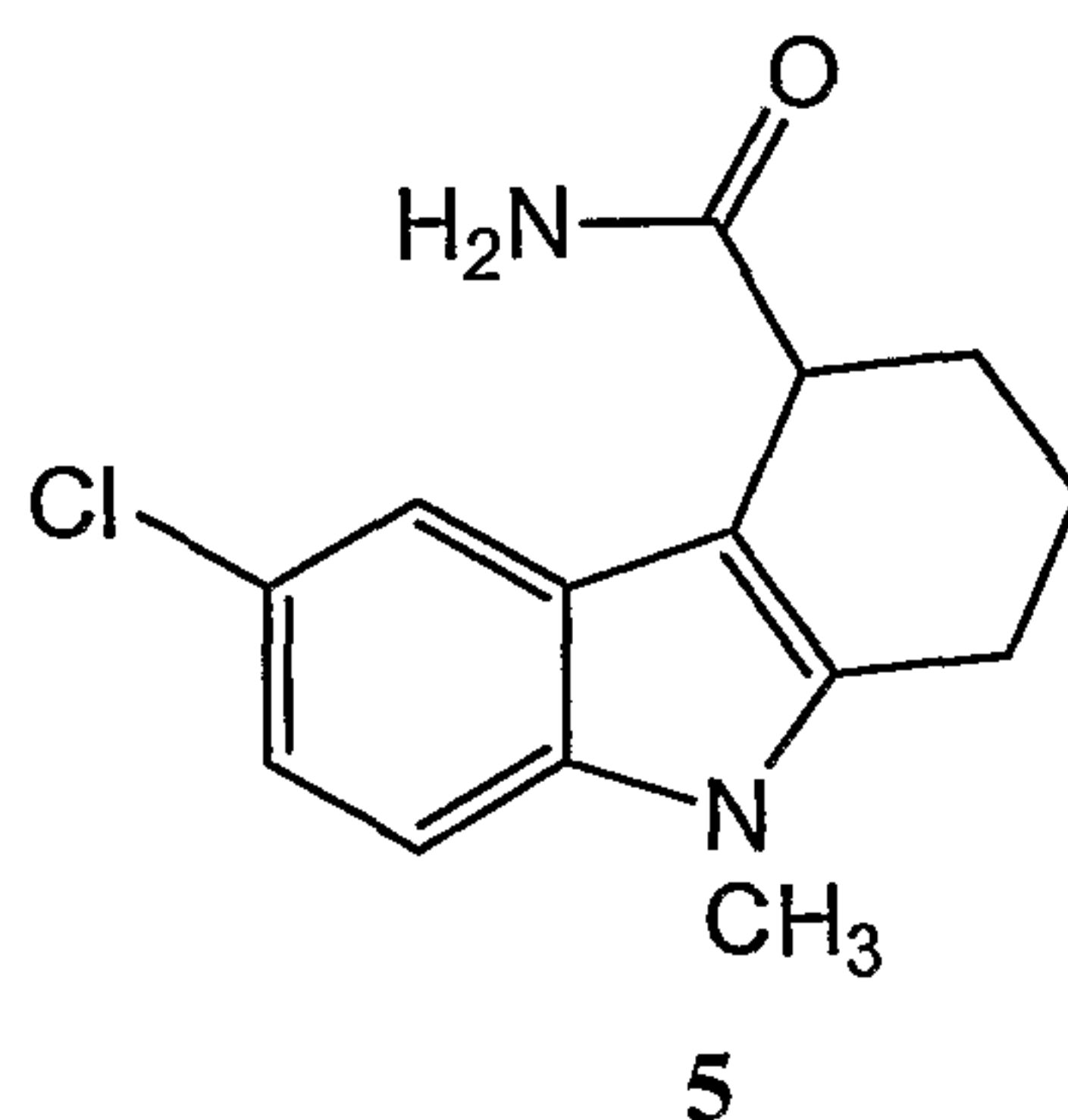
Synthesis of Compounds

The compounds described herein can be obtained from commercial sources (e.g., Asinex, Moscow, Russia; Bionet, Camelford, England; ChemDiv, SanDiego, CA; Comgenex, Budapest, Hungary; Enamine, Kiev, Ukraine; IF Lab, Ukraine; Interbioscreen, Moscow, Russia; Maybridge, Tintagel, UK; Specs, The Netherlands; Timtec, Newark, DE; Vitas-M Lab, Moscow, Russia) or synthesized by conventional methods as shown below using commercially available starting materials and reagents. For example, exemplary compound 4 can be synthesized as shown in Scheme 1 below.

Scheme 1



5 Brominated β -keto ester **1** can be condensed with 4-chloroaniline followed by cyclization can afford indole **2**. Ester saponification can afford acid **3**. Finally amination with PyAOP can yield the amide **4**. Other methods are known in the art, see, e.g., U.S. Patent 3,859,304, U.S. Patent 3,769,298, *J. Am. Chem. Soc.* **1974**, 74, 5495. The synthesis above can be extended to other anilines, e.g., 3,5-dichloroaniline, 3-chloroaniline, and 4-bromoaniline. Regioisomeric products, e.g., **5**, may be obtained using N-substituted anilines, e.g., 4-chloro-N-methylaniline.



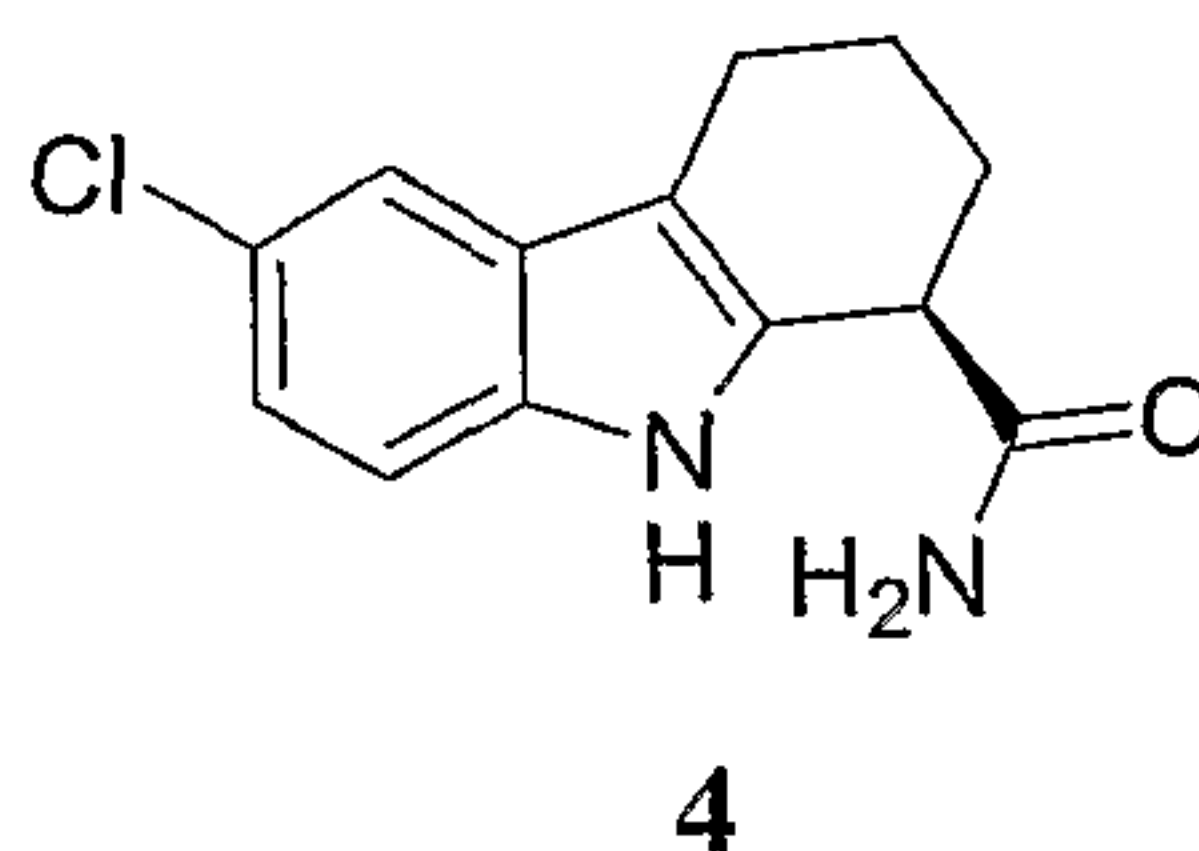
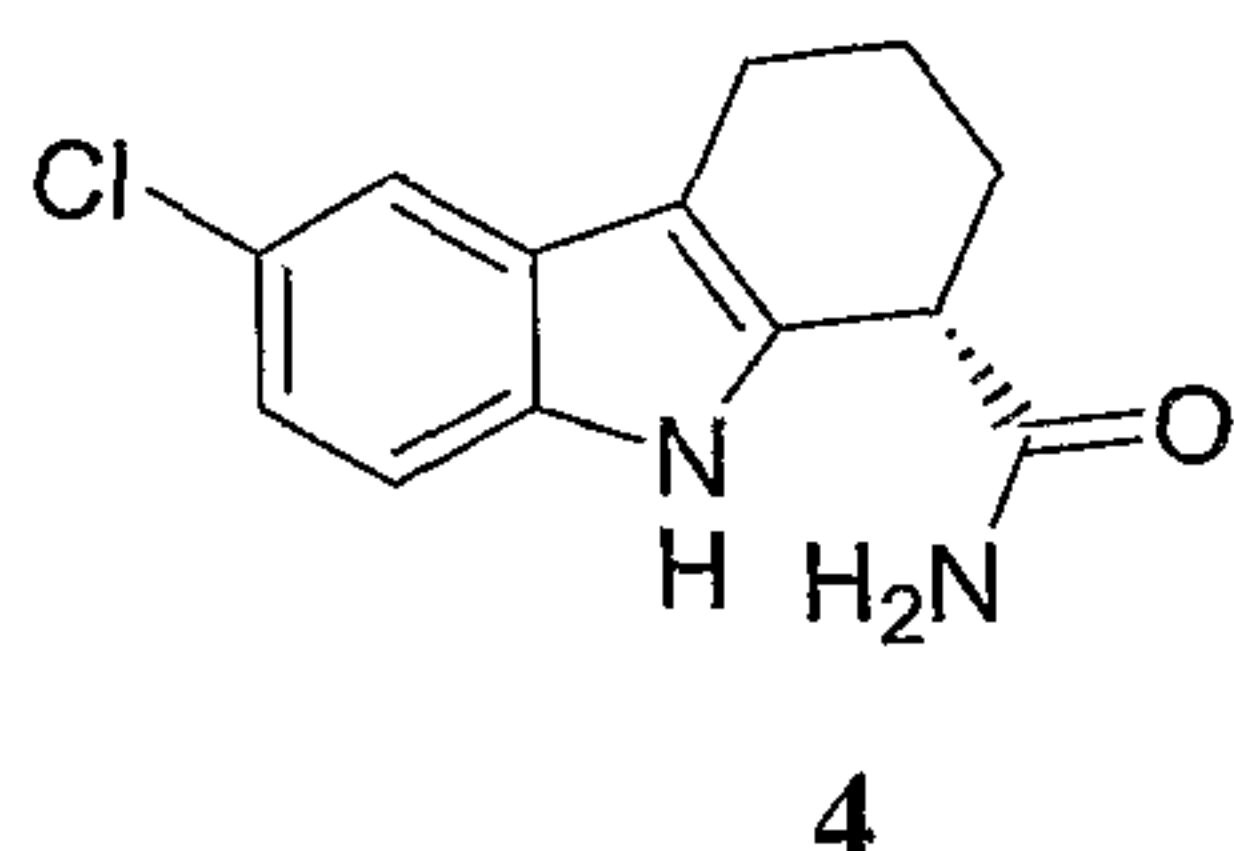
The compounds described herein can be separated from a reaction mixture and further purified by a method such as column chromatography, high-pressure liquid chromatography, or recrystallization. As can be appreciated by the skilled artisan, further methods of synthesizing the compounds of the formulae herein will be evident to those of ordinary skill in the art. Additionally, the various synthetic steps may be performed in an alternate sequence or order to give the desired compounds. Synthetic chemistry transformations and protecting group methodologies (protection and deprotection) useful in synthesizing the compounds described herein are known in the art and include, for example, those such as described in R. Larock, *Comprehensive Organic Transformations*, VCH Publishers (1989); T.W. Greene and P.G.M. Wuts, *Protective Groups in Organic Synthesis*, 2d. Ed., John Wiley and Sons (1991); L. Fieser and M. Fieser, *Fieser and Fieser's Reagents for Organic Synthesis*, John Wiley and Sons (1994); and L. Paquette, ed., *Encyclopedia of Reagents for Organic Synthesis*, John Wiley and Sons (1995), and subsequent editions thereof.

The compounds of this invention may contain one or more asymmetric centers and thus occur as racemates and racemic mixtures, single enantiomers, individual diastereomers and diastereomeric mixtures. All such isomeric forms of these compounds are expressly included in the present invention. The compounds of this invention may also contain linkages (e.g., carbon-carbon bonds) or substituents that can restrict bond rotation, e.g. restriction resulting from the presence of a ring or double bond. Accordingly, all *cis/trans* and *E/Z* isomers are expressly included in the present invention. The compounds of this invention may also be represented in multiple tautomeric forms, in such instances, the invention expressly includes all tautomeric forms of the compounds described herein, even though only a single tautomeric form may be represented (e.g., alkylation of a ring system may result in alkylation at multiple sites, the invention expressly includes all such reaction products). All such isomeric forms of such compounds are expressly included in the present invention. All crystal forms of the compounds described herein are expressly included in the present invention.

