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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 March 2005 (17.03.2005)

PCT

(10) International Publication Number
WO 2005/023807 A2

(51) International Patent Classification[7]: C07D 471/00

(21) International Application Number: PCT/US2004/029583

(22) International Filing Date: 9 September 2004 (09.09.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/501,515 9 September 2003 (09.09.2003) US
60/515,984 31 October 2003 (31.10.2003) US

(71) Applicant: **NEUROGEN CORPORATION** [US/US]; 35 Northeast Industrial Road, Branford, CT 06405 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **BAKTHAVATCHALAM, Rajagopal** [US/US]; 67 Hickory Lane, Madison, CT 06443 (US). **BLUM, Charles, A.** [US/US]; 785 W. Pond Meadow Road, Westbrook, CT 06495 (US). **CHENARD, Bertrand, L.** [US/US]; 7 Whaling Drive, Waterford, CT 06385 (US).

(74) Agents: **ALEXANDER, Ph.D., John, B.** et al.; Edwards & Angell, LLP, P.O. Box 55874, Boston, MA 02205 (US).

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

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

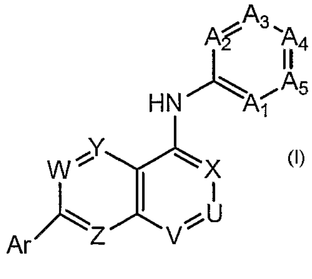
Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

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

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

WO 2005/023807 A2

(54) **Title:** SUBSTITUTED BICYCLIC QUINAZOLIN-4-YLAMINE DERIVATIVES



(I)

(57) **Abstract:** Substituted bicyclic quinazolin-4-ylamine derivatives are provided. Such compounds are ligands that may be used to modulate specific receptor activity *in vivo or in vitro*, and are particularly useful in the treatment of conditions associated with pathological receptor activation in humans, domesticated companion animals and livestock animals. Pharmaceutical compositions and methods for using them to treat such disorders are provided, as are methods for using such ligands for receptor localization studies.

SUBSTITUTED BICYCLIC QUINAZOLIN-4-YLAMINE DERIVATIVES

FIELD OF THE INVENTION

This invention relates generally to substituted bicyclic quinazolin-4-ylamine derivatives that that have useful pharmacological properties. The invention further relates to the use of such compounds for treating conditions related to capsaicin receptor activation, for identifying other agents that bind to capsaicin receptor, and as probes for the detection and localization of capsaicin receptors.

BACKGROUND OF THE INVENTION

Pain perception, or nociception, is mediated by the peripheral terminals of a group of specialized sensory neurons, termed "nociceptors." A wide variety of physical and chemical stimuli induce activation of such neurons in mammals, leading to recognition of a potentially harmful stimulus. Inappropriate or excessive activation of nociceptors, however, can result in debilitating acute or chronic pain.

Neuropathic pain involves pain signal transmission in the absence of stimulus, and typically results from damage to the nervous system. In most instances, such pain is thought to occur because of sensitization in the peripheral and central nervous systems following initial damage to the peripheral system (*e.g.*, via direct injury or systemic disease). Neuropathic pain is typically burning, shooting and unrelenting in its intensity and can sometimes be more debilitating that the initial injury or disease process that induced it.

Existing treatments for neuropathic pain are largely ineffective. Opiates, such as morphine, are potent analgesics, but their usefulness is limited because of adverse side effects, such as physical addictiveness and withdrawal properties, as well as respiratory depression, mood changes, and decreased intestinal motility with concomitant constipation, nausea, vomiting, and alterations in the endocrine and autonomic nervous systems. In addition, neuropathic pain is frequently non-responsive or only partially responsive to conventional opioid analgesic regimens. Treatments employing the N-methyl-D-aspartate antagonist ketamine or the alpha(2)-adrenergic agonist clonidine can reduce acute or chronic pain, and permit a reduction in opioid consumption, but these agents are often poorly tolerated due to side effects.

Topical treatment with capsaicin has been used to treat chronic and acute pain, including neuropathic pain. Capsaicin is a pungent substance derived from the plants of the Solanaceae family (which includes hot chili peppers) and appears to act selectively on the small diameter afferent nerve fibers (A-delta and C fibers) that are believed to mediate pain. The response to capsaicin is characterized by persistent activation of nociceptors in peripheral tissues, followed by eventual desensitization of peripheral nociceptors to one or more stimuli. From studies in animals, capsaicin appears to trigger C fiber membrane depolarization by opening cation selective channels for calcium and sodium.

Similar responses are also evoked by structural analogues of capsaicin that share a common vanilloid moiety. One such analogue is resiniferatoxin (RTX), a natural product of *Euphorbia* plants. The term vanilloid receptor (VR) was coined to describe the neuronal membrane recognition site for capsaicin and such related irritant compounds. The capsaicin response is competitively inhibited (and thereby antagonized) by another capsaicin analog, capsazepine, and is also inhibited by the non-selective cation channel blocker ruthenium red. These antagonists bind to VR with no more than moderate affinity (typically with K_i values of no lower than 140 μM).

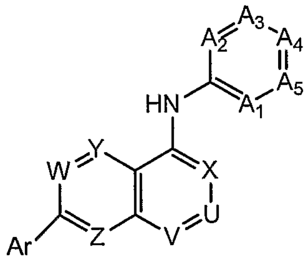
Rat and human vanilloid receptors have been cloned from dorsal root ganglion cells. The first type of vanilloid receptor to be identified is known as vanilloid receptor type 1 (VR1), and the terms "VR1" and "capsaicin receptor" are used interchangeably herein to refer to rat and/or human receptors of this type, as well as mammalian homologues. The role of VR1 in pain sensation has been confirmed using mice lacking this receptor, which exhibit no vanilloid-evoked pain behavior, and impaired responses to heat and inflammation. VR1 is a nonselective cation channel with a threshold for opening that is lowered in response to elevated temperatures, low pH, and capsaicin receptor agonists. For example, the channel usually opens at temperatures higher than about 45°C. Opening of the capsaicin receptor channel is generally followed by the release of inflammatory peptides from neurons expressing the receptor and other nearby neurons, increasing the pain response. After initial activation by capsaicin, the capsaicin receptor undergoes a rapid desensitization via phosphorylation by cAMP-dependent protein kinase.

Because of their ability to desensitize nociceptors in peripheral tissues, VR1 agonist vanilloid compounds have been used as topical anesthetics. However, agonist application may itself cause burning pain, which limits this therapeutic use. Recently, it has been reported that VR1 antagonists, including nonvanilloid compounds, are also useful for the treatment of pain (*see* PCT International Application Publication Number WO 02/08221, which published January 31, 2002 and WO 03/062209, which published July 31, 2003).

Thus, compounds that interact with VR1, but do not elicit the initial painful sensation of VR1 agonist vanilloid compounds, are desirable for the treatment of chronic and acute pain, including neuropathic pain. Antagonists of this receptor are particularly desirable for the treatment of pain, as well as conditions such as tear gas exposure, itch and urinary tract conditions such as urinary incontinence and overactive bladder. The present invention fulfills this need, and provides further related advantages.

SUMMARY OF THE INVENTION

The present invention provides substituted bicyclic quinazolin-4-ylamine derivatives characterized by Formula I:



Formula I

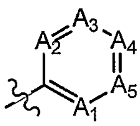
as well as pharmaceutically acceptable salts of such compounds. Within Formula I:

A_2, V, X, W, Y and Z are each independently N or optionally substituted carbon (*e.g.*, CR_1), such that at least one of V and X is N;

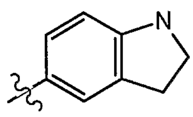
A_3 is N or optionally substituted carbon (*e.g.*, CR_9);

Either:

(i) A_4 is joined to A_5 to form a fused 5- to 7-membered carbocyclic or heterocyclic ring that is substituted with from 0 to 6 substituents that are preferably independently chosen from R_8, and A_1 is N or substituted carbon (*e.g.*, CR_1), such the group designated



is not



that is substituted with C_1-C_6alkylsulfonyl; or

(ii) A_1 is joined to A_5 to form a fused 5- to 7-membered carbocyclic or heterocyclic ring that is substituted with from 0 to 6 substituents that are preferably independently chosen from R_8, and A_4 is N or substituted carbon (*e.g.*, CR_9);

R_1 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy and mono- and di-(C_1-C_6alkyl)amino;

R_8 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, oxo, -COOH, C_1-C_6alkyl, C_1-C_6alkenyl, C_1-C_6alkynyl, C_1-C_6alkyl ether, C_1-

C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6aminoalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_6alkanoyl, mono- and di-(C_1-C_6alkyl)amino(C_0-C_6alkyl), (5- to 7-membered heterocycloalkyl)C_0-C_6alkyl, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

R_9 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

U is N or optionally substituted carbon (*e.g.,* CR_2), such that if V and X are both N, then U is optionally substituted carbon;

R_2 is:

(i) hydrogen, halogen, cyano or –COOH; or

(ii) a group of the formula –R_c-M-A-R_y, wherein:

R_c is C_0-C_3alkylene or is joined to R_y or R_z to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 2 substituents independently selected from R_b;

M is absent, a single covalent bond, O, S, SO, SO_2, C(=O), OC(=O), C(=O)O, O-C(=O)O, C(=O)N(R_z), OC(=O)N(R_z), N(R_z)C(=O), N(R_z)SO_2, SO_2N(R_z), or N(R_z);

A is absent, a single covalent bond or C_1-C_8alkylene substituted with from 0 to 3 substituents independently selected from R_b; and

R_y and R_z, if present, are:

(a) independently hydrogen, C_1-C_8alkyl, C_2-C_8alkanone, C_2-C_8alkyl ether, C_2-C_8alkenyl, a 4- to 10-membered carbocycle or heterocycle, or joined to R_c to form a 4- to 10-membered carbocycle or heterocycle, wherein each R_y and R_z is independently substituted with from 0 to 6 substituents independently selected from R_b; or

(b) joined to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 6 substituents independently selected from R_b;

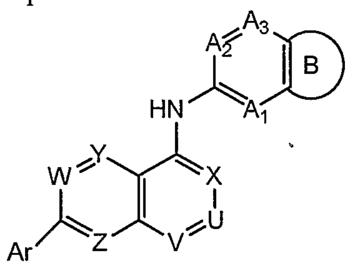
Ar is selected from 5- to 10-membered aromatic carbocycles and heterocycles, each of which is optionally substituted (preferably each of which is substituted with from 0 to 3 substituents independently selected from R_1), such that Ar is not thiophene; and

R_b is independently chosen at each occurrence from:

(i) hydroxy, halogen, amino, aminocarbonyl, cyano, nitro, oxo and –COOH; and

(ii) C_1-C_8alkyl, C_1-C_8alkoxy, C_1-C_8alkanoyl, C_2-C_8alkoxycarbonyl, C_2-C_8alkanoyloxy, C_1-C_8alkylthio, C_2-C_8alkyl ether, phenylC_0-C_8alkyl, phenylC_1-C_8alkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_8alkylsulfonyl, (4- to 7-membered heterocycle)C_0-C_8alkyl; wherein each of (ii) is optionally substituted; preferably each of (ii) is substituted with from 0 to 3 substituents independently chosen from hydroxy, halogen, amino and cyano.

Certain compounds of Formula I further satisfy Formula II:



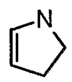
Formula II

or are a pharmaceutically acceptable salt thereof, wherein:

A_2, A_3, U, V, X, W, Y and Z are as described for Formula I;

A_1 is N or CR_1, wherein R_1 is as described for Formula I;

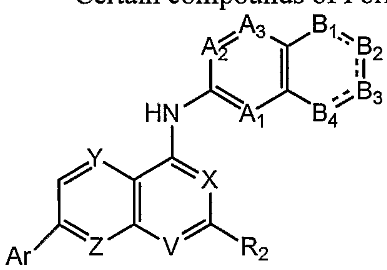
is a 5- to 7-membered aromatic or partially saturated carbocyclic or heterocyclic ring, substituted with from 0 to 6 substituents that are preferably independently chosen from R_8, wherein R_8 is as described for Formula I, and wherein 

is not 

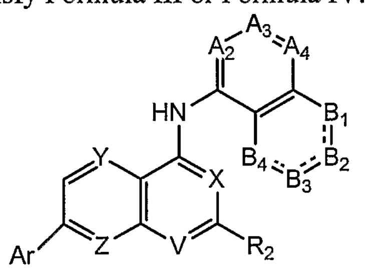
that is substituted with C_1-C_6alkylsulfonyl; and

Ar is selected from phenyl and 6-membered aromatic heterocycles, each of which is optionally substituted (preferably each of which is substituted with from 0 to 3 substituents independently selected from R_1, wherein R_1 is as described for Formula I).

Certain compounds of Formula I further satisfy Formula III or Formula IV:



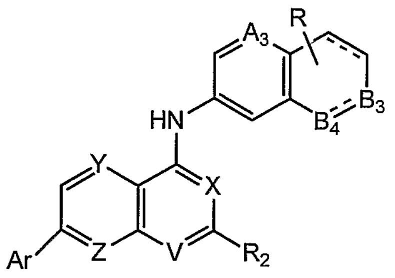
Formula III



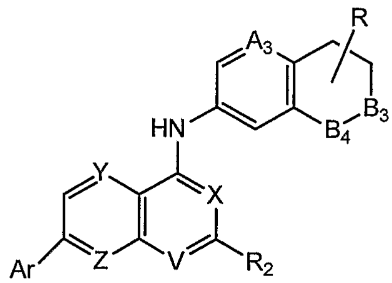
Formula IV

wherein Ar is phenyl or a 6-membered aromatic heterocycle, each of which is substituted with from 0 to 3 substituents independently chosen from R_1; B_1, B_2, B_3 and B_4 are independently chosen from $C(R_8)$ (*e.g.*, CH, C-alkyl, or C=O), $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O; and the remaining variables are as described for Formula I. Each bond shown as ⎓ is independently a single or double bond, provided that the normal valence on each ring member is not exceeded. Within certain compounds of Formula III or Formula IV, B_1 is SO_2 or $C(CH_3)_2$, B_2 is $C(R_8)$ or $N(R_8)$, and B_3 and B_4 are independently $C(R_8)$, $C(R_8)(R_8)$ or $N(R_8)$. For example, in certain such compounds, B_1 is $C(CH_3)_2$, B_2 and B_3 are independently chosen from $C(R_8)$, and B_4 is NH or N-CH_3. In other compounds, B_1 is O, B_2 and B_3 are independently chosen from $C(R_8)$, and B_4 is NH or N-CH_3.

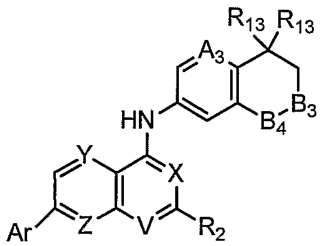
Within certain embodiments, compounds of Formula III further satisfy one or more of Formulas IIIa-IIIc, and compounds of Formula IV further satisfy Formula IVa:



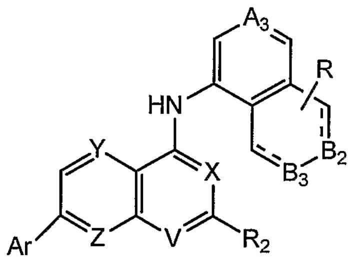
Formula IIIa



Formula IIIb



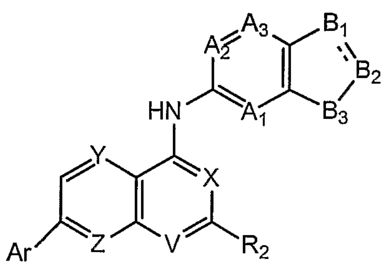
Formula IIIc



Formula IVa

wherein R represents from 0 to 5 substituents (located on the same or different ring members) independently chosen from halogen, hydroxy, oxo, cyano, amino, C_1-C_6alkyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6alkanoyl; each R_{13} is independently chosen from hydrogen, halogen, C_1-C_4alkyl and C_1-C_4haloalkyl, and each bond shown as ⎓ is a single or double bond.

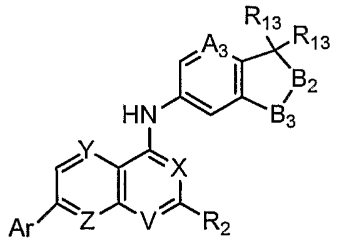
Certain compounds of Formula II further satisfy Formula V:



Formula V

wherein B_1, B_2 and B_3 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O; and the remaining variables are as described for Formula II. The bond between B_1 and B_2 is a single or double bond.

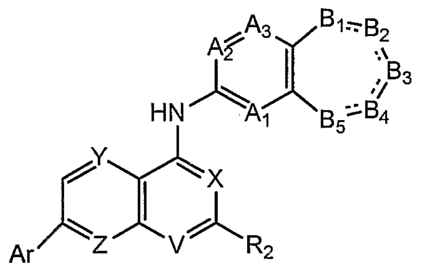
Within certain embodiments, compounds of Formula V further satisfy Formula Va:



Formula Va

wherein each R_{13} is independently chosen from hydrogen and C_1-C_4alkyl.

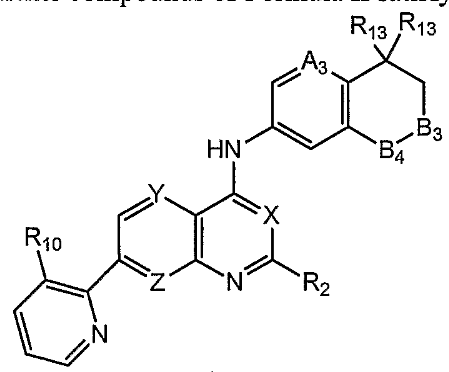
Certain compounds of Formula II further satisfy Formula VI:



Formula VI

wherein B_1, B_2, B_3, B_4 and B_5 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O; and the remaining variables are as described for Formula II. Each bond shown as ⁼⁼⁼ is a single or double bond.

Still further compounds of Formula II satisfy Formula VII:



Formula VII

wherein

X, Y, Z and A_3 are independently N or CH;

R_{10} is hydrogen, halogen, methyl, mono-, di- or tri-fluoromethyl or cyano;

each R_{13} is independently hydrogen or methyl;

one of B_3 and B_4 is $CH(R_8)$ and the other of B_3 and B_4 is $N(R_8)$; and

R_2 is:

(i) hydrogen or halogen; or

(ii) C_1-C_6alkyl, -$(CH_2)_nNH_2$, -$(CH_2)_nN(H)C_1$-C_8alkyl, -$(CH_2)_nN(C_1$-C_8alkyl$)_2$, -$(CH_2)_n$(4- to 8-membered heterocycloalkyl), -$(CH_2)_nOH$, -$(CH_2)_nOC_1$-C_6alkyl or -$(CH_2)_n$O-benzyl, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl and C_1-C_6haloalkyl, wherein each n is 0, 1, 2 or 3.

Within certain aspects, compounds of Formula I are VR1 modulators and exhibit a K_i of no greater than 1 micromolar, 100 nanomolar, 50 nanomolar, 10 nanomolar or 1 nanomolar in a capsaicin receptor binding assay and/or have an EC_{50} or IC_{50} value of no greater than 1 micromolar, 100 nanomolar, 50 nanomolar, 10 nanomolar or 1 nanomolar in an assay for determination of capsaicin receptor agonist or antagonist activity.

In certain embodiments, VR1 modulators as described herein are VR1 antagonists and exhibit no detectable agonist activity in an *in vitro* assay of capsaicin receptor activation.

Within certain aspects, compounds as described herein are labeled with a detectable marker (*e.g.*, radiolabeled or fluorescein conjugated).