Techniques useful for the separation of isomers, e.g., stereoisomers are within skill of the art and are described in Eliel, E.L.; Wilen, S.H.; Mander, L.N.

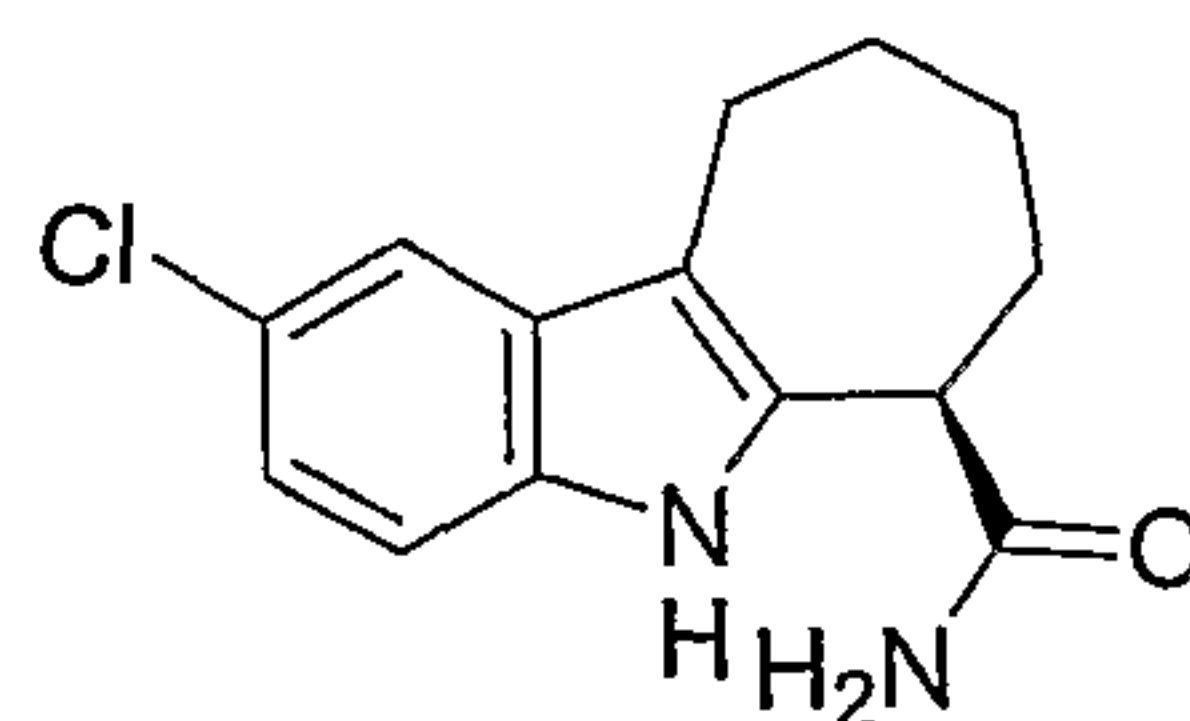
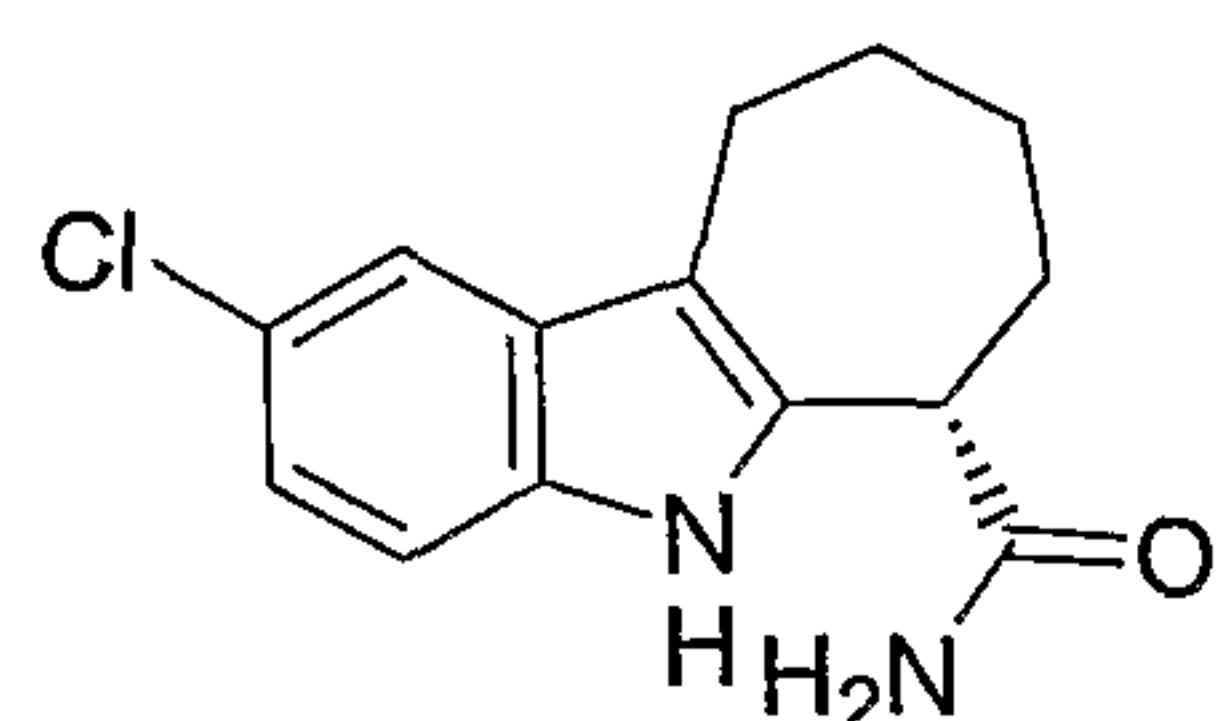
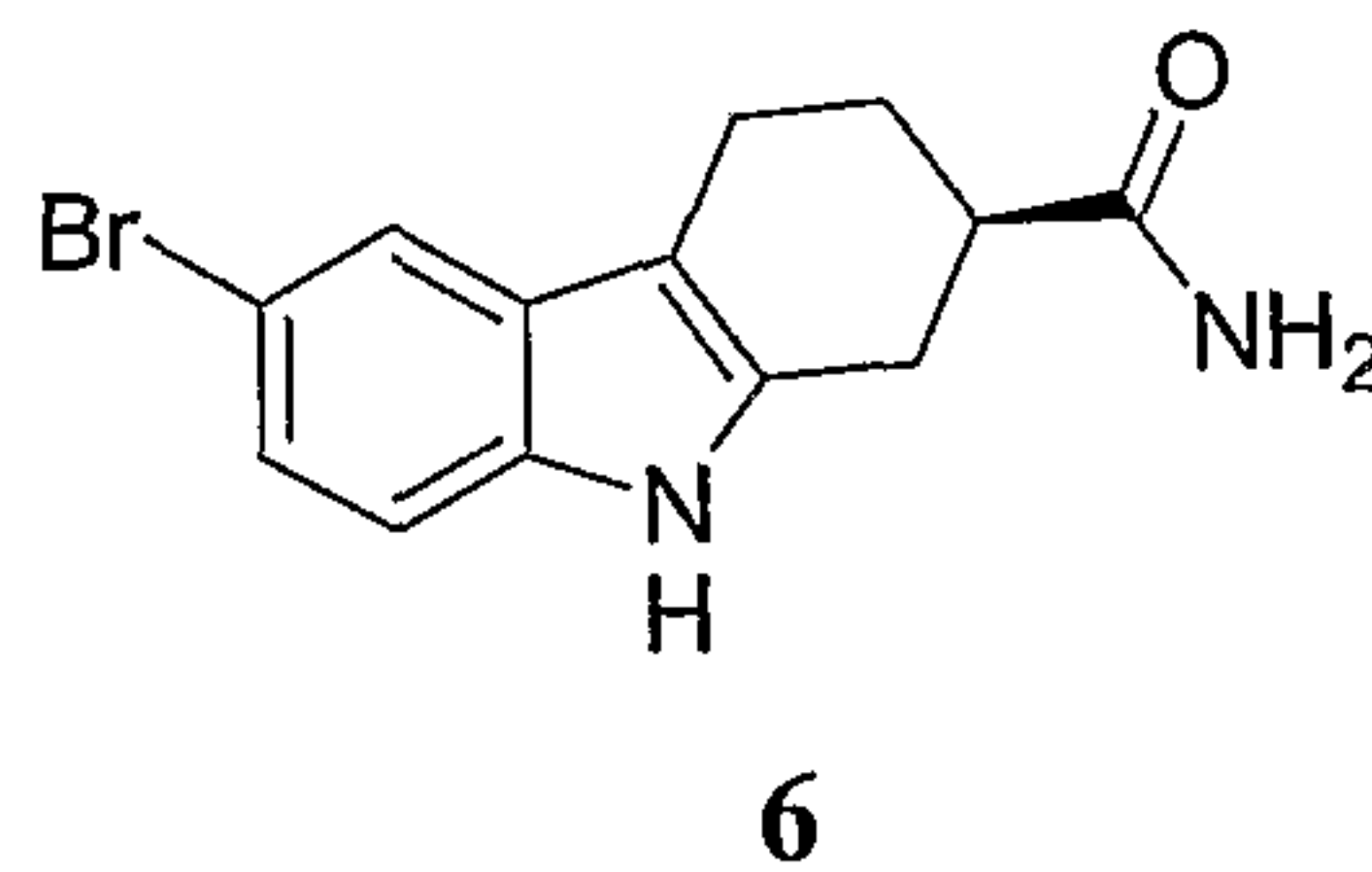
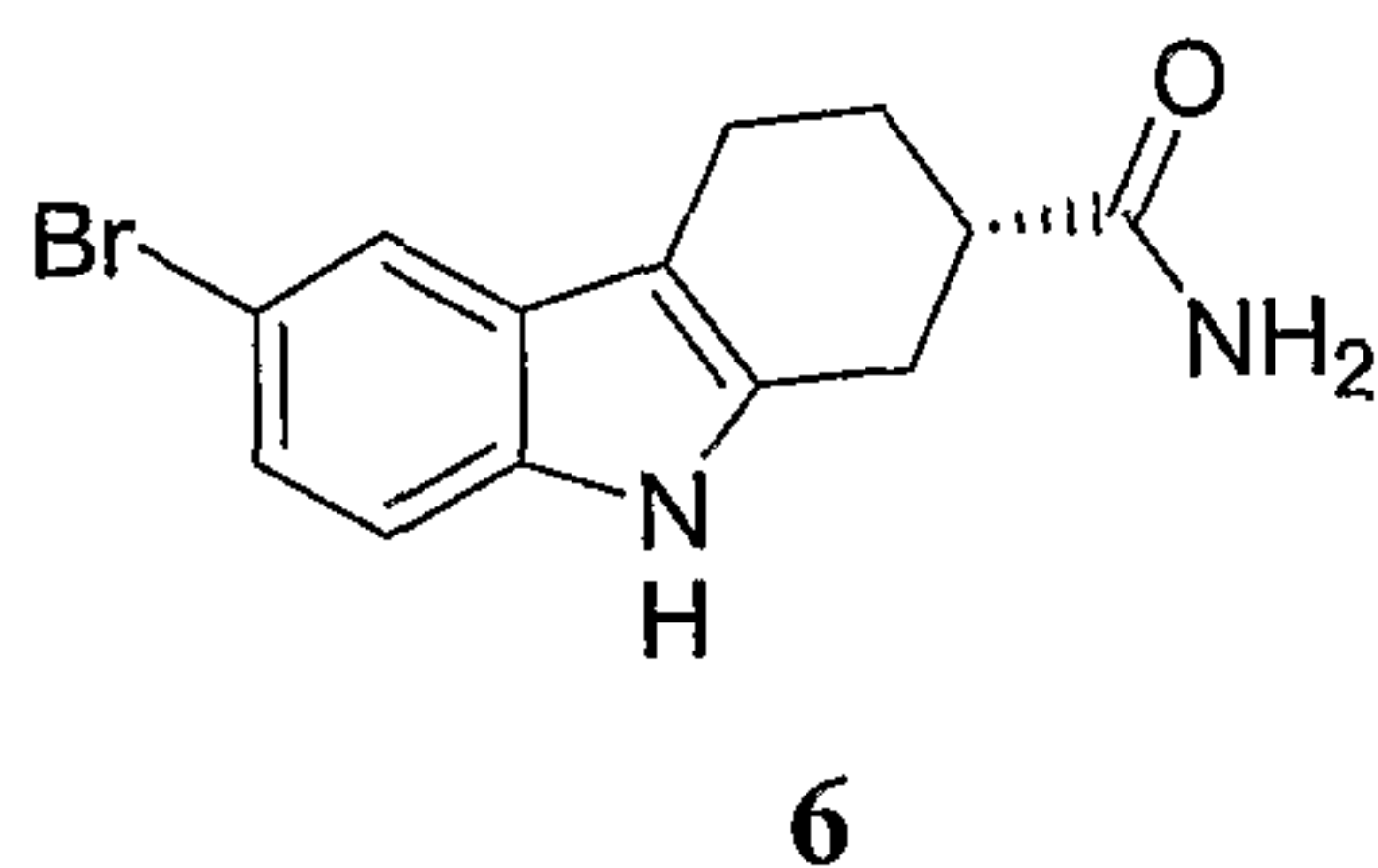
Stereochemistry of Organic Compounds, Wiley Interscience, NY, 1994. For example compound 3 or 4 can be resolved to a high enantiomeric excess (e.g., 60%, 70%, 80%, 85%, 90%, 95%, 99% or greater) via formation of diastomeric salts, e.g. with a chiral base, e.g., (+) or (-) α -methylbenzylamine, or via high performance liquid chromatography using a chiral column. In some embodiments, the crude product 4, is purified directly on a chiral column to provide enantiomerically enriched compound.

For purposes of illustration, enantiomers of compound 4 are shown below.



In some instances, the compounds disclosed herein are administered where one isomer (e.g., the *R* isomer or *S* isomer) is present in high enantiomeric excess. In general, the isomer of compound 4 having a negative optical rotation, e.g., -14.1 ($c=0.33$, DCM) or $[\alpha]_D^{25} -41.18^\circ$ (c 0.960, CH₃OH) has greater activity against the SirT1 enzyme than the enantiomer that has a positive optical rotation of +32.8 ($c=0.38$, DCM) or $[\alpha]_D^{25} +22.72^\circ$ (c 0.910, CH₃OH). Accordingly, in some instances, it is beneficial to administer to a subject a compound 4 having a high enantiomeric excess of the isomer having a negative optical rotation to treat a viral disease such as HIV.

While the enantiomers of compound 4 provide one example of a stereoisomer, other stereoisomers are also envisioned, for example as depicted in compounds 6 and 7 below.

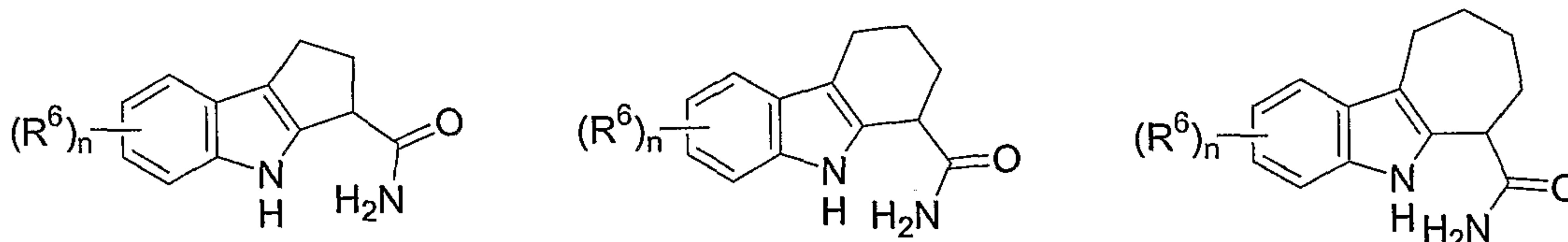


7

7

As with the compound of formula 4, in some instances it is beneficial to administer to a subject an isomer of compounds 6 and 7 that has a greater affinity for SirT1 than its enantiomer. For example, in some instances, it is beneficial to administer a compound 7 wherein the amide (or other substituent) has the same configuration as the negative isomer of compound 4.

In some instances, it is beneficial to administer a compound having the one of the following structures where the stereochemical structure of the amide (or other substituent) corresponds to the amide in compound 4 having a negative optical rotation.



(n is an integer from 0 to 4.)

The compounds of this invention include the compounds themselves, as well as their salts and their prodrugs, if applicable. A salt, for example, can be formed between an anion and a positively charged substituent (e.g., amino) on a compound described herein. Suitable anions include chloride, bromide, iodide, sulfate, nitrate, phosphate, citrate, methanesulfonate, trifluoroacetate, and acetate. Likewise, a salt can also be formed between a cation and a negatively charged substituent (e.g., carboxylate) on a compound described herein. Suitable cations include sodium ion, potassium ion, magnesium ion, calcium ion, and an ammonium cation such as tetramethylammonium ion. Examples of prodrugs include esters and other pharmaceutically acceptable derivatives, which, upon administration to a subject, are capable of providing active compounds.

The compounds of this invention may be modified by appending appropriate functionalities to enhance selected biological properties, e.g., targeting to a particular tissue. Such modifications are known in the art and include those which increase biological penetration into a given biological compartment (e.g., blood, lymphatic system, central nervous system), increase oral availability, increase solubility to allow administration by injection, alter metabolism and alter rate of excretion.

In an alternate embodiment, the compounds described herein may be used as platforms or scaffolds that may be utilized in combinatorial chemistry techniques for preparation of derivatives and/or chemical libraries of compounds. Such derivatives and libraries of compounds have biological activity and are useful for identifying and
5 designing compounds possessing a particular activity. Combinatorial techniques suitable for utilizing the compounds described herein are known in the art as exemplified by Obrecht, D. and Villalgrodo, J.M., *Solid-Supported Combinatorial and Parallel Synthesis of Small-Molecular-Weight Compound Libraries*, Pergamon-Elsevier Science Limited (1998), and include those such as the "split and pool" or "parallel" synthesis techniques,
10 solid-phase and solution-phase techniques, and encoding techniques (see, for example, Czarnik, A.W., *Curr. Opin. Chem. Bio.*, (1997) 1, 60. Thus, one embodiment relates to a method of using the compounds described herein for generating derivatives or chemical libraries comprising: 1) providing a body comprising a plurality of wells; 2) providing one or more compounds identified by methods described herein in each well; 3)
15 providing an additional one or more chemicals in each well; 4) isolating the resulting one or more products from each well. An alternate embodiment relates to a method of using the compounds described herein for generating derivatives or chemical libraries comprising: 1) providing one or more compounds described herein attached to a solid support; 2) treating the one or more compounds identified by methods described herein
20 attached to a solid support with one or more additional chemicals; 3) isolating the resulting one or more products from the solid support. In the methods described above, "tags" or identifier or labeling moieties may be attached to and/or detached from the compounds described herein or their derivatives, to facilitate tracking, identification or isolation of the desired products or their intermediates. Such moieties are known in the
25 art. The chemicals used in the aforementioned methods may include, for example, solvents, reagents, catalysts, protecting group and deprotecting group reagents and the like. Examples of such chemicals are those that appear in the various synthetic and protecting group chemistry texts and treatises referenced herein.

Sirtuins

Sirtuins are members of the Silent Information Regulator (SIR) family of genes. Sirtuins are proteins that include a SIR2 domain as defined as amino acids sequences that are scored as hits in the Pfam family "SIR2" – PF02146. This family is referenced in the INTERPRO database as INTERPRO description (entry IPR003000). To identify the presence of a "SIR2" domain in a protein sequence, and make the determination that a polypeptide or protein of interest has a particular profile, the amino acid sequence of the protein can be searched against the Pfam database of HMMs (e.g., the Pfam database, release 9) using the default parameters (http://www.sanger.ac.uk/Software/Pfam/HMM_search). The SIR2 domain is indexed in Pfam as PF02146 and in INTERPRO as INTERPRO description (entry IPR003000). For example, the hmmsf program, which is available as part of the HMMER package of search programs, is a family specific default program for MILPAT0063 and a score of 15 is the default threshold score for determining a hit. Alternatively, the threshold score for determining a hit can be lowered (e.g., to 8 bits). A description of the Pfam database can be found in "The Pfam Protein Families Database" Bateman A, Birney E, Cerruti L, Durbin R, Eweller L, Eddy SR, Griffiths-Jones S, Howe KL, Marshall M, Sonnhammer EL (2002) *Nucleic Acids Research* 30(1):276-280 and Sonnhammer *et al.* (1997) *Proteins* 28(3):405-420 and a detailed description of HMMs can be found, for example, in Gribskov *et al.* (1990) *Meth. Enzymol.* 183:146-159; Gribskov *et al.* (1987) *Proc. Natl. Acad. Sci. USA* 84:4355-4358; Krogh *et al.* (1994) *J. Mol. Biol.* 235:1501-1531; and Stultz *et al.* (1993) *Protein Sci.* 2:305-314.

The proteins encoded by members of the SIR2 gene family may show high sequence conservation in a 250 amino acid core domain. A well-characterized gene in this family is *S. cerevisiae* SIR2, which is involved in silencing HM loci that contain information specifying yeast mating type, telomere position effects and cell aging (Guarente, 1999; Kaeberlein *et al.*, 1999; Shore, 2000). The yeast Sir2 protein belongs to a family of histone deacetylases (reviewed in Guarente, 2000; Shore, 2000). The Sir2 protein is a deacetylase which can use NAD as a cofactor (Imai *et al.*, 2000; Moazed, 2001; Smith *et al.*, 2000; Tanner *et al.*, 2000; Tanny and Moazed, 2001). Unlike other deacetylases, many of which are involved in gene silencing, Sir2 is relatively insensitive

to histone deacetylase inhibitors like trichostatin A (TSA) (Imai *et al.*, 2000; Landry *et al.*, 2000a; Smith *et al.*, 2000). Mammalian Sir2 homologs, such as SIRT1, have NAD-dependent deacetylase activity (Imai *et al.*, 2000; Smith *et al.*, 2000).

Exemplary mammalian sirtuins include SIRT1, SIRT2, and SIRT3, e.g., human SIRT1, SIRT2, and SIRT3. A compound described herein may inhibit one or more activities of a mammalian sirtuin, e.g., SIRT1, SIRT2, or SIRT3, e.g., with a K_i of less than 500, 200, 100, 50, or 40 nM. For example, the compound may inhibit deacetylase activity, e.g., with respect to a natural or artificial substrate, e.g., a substrate described herein, e.g., as follows.

Natural substrates for SIRT1 include histones, p53, and FoxO transcription factors such as FoxO1 and FoxO3. SIRT1 proteins bind to a number of other proteins, referred to as "SIRT1 binding partners." For example, SIRT1 binds to p53 and plays a role in the p53 pathway, e.g., K370, K371, K372, K381, and/or K382 of p53 or a peptide that include one or more of these lysines. For example, the peptide can be between 5 and 15 amino acids in length. SIRT1 proteins can also deacetylate histones. For example, SIRT1 can deacetylate lysines 9 or 14 of histone H3 or small peptides that include one or more of these lysines. Histone deacetylation alters local chromatin structure and consequently can regulate the transcription of a gene in that vicinity. Many of the SIRT1 binding partners are transcription factors, e.g., proteins that recognize specific DNA sites. For example, SIRT1 deacetylates and downregulates forkhead proteins (i.e., FoxO proteins). Interaction between SIRT1 and SIRT1 binding partners can deliver SIRT1 to specific regions of a genome and can result in a local manifestation of substrates, e.g., histones and transcription factors localized to the specific region.

Natural substrates for SIRT2 include tubulin, e.g., alpha-tubulin. See, e.g., North *et al.* Mol Cell. 2003 Feb;11(2):437-44. Exemplary substrates include a peptide that includes lysine 40 of alpha-tubulin.

Still other exemplary sirtuin substrates include cytochrome c and acetylated peptides thereof, and HIV tat and acetylated peptides thereof.

The terms "SIRT1 protein" and "SIRT1 polypeptide" are used interchangeably herein and refer a polypeptide that is at least 25% identical to the 250 amino acid conserved SIRT1 catalytic domain, amino acid residues 258 to 451 of SEQ ID NO:1.

SEQ ID NO:1 depicts the amino acid sequence of human SIRT1. In preferred
embodiments, a SIRT1 polypeptide can be at least 30, 40, 50, 60, 70, 80, 85, 90, 95, 99%
homologous to SEQ ID NO:1 or to the amino acid sequence between amino acid residues
258 and 451 of SEQ ID NO:1. In other embodiments, the SIRT1 polypeptide can be a
5 fragment, e.g., a fragment of SIRT1 capable of one or more of: deacetylating a substrate
in the presence of NAD and/or a NAD analog and capable of binding a target protein,
e.g., a transcription factor. Such functions can be evaluated, e.g., by the methods
described herein. In other embodiments, the SIRT1 polypeptide can be a “full length”
SIRT1 polypeptide. The term “full length” as used herein refers to a polypeptide that has
10 at least the length of a naturally-occurring SIRT1 polypeptide (or other protein described
herein). A “full length” SIRT1 polypeptide or a fragment thereof can also include other
sequences, e.g., a purification tag, or other attached compounds, e.g., an attached
fluorophore, or cofactor. The term “SIRT1 polypeptides” can also include sequences or
variants that include one or more substitutions, e.g., between one and ten substitutions,
15 with respect to a naturally occurring Sir2 family member. A “SIRT1 activity” refers to
one or more activity of SIRT1, e.g., deacetylation of a substrate (e.g., an amino acid, a
peptide, or a protein), e.g., transcription factors (e.g., p53) or histone proteins, (e.g., in the
presence of a cofactor such as NAD and/or an NAD analog) and binding to a target, e.g.,
a target protein, e.g., a transcription factor.