The present invention further provides, within other aspects, pharmaceutical compositions comprising at least one compound as provided herein or a pharmaceutically acceptable salt thereof in combination with a physiologically acceptable carrier or excipient.

Within further aspects, methods are provided for reducing calcium conductance of a cellular capsaicin receptor, comprising contacting a cell (*e.g.*, neuronal) expressing a capsaicin receptor with at least one compound as described herein. Such contact may occur *in vivo* or *in vitro* and is generally performed using a concentration of compound that is sufficient to alter the binding of vanilloid ligand to VR1 *in vitro* (using the assay provided in Example 5) and/or VR1-mediated signal transduction (using an assay provided in Example 6).

Methods are further provided for inhibiting binding of vanilloid ligand to a capsaicin receptor. Within certain such aspects, the inhibition takes place *in vitro*. Such methods comprise contacting a capsaicin receptor with at least one compound as described herein, under conditions and in an amount sufficient to detectably inhibit vanilloid ligand binding to the capsaicin receptor. Within other such aspects, the capsaicin receptor is in a patient. Such methods comprise contacting cells expressing a capsaicin receptor in a patient with at least one compound as described herein in an amount sufficient to detectably inhibit vanilloid ligand binding to cells expressing a cloned capsaicin receptor *in vitro*, and thereby inhibiting binding of vanilloid ligand to the capsaicin receptor in the patient.

The present invention further provides methods for treating a condition responsive to capsaicin receptor modulation in a patient, comprising administering to the patient a therapeutically effective amount of at least one compound as described herein.

Within other aspects, methods are provided for treating pain in a patient, comprising administering to a patient suffering from pain a therapeutically effective amount of at least one compound as described herein.

Methods are further provided for treating itch, urinary incontinence, overactive bladder, cough and/or hiccup in a patient, comprising administering to a patient suffering from one or more of the foregoing conditions a therapeutically effective amount of at least one compound as described herein.

The present invention further provides methods for promoting weight loss in an obese patient, comprising administering to an obese patient a therapeutically effective amount of at least one VR1 modulator as described herein.

Methods are further provided for identifying an agent that binds to capsaicin receptor, comprising: (a) contacting capsaicin receptor with a labeled compound as described herein under conditions that permit binding of the compound to capsaicin receptor, thereby generating bound, labeled compound; (b) detecting a signal that corresponds to the amount of bound, labeled compound in the absence of test agent; (c) contacting the bound, labeled compound with a test agent; (d) detecting a signal that corresponds to the amount of bound labeled compound in the presence of test agent; and (e) detecting a decrease in signal detected in step (d), as compared to the signal detected in step (b).

Within further aspects, the present invention provides methods for determining the presence or absence of capsaicin receptor in a sample, comprising: (a) contacting a sample with a VR1 modulator as described herein under conditions that permit binding of the VR1 modulator to capsaicin receptor; and (b) detecting a level of the VR1 modulator bound to capsaicin receptor.

The present invention also provides packaged pharmaceutical preparations, comprising: (a) a pharmaceutical composition as described herein in a container; and (b) instructions for using the composition to treat one or more conditions responsive to capsaicin receptor modulation, such as pain, itch, urinary incontinence, overactive bladder, cough, hiccup and/or obesity.

In yet another aspect, the invention provides methods of preparing the compounds disclosed herein, including the intermediates.

These and other aspects of the present invention will become apparent upon reference to the following detailed description.

DETAILED DESCRIPTION

As noted above, the present invention provides substituted bicyclic quinazolin-4-ylamine derivatives. Such modulators may be used *in vitro* or *in vivo*, to modulate capsaicin receptor activity in a variety of contexts.

TERMINOLOGY

Compounds are generally described herein using standard nomenclature. For compounds having asymmetric centers, it should be understood that (unless otherwise specified) all of the optical isomers and mixtures thereof are encompassed. In addition, compounds with carbon-carbon double bonds may occur in Z- and E- forms, with all isomeric forms of the compounds being included in the present invention unless otherwise specified. Where a compound exists in various tautomeric forms, a recited compound is not limited to any one specific tautomer, but rather is intended to encompass all tautomeric forms. Certain compounds are described herein using a general formula that includes variables (*e.g.,* R_3, A_1, X). Unless otherwise specified, each variable within such a formula is defined independently of any other variable, and any variable that occurs more than one time in a formula is defined independently at each occurrence.

The term "substituted bicyclic quinazolin-4-ylamine derivatives," as used herein, encompasses all compounds that satisfy one or more of the Formulas provided herein, including any enantiomers, racemates and stereoisomers, as well as pharmaceutically acceptable salts of such compounds. Such compounds include analogues in which the bicyclic core (which comprises V, X, W, Y and Z) is modified in the number and/or placement of ring nitrogen atoms, as well as analogues in which varied substituents, as described in more detail below, are attached to such a core structure. In other words, compounds that are quinoline-4-ylamines, quinoline-2-ylamines, quinazoline-4-ylamines, and derivatives thereof in which one or more of W, Y and Z are nitrogen are within the scope of quinazolin-4ylamine derivatives. In certain embodiments, preferred bicyclic quinazolin-4-ylamine analogues are those in which at least one of Y and Z is nitrogen.

A "pharmaceutically acceptable salt" of a compound is an acid or base salt that is generally considered in the art to be suitable for use in contact with the tissues of human beings or animals without excessive toxicity, irritation, allergic response, or other problem or complication. Such salts include mineral and organic acid salts of basic residues such as amines, as well as alkali or organic salts of acidic residues such as carboxylic acids. Specific pharmaceutical salts include, but are not limited to, salts of acids such as hydrochloric, phosphoric, hydrobromic, malic, glycolic, fumaric, sulfuric, sulfamic, sulfanilic, formic, toluenesulfonic, methanesulfonic, benzene sulfonic, ethane disulfonic, 2-hydroxyethylsulfonic, nitric, benzoic, 2-acetoxybenzoic, citric, tartaric, lactic, stearic, salicylic, glutamic, ascorbic, pamoic, succinic, fumaric, maleic, propionic, hydroxymaleic, hydroiodic, phenylacetic, alkanoic such as acetic, $HOOC-(CH_2)_n-COOH$ where n is 0-4, and the like. Similarly, pharmaceutically acceptable cations include, but are not limited to sodium, potassium, calcium, aluminum, lithium and ammonium. Those of ordinary skill in the art will recognize further pharmaceutically acceptable salts for the compounds provided herein, including those listed by *Remington's Pharmaceutical Sciences,* 17th ed., Mack Publishing Company, Easton, PA, p. 1418 (1985). In general, a pharmaceutically acceptable acid or base salt can be synthesized from a parent compound that contains a basic or acidic moiety by any conventional chemical method. Briefly, such salts can be prepared by reacting the free acid or base forms of these compounds with a stoichiometric amount of the appropriate base or acid in water or in an organic solvent, or in a mixture of the two; generally, the use of nonaqueous media, such as ether, ethyl acetate, ethanol, isopropanol or acetonitrile, is preferred.

It will be apparent that each substituted bicyclic quinazolin-4-ylamine derivative may, but need not, be formulated as a hydrate, solvate or non-covalent complex. In addition, the various crystal forms and polymorphs are within the scope of the present invention. Also provided herein are prodrugs. A "prodrug" is a compound that may not fully satisfy the structural requirements of the Formulas provided herein, but is modified *in vivo,* following administration to a patient, to produce a compound that satisfies one or more of the Formulas provided herein. For example, a prodrug may be an acylated derivative of a compound as provided herein. Prodrugs include compounds wherein hydroxy, amine or sulfhydryl groups are bonded to any group that, when administered to a mammalian subject, cleaves to form a free hydroxy, amino, or sulfhydryl group, respectively. Examples of prodrugs include, but are not limited to, acetate, formate and benzoate derivatives of alcohol and amine functional groups within the compounds provided herein. Prodrugs of the compounds provided herein may be prepared by modifying functional groups present in the compounds in such a way that the modifications are cleaved to the parent compounds.

As used herein, the term "alkyl" refers to a straight or branched chain or cyclic saturated aliphatic hydrocarbon. Alkyl groups include groups having from 1 to 8 carbon atoms (C_1-C_8alkyl), from 1 to 6 carbon atoms (C_1-C_6alkyl) and from 1 to 4 carbon atoms (C_1-C_4alkyl), such as methyl, ethyl, propyl, isopropyl, n-butyl, *sec*-butyl, *tert*-butyl, pentyl, 2-pentyl, isopentyl, neopentyl, hexyl, 2-hexyl, 3-hexyl, 3-methylpentyl, cyclopropyl, cyclopropylmethyl, cyclopentyl, cyclopentylmethyl, cyclohexyl, cycloheptyl and norbornyl. "C_0-C_4alkyl" refers to a single covalent bond (C_0) or an alkyl group having 1, 2, 3 or 4 carbon atoms; "C_0-C_6alkyl" refers to a single covalent bond or a C_1-C_6alkyl group; "C_0-C_8alkyl" refers to a single covalent bond or a C_1-C_8alkyl group. In certain embodiments, preferred alkyl groups are straight or branched chain. In some instances herein, a substituent of an alkyl group is specifically indicated. For example, "C_1-C_6aminoalkyl" refers to a C_1-C_6alkyl group that has at least one NH_2 substituent. Similarly, "C_1-C_6hydroxyalkyl" refers to a C_1-C_6alkyl group that has at least one -OH substituent.

"Alkylene" refers to a divalent alkyl group, as defined above. C_0-C_3alkylene is a single covalent bond or an alkylene group having 1, 2 or 3 carbon atoms.

"Alkenyl" refers to straight or branched chain or cyclic alkene groups, in which at least one unsaturated carbon-carbon double bond is present. Alkenyl groups include C_2-C_8alkenyl, C_2-C_6alkenyl and C_2-C_4alkenyl groups, which have from 2 to 8, 2 to 6 or 2 to 4 carbon atoms, respectively, such as ethenyl, allyl or isopropenyl. "Alkynyl" refers to straight or branched chain or cyclic alkyne groups, which have one or more unsaturated carbon-carbon bonds, at least one of which is a triple bond. Alkynyl groups include C_2-C_8alkynyl, C_2-C_6alkynyl and C_2-C_4alkynyl groups, which have from 2 to 8, 2 to 6 or 2 to 4 carbon atoms, respectively. In certain embodiments, preferred alkenyl and alkynyl groups are straight or branched chain.

By "alkoxy," as used herein, is meant an alkyl group as described above attached via an oxygen bridge. Alkoxy groups include C_1-C_6alkoxy and C_1-C_4alkoxy groups, which have from 1 to 6 or 1 to 4 carbon atoms, respectively. Methoxy, ethoxy, propoxy, isopropoxy, n-butoxy, *sec*-butoxy, *tert*-butoxy, n-pentoxy, 2-pentoxy, 3-pentoxy, isopentoxy, neopentoxy, hexoxy, 2-hexoxy, 3-hexoxy, and 3-methylpentoxy are specific alkoxy groups.

Similarly, "alkylthio" refers to an alkyl, alkenyl or alkynyl group as described above attached via a sulfur bridge. Preferred alkoxy and alkylthio groups are those in which an alkyl group is attached via the heteroatom bridge.

The term "oxo," as used herein, refers to a keto (C=O) group. An oxo group that is a substituent of a nonaromatic carbon atom results in a conversion of $–CH_2–$ to –C(=O)–.

The term "alkanoyl" refers to an acyl group in a linear or branched arrangement (*e.g.*, -(C=O)-alkyl), where attachment is through the carbon of the keto group. Alkanoyl groups include C_2-C_8alkanoyl, C_2-C_6alkanoyl and C_2-C_4alkanoyl groups, which have from 2 to 8, 2 to 6 or 2 to 4 carbon atoms, respectively. "C_1alkanoyl" refers to –(C=O)-H, which (along with C_2-C_8alkanoyl) is encompassed by the term "C_1-C_8alkanoyl." Ethanoyl is C_2alkanoyl.

An "alkanone" is a ketone group in which carbon atoms are in a linear or branched alkyl arrangement. "C_3-C_8alkanone," "C_3-C_6alkanone" and "C_3-C_4alkanone" refer to an alkanone having from 3 to 8, 6 or 4 carbon atoms, respectively. By way of example, a C_3 alkanone group has the structure $–CH_2$-(C=O)-CH_3.

Similarly, "alkyl ether" refers to a linear or branched ether substituent. Alkyl ether groups include C_2-C_8alkyl ether, C_2-C_6alkyl ether and C_2-C_4alkyl ether groups, which have 2 to 8, 6 or 4 carbon atoms, respectively. By way of example, a C_2 alkyl ether group has the structure $–CH_2$-O-CH_3.

The term "alkoxycarbonyl" refers to an alkoxy group linked via a carbonyl (*i.e.*, a group having the general structure –C(=O)–O–alkyl). Alkoxycarbonyl groups include C_2-C_8, C_2-C_6 and C_2-C_4alkoxycarbonyl groups, which have from 2 to 8, 6 or 4 carbon atoms, respectively. "C_1alkoxycarbonyl" refers to -C(=O)-OH, which is encompassed by the term "C_1-C_8alkoxycarbonyl." "Methoxycarbonyl" refers to C(=O)-OCH_3.

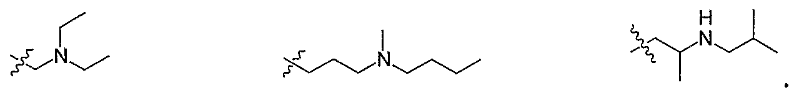
"Alkanoyloxy," as used herein, refers to an alkanoyl group linked via an oxygen bridge (*i.e.*, a group having the general structure –O–C(=O)–alkyl). Alkanoyloxy groups include C_2-C_8, C_2-C_6 and C_2-C_4alkanoyloxy groups, which have from 2 to 8, 6 or 4 carbon atoms, respectively.

"Alkylsulfonyl" refers to groups of the formula –(SO_2)-alkyl, in which the sulfur atom is the point of attachment. Alkylsulfonyl groups include C_1-C_8alkylsulfonyl and C_1-C_6alkylsulfonyl groups, which have from 1 to 8 or 1 to 6 carbon atoms, respectively.

"Alkylsulfonamido" refers to groups of the formula –(SO_2)-N(R)$_2$, in which the sulfur atom is the point of attachment and each R is independently hydrogen or alkyl. The term "mono- or di-(C_1-C_6alkyl)sulfonamido" refers to such groups in which one R is C_1-C_6alkyl and the other R is hydrogen or an independently chosen C_1-C_6alkyl.

"Alkylamino" refers to a secondary or tertiary amine having the general structure –NH–alkyl or –N(alkyl)(alkyl), wherein each alkyl may be the same or different. Such groups include, for example, mono- and di-(C_1-C_8alkyl)amino groups, in which each alkyl may be the same or different and may contain from 1 to 8 carbon atoms, as well as mono- and di-(C_1-C_6alkyl)amino groups and mono- and di-(C_1-C_4alkyl)amino groups.

"Alkylaminoalkyl" refers to an alkylamino group linked via an alkyl group (*i.e.*, a group having the general structure -alkyl–NH–alkyl or -alkyl–N(alkyl)(alkyl)) in which each alkyl is selected independently. Such groups include, for example, mono- and di-(C_1-C_8alkyl)aminoC_1-C_8alkyl, mono- and di-(C_1-C_6alkyl)aminoC_1-C_6alkyl and mono- and di-(C_1-C_4alkyl)aminoC_1-C_4alkyl, in which each alkyl may be the same or different. "Mono- or di-(C_1-C_6alkyl)aminoC_0-C_6alkyl" refers to a mono- or di-(C_1-C_6alkyl)amino group linked via a single covalent bond or a C_1-C_6alkyl group. The following are representative alkylaminoalkyl groups:



The term "aminocarbonyl" refers to an amide group (*i.e.*, -(C=O)NH_2). "Mono- or di-(C_1-C_8alkyl)aminocarbonyl" is an aminocarbonyl group in which one or both of the hydrogen atoms is replaced with C_1-C_8alkyl. If both hydrogen atoms are so replaced, the C_1-C_8alkyl groups may be the same or different.

The term "halogen" refers to fluorine, chlorine, bromine or iodine.

A "haloalkyl" is a branched, straight-chain or cyclic alkyl group, substituted with 1 or more halogen atoms (*e.g.*, "C_1-C_8haloalkyl" groups have from 1 to 8 carbon atoms; "C_1-C_6haloalkyl" groups have from 1 to 6 carbon atoms). Examples of haloalkyl groups include, but are not limited to, mono-, di- or tri-fluoromethyl; mono-, di- or tri-chloromethyl; mono-, di-, tri-, tetra- or penta-fluoroethyl; mono-, di-, tri-, tetra- or penta-chloroethyl; and 1,2,2,2-tetrafluoro-1-trifluoromethyl-ethyl. Typical haloalkyl groups are trifluoromethyl and difluoromethyl. The term "haloalkoxy" refers to a haloalkyl group as defined above attached via an oxygen bridge. "C_1-C_6haloalkoxy" groups have from 1 to 6 carbon atoms.

A dash ("-") that is not between two letters or symbols is used to indicate a point of attachment for a substituent. For example, -$CONH_2$ is attached through the carbon atom.

A "heteroatom," as used herein, is oxygen, sulfur or nitrogen.

A "carbocycle" or "carbocyclic group" comprises at least one ring formed entirely by carbon-carbon bonds (referred to herein as a carbocyclic ring), and does not contain a heterocyclic ring. Unless otherwise specified, each carbocyclic ring within a carbocycle may be saturated, partially saturated or aromatic. A carbocycle generally has from 1 to 3 fused, pendant or spiro rings; carbocycles within certain embodiments have one ring or two fused rings. Typically, each ring contains from 3 to 8 ring members (*i.e.*, C_3-C_8); C_5-C_7 rings are recited in certain embodiments. Carbocycles comprising fused, pendant or spiro rings typically contain from 9 to 14 ring members. Certain representative carbocycles are cycloalkyl (*i.e.*, groups that comprise saturated and/or partially saturated rings, such as cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, adamantyl, decahydro-naphthalenyl, octahydro-indenyl, and partially saturated variants of any of the foregoing, such as cyclohexenyl). Other carbocycles are aryl (*i.e.*, contain at least one aromatic carbocyclic ring, with or without additional fused, pendant or spiro cyclolkyl rings). Such carbocycles include, for example, phenyl, naphthyl, fluorenyl, indanyl and 1,2,3,4-tetrahydronaphthyl.

Certain carbocycles recited herein are (C_6-C_{10}aryl)C_0-C_8alkyl groups (*i.e.*, groups in which a carbocyclic group comprising at least one aromatic ring is linked via a single covalent bond or a C_1-C_8alkyl group). Such groups include, for example, phenyl and indanyl, as well as groups in which either of the foregoing is linked via C_1-C_8alkyl, preferably via C_1-C_4alkyl. Phenyl groups linked via a single covalent bond or alkyl group are designated phenylC_0-C_8alkyl (*e.g.*, benzyl, 1-phenyl-ethyl, 1-phenyl-propyl and 2-phenyl-ethyl). A phenylC_0-C_8alkoxy group is a phenyl ring linked via an oxygen bridge or an alkoxy group having from 1 to 8 carbon atoms (*e.g.*, phenoxy or benzoxy).