20 As used herein, a “biologically active portion” or a “functional domain” of a
protein includes a fragment of a protein of interest which participates in an interaction,
e.g., an intramolecular or an inter-molecular interaction, e.g., a binding or catalytic
interaction. An inter-molecular interaction can be a specific binding interaction or an
enzymatic interaction (e.g., the interaction can be transient and a covalent bond is formed
25 or broken). An inter-molecular interaction can be between the protein and another
protein, between the protein and another compound, or between a first molecule and a
second molecule of the protein (e.g., a dimerization interaction). Biologically active
portions/functional domains of a protein include peptides comprising amino acid
sequences sufficiently homologous to or derived from the amino acid sequence of the
30 protein which include fewer amino acids than the full length, natural protein, and exhibit
at least one activity of the natural protein. Biological active portions/functional domains

can be identified by a variety of techniques including truncation analysis, site-directed mutagenesis, and proteolysis. Mutants or proteolytic fragments can be assayed for activity by an appropriate biochemical or biological (e.g., genetic) assay. In some embodiments, a functional domain is independently folded. Typically, biologically active portions comprise a domain or motif with at least one activity of a protein, e.g., SIRT1. An exemplary domain is the SIRT1 core catalytic domain. A biologically active portion/functional domain of a protein can be a polypeptide which is, for example, 10, 25, 50, 100, 200 or more amino acids in length. Biologically active portions/functional domain of a protein can be used as targets for developing agents which modulate SIRT1.

The following are exemplary SIR sequences:

>sp|Q96EB6|SIR1_HUMAN NAD-dependent deacetylase sirtuin 1
(EC 3.5.1.-) (hSIRT1) (hSIR2) (SIR2-like protein 1) - Homo sapiens (Human).

MADEAALALQPGGSPSAAGADREAASSPAGEPLRKRP RRDGPGLERSPGEPGGAAPERE
V
PAAARGCPGAAAAALWREAEEAAAAGGEQEAQATAAAGEGDNGPGLQGPSREPPLADN
L
YDEDDDDDEGEEEEEEAAAAAIGYRDNLLFGDEIITNGFHSCESEEDRASHASSSDWTPR
P
RIGPYTFVQQHLMIGTDPRTILKDLLPETIPPELDDMTLWQIVINILSEPPKRKKRKD
I
NTIEDAVKLLQECKKIIIVLTGAGVSVSCGIPDFRSRDGIYARLAVDFPDL PDPQAMFDI
E
YFRKDPRPFFKFKEIYPGQFQPSLCHKFIALSDKEGKLLRNYTQNIDTLEQVAGIQRI
I
QCHGSFATASCLICKYKVDCEAVRGDIFNQVVP RCP RCPADEPLAIMKPEIVFFGENLP
E
QFHRAMKYDKDEVDLLIVIGSSLKVRPVALIPSSI PHEVPQILINREPLPHLHFDVELL
G
DCDVIINELCHRLGGEYAKLCCNPVKLSEITEKPPRTQKELAYLSEL PPTPLHVSEDSS
S
PERTSPPDSSVIIVTLLDQAAKSNDLDVSESKGCMEEKPQEVQTSRNVESIAEQMENPD
L
KNVGSSTGEKNERTSVAGTVRK CWPNRVAKEQISRRLDGNQYLFLPPNRYIFHGAEVYS
D
SEDDVLSSSSCGSNSDSGTCQSPSLEEPMEDESEIEEFYNGLEDEPDVPERAGGAGFGT
D
GDDQEAIN EAI SVKQEV TDMNYP SNKS (SEQ ID NO:1)

>sp|Q8IXJ6|SIR2_HUMAN NAD-dependent deacetylase sirtuin 2
(EC 3.5.1.-) (SIR2-like) (SIR2-like protein 2) - Homo
sapiens (Human).

5 MAEPDPSHPLETQAGKVQEAQDSDSDSEGGAAGGEADMDFLRNLFSSQTLSSLGSQKERLL
D
ELTLEGVARYMQSERCRRVICLVGAGISTSAGIPDFRSPSTGLYDNLEKYHLPYPEAIF
E
10 ISYFKKHPEPFFALAKELYPGQFKPTICHYFMRLCLKDKGLLLRCYTONIDTLERAGLE
Q
EDLVEAHGTFYTSCHCVSASCRHEYPLSWMKEKIFSEVTPKCEDCQSLVKPDIVFFGESL
P
ARFFSCMQSDFLKVDLLLVMGTSLOVQPFASLISKAPLSTPRLLINKEKAGQSDPFLGM
I
15 MGLGGGMDFDSKKAYRDVAWLGECDQGCLALAEELGWKKELEDLVRREHASIDAQSGAG
V
PNPSTSASPKKSPPPAKDEARTTEREKPQ (SEQ ID NO:2)

20 >sp|Q9NTG7|SIR3_HUMAN NAD-dependent deacetylase sirtuin 3,
mitochondrial precursor (EC 3.5.1.-) (SIR2-like protein 3)
(hSIRT3) - Homo sapiens (Human).
MAFWGWRAAAALRLWGRVVERVEAGGGVGPFGACGCRLVLGGRDDVSAGLRGSHGARGE
25 P
LDPARPLQRPPRPEVPRAFRQPRAAAPSFFFSSIKGGRRSISFSVGASSVVGSGGSSD
K
GKLSLQDVAELIRARACQRVVVMVGAGISTPSGIPDFRSPGSGLYSNLQQYDLPYPEAI
F
30 ELPFFFHNPKPFFTLAKELYPGNYKPNVTHYFLRLLHDKGLLLRLYTQNIDGLERVSGI
P
ASKLVEAHGTFASATCTVCQRPFGEDIRADVMADRVPRCPVCTGVVKPDIVFFGEPLP
Q
RFLLVHVDVPMADLLLILGTSLEVEPFASLTEAVRSSVPRLINRDLVGPLAWHPRSRD
35 V
AQLGDVVHGVESLVELLGWTEEMRDLVQRETGKLDGPK (SEQ ID NO:3)

40 >sp|Q9Y6E7|SIR4_HUMAN NAD-dependent deacetylase sirtuin 4
(EC 3.5.1.-) (SIR2-like protein 4) - Homo sapiens (Human).
MKMSFALTFRSAKGRWIANPSQPCSKASIGLFVPASPPLDPEKVKELQRFITLSKRLLV
M
TGAGISTESGIPDYRSEKVGLYARTDRRPIQHGFVRSAPIRQRYWARNFVGWPQFSSH
Q
45 PNPAHWALSTWEKLGKLYWLVTQNVDAHHTKAGSRRLTELHGCMDRVLCLDCGEQTPRG
V

LQERFQVLNPTWSAEAHGLAPDGDVFLSEEQVRSFQVPTCVQCGGHLKPDVVFFGDTVN
P

DKVDFVHKRVKEADSLLVVGSSLQVYSGYRFILTAWKKLPAILNIGPTRSDDLACK
L

5 NSRCGELLPLIDPC (SEQ ID NO:4)

>sp|Q9NXA8|SIR5_HUMAN NAD-dependent deacetylase sirtuin 5
(EC 3.5.1.-) (SIR2-like protein 5) - Homo sapiens (Human).

10 MRPLQIVPSRLISQLYCGLKPPASTRNQICLKMARPSSSMADFRKFFAKAKHIVIISGA
G

VSAESGVPTFRGAGGYWRKWQAQDLATPLAFAHNPSRVWEFYHYRREVMGSKEPNAGHR
A

15 IAECETRLGKQGRRVVVITQNIDELHRKAGTKNLLEIHGSLFKTRCTSCGVVAENYKSP
I

CPALSGKGAPFPGTQDASIPVEKLPRCEEAGCGLLRPHVVWFGENLDPAILLEEVDREL
A

HCDLCLVVGTTSSVVYPAAMFAPQVAARGVPVAEFNTETTPATNRFRFHFQGPCGTTLPE
A

20 LACHENETVS (SEQ ID NO:5)

>sp|Q8N6T7|SIR6_HUMAN NAD-dependent deacetylase sirtuin 6
(EC 3.5.1.-) (SIR2-like protein 6) - Homo sapiens (Human).

25 MSVNYAAGLSPYADKGKCGLPEIFDPPEELERKVVWELARLVWQSSSVVFHTGAGISTAS
G

IPDFRGPHGVWTMEERGLAPKFDTTFESARPTQTHMALVQLERVGLLRFLVSQNVDGLH
V

30 RSGFPRDKLAELHGNMFVEECAKCKTQYVRDVTVGTMGLKATGRLCTVAKARGLRACRG
E

LRDTILDWEDSLPDRDLALADEASRNADLSITLGTSLQIRPSGNLPLATKRRGGRLVIV
N

LQPTKHDRHADLRIHGYVDEVMTRLMKHLGLEIPAWDGPRVLERALPPLPRPPTPKLEP
K

35 EESPTRINGSIPAGPKQEPQAHNGSEPASPKRERPTSPAPHRPPKRVKAKAVPS
(SEQ ID NO:6)

>sp|Q9NRC8|SIR7_HUMAN NAD-dependent deacetylase sirtuin 7
(EC 3.5.1.-) (SIR2-like protein 7) - Homo sapiens (Human).

40 MAAGGLSRSERKAAERVRLREEQQRERLRQVSRILRKAAAERSAEEGRLLAESADLVT
E

LQGRSRRREGLKRRQEEVCDDPEELRGKVRELASAVRNAKYLVVYTGAGISTAASIPDY
R

45 GPNGVWTLQKGRSVSAADLSEAEPTLTHMSITRLHEQKLVQHVVSNCDGLHLRSGLP
R

TAISELHGNMYIEVCTSCVPNREYVRVFDVTER TALHRHQTGRTCHKCGTQLRDTIVHF
 G
 ERGTLGQPLNWEAATEAASRADTILCLGSSLKVLKKYPRLWCMTKPPSRRPKLYIVNLQ
 W
 5 TPKDDWAALKLHGKCDDVMRLLMAELGLEIPAYSRWQDPIFSLATPLRAGEEGSHSRKS
 L
 CRSREEAPPGDRGAPLSSAPILGGWFGRGCTKRTKRKKVT (SEQ ID NO:7)

Exemplary compounds described herein may inhibit activity of SIRT1 or a
 10 functional domain thereof by at least 10, 20, 25, 30, 50, 80, or 90%, with respect to a
 natural or artificial substrate described herein. For example, the compounds may have a
 Ki of less than 500, 200, 100, or 50 nM.

A compound described herein may also modulate a complex between a sirtuin and
 a transcription factor, e.g., increase or decrease complex formation, deformation, and/or
 15 stability. Exemplary sirtuin-TF complexes include Sir2-PCAF, SIR2-MyoD, Sir2-PCAF-
 MyoD, and Sir2-p53. A compound described herein may also modulate expression of a
 Sir2 regulated gene, e.g., a gene described in Table 1 of Fulco et al. (2003) *Mol. Cell*
 12:51-62.

20 In Vitro Assays

In some embodiments, interaction with, e.g., binding of, SIRT1 can be assayed *in*
vitro. The reaction mixture can include a SIRT1 co-factor such as NAD and/or a NAD
 analog.

In other embodiments, the reaction mixture can include a SIRT1 binding partner,
 25 e.g., a transcription factor, e.g., a viral transcription factor (e.g., tat), p53 or a
 transcription factor other than p53, and compounds can be screened, e.g., in an *in vitro*
 assay, to evaluate the ability of a test compound to modulate interaction between SIRT1
 and a SIRT1 binding partner, e.g., a transcription factor. This type of assay can be
 accomplished, for example, by coupling one of the components, with a radioisotope or
 30 enzymatic label such that binding of the labeled component to the other can be
 determined by detecting the labeled compound in a complex. A component can be
 labeled with ¹²⁵I, ³⁵S, ¹⁴C, or ³H, either directly or indirectly, and the radioisotope
 detected by direct counting of radioemmission or by scintillation counting. Alternatively,

a component can be enzymatically labeled with, for example, horseradish peroxidase, alkaline phosphatase, or luciferase, and the enzymatic label detected by determination of conversion of an appropriate substrate to product. Competition assays can also be used to evaluate a physical interaction between a test compound and a target.

5 Cell-free assays involve preparing a reaction mixture of the target protein (e.g., SIRT1) and the test compound under conditions and for a time sufficient to allow the two components to interact and bind, thus forming a complex that can be removed and/or detected.

10 The interaction between two molecules can also be detected, e.g., using a fluorescence assay in which at least one molecule is fluorescently labeled. One example of such an assay includes fluorescence energy transfer (FET or FRET for fluorescence resonance energy transfer) (see, for example, Lakowicz *et al.*, U.S. Patent No. 5,631,169; Stavrianopoulos, *et al.*, U.S. Patent No. 4,868,103). A fluorophore label on the first, 'donor' molecule is selected such that its emitted fluorescent energy will be absorbed by
15 a fluorescent label on a second, 'acceptor' molecule, which in turn is able to fluoresce due to the absorbed energy. Alternately, the 'donor' protein molecule may simply utilize the natural fluorescent energy of tryptophan residues. Labels are chosen that emit different wavelengths of light, such that the 'acceptor' molecule label may be differentiated from that of the 'donor'. Since the efficiency of energy transfer between
20 the labels is related to the distance separating the molecules, the spatial relationship between the molecules can be assessed. In a situation in which binding occurs between the molecules, the fluorescent emission of the 'acceptor' molecule label in the assay should be maximal. A FET binding event can be conveniently measured through standard fluorometric detection means well known in the art (e.g., using a fluorimeter).

25 Another example of a fluorescence assay is fluorescence polarization (FP). For FP, only one component needs to be labeled. A binding interaction is detected by a change in molecular size of the labeled component. The size change alters the tumbling rate of the component in solution and is detected as a change in FP. See, e.g., Nasir *et al.* (1999) *Comb Chem HTS* 2:177-190; Jameson *et al.* (1995) *Methods Enzymol* 246:283;
30 Seethala *et al.* (1998) *Anal Biochem.* 255:257. Fluorescence polarization can be monitored in multiwell plates, e.g., using the Tecan Polarion™ reader. See, e.g., Parker

et al. (2000) *Journal of Biomolecular Screening* 5 :77–88; and Shoeman, *et al.* (1999) 38, 16802-16809.