A "heterocycle" or "heterocyclic group" has from 1 to 3 fused, pendant or spiro rings, at least one of which is a heterocyclic ring (*i.e.*, one or more ring atoms is a heteroatom, with the remaining ring atoms being carbon). Typically, a heterocyclic ring comprises 1, 2, 3 or 4 heteroatoms; within certain embodiments each heterocyclic ring has 1 or 2 heteroatoms per ring. Each heterocyclic ring generally contains from 3 to 8 ring members (rings having from 4 or 5 to 7 ring members are recited in certain embodiments) and heterocycles comprising fused, pendant or spiro rings typically contain from 9 to 14 ring members. Certain heterocycles comprise a sulfur atom as a ring member; in certain embodiments, the sulfur atom is oxidized to SO or SO_2. Heterocycles may be optionally substituted with a variety of substituents, as indicated. Unless otherwise specified, a heterocycle may be a heterocycloalkyl group (*i.e.*, each ring is saturated or partially saturated) or a heteroaryl group (*i.e.*, at least one ring within the group is aromatic). A heterocyclic group may generally be linked via any ring or substituent atom, provided that a stable compound results. N-linked heterocyclic groups are linked via a component nitrogen atom.

Heterocyclic groups include, for example, azepanyl, azocinyl, benzimidazolyl, benzimidazolinyl, benzisothiazolyl, benzisoxazolyl, benzofuranyl, benzothiofuranyl, benzoxazolyl, benzothiazolyl, benztetrazolyl, chromanyl, chromenyl, cinnolinyl, decahydroquinolinyl, dihydrofuro[2,3-b]tetrahydrofuranyl, dihydroisoquinolinyl, dihydrotetrahydrofuranyl, 1,4-dioxa-8-aza-spiro[4.5]decyl, dithiazinyl, furanyl, furazanyl, imidazolinyl, imidazolidinyl, imidazolyl, indazolyl, indolenyl, indolinyl, indolizinyl, indolyl, isobenzofuranyl, isochromanyl, isoindazolyl, isoindolinyl, isoindolyl, isothiazolyl, isoxazolyl, isoquinolinyl, morpholinyl, naphthyridinyl, octahydroisoquinolinyl, oxadiazolyl, oxazolidinyl, oxazolyl, phthalazinyl, piperazinyl, piperidinyl, piperidinyl, piperidonyl, pteridinyl, purinyl, pyranyl, pyrazinyl, pyrazolidinyl, pyrazolinyl, pyrazolyl, pyridazinyl, pyridoimidazolyl, pyridooxazolyl, pyridothiazolyl, pyridyl, pyrimidyl, pyrrolidinyl, pyrrolidonyl, pyrrolinyl, pyrrolyl, quinazolinyl, quinolinyl, quinoxalinyl, quinuclidinyl, tetrahydroisoquinolinyl, tetrahydroquinolinyl, tetrazolyl, thiadiazinyl, thiadiazolyl, thiazolyl, thienothiazolyl, thienooxazolyl, thienoimidazolyl, thienyl, thiophenyl, thiomorpholinyl and variants thereof in which the sulfur atom is oxidized, triazinyl, and any of the foregoing that are substituted with from 1 to 4 substituents as described above.

Certain heterocyclic groups are 4- to 10-membered, 5- to 10-membered, 3- to 7-membered, 4- to 7-membered or 5- to 7-membered groups that contain 1 heterocyclic ring or 2 fused or spiro rings, optionally substituted. 4- to 10-membered heterocycloalkyl groups include, for example, piperidinyl, piperazinyl, pyrrolidinyl, azepanyl, 1,4-dioxa-8-aza-spiro[4.5]dec-8-yl, morpholino, thiomorpholino and 1,1-dioxo-thiomorpholin-4-yl. Such groups may be substituted as indicated. Representative aromatic heterocycles are azocinyl, pyridyl, pyrimidyl, imidazolyl, tetrazolyl and 3,4-dihydro-1H-isoquinolin-2-yl. (C_3-C_{10})heterocycloalkyls include, for example, piperidinyl, piperazinyl, pyrrolidinyl, azepanyl, 1,4-dioxa-8-aza-spiro[4.5]dec-8-yl, morpholino, thiomorpholino, and 1,1-dioxo-thiomorpholin-4-yl, as well as groups in which each of the foregoing is substituted. Representative aromatic heterocycles are azocinyl, pyridyl, pyrimidyl, imidazolyl, tetrazolyl and 3,4-dihydro-1H-isoquinolin-2-yl.

Additional heterocyclic groups include, for example, acridinyl, azepanyl, azocinyl, benzimidazolyl, benzimidazolinyl, benzisothiazolyl, benzisoxazolyl, benzofuranyl, benzothiofuranyl, benzothiophenyl, benzoxazolyl, benzothiazolyl, benzotriazolylcarbazolyl, benztetrazolyl, NH-carbazolyl, carbolinyl, chromanyl, chromenyl, cinnolinyl, decahydroquinolinyl, dihydrofuro[2,3-b]tetrahydrofuran, dihydroisoquinolinyl, dihydrotetrahydrofuranyl, 1,4-dioxa-8-aza-spiro[4.5]dec-8-yl, dithiazinyl, furanyl, furazanyl, imidazolinyl, imidazolidinyl, imidazolyl, indazolyl, indolenyl, indolinyl, indolizinyl, indolyl, isobenzofuranyl, isochromanyl, isoindazolyl, isoindolinyl, isoindolyl, isothiazolyl, isoxazolyl, isoquinolinyl, morpholinyl, naphthyridinyl, octahydroisoquinolinyl, oxadiazolyl, oxazolidinyl, oxazolyl, phenanthridinyl, phenanthrolinyl, phenazinyl, phenothiazinyl, phenoxathiinyl, phenoxazinyl, phthalazinyl, piperazinyl, piperidinyl, piperidinyl, piperidonyl, pteridinyl, purinyl, pyranyl, pyrazinyl, pyrazolidinyl, pyrazolinyl, pyrazolyl, pyridazinyl, pyridoimidazolyl, pyridooxazolyl, pyridothiazolyl, pyridyl, pyrimidyl, pyrrolidinyl, pyrrolidonyl, pyrrolinyl, pyrrolyl, quinazolinyl, quinolinyl, quinoxalinyl, quinuclidinyl, tetrahydroisoquinolinyl, tetrahydroquinolinyl, tetrazolyl, thiadiazinyl, thiadiazolyl, thianthrenyl, thiazolyl, thienothiazolyl, thienooxazolyl, thienoimidazolyl, thienyl, thiophenyl, thiomorpholinyl and variants thereof in which the sulfur atom is oxidized, triazinyl, xanthenyl and any of the foregoing that are substituted with from 1 to 4 substituents as described above.

A "heterocycleC_0-C_8alkyl" is a heterocyclic group linked via a single covalent bond or C_1-C_8alkyl group. A (3- to 10-membered heterocycle)C_0-C_6alkyl is a heterocyclic group having from 3 to 10 ring members linked via a single covalent bond or a C_1-C_6alkyl group. A (5- to 7-membered heterocycle)C_0-C_6alkyl is a 5- to 7-membered heterocyclic ring linked via a single covalent bond or a C_1-C_6alkyl group; a (4- to 7-membered heterocycloalkyl)C_0-C_4alkyl is a 4- to 7-membered heterocycloalkyl ring linked via a single covalent bond or a C_1-C_4alkyl group.

A "substituent," as used herein, refers to a molecular moiety that is covalently bonded to an atom within a molecule of interest. For example, a "ring substituent" may be a moiety such as a halogen, alkyl group, haloalkyl group or other group discussed herein that is covalently bonded to an atom (preferably a carbon or nitrogen atom) that is a ring member. The term "substitution" refers to replacing a hydrogen atom in a molecular structure with a substituent as described above, such that the valence on the designated atom is not exceeded, and such that a chemically stable compound (*i.e.*, a compound that can be isolated, characterized, and tested for biological activity) results from the substitution.

Groups that are "optionally substituted" are unsubstituted or are substituted by other than hydrogen at one or more available positions, typically 1, 2, 3, 4 or 5 positions, by one or more suitable groups (which may be the same or different). Such optional substituents include, for example, hydroxy, halogen, cyano, nitro, C_1-C_8alkyl, C_2-C_8alkenyl, C_2-

C_8alkynyl, C_1-C_8alkoxy, C_2-C_8alkyl ether, C_3-C_8alkanone, C_1-C_8alkylthio, amino, mono- or di-(C_1-C_8alkyl)amino, C_1-C_8haloalkyl, C_1-C_8haloalkoxy, C_1-C_8alkanoyl, C_2-C_8alkanoyloxy, C_1-C_8alkoxycarbonyl,

-COOH, -$CONH_2$, mono- or di-(C_1-C_8alkyl)aminocarbonyl, -SO_2NH_2, and/or mono or di(C_1-C_8alkyl)sulfonamido, as well as carbocyclic and heterocyclic groups. Optional substitution is also indicated by the phrase "substituted with from 0 to X substituents," where X is the maximum number of possible substituents. Certain optionally substituted groups are substituted with from 0 to 2, 3 or 4 independently selected substituents (*i.e.,* are unsubstituted or substituted with up to the recited maximum number of substitutents).

The terms "VR1" and "capsaicin receptor" are used interchangeably herein to refer to a type 1 vanilloid receptor. Unless otherwise specified, these terms encompass both rat and human VR1 receptors (*e.g.,* GenBank Accession Numbers AF327067, AJ277028 and NM_018727; sequences of certain human VR1 cDNAs are provided in SEQ ID NOs:1-3, and the encoded amino acid sequences shown in SEQ ID NOs:4 and 5, of U.S. Patent No. 6,482,611), as well as homologues thereof found in other species.

A "VR1 modulator," also referred to herein as a "modulator," is a compound that modulates VR1 activation and/or VR1-mediated signal transduction. VR1 modulators specifically provided herein are compounds of Formula I and pharmaceutically acceptable salts of compounds of Formula I. A VR1 modulator may be a VR1 agonist or antagonist. A modulator binds with “high affinity” if the K_i at VR1 is less than 1 micromolar, preferably less than 100 nanomolar, 10 nanomolar or 1 nanomolar. A representative assay for determining K_i at VR1 is provided in Example 5, herein.

A modulator is considered an "antagonist" if it detectably inhibits vanilloid ligand binding to VR1 and/or VR1-mediated signal transduction (using, for example, the representative assay provided in Example 6); in general, such an antagonist inhibits VR1 activation with a IC_{50} value of less than 1 micromolar, preferably less than 100 nanomolar, and more preferably less than 10 nanomolar or 1 nanomolar within the assay provided in Example 6. VR1 antagonists include neutral antagonists and inverse agonists. In certain embodiments, capsaicin receptor antagonists provided herein are not vanilloids.

An "inverse agonist" of VR1 is a compound that reduces the activity of VR1 below its basal activity level in the absence of added vanilloid ligand. Inverse agonists of VR1 may also inhibit the activity of vanilloid ligand at VR1, and/or may also inhibit binding of vanilloid ligand to VR1. The ability of a compound to inhibit the binding of vanilloid ligand to VR1 may be measured by a binding assay, such as the binding assay given in Example 5.

The basal activity of VR1, as well as the reduction in VR1 activity due to the presence of VR1 antagonist, may be determined from a calcium mobilization assay, such as the assay of Example 6.

A "neutral antagonist" of VR1 is a compound that inhibits the activity of vanilloid ligand at VR1, but does not significantly change the basal activity of the receptor (*i.e.*, within a calcium mobilization assay as described in Example 6 performed in the absence of vanilloid ligand, VR1 activity is reduced by no more than 10%, more preferably by no more than 5%, and even more preferably by no more than 2%; most preferably, there is no detectable reduction in activity). Neutral antagonists of VR1 may inhibit the binding of vanilloid ligand to VR1.

As used herein a "capsaicin receptor agonist" or "VR1 agonist" is a compound that elevates the activity of the receptor above the basal activity level of the receptor (*i.e.*, enhances VR1 activation and/or VR1-mediated signal transduction). Capsaicin receptor agonist activity may be identified using the representative assay provided in Example 6. In general, such an agonist has an EC_{50} value of less than 1 micromolar, preferably less than 100 nanomolar, and more preferably less than 10 nanomolar within the assay provided in Example 6. In certain embodiments, capsaicin receptor agonists provided herein are not vanilloids.

A "vanilloid" is capsaicin or any capsaicin analogue that comprises a phenyl ring with two oxygen atoms bound to adjacent ring carbon atoms (one of which carbon atom is located *para* to the point of attachment of a third moiety that is bound to the phenyl ring). A vanilloid is a "vanilloid ligand" if it binds to VR1 with a K_i (determined as described herein) that is no greater than 10 μM. Vanilloid ligand agonists include capsaicin, olvanil, N-arachidonoyl-dopamine and resiniferatoxin (RTX). Vanilloid ligand antagonists include capsazepine and iodo-resiniferatoxin.

A "therapeutically effective amount" (or dose) is an amount that, upon administration to a patient, results in a discernible patient benefit (*e.g.*, provides detectable relief from a condition being treated). Such relief may be detected using any appropriate criteria, including alleviation of one or more symptoms such as pain. A therapeutically effective amount or dose generally results in a concentration of compound in a body fluid (such as blood, plasma, serum, CSF, synovial fluid, lymph, cellular interstitial fluid, tears or urine) that is sufficient to alter the binding of vanilloid ligand to VR1 *in vitro* (using the assay provided in Example 5) and/or VR1-mediated signal transduction (using an assay provided in Example 6).

A "patient" is any individual treated with a compound (*e.g.*, a VR1 modulator) as provided herein. Patients include humans, as well as other animals such as companion animals (*e.g.*, dogs and cats) and livestock. Patients may be experiencing one or more symptoms of a condition responsive to capsaicin receptor modulation (*e.g.*, pain, exposure to vanilloid ligand, itch, urinary incontinence, overactive bladder, respiratory disorders, cough and/or hiccup), or may be free of such symptom(s) (*i.e.*, treatment may be prophylactic).

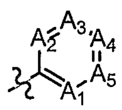
SUBSTITUTED BICYCLIC QUINAZOLIN-4-YLAMINE ANALOGUES

As noted above, the present invention provides substituted bicyclic quinazolin-4-ylamino analogues that may be used in a variety of contexts, including in the treatment of pain (*e.g.*, neuropathic or peripheral nerve-mediated pain); exposure to capsaicin; exposure to acid, heat, light, tear gas air pollutants, pepper spray or related agents; respiratory conditions such as asthma or chronic obstructive pulmonary disease; itch; urinary incontinence or overactive bladder; cough or hiccup; and/or obesity. Such compounds may also be used within *in vitro* assays (*e.g.*, assays for receptor activity), as probes for detection and localization of VR1 and as standards in ligand binding and VR1-mediated signal transduction assays.

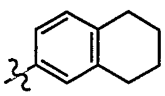
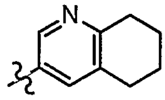
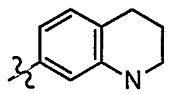
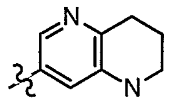
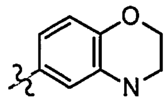
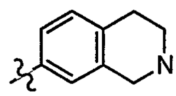
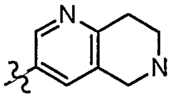
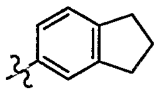
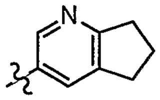
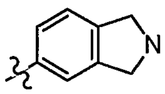
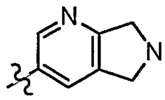
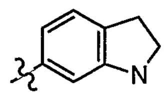
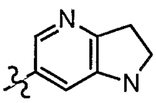
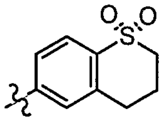
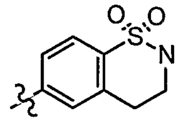
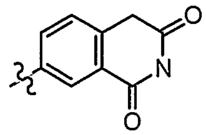
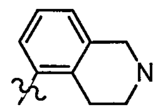
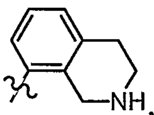
Certain compounds provided herein detectably modulate the binding of capsaicin to VR1 at nanomolar (*i.e.*, submicromolar) concentrations, preferably at subnanomolar concentrations, more preferably at concentrations below 100 picomolar, 20 picomolar, 10 picomolar or 5 picomolar. Such modulators are preferably not vanilloids. Certain preferred modulators are VR1 antagonists and have no detectable agonist activity in the assay described in Example 6. Preferred VR1 modulators further bind with high affinity to VR1, and do not substantially inhibit activity of human EGF receptor tyrosine kinase.

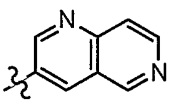
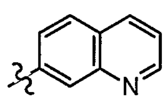
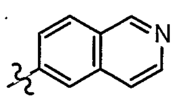
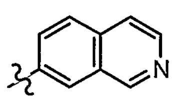
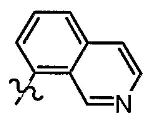
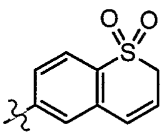
Certain compound provided herein further satisfy one or more of Formulas II – VII, or a subformula thereof, or are a pharmaceutically acceptable salt of such a compound.

Within Formula I, the group designated:

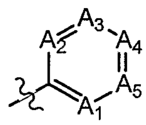


is a bicyclic group in which a fused ring encompasses A_1 and A_5 or A_4 and A_5. Certain such bicyclic groups are illustrated in Formulas II-VII above. By way of example, the following bicyclic groups, optionally substituted as described herein, are specifically contemplated:

, , , , , , , , , , , , , , , ,  and , as well as variants of the foregoing in which the fused ring contains one or more additional double bonds, such as:

, , , , , and .

Substitutions on the group designated:



are generally as described above. In certain embodiments, the ring comprising A_1-A_5 (*i.e.,* not including the fused ring) is unsubstituted or substituted with a single substituent chosen from halogen, hydroxy, cyano, C_1-C_6alkyl and C_1-C_6halolkyl. Within further embodiments, the fused ring (*e.g.,* designated B in Formula II) is substituted with from 0 to 6, 0 to 5 or 0 to 3 substituents. In certain such compounds, one substituent of the fused ring is chosen from oxo, C_1-C_6alkyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6alkanoyl, mono- and di-(C_1-C_6alkyl)aminoC_0-C_6alkyl and (5- to 7-membered heterocycloalkyl)C_0-C_6alkyl; and the other substituent(s), if any are independently chosen from halogen, hydroxy, oxo, cyano and C_1-C_6alkyl. Representative 5- to 7-membered heterocycloalkyl groups include, for example, morpholine, piperazine and piperidine.

Ar, within certain embodiments of Formulas I-VI, is phenyl, pyridyl or pyrimidyl, each of which is unsubstituted or substituted with 1, 2 or 3 substituents as described above;

preferably such substituents, if any, are independently selected from halogen, hydroxy, cyano, amino, nitro, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy. For example, Ar may contain one substituent selected from halogen, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6haloalkyl and C_1-C_6haloalkoxy. If one or more Ar substituents is present, at least one such substituent is located *ortho* to the point of attachment in certain embodiments (*e.g.*, Ar may be phenyl substituted at the 2-position, or 2-pyridyl substituted at the 3-position). Alternatively, or in addition, at least one such substituent is located *para* to the point of attachment in certain embodiments. Ar_1 groups include, but are not limited to, pyridin-2-yl, 3-methyl-pyridin-2-yl, 3-trifluoromethyl-pyridin-2-yl and 3-halo-pyridin-2-yl.

In certain embodiments of Formulas I-VI, the variables X and V are independently CH or N, with the proviso that at least one of X and V is N. In certain such compounds, X is N and V is CH. In other such compounds, X and V are both N, or X is CH and V is N. In certain embodiments of Formula VII, X is N or CH.