In another embodiment, determining the ability of the SIRT1 protein to bind to a target molecule can be accomplished using real-time Biomolecular Interaction Analysis (BIA) (see, e.g., Sjolander, S. and Urbaniczky, C. (1991) *Anal. Chem.* 63:2338-2345 and Szabo *et al.* (1995) *Curr. Opin. Struct. Biol.* 5:699-705). "Surface plasmon resonance" or "BIA" detects biospecific interactions in real time, without labeling any of the interactants (e.g., BIAcore). Changes in the mass at the binding surface (indicative of a binding event) result in alterations of the refractive index of light near the surface (the optical phenomenon of surface plasmon resonance (SPR)), resulting in a detectable signal which can be used as an indication of real-time reactions between biological molecules.

In one embodiment, SIRT1 is anchored onto a solid phase. The SIRT1/test compound complexes anchored on the solid phase can be detected at the end of the reaction, e.g., the binding reaction. For example, SIRT1 can be anchored onto a solid surface, and the test compound, (which is not anchored), can be labeled, either directly or indirectly, with detectable labels discussed herein.

It may be desirable to immobilize either the SIRT1 or an anti-SIRT1 antibody to facilitate separation of complexed from uncomplexed forms of one or both of the proteins, as well as to accommodate automation of the assay. Binding of a test compound to a SIRT1 protein, or interaction of a SIRT1 protein with a second component in the presence and absence of a candidate compound, can be accomplished in any vessel suitable for containing the reactants. Examples of such vessels include microtiter plates, test tubes, and micro-centrifuge tubes. In one embodiment, a fusion protein can be provided which adds a domain that allows one or both of the proteins to be bound to a matrix. For example, glutathione-S-transferase/SIRT1 fusion proteins or glutathione-S-transferase/target fusion proteins can be adsorbed onto glutathione sepharose beads (Sigma Chemical, St. Louis, MO) or glutathione derivatized microtiter plates, which are then combined with the test compound or the test compound and either the non-adsorbed target protein or SIRT1 protein, and the mixture incubated under conditions conducive to complex formation (e.g., at physiological conditions for salt and pH). Following incubation, the beads or microtiter plate wells are washed to remove any

unbound components, the matrix immobilized in the case of beads, complex determined either directly or indirectly, for example, as described above. Alternatively, the complexes can be dissociated from the matrix, and the level of SIRT1 binding or activity determined using standard techniques.

5 Other techniques for immobilizing either a SIRT1 protein or a target molecule on matrices include using conjugation of biotin and streptavidin. Biotinylated SIRT1 protein or target molecules can be prepared from biotin-NHS (N-hydroxy-succinimide) using techniques known in the art (e.g., biotinylation kit, Pierce Chemicals, Rockford, IL), and immobilized in the wells of streptavidin-coated 96 well plates (Pierce Chemical).

10 In order to conduct the assay, the non-immobilized component is added to the coated surface containing the anchored component. After the reaction is complete, unreacted components are removed (e.g., by washing) under conditions such that any complexes formed will remain immobilized on the solid surface. The detection of complexes anchored on the solid surface can be accomplished in a number of ways.

15 Where the previously non-immobilized component is pre-labeled, the detection of label immobilized on the surface indicates that complexes were formed. Where the previously non-immobilized component is not pre-labeled, an indirect label can be used to detect complexes anchored on the surface, e.g., using a labeled antibody specific for the immobilized component (the antibody, in turn, can be directly labeled or indirectly
20 labeled with, e.g., a labeled anti-Ig antibody).

In one embodiment, this assay is performed utilizing antibodies reactive with a SIRT1 protein or target molecules but which do not interfere with binding of the SIRT1 protein to its target molecule. Such antibodies can be derivatized to the wells of the plate, and unbound target or the SIRT1 protein trapped in the wells by antibody conjugation.
25 Methods for detecting such complexes, in addition to those described above for the GST-immobilized complexes, include immunodetection of complexes using antibodies reactive with the SIRT1 protein or target molecule, as well as enzyme-linked assays which rely on detecting an enzymatic activity associated with the SIRT1 protein or target molecule.

30 Alternatively, cell free assays can be conducted in a liquid phase. In such an assay, the reaction products are separated from unreacted components, by any of a

number of standard techniques, including but not limited to: differential centrifugation (see, for example, Rivas, G., and Minton, A.P., (1993) *Trends Biochem Sci* 18:284-7); chromatography (gel filtration chromatography, ion-exchange chromatography); electrophoresis (see, e.g., Ausubel, F. *et al.*, eds. *Current Protocols in Molecular Biology* 1999, J. Wiley: New York.); and immunoprecipitation (see, for example, Ausubel, F. *et al.*, eds. (1999) *Current Protocols in Molecular Biology*, J. Wiley: New York). Such resins and chromatographic techniques are known to one skilled in the art (see, e.g., Heegaard, N.H., (1998) *J Mol Recognit* 11:141-8; Hage, D.S., and Tweed, S.A. (1997) *J Chromatogr B Biomed Sci Appl.* 699:499-525). Further, fluorescence energy transfer may also be conveniently utilized, as described herein, to detect binding without further purification of the complex from solution.

In a preferred embodiment, the assay includes contacting the SIRT1 protein or biologically active portion thereof with a known compound which binds a SIRT1 to form an assay mixture, contacting the assay mixture with a test compound, and determining the ability of the test compound to interact with a SIRT1 protein, wherein determining the ability of the test compound to interact with the SIRT1 protein includes determining the ability of the test compound to preferentially bind to the SIRT1 or biologically active portion thereof, or to modulate the activity of a target molecule, as compared to the known compound.

An exemplary assay method includes a 1536 well format of the SirT1 enzymatic assay that is based on the commercial “Fluor-de-Lys” assay principle by Biomol, which is fluorogenic (www.biomol.com/store/Product_Data_PDFs/ak500.pdf). In this assay, deacetylation of the e-amino function of a lysyl residue is coupled to a fluorogenic “development step that is dependent on the unblocked e-amino functionality and generates fluorescent aminomethylcoumarin. Fluorescence can be read on a commercial macroscopic reader.

Additional Assays

A compound or library of compounds described herein can also be evaluated using model systems for a disease or disorder, or other known models of a disease or disorder described herein.

Structure-Activity Relationships and Structure-Based Design. It is also possible to use structure-activity relationships (SAR) and structure-based design principles to produce a compound that interact with a sirtuin, e.g., antagonizes or agonizes a sirtuin. SARs provide information about the activity of related compounds in at least one relevant assay. Correlations are made between structural features of a compound of interest and an activity. For example, it may be possible by evaluating SARs for a family of compounds related to a compound described herein to identify one or more structural features required for the agonist's activity. A library of compounds can then be chemically produced that vary these features. In another example, a single compound that is predicted to interact is produced and evaluated in vitro or in vivo.

Structure-based design can include determining a structural model of the physical interaction of a functional domain of a sirtuin and a compound. The structural model can indicate how the compound can be engineered, e.g., to improve interaction or reduce unfavorable interactions. The compound's interaction with the sirtuin can be identified, e.g., by solution of a crystal structure, NMR, or computer-based modeling, e.g., docking methods. See, e.g., Ewing et al. J Comput Aided Mol Des. 2001 May;15(5):411-28.

Both the SAR and the structure-based design approach, as well as other methods, can be used to identify a pharmacophore. A pharmacophore is defined as a distinct three dimensional (3D) arrangement of chemical groups. The selection of such groups may be favorable for biological activity. Since a pharmaceutically active molecule must interact with one or more molecular structures within the body of the subject in order to be effective, and the desired functional properties of the molecule are derived from these interactions, each active compound must contain a distinct arrangement of chemical groups which enable this interaction to occur. The chemical groups, commonly termed descriptor centers, can be represented by (a) an atom or group of atoms; (b) pseudo-atoms, for example a center of a ring, or the center of mass of a molecule; (c) vectors, for example atomic pairs, electron lone pair directions, or the normal to a plane. Once formulated a pharmacophore can be used to search a database of chemical compound, e.g., for those having a structure compatible with the pharmacophore. See, for example, U.S. 6,343,257 ; Y. C. Martin, 3D Database Searching in Drug Design, J. Med. Chem. 35,

2145(1992); and A. C. Good and J. S. Mason, Three Dimensional Structure Database Searches, Reviews in Comp. Chem. 7, 67(1996). Database search queries are based not only on chemical property information but also on precise geometric information.

Computer-based approaches can use database searching to find matching
5 templates; Y. C. Martin, Database searching in drug design, J. Medicinal Chemistry, vol. 35, pp 2145-54 (1992), which is herein incorporated by reference. Existing methods for searching 2-D and 3-D databases of compounds are applicable. Lederle of American Cyanamid (Pearl River, N.Y.) has pioneered molecular shape-searching, 3D searching and trend-vectors of databases. Commercial vendors and other research groups also
10 provide searching capabilities (MACSS-3D, Molecular Design Ltd. (San Leandro, Calif.); CAVEAT, Lauri, G. et al., University of California (Berkeley, Calif.); CHEM-X, Chemical Design, Inc. (Mahwah, N.J.)). Software for these searches can be used to analyze databases of potential drug compounds indexed by their significant chemical and geometric structure (e.g., the Standard Drugs File (Derwent Publications Ltd., London,
15 England), the Bielstein database (Bielstein Information, Frankfurt, Germany or Chicago), and the Chemical Registry database (CAS, Columbus, Ohio)).

Once a compound is identified that matches the pharmacophore, it can be tested for activity in vitro, in vivo, or in silico, e.g., for binding to a sirtuin or domain thereof.

In one embodiment, a compound that is an agonist or a candidate agonist, e.g., a
20 compound described in Nature. 2003 Sep 11;425(6954):191-196 can be modified to identify an antagonist, e.g., using the method described herein. For example, a library of related compounds can be prepared and the library can be screened in an assay described herein.

Pharmaceutically acceptable salts of the compounds of this invention include
25 those derived from pharmaceutically acceptable inorganic and organic acids and bases. Examples of suitable acid salts include acetate, adipate, alginate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, citrate, camphorate, camphorsulfonate, digluconate, dodecylsulfate, ethanesulfonate, formate, fumarate, glucoheptanoate, glycolate, hemisulfate, heptanoate, hexanoate, hydrochloride, hydrobromide, hydroiodide, 2-
30 hydroxyethanesulfonate, lactate, maleate, malonate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, palmoate, pectinate, persulfate, 3-

phenylpropionate, phosphate, picrate, pivalate, propionate, salicylate, succinate, sulfate, tartrate, thiocyanate, tosylate and undecanoate. Other acids, such as oxalic, while not in themselves pharmaceutically acceptable, may be employed in the preparation of salts useful as intermediates in obtaining the compounds of the invention and their

5 pharmaceutically acceptable acid addition salts. Salts derived from appropriate bases include alkali metal (e.g., sodium), alkaline earth metal (e.g., magnesium), ammonium and N-(alkyl)₄⁺ salts. This invention also envisions the quaternization of any basic nitrogen-containing groups of the compounds disclosed herein. Water or oil-soluble or dispersible products may be obtained by such quaternization. Salt forms of the
10 compounds of any of the formulae herein can be amino acid salts of carboxy groups (e.g. L-arginine, -lysine, -histidine salts).

The compounds of the formulae described herein can, for example, be administered by injection, intravenously, intraarterially, subdermally, intraperitoneally, intramuscularly, or subcutaneously; or orally, buccally, nasally, transmucosally, topically,
15 in an ophthalmic preparation, or by inhalation, with a dosage ranging from about 0.5 to about 100 mg/kg of body weight, alternatively dosages between 1 mg and 1000 mg/dose, every 4 to 120 hours, or according to the requirements of the particular drug. The methods herein contemplate administration of an effective amount of compound or compound composition to achieve the desired or stated effect. Typically, the
20 pharmaceutical compositions of this invention will be administered from about 1 to about 6 times per day or alternatively, as a continuous infusion. Such administration can be used as a chronic or acute therapy. The amount of active ingredient that may be combined with the carrier materials to produce a single dosage form will vary depending upon the host treated and the particular mode of administration. A typical preparation will contain
25 from about 5% to about 95% active compound (w/w). Alternatively, such preparations contain from about 20% to about 80% active compound.

The compounds can be administered alone, or in combination with one or more additional therapeutic agents, e.g., a protease inhibitor, e.g., a HIV protease inhibitor, a fusion inhibitor, an integrase inhibitor, or a reverse transcriptase inhibitor, (e.g., a
30 nucleotide analog, e.g., AZT, or a non-nucleoside reverse transcriptase inhibitor). When a compound is administered in combination with another (e.g., at least one additional)

therapeutic agent the compound and agent can be administered in a single composition, for example a single pill or suspension, or the compound and agent (or agents) can be administered separately, for example in multiple compositions such as pills or suspensions. When administered separately, the compound and agent (or agents) can be administered at the same time, or at different times. In some instances, the compound and agent (or agents) have the same course of therapy, and in other times, the courses are either skewed or sequential.

Lower or higher doses than those recited above may be required. Specific dosage and treatment regimens for any particular patient will depend upon a variety of factors, including the activity of the specific compound employed, the age, body weight, general health status, sex, diet, time of administration, rate of excretion, drug combination, the severity and course of the disease, condition or symptoms, the patient's disposition to the disease, condition or symptoms, and the judgment of the treating physician.