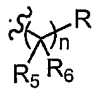
In further embodiments of Formulas I and II, the variables W, Y and Z are independently CR_1 or N, where R_1 at the W, Y and Z positions is hydrogen, C_1-C_4alkyl or C_1-C_4haloalkyl, with hydrogen preferred. In certain such compounds, at least one of Y and Z is preferably N. Within certain further compounds, each R_1 is CH. Compounds provided herein include, for example, those in which W is CH (*e.g.*, compounds of Formulas III-VII, including subformulas) and R_1 at the Y and Z positions is hydrogen, C_1-C_4alkyl or C_1-C_4haloalkyl, with hydrogen preferred. In certain such compounds, Y is N and Z is CH. In other such compounds, Y and Z are both CH, or Z is N and Y is CH.

U, within certain embodiments of Formulas I and II, is CR_2 (Formulas III-VII, including subformulas, illustrate certain such compounds). Certain R_2 groups are described herein using the formula $-R_c$-M-A-R_y, where each term is selected independently of the others. M is absent, a single covalent bond or a linking moiety that comprises at least one heteroatom. Suitable M groups include O, S, SO (*i.e.*, $-\overset{O}{\overset{\|}{S}}-$), SO_2 (*i.e.*, $-\overset{O\ O}{\overset{\backslash\!\!\ /}{S}}-$), C(=O) (*i.e.*, $-\overset{O}{\overset{\|}{C}}-$), OC(=O) (*i.e.*, $-O-\overset{O}{\overset{\|}{C}}-$), C(=O)O (*i.e.*, $-\overset{O}{\overset{\|}{C}}-O-$), O-C(=O)O (*i.e.*, $-O-\overset{O}{\overset{\|}{C}}-O-$), C(=O)N($R_z$) (*i.e.*, $-\overset{O}{\overset{\|}{C}}-\overset{R_z}{\overset{|}{N}}-$), OC(=O)N($R_z$) (*i.e.*, $-O-\overset{O}{\overset{\|}{C}}-\overset{R_z}{\overset{|}{N}}-$), N($R_z$)C(=O) (*i.e.*, $-\overset{R_z}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-$), N($R_z$) (*i.e.*, $-\overset{R_z}{\overset{|}{N}}-$), $SO_2N(R_z)$ (*i.e.*, $-\overset{O\ O}{\overset{\backslash\!\!\ /}{S}}-\overset{R_z}{\overset{|}{N}}-$), or $N(R_z)SO_2$ (*i.e.*, $-\overset{R_z}{\overset{|}{N}}-\overset{O\ O}{\overset{\backslash\!\!\ /}{S}}-$). In certain embodiments, M is absent, a single covalent bond, O, OC(=O), C(=O)O, C(=O)N(R_z), N(R_z)C(=O) or N(R_z), wherein R_z is optionally joined to R_y to form a 5- to 7-membered carbocycle or heterocycle that is substituted with from 0 to 3 substituents independently chosen from R_b. It will be apparent that, within groups of the formula R_c-M-A-R_y, if R_c is C_0alkylene and M and A are absent, then R_2 is $-R_y$.

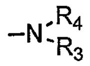
In other such compounds, R_2 is:

(i) hydrogen or halogen; or

(ii) a group of the formula:



wherein

R is -O-R_7 or ;

R_7 is selected from:

(i) hydrogen;

(ii) C_1-C_8alkyl, C_2-C_8alkenyl, C_2-C_8alkynyl, C_2-C_8alkanoyl, C_3-C_8alkanone, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl, and (5- to 10-membered heterocycle)C_0-C_8alkyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b; and

(iii) groups that are joined to an R_5 or R_6 to form a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b;

R_3 and R_4 are:

(i) each independently selected from:

(a) hydrogen;

(b) C_1-C_8alkyl (*e.g.*, C_4-C_7cycloalkyl), C_2-C_8alkenyl, C_2-C_8alkynyl, C_1-C_8alkoxy, C_3-C_8alkanone, C_2-C_8alkanoyl, C_1-C_8alkoxycarbonyl, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl, (5- to 10-membered heterocycle)C_0-C_8alkyl and C_1-C_8alkylsulfonyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b; and

(c) groups that are joined to an R_5 or R_6 to form a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b; or

(ii) joined to form, with the N to which they are bound, a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b, C_1-C_8alkanoyl, (4- to 7-membered heterocycloalkyl)C_0-C_4alkyl, and mono- and di-(C_1-C_6alkyl)aminoC_1-C_6alkyl; and

R_5 and R_6 are, independently at each occurrence:

(i) each independently selected from:

(a) hydrogen or hydroxy;

(b) C_1-C_8alkyl, unsubstituted or substituted with 1 or 2 substituents independently selected from R_b; and

(c) groups that are joined to R_3 or R_7 to form a 5- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b;

(ii) taken together to form a keto group -(C=O)-; or

(iii) joined to form a 3- to 7-membered carbocyclic or heterocyclic ring that is substituted with from 0 to 4 substituents selected from R_b; and

n is 1, 2 or 3.

Representative R_2 groups include, for example:

(i) hydrogen or halogen; or

(ii) C_1-C_6alkyl, -$(CH_2)_n$$NH_2$, -$(CH_2)_n$N(H)$C_1$-$C_8$alkyl, -$(CH_2)_n$N($C_1$-$C_8$alkyl)$_2$, -$(CH_2)_n$(4- to 8-membered heterocycloalkyl), -$(CH_2)_n$OH, -$(CH_2)_n$OC_1-C_6alkyl or -$(CH_2)_n$O-benzyl, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl, and C_1-C_6haloalkyl, wherein each n is 0, 1, 2 or 3.

Within certain embodiments, R_3 and R_4 are each independently selected from (i) hydrogen or (ii) C_1-C_8alkyl, C_2-C_8alkenyl, C_2-C_8alkynyl, C_3-C_8alkanone, C_1-C_8alkanoyl, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl, (5- to 10-membered heterocycle)C_0-C_8alkyl and C_1-C_8alkylsulfonyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b. Within other embodiments, R_3 and R_4 are each independently selected from (i) hydrogen and (ii) C_1-C_8alkyl, C_2-C_8alkenyl, phenylC_0-C_4alkyl, indanylC_0-C_4alkyl, 5- to 6-membered heteroarylC_0-C_4alkyl and (4- to 7-membered heterocycloalkyl)C_0-C_4alkyl, each of which is substituted with from 0 to 4 substituents independently selected from hydroxy, halogen, amino, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy. Representative R_3 and R_4 groups include C_1-C_6alkyl, C_2-C_6alkenyl, (5- to 7-membered heterocycle)C_0-C_4alkyl, C_2-C_6alkyl ether, indanyl, benzyl, 1-phenyl-ethyl, 1-phenyl-propyl and 2-phenyl-ethyl, each of which is substituted with from 0 to 3 substituents independently selected from hydroxy, halogen and C_1-C_4alkyl. For example, at least one of R_3 and R_4 may be pyridylC_0-C_4alkyl, pyrimidylC_0-C_4alkyl, imidazolylC_0-C_4alkyl or tetrazolylC_0-C_4alkyl, each of which is substituted with 0, 1 or 2 substituents. Alternatively, R_3 and/or R_4 may be joined to an R_5 or R_6 group (along with the N to which R_3 and R_4 are bound and any carbon atoms between the N and R_5 or R_6) to form an optionally substituted heterocycle, such as a 5- to 10-membered mono- or bi-cyclic group.

Within other embodiments, R_3 and/or R_4 of Formula II form an optionally substituted heterocycle. For example, R_3 and R_4 may be joined to form, with the N to which they are bound, an optionally substituted heterocycle; or R_3 or R_4 may be joined to an R_5 or R_6 moiety to from an optionally substituted heterocycle. In either case, the resulting heterocycle may be, for example, a 4- or 5- to 10-membered, mono- or bi-cyclic group substituted with from 0 to 4 substituents (*e.g.*, from 1 to 4 substituents or 0, 1 or 2 substituents). In certain embodiments, each substituent is independently selected from hydroxy, halogen, C_1-C_4alkyl, C_1-C_4haloalkyl, C_1-C_4alkoxy, C_1-C_4haloalkoxy, C_1-C_4alkanoyl, C_1-C_4alkoxycarbonyl, aminocarbonyl, heterocycleC_0-C_8alkyl and heterocycleC_1-C_8alkoxycarbonyl. In certain embodiments, such substituents are lower alkyl groups such as methyl and/or ethyl.

A heterocyclic group that comprises R_3 and/or R_4 may be a heteroaryl group, which comprises an aromatic ring (*e.g.*, optionally substituted acridinyl, benzimidazolinyl, benzimidazolyl, benzotriazolyl, carbazolyl, cinnolinyl, indazolyl, indolinyl, indolyl, isoquinolinyl, quinoxalinyl, naphthyridinyl, phenanthridinyl, phenazinyl, phenothiazinyl, phenoxazinyl, phthalazinyl, pteridinyl, purinyl, quinolinyl, quinoxalinyl, quinazolinyl, tetrahydroisoquinolinyl or tetrahydroquinolinyl). One such heteroaryl is 3,4-dihydro-1H-isoquinolin-2-yl. Alternatively, the heterocycle may be an optionally substituted heterocycloalkyl group, such as azepanyl, azocinyl, decahydroquinolinyl, 1,4-dioxa-8-aza-spiro[4.5]dec-8-yl, imidazolidinyl, imidazolinyl, morpholino, piperadinyl, piperazinyl, pyridazinyl, pyrazolidinyl, pyrazolinyl, pyrrolidinyl, pyrrolinyl, thiomorpholino or 1,1-dioxo-thiomorpholin-4-yl. Representative heterocycles that may be formed from R_3 and R_4 include, but are not limited to, optionally substituted azepane, azocane, dihydroisoquinoline, imidazole, morpholine, octahydroquinoline, piperazine, piperidine and pyrrolidine. Representative heterocycles that may be formed from R_3 or R_4, in combination with an R_5 or R_6, include (but are not limited to) optionally substituted piperadine and pyrrolidine.

R_7, in certain embodiments, is: (i) hydrogen or (ii) C_1-C_8alkyl (*e.g.*, C_4-C_7cycloalkyl), C_2-C_8alkenyl, C_2-C_8alkynyl, C_3-C_8alkanone, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl or (5- to 10-membered heterocycle)C_0-C_8alkyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b. Within other embodiments, R_7 is (i) hydrogen or (ii) C_1-C_6alkyl, C_2-C_6alkyl ether, phenylC_0-C_4alkyl, (5- to 6-membered heteroaryl)C_0-C_4alkyl or (4- to 7-membered heterocycloalkyl)C_0-C_4alkyl, each of which is substituted with from 0 to 4 substituents independently selected from hydroxy, halogen, amino, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy. Representative R_7 groups include hydrogen, C_1-C_4alkyl, C_1-C_4alkyl ether and benzyl, each of which is substituted with from 0 to 3 substituents independently selected from hydroxy, halogen and C_1-C_4alkyl. Alternatively, R_7 may be joined to an R_5 or R_6 group (along with the O to which R_7 is bound and any carbon atoms between the O and R_5 or R_6) to form an optionally substituted heterocycle, such as a 5- to 10-membered mono- or bi-cyclic group. The resulting heterocycle may, for example, be substituted with from 0 to 4 (*e.g.*, 0, 1 or 2) substituents independently chosen from hydroxy, halogen, C_1-C_4alkyl, C_1-C_4haloalkyl, C_1-C_4alkoxy, C_1-C_4haloalkoxy, C_1-C_4alkanoyl, C_1-C_4alkoxycarbonyl, aminocarbonyl, heterocycleC_0-C_8alkyl and heterocycleC_1-C_8alkoxycarbonyl.

R_5 and R_6, within certain embodiments, are independently (at each occurrence) hydrogen or optionally substituted C_1-C_6alkyl; in addition, or alternatively, any R_5 or R_6 may be joined with any other R_5 or R_6 to form an optionally substituted 5- to 7-membered cycloalkyl, or (as discussed above) joined with R_3 or R_4 to form an optionally substituted heterocycle. In certain such embodiments, each R_5 and R_6 is hydrogen. n may be 1, 2 or 3, with 1 preferred in certain embodiments.

Within certain compounds, U is R_2 and R_2 is C_1-C_6alkyl, C_2-C_6alkyl ether, mono- or di-(C_1-C_6alkyl)amino, morpholino, benzyloxymethyl, piperazinyl, piperidinyl, phenyl or pyridyl, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl and C_1-C_6haloalkyl.

In certain embodiments, R_2 in Formula I is hydrogen, amino, hydroxy, halogen, or optionally substituted $-(CH_2)_nNH_2$, $-(CH_2)_nNH(C_1\text{-}C_8\text{alkyl})$, $-(CH_2)_nN(C_1\text{-}C_8\text{alkyl})_2$, $-(CH_2)_n$(4- to 8-membered heterocycloalkyl) or $-(CH_2)_nOH$. Optionally substituted groups include, for example, groups substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl, and C_1-C_6haloalkyl. Heterocycloalkyl groups include those in which the heterocycloalkyl comprises a nitrogen or oxygen atom directly linked to the $-(CH_2)_n$.

Representative compounds provided herein include, but are not limited to, those specifically described in Examples 1-3. It will be apparent that the specific compounds recited herein are representative only, and are not intended to limit the scope of the present invention. Further, as noted above, all compounds of the present invention may be present as a free acid or base or as a pharmaceutically acceptable salt.

Within certain aspects of the present invention, substituted bicyclic quinazolin-4-ylamine derivatives provided herein detectably alter (modulate) VR1 activity, as determined using an *in vitro* VR1 functional assay such as a calcium mobilization assay, dorsal root ganglion assay or *in vivo* pain relief assay. As an initial screen for such activity, a VR1 ligand binding assay may be used. References herein to a "VR1 ligand binding assay" are intended to refer to a standard *in vitro* receptor binding assay such as that provided in Example 5, and a "calcium mobilization assay" (also referred to herein as a "signal transduction assay") may be performed as described in Example 6. Briefly, to assess binding to VR1, a competition assay may be performed in which a VR1 preparation is incubated with labeled (*e.g.*, ^{125}I or ^{3}H) compound that binds to VR1 (*e.g.*, a capsaicin receptor agonist such as RTX) and unlabeled test compound. Within the assays provided herein, the VR1 used is preferably mammalian VR1, more preferably human or rat VR1. The receptor may be recombinantly expressed or naturally expressed. The VR1 preparation may be, for example, a membrane preparation from HEK293 or CHO cells that recombinantly express human VR1. Incubation with a compound that detectably modulates vanilloid ligand binding to VR1 results in a decrease or increase in the amount of label bound to the VR1 preparation, relative to the amount of label bound in the absence of the compound. This decrease or increase may be used to determine the K_i at VR1 as described herein. In general, compounds that decrease the amount of label bound to the VR1 preparation within such an assay are preferred.

As noted above, compounds that are VR1 antagonists are preferred within certain embodiments. IC_{50} values for such compounds may be determined using a standard *in vitro* VR1-mediated calcium mobilization assay, as provided in Example 6. Briefly, cells expressing capsaicin receptor are contacted with a compound of interest and with an indicator of intracellular calcium concentration (*e.g.*, a membrane permeable calcium sensitivity dye such as Fluo-3 or Fura-2 (both of which are available, for example, from Molecular Probes, Eugene, OR), each of which produce a fluorescent signal when bound to Ca^{++}). Such contact is preferably carried out by one or more incubations of the cells in buffer or culture medium comprising either or both of the compound and the indicator in solution. Contact is maintained for an amount of time sufficient to allow the dye to enter the cells (*e.g.*, 1-2 hours). Cells are washed or filtered to remove excess dye and are then contacted with a vanilloid receptor agonist (*e.g.*, capsaicin, RTX or olvanil), typically at a concentration equal to the EC_{50} concentration, and a fluorescence response is measured. When agonist-contacted cells are contacted with a compound that is a VR1 antagonist the fluorescence response is generally reduced by at least 20%, preferably at least 50% and more preferably at least 80%, as compared to cells that are contacted with the agonist in the absence of test compound. The IC_{50} for VR1 antagonists provided herein is preferably less than 1 micromolar, less than 100 nM, less than 10 nM or less than 1 nM.

In other embodiments, compounds that are capsaicin receptor agonists are preferred. Capsaicin receptor agonist activity may generally be determined as described in Example 6. When cells are contacted with 1 micromolar of a compound that is a VR1 agonist, the fluorescence response is generally increased by an amount that is at least 30% of the increase observed when cells are contacted with 100 nM capsaicin. The EC_{50} for VR1 agonists provided herein is preferably less than 1 micromolar, less than 100 nM or less than 10 nM.

VR1 modulating activity may also, or alternatively, be assessed using a cultured dorsal root ganglion assay as provided in Example 9 and/or an *in vivo* pain relief assay as provided in Example 10. Compounds provided herein preferably have a statistically significant specific effect on VR1 activity within one or more functional assays provided herein.

Within certain embodiments, VR1 modulators provided herein do not substantially modulate ligand binding to other cell surface receptors, such as EGF receptor tyrosine kinase or the nicotinic acetylcholine receptor. In other words, such modulators do not substantially inhibit activity of a cell surface receptor such as the human epidermal growth factor (EGF) receptor tyrosine kinase or the nicotinic acetylcholine receptor (*e.g.*, the IC_{50} or IC_{40} at such a receptor is preferably greater than 1 micromolar, and most preferably greater than 10 micromolar). Preferably, a modulator does not detectably inhibit EGF receptor activity or nicotinic acetylcholine receptor activity at a concentration of 0.5 micromolar, 1 micromolar or more preferably 10 micromolar. Assays for determining cell surface receptor activity are commercially available, and include the tyrosine kinase assay kits available from Panvera (Madison, WI).

Preferred compounds provided herein are non-sedating. In other words, a dose of compound that is twice the minimum dose sufficient to provide analgesia in an animal model for determining pain relief (such as a model provided in Example 10, herein) causes only transient (*i.e.*, lasting for no more than ½ the time that pain relief lasts) or preferably no statistically significant sedation in an animal model assay of sedation (using the method described by Fitzgerald et al. (1988) *Toxicology* 49(2-3):433-9). Preferably, a dose that is five times the minimum dose sufficient to provide analgesia does not produce statistically significant sedation. More preferably, a compound provided herein does not produce sedation at intravenous doses of less than 25 mg/kg (preferably less than 10 mg/kg) or at oral doses of less than 140 mg/kg (preferably less than 50 mg/kg, more preferably less than 30 mg/kg).

If desired, VR1 modulators provided herein may be evaluated for certain pharmacological properties including, but not limited to, oral bioavailability (preferred compounds are orally bioavailable to an extent allowing for therapeutically effective concentrations of the compound to be achieved at oral doses of less than 140 mg/kg, preferably less than 50 mg/kg, more preferably less than 30 mg/kg, even more preferably less than 10 mg/kg, still more preferably less than 1 mg/kg and most preferably less than 0.1 mg/kg), toxicity (a preferred VR1 modulator is nontoxic when a therapeutically effective amount is administered to a subject), side effects (a preferred VR1 modulator produces side effects comparable to placebo when a therapeutically effective amount of the compound is administered to a subject), serum protein binding and *in vitro* and *in vivo* half-life (a preferred VR1 modulator exhibits an *in vivo* half-life allowing for Q.I.D. dosing, preferably T.I.D. dosing, more preferably B.I.D. dosing, and most preferably once-a-day dosing). In addition, differential penetration of the blood brain barrier may be desirable for VR1 modulators used to treat pain by modulating CNS VR1 activity such that total daily oral doses as described above provide such modulation to a therapeutically effective extent, while low brain levels of VR1 modulators used to treat peripheral nerve mediated pain may be preferred (*i.e.*, such doses do not provide brain (*e.g.*, CSF) levels of the compound sufficient to significantly modulate VR1 activity). Routine assays that are well known in the art may be used to assess these properties, and identify superior compounds for a particular use. For example, assays used to predict bioavailability include transport across human intestinal cell monolayers, including Caco-2 cell monolayers. Penetration of the blood brain barrier of a compound in humans may be predicted from the brain levels of the compound in laboratory animals given the compound (*e.g.*, intravenously). Serum protein binding may be predicted from albumin binding assays. Compound half-life is inversely proportional to the frequency of dosage of a compound. *In vitro* half-lives of compounds may be predicted from assays of microsomal half-life as described within Example 7, herein.