Upon improvement of a patient's condition, a maintenance dose of a compound, composition or combination of this invention may be administered, if necessary. Subsequently, the dosage or frequency of administration, or both, may be reduced, as a function of the symptoms, to a level at which the improved condition is retained when the symptoms have been alleviated to the desired level. Patients may, however, require intermittent treatment on a long-term basis upon any recurrence of disease symptoms.

The compositions delineated herein include the compounds of the formulae delineated herein, as well as additional therapeutic agents if present, in amounts effective for achieving a modulation of disease or disease symptoms, including those described herein.

The term "pharmaceutically acceptable carrier or adjuvant" refers to a carrier or adjuvant that may be administered to a patient, together with a compound of this invention, and which does not destroy the pharmacological activity thereof and is nontoxic when administered in doses sufficient to deliver a therapeutic amount of the compound.

Pharmaceutically acceptable carriers, adjuvants and vehicles that may be used in the pharmaceutical compositions of this invention include, but are not limited to, ion exchangers, alumina, aluminum stearate, lecithin, self-emulsifying drug delivery systems

(SEDDS) such as d- α -tocopherol polyethyleneglycol 1000 succinate, surfactants used in pharmaceutical dosage forms such as Tweens or other similar polymeric delivery matrices, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycine, sorbic acid, potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulfate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate, polyvinyl pyrrolidone, cellulose-based substances, polyethylene glycol, sodium carboxymethylcellulose, polyacrylates, waxes, polyethylene-polyoxypropylene-block polymers, polyethylene glycol and wool fat.

Cyclodextrins such as α -, β -, and γ -cyclodextrin, or chemically modified derivatives such as hydroxyalkylcyclodextrins, including 2- and 3-hydroxypropyl- β -cyclodextrins, or other solubilized derivatives may also be advantageously used to enhance delivery of compounds of the formulae described herein.

The pharmaceutical compositions of this invention may be administered orally, parenterally, by inhalation spray, topically, rectally, nasally, buccally, vaginally or via an implanted reservoir, preferably by oral administration or administration by injection. The pharmaceutical compositions of this invention may contain any conventional non-toxic pharmaceutically-acceptable carriers, adjuvants or vehicles. In some cases, the pH of the formulation may be adjusted with pharmaceutically acceptable acids, bases or buffers to enhance the stability of the formulated compound or its delivery form. The term parenteral as used herein includes subcutaneous, intracutaneous, intravenous, intramuscular, intraarticular, intraarterial, intrasynovial, intrasternal, intrathecal, intralesional and intracranial injection or infusion techniques.

The pharmaceutical compositions may be in the form of a sterile injectable preparation, for example, as a sterile injectable aqueous or oleaginous suspension. This suspension may be formulated according to techniques known in the art using suitable dispersing or wetting agents (such as, for example, Tween 80) and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are mannitol, water, Ringer's solution and isotonic sodium chloride solution. In addition,

sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose, any bland fixed oil may be employed including synthetic mono- or diglycerides. Fatty acids, such as oleic acid and its glyceride derivatives are useful in the preparation of injectables, as are natural pharmaceutically-acceptable oils, such as olive
5 oil or castor oil, especially in their polyoxyethylated versions. These oil solutions or suspensions may also contain a long-chain alcohol diluent or dispersant, or carboxymethyl cellulose or similar dispersing agents which are commonly used in the formulation of pharmaceutically acceptable dosage forms such as emulsions and or suspensions. Other commonly used surfactants such as Tweens or Spans and/or other
10 similar emulsifying agents or bioavailability enhancers which are commonly used in the manufacture of pharmaceutically acceptable solid, liquid, or other dosage forms may also be used for the purposes of formulation.

The pharmaceutical compositions of this invention may be orally administered in any orally acceptable dosage form including, but not limited to, capsules, tablets,
15 emulsions and aqueous suspensions, dispersions and solutions. In the case of tablets for oral use, carriers which are commonly used include lactose and corn starch. Lubricating agents, such as magnesium stearate, are also typically added. For oral administration in a capsule form, useful diluents include lactose and dried corn starch. When aqueous suspensions and/or emulsions are administered orally, the active ingredient may be
20 suspended or dissolved in an oily phase is combined with emulsifying and/or suspending agents. If desired, certain sweetening and/or flavoring and/or coloring agents may be added.

The pharmaceutical compositions of this invention may also be administered in the form of suppositories for rectal administration. These compositions can be prepared
25 by mixing a compound of this invention with a suitable non-irritating excipient which is solid at room temperature but liquid at the rectal temperature and therefore will melt in the rectum to release the active components. Such materials include, but are not limited to, cocoa butter, beeswax and polyethylene glycols.

Topical administration of the pharmaceutical compositions of this invention is
30 useful when the desired treatment involves areas or organs readily accessible by topical application. For application topically to the skin, the pharmaceutical composition should

be formulated with a suitable ointment containing the active components suspended or dissolved in a carrier. Carriers for topical administration of the compounds of this invention include, but are not limited to, mineral oil, liquid petroleum, white petroleum, propylene glycol, polyoxyethylene polyoxypropylene compound, emulsifying wax and water. Alternatively, the pharmaceutical composition can be formulated with a suitable lotion or cream containing the active compound suspended or dissolved in a carrier with suitable emulsifying agents. Suitable carriers include, but are not limited to, mineral oil, sorbitan monostearate, polysorbate 60, cetyl esters wax, cetearyl alcohol, 2-octyldodecanol, benzyl alcohol and water. The pharmaceutical compositions of this invention may also be topically applied to the lower intestinal tract by rectal suppository formulation or in a suitable enema formulation. Topically-transdermal patches are also included in this invention.

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

A composition having the compound of the formulae herein and an additional agent (e.g., a therapeutic agent) can be administered using an implantable device. Implantable devices and related technology are known in the art and are useful as delivery systems where a continuous, or timed-release delivery of compounds or compositions delineated herein is desired. Additionally, the implantable device delivery system is useful for targeting specific points of compound or composition delivery (e.g., localized sites, organs). Negrin et al., *Biomaterials*, 22(6):563 (2001). Timed-release technology involving alternate delivery methods can also be used in this invention. For example, timed-release formulations based on polymer technologies, sustained-release techniques and encapsulation techniques (e.g., polymeric, liposomal) can also be used for delivery of the compounds and compositions delineated herein.

Also within the invention is a patch to deliver active chemotherapeutic combinations herein. A patch includes a material layer (e.g., polymeric, cloth, gauze,

bandage) and the compound of the formulae herein as delineated herein. One side of the material layer can have a protective layer adhered to it to resist passage of the compounds or compositions. The patch can additionally include an adhesive to hold the patch in place on a subject. An adhesive is a composition, including those of either natural or synthetic origin, that when contacted with the skin of a subject, temporarily adheres to the skin. It can be water resistant. The adhesive can be placed on the patch to hold it in contact with the skin of the subject for an extended period of time. The adhesive can be made of a tackiness, or adhesive strength, such that it holds the device in place subject to incidental contact, however, upon an affirmative act (e.g., ripping, peeling, or other intentional removal) the adhesive gives way to the external pressure placed on the device or the adhesive itself, and allows for breaking of the adhesion contact. The adhesive can be pressure sensitive, that is, it can allow for positioning of the adhesive (and the device to be adhered to the skin) against the skin by the application of pressure (e.g., pushing, rubbing,) on the adhesive or device.

When the compositions of this invention comprise a combination of a compound of the formulae described herein and one or more additional therapeutic or prophylactic agents, both the compound and the additional agent should be present at dosage levels of between about 1 to 100%, and more preferably between about 5 to 95% of the dosage normally administered in a monotherapy regimen. The additional agents may be administered separately, as part of a multiple dose regimen, from the compounds of this invention. Alternatively, those agents may be part of a single dosage form, mixed together with the compounds of this invention in a single composition.

Viral Disorders

The compounds of the invention can be used in the treatment of a viral disease or disorder. For example, the disease or disorder can be a retroviral disorder, e.g., an HIV-mediated disorder such as AIDS. SIRT1 deacetylates the HIV Tat protein and is required for Tat-mediated transactivation of the HIV promoter. The compounds of the invention can also be used to treat a Tat-mediated or Tat-related disorder.

A compound described herein can be formulated with one or more other anti-viral agents. In another implementation the compound is administered in conjunction with

(e.g., concurrently with) one or more anti-viral agents, e.g., as separate formulations.

Exemplary anti-viral agents include drugs for treating AIDS such as:

Generic Name	Trade Name	Also Known As:	Manufacturer
saquinavir	INVIRASE®	SQV	Roche
ritonavir	NORVIR®	RTV	Abbott
indinavir	CRIXIVAN®	IDV	Merck
nelfinavir	VIRACEPT®	NFV	Pfizer
saquinavir	FORTOVASE®	SQV	Roche
amprenavir	AGENERASE®	APV, 141W94	GlaxoSmithKline
lopinavir	KALETRA®	ABT-378/r	Abbott
tenofovir disoproxil fumarate	VIREAD®		Gilead
emtricitabine	EMTRIVA®		Gilead
a fixed dose of emtricitabine and tenofovir disoproxil fumarate	TRUVADA®		Gilead

ATAZANAVIR® (BMS 232632) by Bristol-Myers Squibb, GW433908 by GlaxoSmithKline, L-756,423 by Merck, Mozenavir (DMP-450) by Triangle Pharmaceuticals, TIPRANAVIR® by Boehringer Ingelheim and TMC114 by Tibotec Virco.

The invention includes, inter alia, methods for modulating activity of a virus. For example, the compounds of the invention can be used to modulate the acetylation state of a viral factor. An exemplary viral factor that is a substrate for sirtuins is HIV tat

An exemplary amino acid sequence of HIV-1 tat is as follows:

CSNCYCKVCCWHCQLCFMTKGLSISYGR
 KKRKRRRGTPHGSQEDHQNLSKQPSSQPRGDPTGPKEQKKKVESKAEADPFD
 (SEQ ID NO: 8). An exemplary amino acid sequence of HIV-2 tat is as follows:

5 MGIPLQEQENSLEFSSERSSSTSEEGANTRGLDNQGEEILSQLYRPLEACRN
 KCYCKKCCYHCQLCFLKKGLGICYDHSRKRSSKRAKVTAPTASNDLSTRARDG
 QPAKKQKKEVETTRTTDPGLGRSDTSTS (SEQ ID NO:9).

Kits

10 A compound described herein described herein can be provided in a kit. The kit includes (a) a compound described herein, e.g., a composition that includes a compound described herein, and, optionally (b) informational material. The informational material can be descriptive, instructional, marketing or other material that relates to the methods described herein and/or the use of a compound described herein for the methods described herein.

15 The informational material of the kits is not limited in its form. In one embodiment, the informational material can include information about production of the compound, molecular weight of the compound, concentration, date of expiration, batch or production site information, and so forth. In one embodiment, the informational material relates to methods for administering the compound.

20 In one embodiment, the informational material can include instructions to administer a compound described herein in a suitable manner to perform the methods described herein, e.g., in a suitable dose, dosage form, or mode of administration (e.g., a dose, dosage form, or mode of administration described herein). In another embodiment, the informational material can include instructions to administer a compound described herein to a suitable subject, e.g., a human, e.g., a human having or at risk for a viral
 25 disorder described herein.

The informational material of the kits is not limited in its form. In many cases, the informational material, e.g., instructions, is provided in printed matter, e.g., a printed text, drawing, and/or photograph, e.g., a label or printed sheet. However, the informational material can also be provided in other formats, such as Braille, computer
 30 readable material, video recording, or audio recording. In another embodiment, the

informational material of the kit is contact information, e.g., a physical address, email address, website, or telephone number, where a user of the kit can obtain substantive information about a compound described herein and/or its use in the methods described herein. Of course, the informational material can also be provided in any combination of
5 formats.

In addition to a compound described herein, the composition of the kit can include other ingredients, such as a solvent or buffer, a stabilizer, a preservative, a flavoring agent (e.g., a bitter antagonist or a sweetener), a fragrance or other cosmetic ingredient, and/or a second agent for treating a condition or disorder described herein. Alternatively, the
10 other ingredients can be included in the kit, but in different compositions or containers than a compound described herein. In such embodiments, the kit can include instructions for admixing a compound described herein and the other ingredients, or for using a compound described herein together with the other ingredients.

A compound described herein can be provided in any form, e.g., liquid, dried or
15 lyophilized form. It is preferred that a compound described herein be substantially pure and/or sterile. When a compound described herein is provided in a liquid solution, the liquid solution preferably is an aqueous solution, with a sterile aqueous solution being preferred. When a compound described herein is provided as a dried form, reconstitution generally is by the addition of a suitable solvent. The solvent, e.g., sterile water or buffer,
20 can optionally be provided in the kit.

The kit can include one or more containers for the composition containing a compound described herein. In some embodiments, the kit contains separate containers, dividers or compartments for the composition and informational material. For example, the composition can be contained in a bottle, vial, or syringe, and the informational
25 material can be contained in a plastic sleeve or packet. In other embodiments, the separate elements of the kit are contained within a single, undivided container. For example, the composition is contained in a bottle, vial or syringe that has attached thereto the informational material in the form of a label. In some embodiments, the kit includes a plurality (e.g., a pack) of individual containers, each containing one or more unit dosage
30 forms (e.g., a dosage form described herein) of a compound described herein. For example, the kit includes a plurality of syringes, ampules, foil packets, or blister packs,

each containing a single unit dose of a compound described herein. The containers of the kits can be air tight, waterproof (e.g., impermeable to changes in moisture or evaporation), and/or light-tight.