As noted above, preferred compounds provided herein are nontoxic. In general, the term "nontoxic" as used herein shall be understood in a relative sense and is intended to refer to any substance that has been approved by the United States Food and Drug Administration

("FDA") for administration to mammals (preferably humans) or, in keeping with established criteria, is susceptible to approval by the FDA for administration to mammals (preferably humans). In addition, a highly preferred nontoxic compound generally satisfies one or more of the following criteria: (1) does not substantially inhibit cellular ATP production; (2) does not significantly prolong heart QT intervals; (3) does not cause substantial liver enlargement, or (4) does not cause substantial release of liver enzymes.

As used herein, a compound that does not substantially inhibit cellular ATP production is a compound that satisfies the criteria set forth in Example 8, herein. In other words, cells treated as described in Example 8 with 100 µM of such a compound exhibit ATP levels that are at least 50% of the ATP levels detected in untreated cells. In more highly preferred embodiments, such cells exhibit ATP levels that are at least 80% of the ATP levels detected in untreated cells.

A compound that does not significantly prolong heart QT intervals is a compound that does not result in a statistically significant prolongation of heart QT intervals (as determined by electrocardiography) in guinea pigs, minipigs or dogs upon administration of a dose that yields a serum concentration equal to the EC_{50} or IC_{50} for the compound. In certain preferred embodiments, a dose of 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 40 or 50 mg/kg administered parenterally or orally does not result in a statistically significant prolongation of heart QT intervals. By "statistically significant" is meant results varying from control at the $p<0.1$ level or more preferably at the $p<0.05$ level of significance as measured using a standard parametric assay of statistical significance such as a student's T test.

A compound does not cause substantial liver enlargement if daily treatment of laboratory rodents (*e.g.,* mice or rats) for 5-10 days with a dose that yields a serum concentration equal to the EC_{50} or IC_{50} for the compound results in an increase in liver to body weight ratio that is no more than 100% over matched controls. In more highly preferred embodiments, such doses do not cause liver enlargement of more than 75% or 50% over matched controls. If non-rodent mammals (*e.g.,* dogs) are used, such doses should not result in an increase of liver to body weight ratio of more than 50%, preferably not more than 25%, and more preferably not more than 10% over matched untreated controls. Preferred doses within such assays include 0.01, 0.05. 0.1, 0.5, 1, 5, 10, 40 or 50 mg/kg administered parenterally or orally.

Similarly, a compound does not promote substantial release of liver enzymes if administration of twice the minimum dose that yields a serum concentration equal to the EC_{50} or IC_{50} for the compound does not elevate serum levels of ALT, LDH or AST in laboratory rodents by more than 100% over matched mock-treated controls. In more highly preferred embodiments, such doses do not elevate such serum levels by more than 75% or 50% over matched controls. Alternatively, a VR1 modulator does not promote substantial release of liver enzymes if, in an *in vitro* hepatocyte assay, concentrations (in culture media or other such solutions that are contacted and incubated with hepatocytes *in vitro*) that are equal to the EC_{50} or IC_{50} for the compound do not cause detectable release of any of such liver enzymes into culture medium above baseline levels seen in media from matched mock-treated control cells. In more highly preferred embodiments, there is no detectable release of any of such liver enzymes into culture medium above baseline levels when such compound concentrations are five-fold, and preferably ten-fold the EC_{50} or IC_{50} for the compound.

In other embodiments, certain preferred compounds do not inhibit or induce microsomal cytochrome P450 enzyme activities, such as CYP1A2 activity, CYP2A6 activity, CYP2C9 activity, CYP2C19 activity, CYP2D6 activity, CYP2E1 activity or CYP3A4 activity at a concentration equal to the EC_{50} or IC_{50} for the compound.

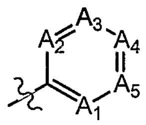
Certain preferred compounds are not clastogenic (*e.g.*, as determined using a mouse erythrocyte precursor cell micronucleus assay, an Ames micronucleus assay, a spiral micronucleus assay or the like) at a concentration equal the EC_{50} or IC_{50} for the compound. In other embodiments, certain preferred VR1 modulators do not induce sister chromatid exchange (*e.g.*, in Chinese hamster ovary cells) at such concentrations.

For detection purposes, as discussed in more detail below, VR1 modulators provided herein may be isotopically-labeled or radiolabeled. For example, compounds recited in Formulas I-III may have one or more atoms replaced by an atom of the same element having an atomic mass or mass number different from the atomic mass or mass number usually found in nature. Examples of isotopes that can be present in the compounds provided herein include isotopes of hydrogen, carbon, nitrogen, oxygen, phosphorous, fluorine and chlorine, such as ^{2}H, ^{3}H, ^{11}C, ^{13}C, ^{14}C, ^{15}N, ^{18}O, ^{17}O, ^{31}P, ^{32}P, ^{35}S, ^{18}F and ^{36}Cl. In addition, substitution with heavy isotopes such as deuterium (*i.e.*, ^{2}H) can afford certain therapeutic advantages resulting from greater metabolic stability, for example increased in vivo half-life or reduced dosage requirements and, hence, may be preferred in some circumstances.

PREPARATION OF SUBSTITUTED BICYCLIC QUINAZOLIN-4-YLAMINE ANALOGUES

Substituted bicyclic quinazoline-4-ylamine derivatives may generally be prepared using standard synthetic methods. In general, starting materials are commercially available from suppliers such as Sigma-Aldrich Corp. (St. Louis, MO), or may be synthesized from commercially available precursors using established protocols. By way of example, a synthetic route similar to that shown in any of Schemes 1-5, along with Scheme 6) may be used, together with synthetic methods known in the art of synthetic organic chemistry, or variations thereon as appreciated by those skilled in the art. Each variable in the following Schemes, refers to any group consistent with the description of the compounds provided herein.

Synthetic methods illustrated in Schemes 1-5 may be used to prepare various bicyclic groups indicated by:



in Formula I. Using procedures known in the art (*see, e.g.,* PCT Application Publication No. WO 03/062209 at, for example, Schemes 1-5 (page 40-41) and Example 1 (pages 66-82), which are hereby incorporated by reference for their disclosure of methods of joining various amines to core aromatic groups), such bicyclic groups may be linked to the remainder of the compound to yield a bicyclic quinazolin-4-ylamine derivative of Formula I. One such procedure is illustrated in Scheme 6, herein.

In the Schemes that follow, "reduce" refers to the process of reducing a nitro functionality to an amino functionality. This transformation can be carried out in a number of ways well known to those skilled in the art of organic synthesis including, but not limited to, catalytic hydrogenation, reduction with $SnCl_2$, and reduction with titanium trichloride. For an overview of reduction methods see: Hudlicky, M. *Reductions in Organic Chemistry*, ACS Monograph 188: 1996.

"Deprotect," in the following schemes, refers to removal of a methyl or benzyl or other suitable protecting group from an amide or amino functionality. Similarly, "protect" refers tot he addition of such a group. An example of such a protecting group is the 4-methoxybenzyl group and "Deprotect" refers to a chemical method by which such a protecting group can be removed. For an overview of protection and deprotection methods as used by those skilled in the art of organic synthesis, see: Greene, T. and Wuts, P. *Protective Groups in Organic Synthesis*, 3rd ed., John Wiley and Sons: 1999.

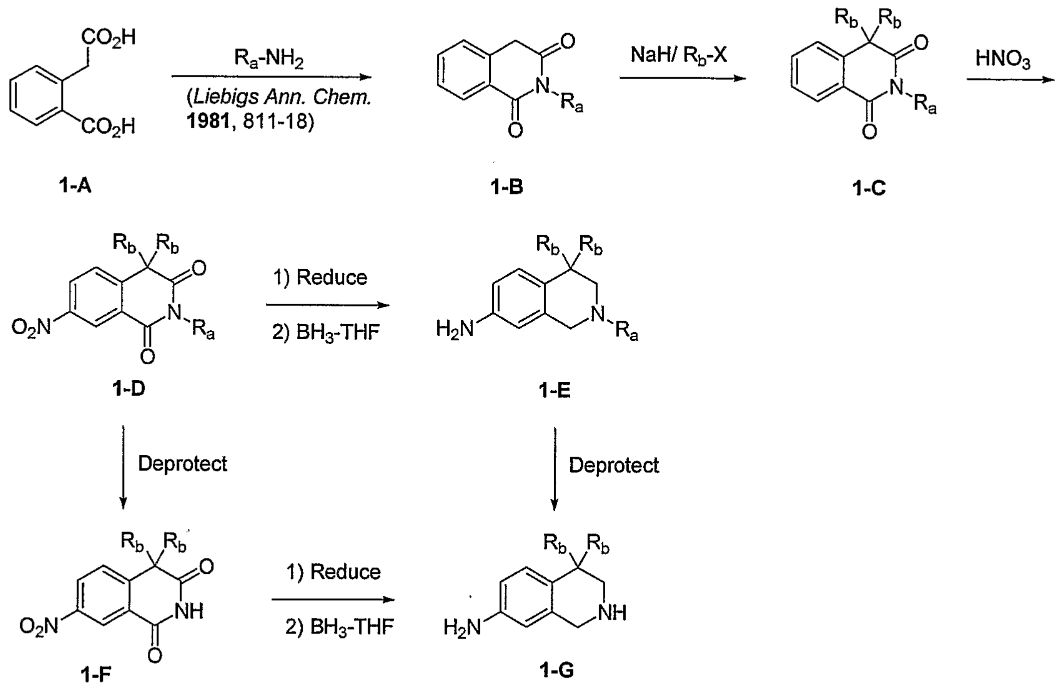
In the following Schemes, "Nucleophile" refers to primary and secondary amines as well as alkoxides.

Other definitions used in the following Schemes and in the Examples include:

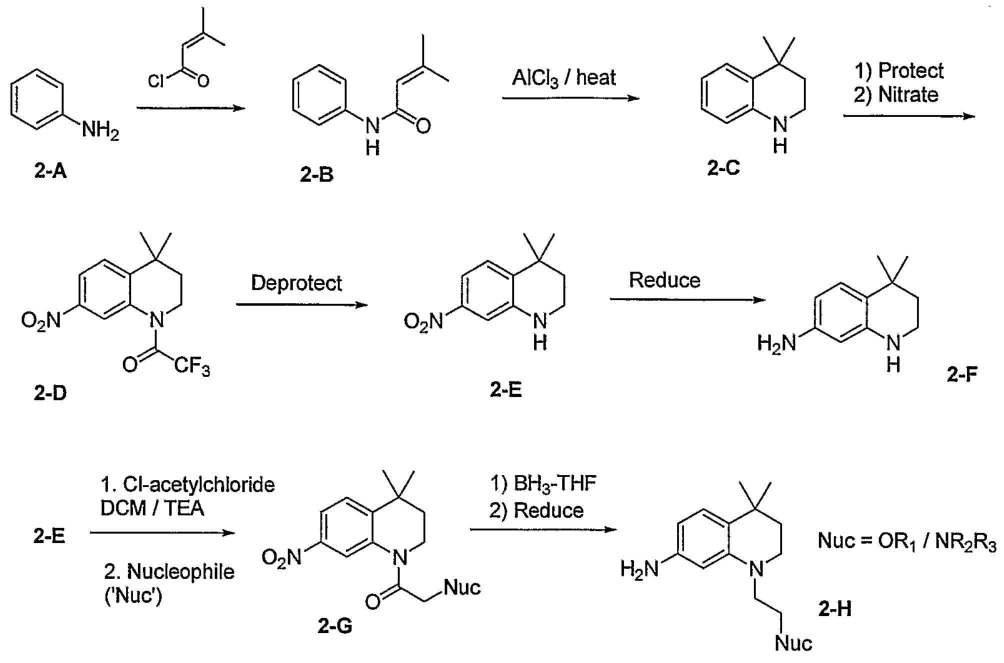
Ac	acetic (or acetate)

AcOH	acetic acid
DCM	dichloromethane
DMA	dimethylacetamide
DME	ethylene glycol dimethyl ether
EtOAc	ethyl acetate
IPA	isopropyl alcohol
$Pd(PPh_3)_4$	tetrakis(triphenylphosphine) palladium (0)
TEA	triethylamine
THF	tetrahydrofuran

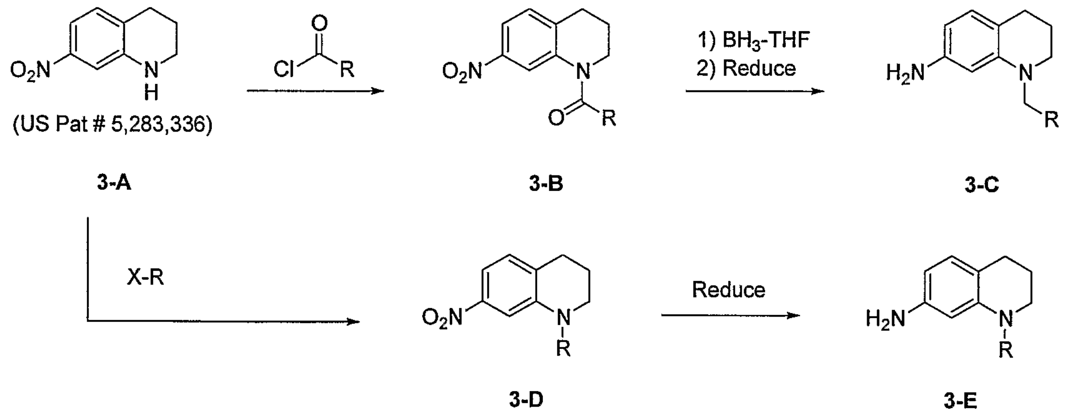
Scheme 1



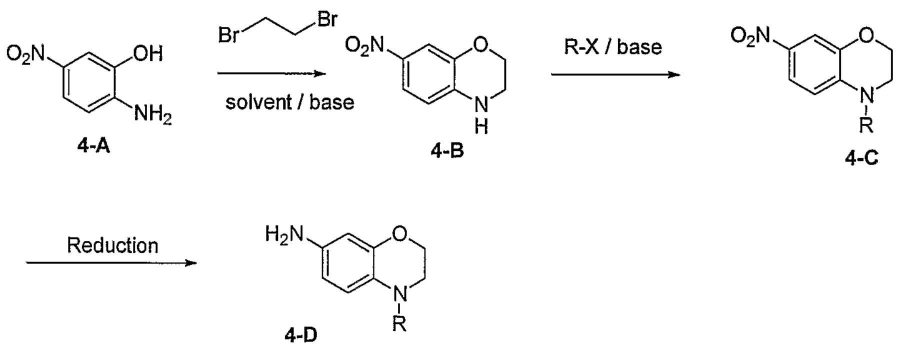
Scheme 2



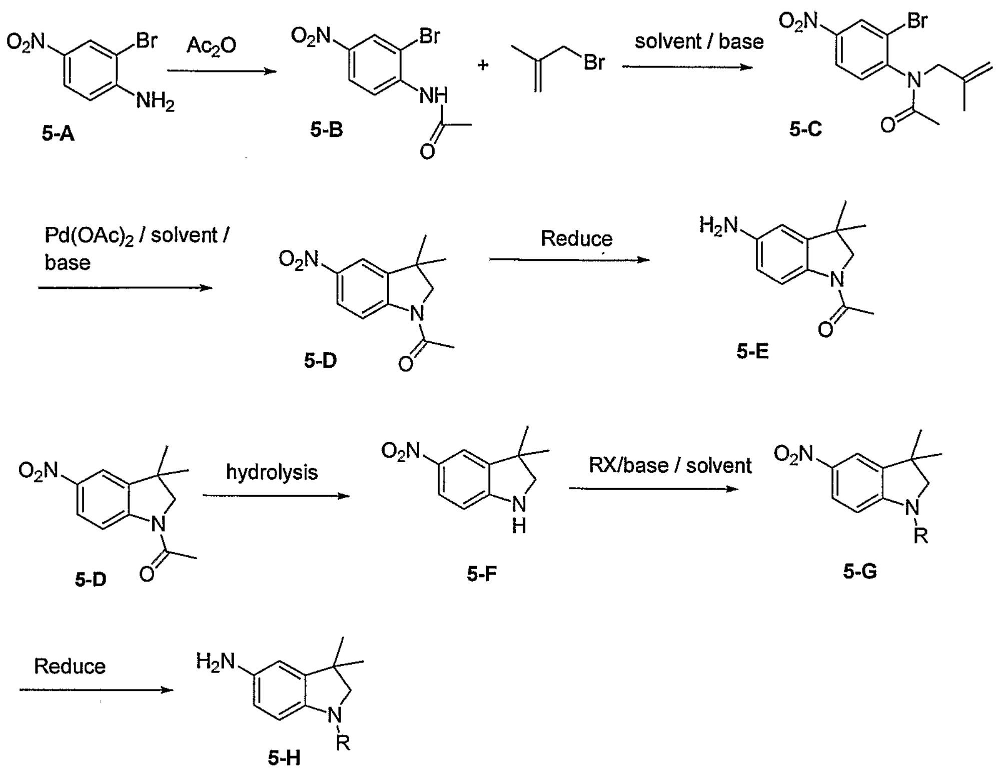
Scheme 3



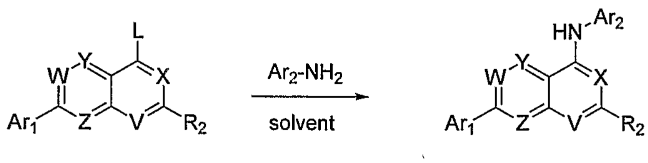
Scheme 4



Scheme 5



Scheme 6



L = Cl,Br,I,OSO_2CF_3

6-A 6-B

In certain embodiments, a compound provided herein may contain one or more asymmetric carbon atoms, so that the compound can exist in different stereoisomeric forms. Such forms can be, for example, racemates or optically active forms. As noted above, all stereoisomers are encompassed by the present invention. Nonetheless, it may be desirable to obtain single enantiomers (*i.e.*, optically active forms). Standard methods for preparing single enantiomers include asymmetric synthesis and resolution of the racemates. Resolution of the racemates can be accomplished, for example, by conventional methods such as crystallization in the presence of a resolving agent, or chromatography using, for example a chiral HPLC column.

Compounds may be radiolabeled by carrying out their synthesis using precursors comprising at least one atom that is a radioisotope. Each radioisotope is preferably carbon (*e.g.*, ^{14}C), hydrogen (*e.g.*, ^{3}H), sulfur (*e.g.*, ^{35}S) or iodine (*e.g.*, ^{125}I). Tritium labeled compounds may also be prepared catalytically via platinum-catalyzed exchange in tritiated acetic acid, acid-catalyzed exchange in tritiated trifluoroacetic acid, or heterogeneous-catalyzed exchange with tritium gas using the compound as substrate. In addition, certain precursors may be subjected to tritium-halogen exchange with tritium gas, tritium gas reduction of unsaturated bonds, or reduction using sodium borotritide, as appropriate. Preparation of radiolabeled compounds may be conveniently performed by a radioisotope supplier specializing in custom synthesis of radiolabeled probe compounds.

PHARMACEUTICAL COMPOSITIONS

The present invention also provides pharmaceutical compositions comprising one or more substituted bicyclic quinazolin-4-ylamine analogues, together with at least one physiologically acceptable carrier or excipient. Pharmaceutical compositions may comprise, for example, one or more of water, buffers (*e.g.*, neutral buffered saline or phosphate buffered saline), ethanol, mineral oil, vegetable oil, dimethylsulfoxide, carbohydrates (*e.g.*, glucose, mannose, sucrose or dextrans), mannitol, proteins, adjuvants, polypeptides or amino acids such as glycine, antioxidants, chelating agents such as EDTA or glutathione and/or preservatives. In addition, other active ingredients may (but need not) be included in the pharmaceutical compositions provided herein.

Pharmaceutical compositions may be formulated for any appropriate manner of administration, including, for example, topical, oral, nasal, rectal or parenteral administration. The term parenteral as used herein includes subcutaneous, intradermal, intravascular (*e.g.*, intravenous), intramuscular, spinal, intracranial, intrathecal and intraperitoneal injection, as well as any similar injection or infusion technique. In certain embodiments, compositions suitable for oral use are preferred. Such compositions include, for example, tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsion, hard or soft capsules, or syrups or elixirs. Within yet other embodiments, compositions of the present invention may be formulated as a lyophilizate. Formulation for topical administration may be preferred for certain conditions (*e.g.*, in the treatment of skin conditions such as burns or itch). Formulation for direct administration into the bladder (intravesicular administration) may be preferred for treatment of urinary incontinence and overactive bladder.

Compositions intended for oral use may further comprise one or more components such as sweetening agents, flavoring agents, coloring agents and/or preserving agents in order to provide appealing and palatable preparations. Tablets contain the active ingredient in admixture with physiologically acceptable excipients that are suitable for the manufacture of tablets. Such excipients include, for example, inert diluents (*e.g.*, calcium carbonate, sodium carbonate, lactose, calcium phosphate or sodium phosphate), granulating and disintegrating agents (*e.g.*, corn starch or alginic acid), binding agents (*e.g.*, starch, gelatin or acacia) and lubricating agents (*e.g.*, magnesium stearate, stearic acid or talc). The tablets may be uncoated or they may be coated by known techniques to delay disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monosterate or glyceryl distearate may be employed.

Formulations for oral use may also be presented as hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent (*e.g.*, calcium carbonate, calcium phosphate or kaolin), or as soft gelatin capsules wherein the active ingredient is mixed with water or an oil medium (*e.g.*, peanut oil, liquid paraffin or olive oil).

Aqueous suspensions contain the active material(s) in admixture with excipients suitable for the manufacture of aqueous suspensions. Such excipients include suspending agents (*e.g.*, sodium carboxymethylcellulose, methylcellulose, hydropropylmethylcellulose, sodium alginate, polyvinylpyrrolidone, gum tragacanth and gum acacia); and dispersing or wetting agents (*e.g.*, naturally-occurring phosphatides such as lecithin, condensation products of an alkylene oxide with fatty acids such as polyoxyethylene stearate, condensation products of ethylene oxide with long chain aliphatic alcohols such as heptadecaethyleneoxycetanol, condensation products of ethylene oxide with partial esters derived from fatty acids and a hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with partial esters derived from fatty acids and hexitol anhydrides such as polyethylene sorbitan monooleate). Aqueous suspensions may also comprise one or more preservatives, such as ethyl or n-propyl p-hydroxybenzoate, one or more coloring agents, one or more flavoring agents, and one or more sweetening agents, such as sucrose or saccharin.

Oily suspensions may be formulated by suspending the active ingredient(s) in a vegetable oil (*e.g.*, arachis oil, olive oil, sesame oil or coconut oil) or in a mineral oil such as liquid paraffin. The oily suspensions may contain a thickening agent such as beeswax, hard paraffin or cetyl alcohol. Sweetening agents such as those set forth above, and/or flavoring agents may be added to provide palatable oral preparations. Such suspensions may be preserved by the addition of an anti-oxidant such as ascorbic acid.

Dispersible powders and granules suitable for preparation of an aqueous suspension by the addition of water provide the active ingredient in admixture with a dispersing or wetting agent, suspending agent and one or more preservatives. Suitable dispersing or wetting agents and suspending agents are exemplified by those already mentioned above. Additional excipients, such as sweetening, flavoring and coloring agents, may also be present.

Pharmaceutical compositions may also be formulated as oil-in-water emulsions. The oily phase may be a vegetable oil (*e.g.*, olive oil or arachis oil), a mineral oil (*e.g.*, liquid paraffin) or a mixture thereof. Suitable emulsifying agents include naturally-occurring gums (*e.g.*, gum acacia or gum tragacanth), naturally-occurring phosphatides (*e.g.*, soy bean lecithin, and esters or partial esters derived from fatty acids and hexitol), anhydrides (*e.g.*, sorbitan monoleate) and condensation products of partial esters derived from fatty acids and hexitol with ethylene oxide (*e.g.*, polyoxyethylene sorbitan monoleate). An emulsion may also comprise one or more sweetening and/or flavoring agents.

Syrups and elixirs may be formulated with sweetening agents, such as glycerol, propylene glycol, sorbitol or sucrose. Such formulations may also comprise one or more demulcents, preservatives, flavoring agents and/or coloring agents.

Formulations for topical administration typically comprise a topical vehicle combined with active agent(s), with or without additional optional components. Suitable topical vehicles and additional components are well known in the art, and it will be apparent that the choice of a vehicle will depend on the particular physical form and mode of delivery. Topical vehicles include water; organic solvents such as alcohols (*e.g.*, ethanol or isopropyl alcohol) or glycerin; glycols (*e.g.*, butylene, isoprene or propylene glycol); aliphatic alcohols (*e.g.*, lanolin); mixtures of water and organic solvents and mixtures of organic solvents such as alcohol and glycerin; lipid-based materials such as fatty acids, acylglycerols (including oils, such as mineral oil, and fats of natural or synthetic origin), phosphoglycerides, sphingolipids and waxes; protein-based materials such as collagen and gelatin; silicone-based materials (both non-volatile and volatile); and hydrocarbon-based materials such as microsponges and polymer matrices. A composition may further include one or more components adapted to improve the stability or effectiveness of the applied formulation, such as stabilizing agents, suspending agents, emulsifying agents, viscosity adjusters, gelling agents, preservatives, antioxidants, skin penetration enhancers, moisturizers and sustained release materials. Examples of such components are described in Martindale--The Extra Pharmacopoeia (Pharmaceutical Press, London 1993) and Martin (ed.), Remington's Pharmaceutical Sciences. Formulations may comprise microcapsules, such as hydroxymethylcellulose or gelatin-microcapsules, liposomes, albumin microspheres, microemulsions, nanoparticles or nanocapsules.

A topical formulation may be prepared in a variety of physical forms including, for example, solids, pastes, creams, foams, lotions, gels, powders, aqueous liquids and emulsions. The physical appearance and viscosity of such forms can be governed by the presence and amount of emulsifier(s) and viscosity adjuster(s) present in the formulation. Solids are generally firm and non-pourable and commonly are formulated as bars or sticks, or in particulate form; solids can be opaque or transparent, and optionally can contain solvents, emulsifiers, moisturizers, emollients, fragrances, dyes/colorants, preservatives and other active ingredients that increase or enhance the efficacy of the final product. Creams and lotions are often similar to one another, differing mainly in their viscosity; both lotions and creams may be opaque, translucent or clear and often contain emulsifiers, solvents, and viscosity adjusting agents, as well as moisturizers, emollients, fragrances, dyes/colorants, preservatives and other active ingredients that increase or enhance the efficacy of the final product. Gels can be prepared with a range of viscosities, from thick or high viscosity to thin or low viscosity. These formulations, like those of lotions and creams, may also contain solvents, emulsifiers, moisturizers, emollients, fragrances, dyes/colorants, preservatives and other active ingredients that increase or enhance the efficacy of the final product. Liquids are thinner than creams, lotions or gels, and often do not contain emulsifiers. Liquid topical products often contain solvents, emulsifiers, moisturizers, emollients, fragrances, dyes/colorants, preservatives and other active ingredients that increase or enhance the efficacy of the final product.

Suitable emulsifiers for use in topical formulations include, but are not limited to, ionic emulsifiers, cetearyl alcohol, non-ionic emulsifiers like polyoxyethylene oleyl ether, PEG-40 stearate, ceteareth-12, ceteareth-20, ceteareth-30, ceteareth alcohol, PEG-100 stearate and glyceryl stearate. Suitable viscosity adjusting agents include, but are not limited to, protective colloids or non-ionic gums such as hydroxyethylcellulose, xanthan gum, magnesium aluminum silicate, silica, microcrystalline wax, beeswax, paraffin, and cetyl palmitate. A gel composition may be formed by the addition of a gelling agent such as chitosan, methyl cellulose, ethyl cellulose, polyvinyl alcohol, polyquaterniums, hydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose, carbomer or ammoniated glycyrrhizinate. Suitable surfactants include, but are not limited to, nonionic, amphoteric, ionic and anionic surfactants. For example, one or more of dimethicone copolyol, polysorbate 20, polysorbate 40, polysorbate 60, polysorbate 80, lauramide DEA, cocamide DEA, and cocamide MEA, oleyl betaine, cocamidopropyl phosphatidyl PG-dimonium chloride, and ammonium laureth sulfate may be used within topical formulations. Suitable preservatives include, but are not limited to, antimicrobials such as methylparaben, propylparaben, sorbic acid, benzoic acid, and formaldehyde, as well as physical stabilizers and antioxidants such as vitamin E, sodium ascorbate/ascorbic acid and propyl gallate. Suitable moisturizers include, but are not limited to, lactic acid and other hydroxy acids and their salts, glycerin, propylene glycol, and butylene glycol. Suitable emollients include lanolin alcohol, lanolin, lanolin derivatives, cholesterol, petrolatum, isostearyl neopentanoate and mineral oils. Suitable fragrances and colors include, but are not limited to, FD&C Red No. 40 and FD&C Yellow No. 5. Other suitable additional ingredients that may be included a topical formulation include, but are not limited to, abrasives, absorbents, anti-caking agents, anti-foaming agents, anti-static agents, astringents (*e.g.*, witch hazel, alcohol and herbal extracts such as chamomile extract), binders/excipients, buffering agents, chelating agents, film forming agents, conditioning agents, propellants, opacifying agents, pH adjusters and protectants.

An example of a suitable topical vehicle for formulation of a gel is: hydroxypropylcellulose (2.1%); 70/30 isopropyl alcohol/water (90.9%); propylene glycol (5.1%); and Polysorbate 80 (1.9%). An example of a suitable topical vehicle for formulation as a foam is: cetyl alcohol (1.1%); stearyl alcohol (0.5%; Quaternium 52 (1.0%); propylene glycol (2.0%); Ethanol 95 PGF3 (61.05%); deionized water (30.05%); P75 hydrocarbon propellant (4.30%). All percents are by weight.

Typical modes of delivery for topical compositions include application using the fingers; application using a physical applicator such as a cloth, tissue, swab, stick or brush; spraying (including mist, aerosol or foam spraying); dropper application; sprinkling; soaking; and rinsing. Controlled release vehicles can also be used.

A pharmaceutical composition may be prepared as a sterile injectible aqueous or oleaginous suspension. The modulator, depending on the vehicle and concentration used, can either be suspended or dissolved in the vehicle. Such a composition may be formulated according to the known art using suitable dispersing, wetting agents and/or suspending agents such as those mentioned above. Among the acceptable vehicles and solvents that may be employed are water, 1,3-butanediol, Ringer's solution and isotonic sodium chloride solution.

In addition, sterile, fixed oils may be employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed, including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectible compositions, and adjuvants such as local anesthetics, preservatives and/or buffering agents can be dissolved in the vehicle.

Compounds may also be formulated as suppositories (*e.g.*, for rectal administration). Such compositions can be prepared by mixing the drug with a suitable non-irritating excipient that is solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum to release the drug. Suitable excipients include, for example, cocoa butter and polyethylene glycols.

Pharmaceutical compositions may be formulated as sustained release formulations (*i.e.*, a formulation such as a capsule that effects a slow release of modulator following administration). Such formulations may generally be prepared using well known technology and administered by, for example, oral, rectal or subcutaneous implantation, or by implantation at the desired target site. Carriers for use within such formulations are biocompatible, and may also be biodegradable; preferably the formulation provides a relatively constant level of modulator release. The amount of modulator contained within a sustained release formulation depends upon, for example, the site of implantation, the rate and expected duration of release and the nature of the condition to be treated or prevented.

In addition to or together with the above modes of administration, a modulator may be conveniently added to food or drinking water (*e.g.*, for administration to non-human animals including companion animals (such as dogs and cats) and livestock). Animal feed and drinking water compositions may be formulated so that the animal takes in an appropriate quantity of the composition along with its diet. It may also be convenient to present the composition as a premix for addition to feed or drinking water.

Modulators are generally administered in a therapeutically effective amount. Preferred systemic doses are no higher than 50 mg per kilogram of body weight per day (*e.g.*, ranging from about 0.001 mg to about 50 mg per kilogram of body weight per day), with oral doses generally being about 5-20 fold higher than intravenous doses (*e.g.*, ranging from 0.01 to 40 mg per kilogram of body weight per day).

The amount of active ingredient that may be combined with the carrier materials to produce a single dosage unit will vary depending, for example, upon the patient being treated and the particular mode of administration. Dosage units will generally contain between from about 10 μg to about 500 mg of an active ingredient. Optimal dosages may be established using routine testing, and procedures that are well known in the art.

Pharmaceutical compositions may be packaged for treating conditions responsive to VR1 modulation (*e.g.*, treatment of exposure to vanilloid ligand, pain, itch, obesity or urinary incontinence). Packaged pharmaceutical compositions may include a container holding a therapeutically effective amount of at least one VR1 modulator as described herein and instructions (*e.g.*, labeling) indicating that the contained composition is to be used for treating a condition responsive to VR1 modulation in the patient.

METHODS OF USE

VR1 modulators provided herein may be used to alter activity and/or activation of capsaicin receptors in a variety of contexts, both *in vitro* and *in vivo*. Within certain aspects, VR1 antagonists may be used to inhibit the binding of vanilloid ligand agonist (such as capsaicin and/or RTX) to capsaicin receptor *in vitro* or *in vivo*. In general, such methods comprise the step of contacting a capsaicin receptor with one or more VR1 modulators provided herein, in the presence of vanilloid ligand in aqueous solution and under conditions otherwise suitable for binding of the ligand to capsaicin receptor. The VR1 modulator(s) are generally present at a concentration that is sufficient to alter the binding of vanilloid ligand to VR1 *in vitro* (using the assay provided in Example 5) and/or VR1-mediated signal transduction (using an assay provided in Example 6). The capsaicin receptor may be present in solution or suspension (*e.g.*, in an isolated membrane or cell preparation), or in a cultured or isolated cell. Within certain embodiments, the capsaicin receptor is expressed by a neuronal cell present in a patient, and the aqueous solution is a body fluid. Preferably, one or more VR1 modulators are administered to an animal in an amount such that the VR1 modulator is present in at least one body fluid of the animal at a therapeutically effective concentration that is 1 micromolar or less; preferably 500 nanomolar or less; more preferably 100 nanomolar or less, 50 nanomolar or less, 20 nanomolar or less, or 10 nanomolar or less. For example, such compounds may be administered at a dose that is less than 20 mg/kg body weight, preferably less than 5 mg/kg and, in some instances, less than 1 mg/kg.

Also provided herein are methods for modulating, preferably reducing, the signal-transducing activity (*i.e.*, the calcium conductance) of a cellular capsaicin receptor. Such modulation may be achieved by contacting a capsaicin receptor (either *in vitro* or *in vivo*) with one or more VR1 modulators provided herein under conditions suitable for binding of the modulator(s) to the receptor. The VR1 modulator(s) are generally present at a concentration that is sufficient to alter the binding of vanilloid ligand to VR1 *in vitro* and/or VR1-mediated signal transduction as described herein. The receptor may be present in solution or suspension, in a cultured or isolated cell preparation or in a cell within a patient. For example, the cell may be a neuronal cell that is contacted *in vivo* in an animal. Alternatively, the cell may be an epithelial cell, such as a urinary bladder epithelial cell (urothelial cell) or an airway epithelial cell that is contacted *in vivo* in an animal. Modulation of signal tranducing activity may be assessed by detecting an effect on calcium ion conductance (also referred to as calcium mobilization or flux). Modulation of signal transducing activity may alternatively be assessed by detecting an alteration of a symptom (*e.g.*, pain, burning sensation, broncho-constriction, inflammation, cough, hiccup, itch, urinary incontinence or overactive bladder) of a patient being treated with one or more VR1 modulators provided herein.

VR1 modulator(s) provided herein are preferably administered to a patient (*e.g.*, a human) orally or topically, and are present within at least one body fluid of the animal while modulating VR1 signal-transducing activity. Preferred VR1 modulators for use in such methods modulate VR1 signal-transducing activity *in vitro* at a concentration of 1 nanomolar or less, preferably 100 picomolar or less, more preferably 20 picomolar or less, and *in vivo* at a concentration of 1 micromolar or less, 500 nanomolar or less, or 100 nanomolar or less in a body fluid such as blood.

The present invention further provides methods for treating conditions responsive to VR1 modulation. Within the context of the present invention, the term "treatment" encompasses both disease-modifying treatment and symptomatic treatment, either of which may be prophylactic (*i.e.*, before the onset of symptoms, in order to prevent, delay or reduce the severity of symptoms) or therapeutic (*i.e.*, after the onset of symptoms, in order to reduce the severity and/or duration of symptoms). A condition is "responsive to VR1 modulation" if it is characterized by inappropriate activity of a capsaicin receptor, regardless of the amount of vanilloid ligand present locally, and/or if modulation of capsaicin receptor activity results in alleviation of the condition or a symptom thereof. Such conditions include, for example, symptoms resulting from exposure to VR1-activating stimuli, pain, respiratory disorders such as asthma and chronic obstructive pulmonary disease, itch, urinary incontinence, overactive bladder, cough, hiccup, and obesity, as described in more detail below. Such conditions may be diagnosed and monitored using criteria that have been established in the art. Patients may include humans, domesticated companion animals and livestock, with dosages as described above.

Treatment regimens may vary depending on the compound used and the particular condition to be treated. However, for treatment of most disorders, a frequency of administration of 4 times daily or less is preferred. In general, a dosage regimen of 2 times daily is more preferred, with once a day dosing particularly preferred. For the treatment of acute pain, a single dose that rapidly reaches effective concentrations is desirable. It will be understood, however, that the specific dose level and treatment regimen for any particular patient will depend upon a variety of factors including the activity of the specific compound employed, the age, body weight, general health, sex, diet, time of administration, route of administration, and rate of excretion, drug combination and the severity of the particular disease undergoing therapy. In general, the use of the minimum dose sufficient to provide effective therapy is preferred. Patients may generally be monitored for therapeutic effectiveness using medical or veterinary criteria suitable for the condition being treated or prevented.

Patients experiencing symptoms resulting from exposure to capsaicin receptor-activating stimuli include individuals with burns caused by heat, light, tear gas or acid and those whose mucous membranes are exposed (*e.g.*, via ingestion, inhalation or eye contact) to capsaicin (*e.g.*, from hot peppers or in pepper spray) or a related irritant such as acid, tear gas or air pollutants. The resulting symptoms (which may be treated using VR1 modulators, especially antagonists, provided herein) may include, for example, pain, broncho-constriction and inflammation.