The kit optionally includes a device suitable for administration of the composition, e.g., a syringe, inhalant, pipette, forceps, measured spoon, dropper (e.g., eye dropper), swab (e.g., a cotton swab or wooden swab), or any such delivery device. In a preferred embodiment, the device is a medical implant device, e.g., packaged for surgical insertion.

The fact that a patient has been treated with a molecule of the invention, or the patient's response to treatment with a molecule of the invention, can be used, alone or in combination with other information, e.g., other information about the patient, to determine whether to authorize or transfer of funds to pay for a service or treatment provided to a subject. For example, an entity, e.g., a hospital, care giver, government entity, or an insurance company or other entity which pays for, or reimburses medical expenses, can use such information to determine whether a party, e.g., a party other than the subject patient, will pay for services or treatment provided to the patient. For example, a first entity, e.g., an insurance company, can use such information to determine whether to provide financial payment to, or on behalf of, a patient, e.g., whether to reimburse a third party, e.g., a vendor of goods or services, a hospital, physician, or other care-giver, for a service or treatment provided to a patient. For example, a first entity, e.g., an insurance company, can use such information to determine whether to authorize, recommend, pay, reimburse, continue, discontinue, enroll an individual in an insurance plan or program, e.g., a health insurance or life insurance plan or program.

Databases

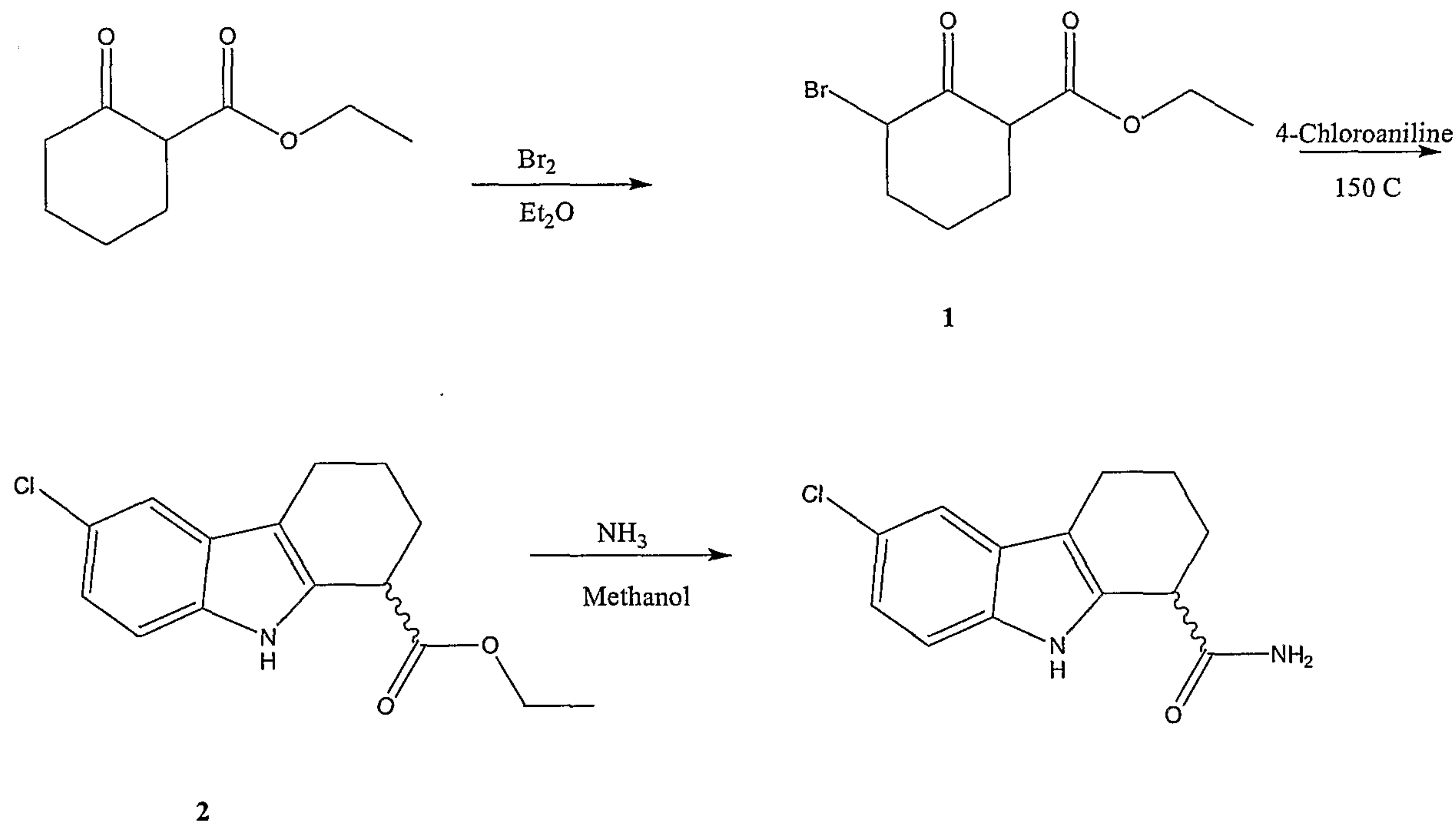
The invention also features a database that associates information about or identifying one or more of the compounds described herein with a parameter about a patient, e.g., a patient being treated with a disorder herein. The parameter can be a general parameter, e.g., blood pressure, core body temperature, etc. , or a parameter

related to a viral disease or disorder, e.g., as described herein, e.g., viral load or white blood cell count.

Example:

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Synthesis of compound 4



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Preparation of 1: Ethyl-2-oxocyclohexanecarboxylate (12.5 g, 73 mmole) was dissolved in ether (50 mL) and chilled in a salt ice bath under N_2 to 0°C . Bromine (11.7 g, 3.8 ml, 73 mmole) was added in portions over ~20 minutes allowing the exotherm to subside between additions. The temperature never rose above 6°C during the addition of bromine. The reaction was worked up by diluting with an additional portion of ether (50 mL) and washing with water (50 mL) then saturated sodium bicarbonate (25 mL). The organic layer was then dried over sodium sulfate and the solvent removed *in vacuo*. To give 1 (17.5 g, 71 mmole, 97%) as a clear liquid that was of satisfactory purity to be carried on without further purification.

Preparation of 2: **1** (14.8 g, 59 mmole) was added to a 500 mL 4 nk flask containing 4-chloroaniline (16.0 g, 126 mmole). The flask was purged with nitrogen, and the contents of the flask were warmed with mechanical stirring of the slurry. As the temperature of the mixture passed 140°C a relatively rapid exotherm to 155°C, and vigorous evolution of gas (water), occurred. The reaction subsided and the temperature of the reaction was maintained at 150°C for an additional 4 hours. The reaction was worked up by cooling to room temperature in a water bath. The material was then dissolved/suspended in methylene chloride (750 mL). The material was transferred into a separatory funnel and washed with 3N HCl (3x250 mL). The methylene chloride layer was dried over sodium sulfate, and the solvent removed in vacuo. The crude residue was applied to a Biotage 40L column (120g silica gel), and eluted with 9/1 heptane/ethyl acetate. Chromatography yielded clean **2** (11.9 g, 43 mmole, 72% yield) as an off-white solid. ¹H NMR δ (CDCl₃, ppm) 8.46 (br s, 1H), 7.42-7.43 (m, 1H), 7.18-7.24 (m, 1H), 4.18-4.26 (m, 2H), 3.78-3.83 (m, 1H), 2.64-2.68 (m, 2H), 2.13-2.19 (m, 2H), 1.93-2.12 (m, 1H), 1.71-1.88 (m, 1H), 1.25-1.34 (m, 3H).

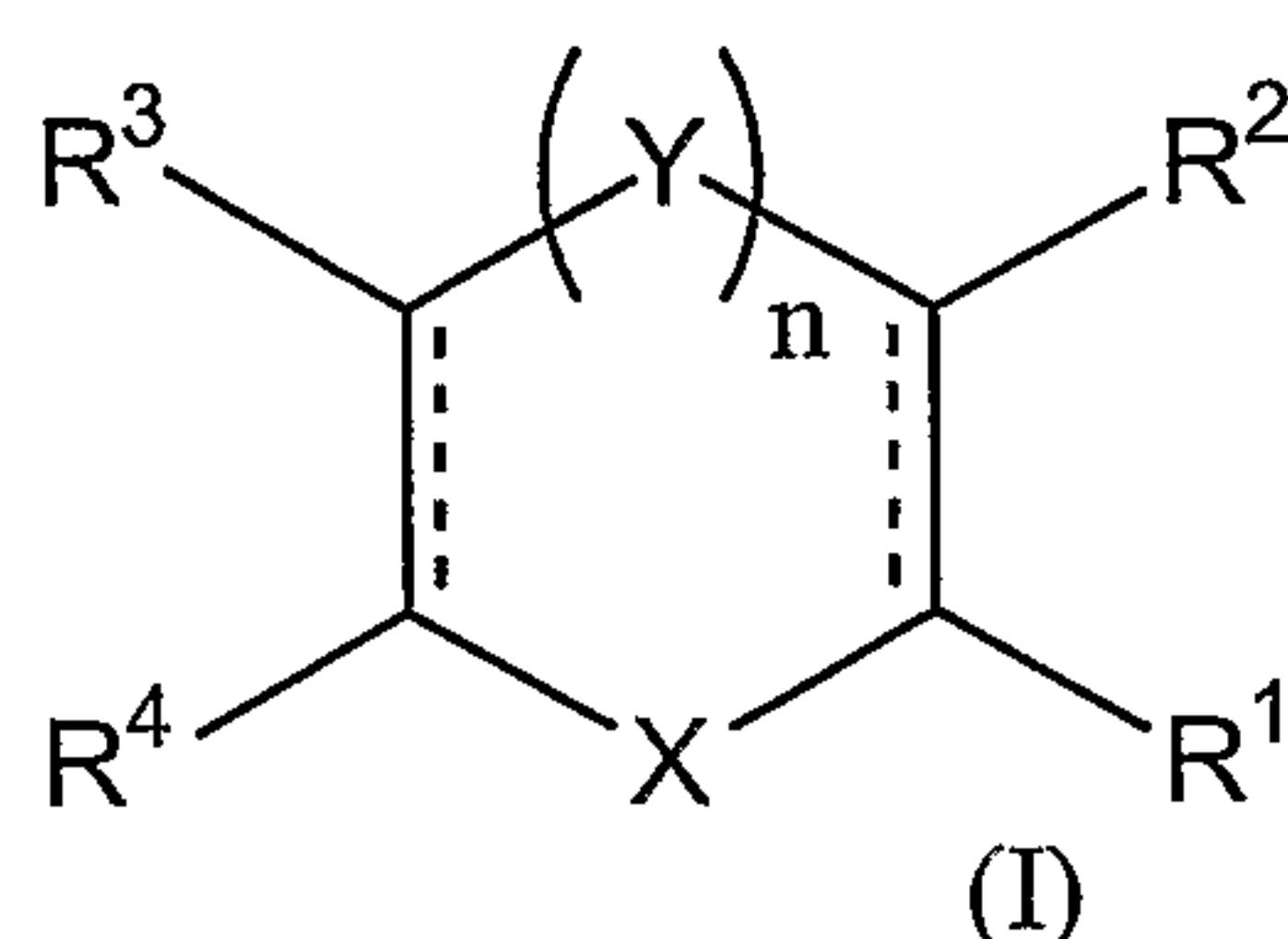
Preparation of 4: **2** (10 g, 40 mmole) was dissolved in ethanol (100 mL) 7M ammonia in ethanol (200 mL) was added and the material transferred to a Parr pressure reactor. The reaction vessel was purged briefly to displace any air with ammonia vapor. The reaction was then heated to 60°C. The reaction temperature overshoot to ~75°C briefly then returned to 60°C within ~45 min. The material was stirred at this temperature for 24 hours. The reaction was then cooled to room temperature and the solvent removed in vacuo. This gave the crude product (9.6 gms) as an off-white foam. The material was chromatographed twice on a Biotage 40L column. The first chromatography, elution with 100% ethyl acetate, failed to remove a trace impurity. A second chromatography utilizing a step gradient (starting with 1/1 heptane/ethyl acetate jumping to 1/4 heptane/ethyl acetate as the impurity began to elute) provided clean **4** (7.8 g, 31.4 mmole, 78%) as an off-white crystalline solid. (7.8 g, 31.4 mmole, 78%) as an off-white crystalline solid. ¹H NMR δ (CD₃OD, ppm) 7.34-7.38 (s, 1H), 7.20-7.24 (m, 1H), 6.95-7.03 (m, 1H), 3.69-3.75 (m, 1H), 2.59-2.75 (m, 2H), 1.76-2.20 (m, 4H).

Isolation of (-) - 4: Separation of enantiomers was carried out by elution from a Chiralpak AD column with isopropanol/hexanes (30:70; **4** RT = 10.65 minutes, $[\alpha]_D^{25}$ -41.18° (*c* 0.960, CH₃OH); **4** = 20.17 minutes, $[\alpha]_D^{25}$ +22.72° (*c* 0.910, CH₃OH).