Pain that may be treated using the VR1 modulators provided herein may be chronic or acute and includes, but is not limited to, peripheral nerve-mediated pain (especially neuropathic pain). Compounds provided herein may be used in the treatment of, for example, postmastectomy pain syndrome, stump pain, phantom limb pain, oral neuropathic pain, toothache (dental pain), denture pain, postherpetic neuralgia, diabetic neuropathy, reflex sympathetic dystrophy, trigeminal neuralgia, osteoarthritis, rheumatoid arthritis, fibromyalgia, Guillain-Barre syndrome, meralgia paresthetica, burning-mouth syndrome and/or bilateral peripheral neuropathy. Additional neuropathic pain conditions include causalgia (reflex sympathetic dystrophy - RSD, secondary to injury of a peripheral nerve), neuritis (including, for example, sciatic neuritis, peripheral neuritis, polyneuritis, optic neuritis, postfebrile neuritis, migrating neuritis, segmental neuritis and Gombault's neuritis), neuronitis, neuralgias (*e.g.*, those mentioned above, cervicobrachial neuralgia, cranial neuralgia, geniculate neuralgia, glossopharyngial neuralgia, migranous neuralgia, idiopathic neuralgia, intercostals neuralgia, mammary neuralgia, mandibular joint neuralgia, Morton's neuralgia, nasociliary neuralgia, occipital neuralgia, red neuralgia, Sluder's neuralgia, splenopalatine neuralgia, supraorbital neuralgia and vidian neuralgia), surgery-related pain, musculoskeletal pain, AIDS-related neuropathy, MS-related neuropathy, and spinal cord injury-related pain. Headache, including headaches involving peripheral nerve activity, such as sinus, cluster (*i.e.*, migranous neuralgia) and some tension headaches and migraine, may also be treated as described herein. For example, migraine headaches may be prevented by administration of a compound provided herein as soon as a pre-migrainous aura is experienced by the patient. Further pain conditions that can be treated as described herein include "burning mouth syndrome," labor pains, Charcot's pains, intestinal gas pains, menstrual pain, acute and chronic back pain (*e.g.*, lower back pain), hemorrhoidal pain, dyspeptic pains, angina, nerve root pain, homotopic pain and heterotopic pain – including cancer associated pain (*e.g.*, in patients with bone cancer), pain (and inflammation) associated with venom exposure (*e.g.*, due to snake bite, spider bite or insect sting) and trauma associated pain (*e.g.*, post-surgical pain, pain from cuts, bruises and broken bones, and burn pain). Additional pain conditions that may be treated as described herein include pain associated with inflammatory bowel disease, irritable bowel syndrome and/or inflammatory bowel disease.

Within certain aspects, VR1 modulators provided herein may be used for the treatment of mechanical pain. As used herein, the term "mechanical pain" refers to pain other than headache pain that is not neuropathic or a result of exposure to heat, cold or external chemical stimuli. Mechanical pain includes physical trauma (other than thermal or chemical burns or other irritating and/or painful exposures to noxious chemicals) such as post-surgical pain and pain from cuts, bruises and broken bones; toothache; denture pain; nerve root pain; osteoartiritis; rheumatoid arthritis; fibromyalgia; meralgia paresthetica; back pain; cancer-associated pain; angina; carpel tunnel syndrome; and pain resulting from bone fracture, labor, hemorrhoids, intestinal gas, dyspepsia, and menstruation.

Itching conditions that may be treated include psoriatic pruritis, itch due to hemodialysis, aguagenic pruritus, and itching associated with vulvar vestibulitis, contact dermatitis, insect bites and skin allergies. Urinary tract conditions that may be treated as described herein include urinary incontinence (including overflow incontinence, urge incontinence and stress incontinence), as well as overactive or unstable bladder conditions (including detrusor hyperflexia of spinal origin and bladder hypersensitivity). In certain such treatment methods, VR1 modulator is administered via a catheter or similar device, resulting in direct injection of VR1 modulator into the bladder. Compounds provided herein may also be used as anti-tussive agents (to prevent, relieve or suppress coughing) and for the treatment of hiccup, and to promote weight loss in an obese patient.

Within other aspects, VR1 modulators provided herein may be used within combination therapy for the treatment of conditions involving inflammatory components. Such conditions include, for example, autoimmune disorders and pathologic autoimmune responses known to have an inflammatory component including, but not limited to, arthritis (especially rheumatoid arthritis), psoriasis, Crohn's disease, lupus erythematosus, irritable bowel syndrome, tissue graft rejection, and hyperacute rejection of transplanted organs. Other such conditions include trauma (*e.g.*, injury to the head or spinal cord), cardio- and cerebo-vascular disease and certain infectious diseases.

Within such combination therapy, a VR1 modulator is administered to a patient along with an anti-inflammatory agent. The VR1 modulator and anti-inflammatory agent may be present in the same pharmaceutical composition, or may be administered separately in either order. Anti-inflammatory agents include, for example, non-steroidal anti-inflammatory drugs (NSAIDs), non-specific and cyclooxygenase-2 (COX-2) specific cyclooxgenase enzyme inhibitors, gold compounds, corticosteroids, methotrexate, tumor necrosis factor (TNF) receptor antagonists, anti-TNF alpha antibodies, anti-C5 antibodies, and interleukin-1 (IL-1) receptor antagonists. Examples of NSAIDs include, but are not limited to ibuprofen (*e.g.*, ADVIL™, MOTRIN™), flurbiprofen (ANSAID™), naproxen or naproxen sodium (*e.g.*, NAPROSYN, ANAPROX, ALEVE™), diclofenac (*e.g.*, CATAFLAM™, VOLTAREN™), combinations of diclofenac sodium and misoprostol (*e.g.*, ARTHROTEC™), sulindac (CLINORIL™), oxaprozin (DAYPRO™), diflunisal (DOLOBID™), piroxicam (FELDENE™), indomethacin (INDOCIN™), etodolac (LODINE™), fenoprofen calcium (NALFON™), ketoprofen (*e.g.*, ORUDIS™, ORUVAIL™), sodium nabumetone (RELAFEN™), sulfasalazine (AZULFIDINE™), tolmetin sodium (TOLECTIN™), and hydroxychloroquine (PLAQUENIL™). A particular class of NSAIDs consists of compounds that inhibit cyclooxygenase (COX) enzymes, such as celecoxib (CELEBREX™) and rofecoxib (VIOXX™). NSAIDs further include salicylates such as acetylsalicylic acid or aspirin, sodium salicylate, choline and magnesium salicylates (TRILISATE™), and salsalate (DISALCID™), as well as corticosteroids such as cortisone (CORTONE™ acetate), dexamethasone (e.g., DECADRON™), methylprednisolone (MEDROL™) prednisolone (PRELONE™), prednisolone sodium phosphate (PEDIAPRED™), and prednisone (*e.g.*, PREDNICEN-M™, DELTASONE™, STERAPRED™).

Suitable dosages for VR1 modulator within such combination therapy are generally as described above. Dosages and methods of administration of anti-inflammatory agents can be found, for example, in the manufacturer's instructions in the *Physician's Desk Reference*. In certain embodiments, the combination administration of a VR1 modulator with an anti-inflammatory agent results in a reduction of the dosage of the anti-inflammatory agent required to produce a therapeutic effect (*i.e.*, a decrease in the minimum therapeutically effective amount). Thus, preferably, the dosage of anti-inflammatory agent in a combination or combination treatment method of the invention is less than the maximum dose advised by the manufacturer for administration of the anti-inflammatory agent without combination administration of a VR1 antagonist. More preferably this dosage is less than ¾, even more preferably less than ½, and highly preferably, less than ¼ of the maximum dose, while most preferably the dose is less than 10% of the maximum dose advised by the manufacturer for administration of the anti-inflammatory agent(s) when administered without combination administration of a VR1 antagonist. It will be apparent that the dosage amount of VR1 antagonist component of the combination needed to achieve the desired effect may similarly be affected by the dosage amount and potency of the anti-inflammatory agent component of the combination.

In certain preferred embodiments, the combination administration of a VR1 modulator with an anti-inflammatory agent is accomplished by packaging one or more VR1 modulators and one or more anti-inflammatory agents in the same package, either in separate containers within the package or in the same contained as a mixture of one or more VR1 antagonists and one or more anti-inflammatory agents. Preferred mixtures are formulated for oral administration (*e.g.*, as pills, capsules, tablets or the like). In certain embodiments, the package comprises a label bearing indicia indicating that the one or more VR1 modulators and one or more anti-inflammatory agents are to be taken together for the treatment of an inflammatory pain condition. A highly preferred combination is one in which the anti-inflammatory agent(s) include at least one COX-2 specific cyclooxgenase enzyme inhibitor such as valdecoxib (BEXTRA®), lumiracoxib (PREXIGE™), etoricoxib (ARCOXIA®), celecoxib (CELEBREX®) and/or rofecoxib (VIOXX®).

Within further aspects, VR1 modulators provided herein may be used in combination with one or more additional pain relief medications. Certain such medications are also anti-inflammatory agents, and are listed above. Other such medications are narcotic analgesic agents, which typically act at one or more opioid receptor subtypes (*e.g.*, μ, κ and/or δ), preferably as agonists or partial agonists. Such agents include opiates, opiate derivatives and opioids, as well as pharmaceutically acceptable salts and hydrates thereof. Specific examples of narcotic analgesics include, within preferred embodiments, alfentanyl, alphaprodine, anileridine, bezitramide, buprenorphine, codeine, diacetyldihydromorphine, diacetylmorphine, dihydrocodeine, diphenoxylate, ethylmorphine, fentanyl, heroin, hydrocodone, hydromorphone, isomethadone, levomethorphan, levorphane, levorphanol, meperidine, metazocine, methadone, methorphan, metopon, morphine, opium extracts, opium fluid extracts, powdered opium, granulated opium, raw opium, tincture of opium, oxycodone, oxymorphone, paregoric, pentazocine, pethidine, phenazocine, piminodine, propoxyphene, racemethorphan, racemorphan, thebaine and pharmaceutically acceptable salts and hydrates of the foregoing agents.

Other examples of narcotic analgesic agents include acetorphine, acetyldihydrocodeine, acetylmethadol, allylprodine, alphracetylmethadol, alphameprodine, alphamethadol, benzethidine, benzylmorphine, betacetylmethadol, betameprodine, betamethadol, betaprodine, butorphanol, clonitazene, codeine methylbromide, codeine-N-oxide, cyprenorphine, desomorphine, dextromoramide, diampromide, diethylthiambutene, dihydromorphine, dimenoxadol, dimepheptanol, dimethylthiamubutene, dioxaphetyl butyrate, dipipanone, drotebanol, ethanol, ethylmethylthiambutene, etonitazene, etorphine, etoxeridine, furethidine, hydromorphinol, hydroxypethidine, ketobemidone, levomoramide, levophenacylmorphan, methyldesorphine, methyldihydromorphine, morpheridine, morphine methylpromide, morphine methylsulfonate, morphine-N-oxide, myrophin, naloxone, nalbuyphine, naltyhexone, nicocodeine, nicomorphine, noracymethadol, norlevorphanol, normethadone, normorphine, norpipanone, pentazocaine, phenadoxone, phenampromide, phenomorphan, phenoperidine, piritramide, pholcodine, proheptazoine, properidine, propiran, racemoramide, thebacon, trimeperidine and the pharmaceutically acceptable salts and hydrates thereof.

Further specific representative analgesic agents include, for example: TALWIN® Nx and DEMEROL® (both available from Sanofi Winthrop Pharmaceuticals; New York, NY); LEVO-DROMORAN®; BUPRENEX® (Reckitt & Coleman Pharmaceuticals, Inc.; Richmond, VA); MSIR® (Purdue Pharma L.P.; Norwalk, CT); DILAUDID® (Knoll Pharmaceutical Co.; Mount Olive, NJ); SUBLIMAZE®; SUFENTA® (Janssen Pharmaceutica Inc.; Titusville, NJ); PERCOCET®, NUBAIN® and NUMORPHAN® (all available from Endo Pharmaceuticals Inc.; Chadds Ford, PA) HYDROSTAT® IR, MS/S and MS/L (all available from Richwood Pharmaceutical Co. Inc; Florence, KY), ORAMORPH® SR and ROXICODONE® (both available from Roxanne Laboratories; Columbus OH) and

STADOL® (Bristol-Myers Squibb; New York, NY). Still further analgesic agents include CB2-receptor agonists, such as AM1241, and compounds that bind to the $\alpha 2\delta$ subunit, such as Neurontin (Gabapentin) and pregabalin.

Within still further aspects, VR1 modulators provided herein may be used in combination with one or more leukotriene receptor antagonists (*e.g.*, agents that inhibits the cysteinyl leukotriene $CysLT_1$ receptor). $CysLT_1$ antagonists include Montelukast (SINGULAIR®; Merck & Co., Inc.). Such combinations find use in the treatment of pulmonary disorders such as asthma.

The present invention further provides combination therapy for the treatment of urinary incontinence. Within such aspects, a VR1 modulator provided herein may be used in combination with a muscarinic receptor antagonist such as Tolterodine (DETROL®; Pharmacia Corporation) or an anticholinergic agent such as Oxybutynin (DITROPAN®; Ortho-McNeil Pharmaceutical, Inc., Raritan, NJ).

Suitable dosages for VR1 modulator within such combination therapy are generally as described above. Dosages and methods of administration of other pain relief medications can be found, for example, in the manufacturer's instructions in the *Physician's Desk Reference.* In certain embodiments, the combination administration of a VR1 modulator with one or more additional pain medications results in a reduction of the dosage of each therapeutic agent required to produce a therapeutic effect (*e.g.*, the dosage or one or both agent may less than ¾, less than ½, less than ¼ or less than 10% of the maximum dose listed above or advised by the manufacturer). In certain preferred embodiments, the combination administration of a VR1 modulator with one or more additional pain relief medications is accomplished by packaging one or more VR1 modulators and one or more additional pain relief medications in the same package, as described above.

Compounds that are VR1 agonists may further be used, for example, in crowd control (as a substitute for tear gas) or personal protection (*e.g.*, in a spray formulation) or as pharmaceutical agents for the treatment of pain, itch, urinary incontinence or overactive bladder via capsaicin receptor desensitization. In general, compounds for use in crowd control or personal protection are formulated and used according to conventional tear gas or pepper spray technology.

Within separate aspects, the present invention provides a variety of non-pharmaceutical *in vitro* and *in vivo* uses for the compounds provided herein. For example, such compounds may be labeled and used as probes for the detection and localization of capsaicin receptor (in samples such as cell preparations or tissue sections, preparations or fractions thereof). In addition, compounds provided herein that comprise a suitable reactive group (such as an aryl carbonyl, nitro or azide group) may be used in photoaffinity labeling studies of receptor binding sites. In addition, compounds provided herein may be used as positive controls in assays for receptor activity, as standards for determining the ability of a candidate agent to bind to capsaicin receptor, or as radiotracers for positron emission tomography (PET) imaging or for single photon emission computerized tomography (SPECT). Such methods can be used to characterize capsaicin receptors in living subjects. For example, a VR1 modulator may be labeled using any of a variety of well known techniques (*e.g.*, radiolabeled with a radionuclide such as tritium, as described herein), and incubated with a sample for a suitable incubation time (*e.g.*, determined by first assaying a time course of binding). Following incubation, unbound compound is removed (*e.g.*, by washing), and bound compound detected using any method suitable for the label employed (*e.g.*, autoradiography or scintillation counting for radiolabeled compounds; spectroscopic methods may be used to detect luminescent groups and fluorescent groups). As a control, a matched sample containing labeled compound and a greater (*e.g.*, 10-fold greater) amount of unlabeled compound may be processed in the same manner. A greater amount of detectable label remaining in the test sample than in the control indicates the presence of capsaicin receptor in the sample. Detection assays, including receptor autoradiography (receptor mapping) of capsaicin receptor in cultured cells or tissue samples may be performed as described by Kuhar in sections 8.1.1 to 8.1.9 of Current Protocols in Pharmacology (1998) John Wiley & Sons, New York.

Compounds provided herein may also be used within a variety of well known cell separation methods. For example, modulators may be linked to the interior surface of a tissue culture plate or other support, for use as affinity ligands for immobilizing and thereby isolating, capsaicin receptors (*e.g.*, isolating receptor-expressing cells) *in vitro*. Within one preferred embodiment, a modulator linked to a fluorescent marker, such as fluorescein, is contacted with the cells, which are then analyzed (or isolated) by fluorescence activated cell sorting (FACS).

VR1 modulators provided herein may further be used within assays for the identification of other agents that bind to capsaicin receptor. In general, such assays are standard competition binding assays, in which bound, labeled VR1 modulator is displaced by a test compound. Briefly, such assays are performed by: (a) contacting capsaicin receptor with a radiolabeled VR1 modulator as described herein, under conditions that permit binding of the VR1 modulator to capsaicin receptor, thereby generating bound, labeled VR1 modulator; (b) detecting a signal that corresponds to the amount of bound, labeled VR1 modulator in the absence of test agent; (c) contacting the bound, labeled VR1 modulator with a test agent; (d) detecting a signal that corresponds to the amount of bound labeled VR1 modulator in the presence of test agent; and (e) detecting a decrease in signal detected in step (d), as compared to the signal detected in step (b).

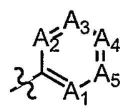
The following Examples are offered by way of illustration and not by way of limitation. Unless otherwise specified all reagents and solvent are of standard commercial grade and are used without further purification. Using routine modifications, the starting materials may be varied and additional steps employed to produce other compounds provided herein.

EXAMPLES

EXAMPLE 1

Preparation of Representative Substituted Bicyclic Quinazoline-4-ylamine Derivatives

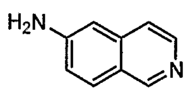
This Example illustrates the preparation of representative bicyclic groups indicated by:



in Formula I. Such groups may be used to generate a compound of Formula I as illustrated in Scheme 4 and Examples 2 and 3.

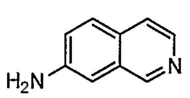
A. 6-AMINOISOQUINOLINE

6-aminoisoquinoline is prepared essentially as described by Durant et. al. (European Patent Application: EP266949)



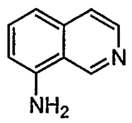
B. 7-AMINOISOQUINOLINE

7-aminoisoquinoline is prepared essentially as described by Macdonald et. al. (International Patent Application: WO 97/06158)



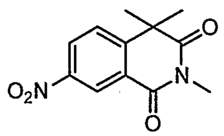
C. 8-AMINOISOQUINOLINE

8-aminoisoquinoline is prepared essentially as described by Denny et. al. (2002) *J. Med. Chem. 45*(3):740.



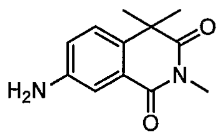
D. 2,4,4-TRIMETHYL-1,2,3,4-TETRAHYDRO-ISOQUINOLINE-7-YLAMINE

1. *2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione*



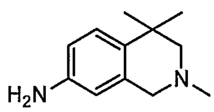
To a solution of 2,4,4-trimethyl-4H-isoquinoline-1,3-dione (Takechi et al. (1992) *Synthesis*, 778; 25.0 mmol) in conc. H_2SO_4 (50 ml) at 0°C, add fuming HNO_3 (5 ml) dropwise. Stir the mixture for 30 minutes at room temperature. Pour the mixture into ice-water (100 ml), extract with DCM (3 x 50 ml), wash with brine, and dry over N_2SO_4. Concentrate to give the title compound.