5 A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Other embodiments are in the claims.

WHAT IS CLAIMED IS:

1. A method of treating an HIV-mediated disorder, the method comprising administering to a subject an effective amount of a compound having a formula (I):



wherein,

R^1 and R^2 , together with the carbons to which they are attached, form C_5 - C_{10} cycloalkyl, C_5 - C_{10} heterocyclyl, C_5 - C_{10} cycloalkenyl, C_5 - C_{10} heterocycloalkenyl, C_6 - C_{10} aryl, or C_6 - C_{10} heteroaryl, each of which may be optionally substituted with 1-5 R^5 ; or R^1 is H, S-alkyl, or S-aryl, and R^2 is amidoalkyl wherein the nitrogen is substituted with alkyl, aryl, or arylalkyl, each of which is optionally further substituted with alkyl, halo, hydroxy, or alkoxy;

R^3 and R^4 , together with the carbons to which they are attached, form C_5 - C_{10} cycloalkyl, C_5 - C_{10} heterocyclyl, C_5 - C_{10} cycloalkenyl, C_5 - C_{10} heterocycloalkenyl, C_6 - C_{10} aryl, or C_6 - C_{10} heteroaryl, each of which are optionally substituted with 1-5 R^6 ;

each of R^5 and R^6 is, independently, halo, hydroxy, C_1 - C_{10} alkyl, C_1 - C_6 haloalkyl, C_1 - C_{10} alkoxy, C_1 - C_6 haloalkoxy, C_6 - C_{10} aryl, C_5 - C_{10} heteroaryl, C_7 - C_{12} aralkyl, C_7 - C_{12} heteroaralkyl, C_3 - C_8 heterocyclyl, C_2 - C_{12} alkenyl, C_2 - C_{12} alkynyl, C_5 - C_{10} cycloalkenyl, C_5 - C_{10} heterocycloalkenyl, carboxy, carboxylate, cyano, nitro, amino, C_1 - C_6 alkyl amino, C_1 - C_6 dialkyl amino, mercapto, SO_3H , sulfate, $S(O)NH_2$, $S(O)_2NH_2$, phosphate, C_1 - C_4 alkylenedioxy, oxo, acyl, aminocarbonyl, C_1 - C_6 alkyl aminocarbonyl, C_1 - C_6 dialkyl aminocarbonyl, C_1 - C_{10} alkoxycarbonyl, C_1 - C_{10} thioalkoxycarbonyl, hydrazinocarbonyl, C_1 - C_6 alkyl hydrazinocarbonyl, C_1 - C_6 dialkyl hydrazinocarbonyl, hydroxyaminocarbonyl; alkoxyaminocarbonyl; or one of R^5 or R^6 and R^7 form a cyclic moiety containing 4-6 carbons, 1-3 nitrogens, 0-2 oxygens and 0-2 sulfurs, which are optionally substituted with oxo or C_1 - C_6 alkyl;

X is NR^7 , O, or S; Y is $\text{NR}^{7'}$, O or S;

- - - - represent optional double bonds;

each of R^7 and $\text{R}^{7'}$ is, independently, hydrogen, $\text{C}_1\text{-C}_6$ alkyl, $\text{C}_7\text{-C}_{12}$ arylalkyl, $\text{C}_7\text{-C}_{12}$ heteroarylalkyl; or R^7 and one of R^5 or R^6 form a cyclic moiety containing 4-6 carbons, 1-3 nitrogens, 0-2 oxygens and 0-2 sulfurs, which are optionally substituted with oxo or $\text{C}_1\text{-C}_6$ alkyl; and
n is 0 or 1.

2. The method of claim 1, wherein R^1 and R^2 , together with the carbons to which they are attached, form $\text{C}_5\text{-C}_{10}$ cycloalkyl, $\text{C}_5\text{-C}_{10}$ heterocyclyl, $\text{C}_5\text{-C}_{10}$ cycloalkenyl, $\text{C}_5\text{-C}_{10}$ heterocycloalkenyl, $\text{C}_6\text{-C}_{10}$ aryl, or $\text{C}_6\text{-C}_{10}$ heteroaryl, each of which may be optionally substituted with 1-5 R^5 .

3. The method of claim 1, wherein R^1 and R^2 , together with the carbons to which they are attached, form $\text{C}_5\text{-C}_{10}$ cycloalkenyl.

4. The method of claim 3, wherein R^1 and R^2 are substituted with R^5 .

5. The method of claim 4, wherein R^5 is, $\text{C}_1\text{-C}_6$ alkyl substituted with a substituent or amino carbonyl, substituted with a substituent.

6. The method of claim 5, wherein the substituent is an amino substituent, or aminocarbonyl.

7. The method of claim 1, wherein R^3 and R^4 , together with the carbons to which they are attached, form $\text{C}_6\text{-C}_{10}$ aryl.

8. The method of claim 5, wherein R^3 and R^4 are substituted with R^6 .

9. The method of claim 6 wherein R^6 is halo or $\text{C}_1\text{-C}_6$ alkyl.

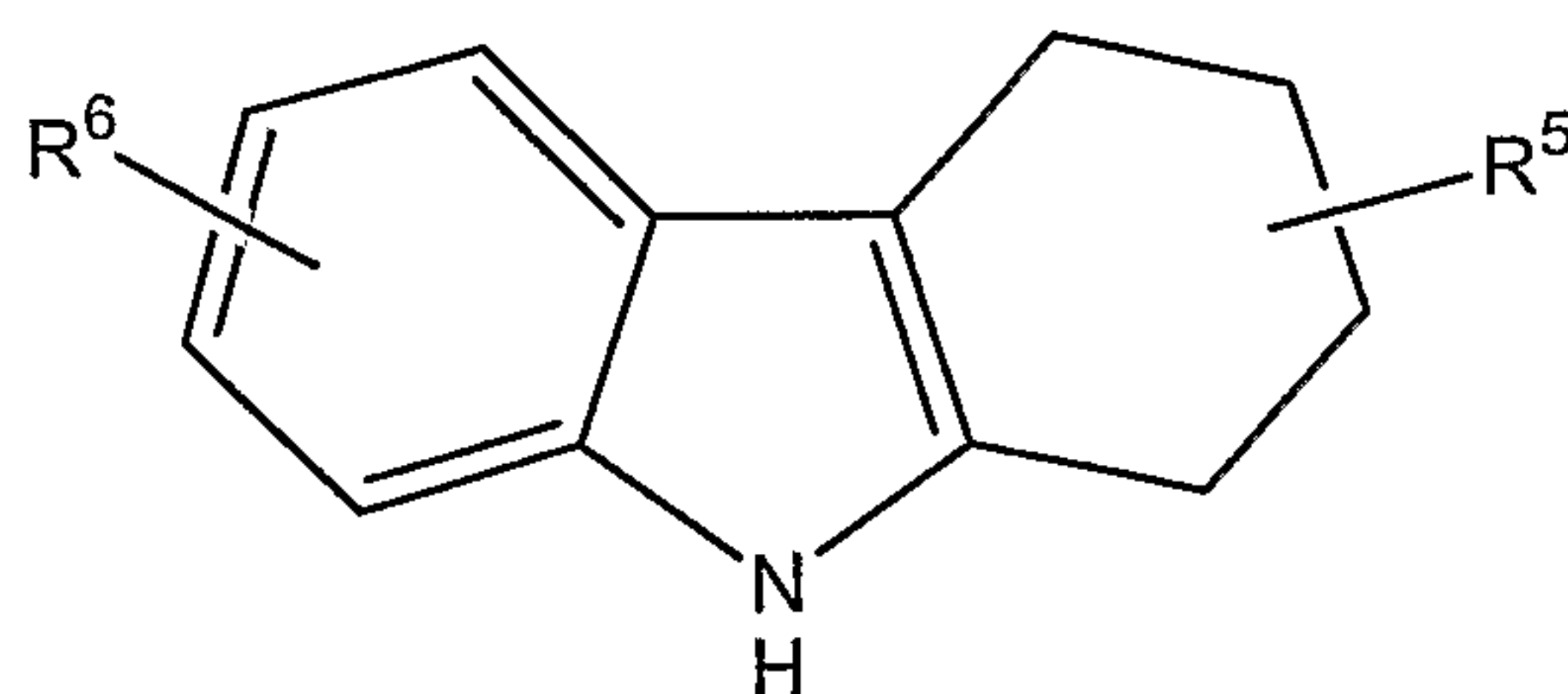
10. The method of claim 1, wherein n is 0.

11. The method of claim 1 wherein X is NR^7 .

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12. The method of claim 1 wherein n is 0 and X is NR^7 .

13. The method of claim 1, having the formula (X) below:



formula (X).

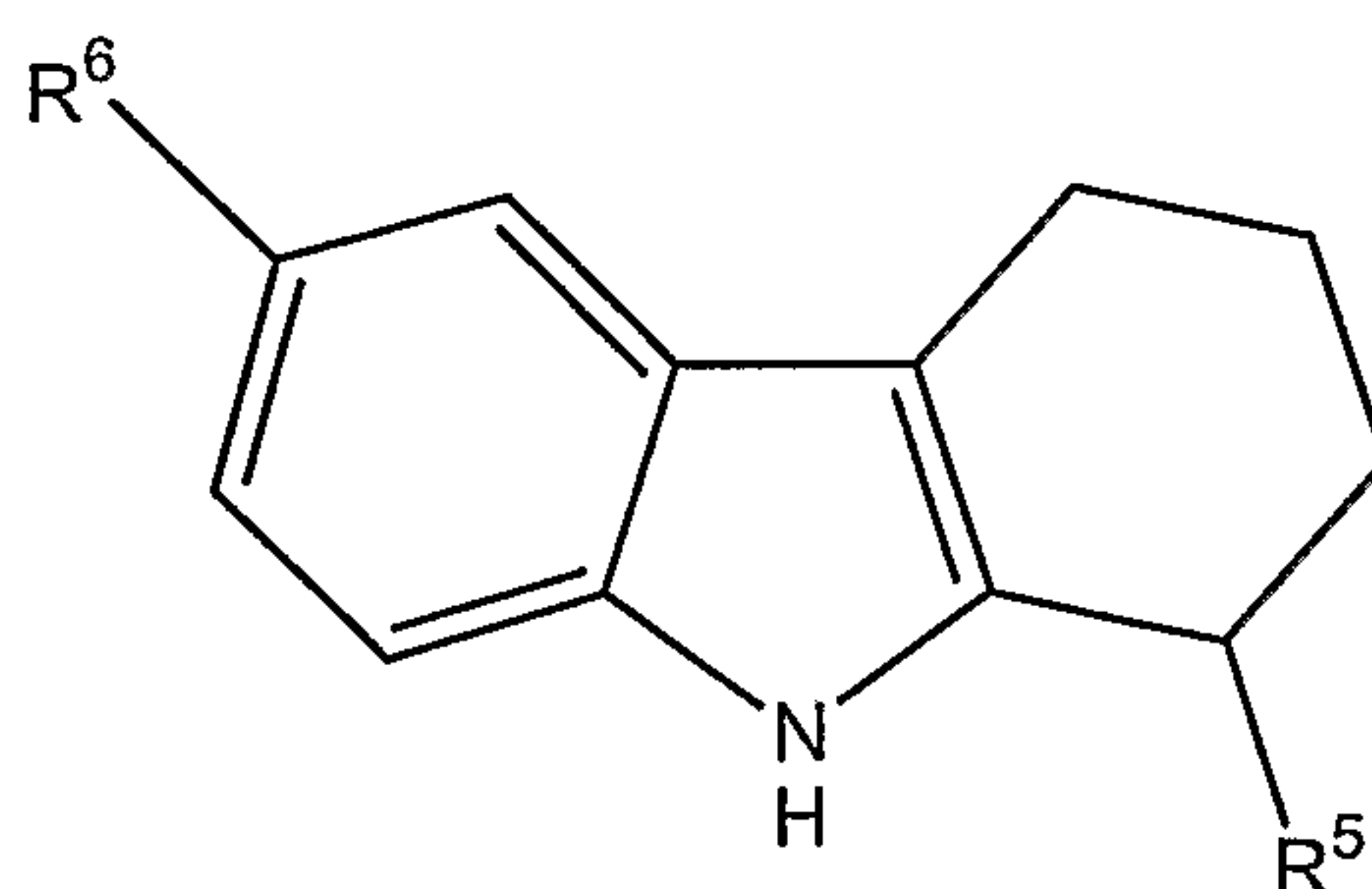
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14. The method of claim 13, wherein R^6 is halo or $\text{C}_1\text{-C}_6$ alkyl.

15. The method of claim 13, wherein R^5 is aminocarbonyl.

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16. The method of claim 13, having the formula (XI) below:



formula (XI).

17. The method of claim 16, wherein R^6 is halo or alkyl.

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18. The method of claim 16, wherein R^5 is aminocarbonyl.

19. The method of claim 16, wherein wherein R^6 is halo or alkyl and wherein R^5 is aminocarbonyl.

20. The method of claim 13 wherein the compound is 6-Chloro-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylic acid amide.

21. The method of claim 20 wherein the compound comprises greater than a 60% enantiomeric excess of the enantiomer having an optical rotation of -14.1 ($c=0.33$ DCM).

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22. The method of claim 21, wherein the compound comprises greater than a 90% enantiomeric excess of the enantiomer having an optical rotation of -14.1 ($c=0.33$ DCM).

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23. The compound of claim 1, wherein the compound preferentially inhibits SirT1 relative to a non-SirT1 sirtuin.

24. The compound of claim 1, wherein the compound has at least a 5 fold preference for SirT1.

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25. The compound of claim 1, wherein the compound has a K_i for SirT1 of less than about $1\mu M$.