2. *7-amino-2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione*



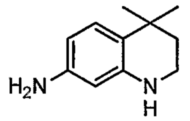
Hydrogenate the solution of 2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione (10 mmol) in MeOH-DCM (5:1, 300 ml) with 10%Pd-C for 3 hours. Filter through Celite pad and concentrate to give the title compound.

3. *2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinoline-7-ylamine*



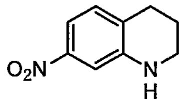
To a refluxing solution of 7-amino-2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione (10 mmol) in THF (200 ml), add BH_3-THF solution (1M, 40 ml) dropwise and continue to reflux for 3 hours. Cool to 0°C and add MeOH (200 ml) dropwise. Concentrate, add 3N HCl 200 ml, and reflux for 30 minutes. Cool to 0°C, adjust to pH 9 with NaOH, extract with DCM (3X50 ml), dry over Na_2SO_4, and concentrate to give the title compound.

E. 7-AMINO-4,4-DIMETHYL-1,2,3,4-TETRAHYDROQUINOLINE



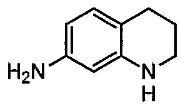
7-Amino-4,4-dimethyl-1,2,3,4-tetrahydroquinoline is prepared essentially as described by Elbaum et. al. (U.S. Patent Application Publication No. 2003/0134836).

F. 7-NITRO-1,2,3,4-TETRAHYDRO-QUINOLINE



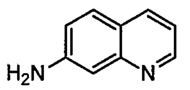
7-Nitro-1,2,3,4-tetrahydro-quinoline is prepared essentially as described by Field and Hammond (US Patent No. 5,283,336).

G. 7-AMINO-1,2,3,4-TETRAHYDROQUINOLINE



7-Amino-1,2,3,4-tetrahydroquinoline is prepared essentially as described by Field and Hammond (US Patent No. 5,283,336).

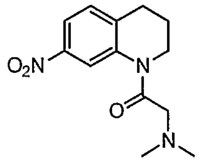
H. 7-AMINOQUINOLINE



7-Aminoquinoline is prepared essentially as described by Linsker and Evans (1946) *J. Am. Chem. Soc. 48*:149-50.

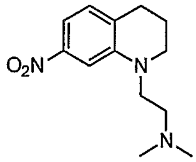
I. 1-(2-DIMETHYLAMINO-ETHYL)-1,2,3,4-TETRAHYDRO-QUINOLIN-7-YLAMINE

1. *2-Dimethylamino-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone*



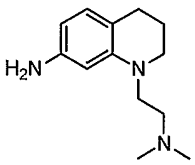
Add dimethylaminoacetyl chloride (5.7 mmol)to a solution of 7-nitro-1,2,3,4-tetrahydro-quinoline (1g, 5.6mmol) and triethylamine (8.6 mmol) in methylene chloride at 0°C. Stir the reaction at room temperature for 16 hours, and then partition between methylene chloride and saturated $NaHCO_3$. Dry the organic layer (Na_2SO_4) and concentrate under reduced pressure to give the title compound.

2. *Dimethyl-[2-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethyl]-amine*



Add borane/THF complex (4.5 mmol) to a solution of 2-dimethylamino-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone (0.85 mmol) in dry THF (10 mL) at 0°C under nitrogen atmosphere. Continue to stir at 0°C for 30 minutes, followed by 3 hours at room temperature. Add 3N HCl (3 mL) slowly, followed by water (10 mL). Extract the resulting solution with ethyl acetate, dry the organic layer (Na_2SO_4) and concentrate under reduced pressure to give the title compound.

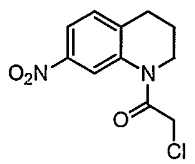
3. *1-(2-Dimethylamino-ethyl)-1,2,3,4-tetrahydro-quinolin-7-ylamine*



Hydrogenate an ethanolic solution of dimethyl-[2-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethyl]-amine (5.5 mmol) for 24 hours at 50 psi and room temperature using 10% palladium on carbon (150mg). Filter the solution through celite and concentrate the filtrate under reduced pressure to give the title compound.

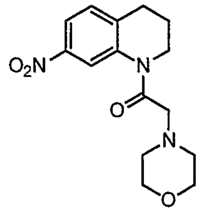
J. 1-(2-MORPHOLIN-4-YL-ETHYL)-1,2,3,4-TETRAHYDRO-QUINOLIN-7-YLAMINE

1. *2-Chloro-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone*



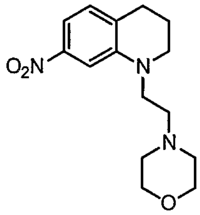
Using a procedure analogous to that given in I-1 above, 7-nitro-1,2,3,4-tetrahydro-quinoline is converted into the title compound using chloroacetylchloride.

2. *2-Morpholin-4-yl-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone*



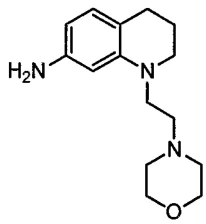
Heat a mixture of 2-chloro-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone (26 mmol) and morpholine (260 mmol) in dimethylacetamide at 80°C for 16 hours. Partition the reaction mixture between 10% NaOH solution and ethyl acetate. Dry the organic layer (Na_2SO_4) and concentrate under reduced pressure. Purify by silica gel flash column chromatography using 0-5% MeOH/methylene chloride as eluent to give the title compound.

3. *1-(2-Morpholin-4-yl-ethyl)-7-nitro-1,2,3,4-tetrahydro-quinoline*



Using a procedure analogous to that given in I-2 above, 2-morpholin-4-yl-1-(7-nitro-3,4-dihydro-2H-quinolin-1-yl)-ethanone is converted into the title compound.

4. *1-(2-Morpholin-4-yl-ethyl)-1,2,3,4-tetrahydro-quinolin-7-ylamine*



Using a procedure analogous to that given in I-3 above, 1-(2-morpholin-4-yl-ethyl)-7-nitro-1,2,3,4-tetrahydro-quinoline is converted into the title compound.

EXAMPLE 2

Preparation of Representative Substituted Bicyclic Quinazoline-4-ylamine Derivatives

This Example illustrates the preparation of representative substituted bicyclic quiinazoline-4-ylamine derivatives.

Mass spectroscopy data in this and subsequent Examples is Electrospray MS, obtained in positive ion mode with a 15V or 30V cone voltage, using a Micromass Time-of-

Flight LCT, equipped with a Waters 600 pump, Waters 996 photodiode array detector, Gilson 215 autosampler, and a Gilson 841 microinjector. MassLynx (Advanced Chemistry Development, Inc; Toronto, Canada) version 4.0 software was used for data collection and analysis. Sample volume of 1 microliter was injected onto a 50x4.6mm Chromolith SpeedROD C18 column, and eluted using a 2-phase linear gradient at 6ml/min flow rate. Sample was detected using total absorbance count over the 220-340nm UV range. The elution conditions were: Mobile Phase A- 95/5/0.05 Water/Methanol/TFA; Mobile Phase B- 5/95/0.025 Water/Methanol/TFA.

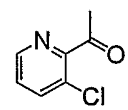
Gradient:	Time(min)	%B
	0	10
	0.5	100
	1.2	100
	1.21	10

The total run time was 2 minutes inject to inject. Data is presented as mass + 1 (M+1).

IC_{50} values provided below are determined as described in Example 6.

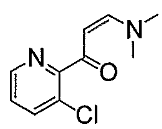
A. [7-(3-Chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1-methyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine (compound 1)

1. *2-Acetyl-3-chloropyridine*



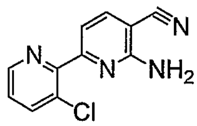
Dissolve 3-chloro-2-cyanopyridine (10.0 g, 0.072 mol, Chem. Pharm. Bull. (1985) 33:565-571) in anhydrous THF (200 mL) under N_2 atmosphere and cool in an ice bath. Add drop wise 3.0 M MeMgI in diethyl ether (48 ml, 0.14 mol) to the reaction mixture and stir in an ice bath for 2 hours. Pour the reaction mixture over ice cold water, acidify the mixture with 2.0 N aq. HCl to pH 2 to 3. Extract the reaction mixture with EtOAc (3 x 100 mL) and dry over anhydrous $MgSO_4$. Filter, concentrate under vacuum and then filter through a pad of silica gel using 20% ethyl acetate / hexane as eluent. Removal of solvent under reduced pressure gives pure 2-acetyl-3-chloropyridine as oil.

2. *1-(3-Chloro-pyridin-2-yl)-3-dimethylaminopropenone*



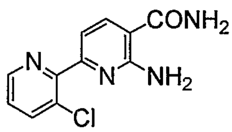
Heat 2-acetyl-3-chloropyridine (0.77 g, 5.0 mmol) with N,N-dimethylformamide dimetylacetal (3.0 g) at 105°C for 20 hours. Concentrate under reduced pressure to give 1-(3-chloro-pyridin-2-yl)-3-dimethylaminopropenone as oil.

3. 2-Amino-4-(3-chloro-pyridin-2-yl)-benzonitrile



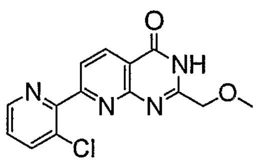
Heat a solution of 1-(3-chloro-pyridin-2-yl)-3-dimethylaminopropenone (1.05 g, 5 mmol), 3-amino-3-methoxy-acrylonitrile hydrochloride (1.35 g, 10 mmol) and ammonium acetate (2.2 g, 15.0 mmol) in ethanol (25 mL) at reflux for 20 hours. Cool the mixture and concentrate under reduced pressure to give dark oil. Dissolve the residue in EtOAc / water (100 mL). Extract the aqueous solution with EtOAc, wash the EtOAc with brine, dry ($MgSO_4$) and concentrate under reduced pressure to give 2-amino-4-(3-chloro-pyridin-2-yl)-benzonitrile as a brown solid.

4. *6-Amino-3'-chloro-[2,2']bipyridinyl-5-carboxylic acid amide*



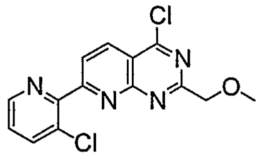
Cool concentrated sulfuric acid (10 mL) in an ice bath under nitrogen atmosphere. Add in portions 2-amino-4-(3-chloro-pyridin-2-yl)-benzonitrile (1.0 g, 4.3 mmol) over a period of 15 minutes. Stir at room temperature overnight. Pour the reaction mixture over ice, adjust the pH to 10 using 10 N aq. NaOH, filter the solid, wash the solid with water and dry under vacuum to give 6-amino-3'-chloro-[2,2']bipyridinyl-5-carboxylic acid amide as a yellow solid.

5. 7-(3-Chloro-pyridin-2-yl)-2-methoxymethyl-3H-pyrido[2,3-d]pyrimidin-4-one



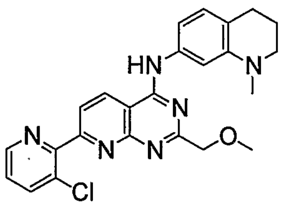
Dissolve 6-amino-3'-chloro-[2,2']bipyridinyl-5-carboxylic acid amide (0.5 g, 2.02 mmol) in anhydrous THF (10 mL) under N_2 atmosphere. Add drop wise pyridine (0.36 g, 4.04 mmol) and methoxyacetyl chloride (0.48 g, 4.04 mmol) to the reaction mixture and stir at room temperature overnight. Add 10 % aq. NaOH (10 mL) and reflux for 4 hours. Concentrate in vacuum, adjust the pH to 6.0 using AcOH, collect the solid by filtration and dry under vacuum to give 7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-3H-pyrido[2,3-d]pyrimidin-4-one as a white solid.

6. *4-Chloro-7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidine*



Reflux a mixture of 7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-3H-pyrido[2,3-d]pyrimidin-4-one (0.25 g), 2,6-lutidine (0.44 g), and $POCl_3$ (0.51 g) in $CHCl_3$ (5 mL) for 20 hours. Cool the mixture and concentrate under reduced pressure. Partition the residue between EtOAc and saturated $NaHCO_3$ solution. Wash the EtOAc portion with additional $NaHCO_3$ and then dry (Na_2SO_4) and concentrate under reduced pressure. Filter the brown residue through 2 inches of silica gel (1:1 EtOAc/hexanes eluent) and concentrate under reduced pressure to give 4-chloro-7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidine.

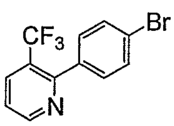
7. *[7-(3-Chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1-methyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine*



Heat a mixture of 4-chloro-7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidine (0.1 mmol) and 1-methyl-1,2,3,4-tetrahydro-quinolin-7-ylamine (0.1mmol) in CH_3N (1 mL) at 80°C for 24 hours. Cool the mixture and wash the precipitate with ether to give [7-(3-chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4-trifluoromethyl-phenyl)-amine as the mono-HCl salt. Mass Spec. (M+1) 481.3. The IC_{50} is less than 1 micromolar.

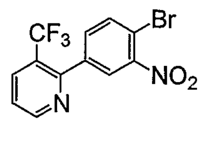
<u>B. (2-methyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-[7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-amine (compound 2)</u>

1. *2-(4-bromo phenyl)-3-(trifluoromethyl)-pyridine*



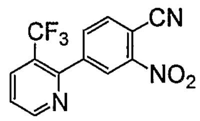
To a de-gassed mixture of 2-bromo-3-(trifluoromethyl)-pyridine (2.26 mmol), 4-bromo-phenylbronic acid (2.49 mmol), and 2M Na_2CO_3 (5.65 mmol), in DME (10 mL) under nitrogen add $Pd(PPh_3)_4$ (0.09 mmol). Stir the mixture at 80°C for overnight, concentrate, extract with EtOAc. Dry over Na_2SO_4, concentrate under vacuum, and purify by flash chromatography (4:1 hexanes/EtOAc) to give 2-(4-bromo phenyl)-3-(trifluoromethyl)-pyridine.

2. *2-(4-bromo-3-nitro-phenyl)-3-(trifluoromethyl)-pyridine*



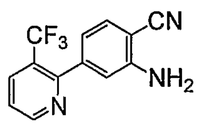
To a solution of 2-(4-bromophenyl)-3-(trifluoromethyl)-pyridine (0.93 mmol) in H_2SO_4 (4 mL) cautiously add fuming HNO_3 (2 ml). Stir the mixture 30 minutes at room temperature. Pour the mixture onto ice-water (20 mL) and collect the precipitate. Dissolve the precipitate in EtOAc and neutralize with saturated $NaHCO_3$, dry over Na_2SO_4, concentrate under vacuum to obtain 2-(4-bromo-3-nitro-phenyl)-3-(trifluoromethyl)-pyridine.

3. *2-nitro-4(3-trifluoromethyl-pyridin-2-yl)-benzonitrile*



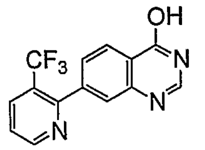
To a solution of 2-(4-bromo-3-nitro-phenyl)-3-(trifluoromethyl)-pyridine (0.55 mmol) in DMA (4 mL) add CuCN (0.60 mmol). Stir the mixture 4 hours at 110°C. Cool to room temperature, dilute with 20 ml of EtOAc, and filter through celite pad. Wash the filtrated with brine, dry over Na_2SO_4, concentrate under vacuum, and purify by flash chromatography (1:1 hexanes/EtOAc) to give 2-nitro-4(3-trifluoromethyl-pyridin-2-yl)-benzonitrile.

4. *2-amino-4-(3-trifluoromethyl-pyridin-2-yl)-benzo-nitrile*



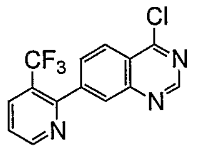
To an ice-water cooled solution of 2-nitro-4-(3-trifluoromethyl-pyridin-2-yl)-benzonitrile (0.44 mmol) in conc. HCl (6 mL), add $SnCl_2$ (1.457 mmol). Stir the mixture for 2 hours at room temperature. Neutralize with NaOH, extract with EtOAc, dry over Na_2SO_4, and concentrate under vacuum. Purify the residue by flash chromatography (4:1 hexanes/EtOAc) to give 2-amino-4(3-trifluoromethyl-pyridin-2-yl)-benzo-nitrile.

5. *7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-ol*



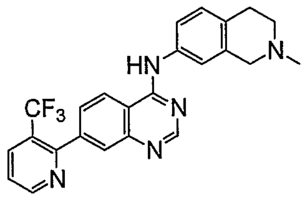
Reflux 2-amino-4-(3-trifluoromethyl-pyridin-2-yl)-benzonitrile (0.41 mmol) and NaOAc (1.23 mmol) for 16 hours in HCOOH (10 mL). Evaporate the solvent *in vacuo*, suspend the residue in 20 ml of 20% NaOH, stir for 30 minutes at room temperature. Filter, extract with EtOAc, dry over Na_2SO_4, and concentrate under vacuum to give 7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-ol.

6. *4-chloro-7-(3-trifluoromethyl-pyridin-2-yl)-quinazoline*



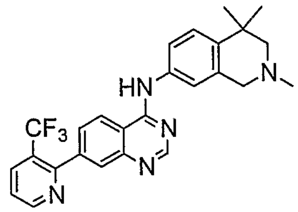
Reflux 7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-ol (0.38 mmol) for 18 hours in $POCl_3$ (5 mL). Evaporate the solvent *in vacuo*, then carefully neutralize with saturated $NaHCO_3$, and extract with EtOAc. Dry over Na_2SO_4, concentrate under vacuum to obtain 4-chloro-7-(3-trifluoromethyl-pyridin-2-yl)-quinazoline.

7. *(2-Methyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-[7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-amine*



Stir 4-chloro-7-(3-trifluoromethyl-pyridin-2-yl)-quinazoline (0.16 mmol) and 2-methyl-1,2,3,4-tetrahydro-isoquinolin-7-ylamine (0.32 mmol) in IPA (4 mL) at 80°C for 6 hours. Cool the mixture and collect the precipitate to obtain (2-methyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-[7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-amine hydrochloride.

C. [7-(3-Trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine hydrochloride (compound 3)



1. 2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione

To a solution of 2,4,4-trimethyl-4H-isoquinoline-1,3-dione [Takechi, H. *et al* Synthesis, 1992, 778] (25.0 mmol) in conc. H_2SO_4 (50 ml) at 0°C add fuming HNO_3 (5 ml) dropwise. Stir the mixture forc30 minutes at room temperature. Pour the mixture into ice-water (100 ml), extract with DCM (3 x 50 ml), wash with brine, and dry over N_2SO_4. Concentrate to give the title compound.

2. 7-amino-2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione

Hydrogenate the solution of 2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione (10 mmol) in MeOH-DCM (5:1, 300 ml) with 10%Pd-C for 3 hours. Filter through Celite pad and concentrate to give the title compound.

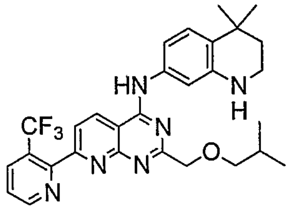
3. 2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinoline-7-ylamine

To a refluxing solution of 7-amino-2,4,4-trimethyl-7-nitro-4H-isoquinoline-1,3-dione (10 mmol) in THF (200 ml) add BH_3-THF solution (1M, 40 ml) dropwise and continue to reflux 3 hours. Cool to 0°C and add MeOH (200 ml) dropwise. Concentrate, add 3N HCl 200 ml, and reflux for 30 minutes. Cool to 0°C, adjust to pH 9 with NaOH, extract with DCM (3X50 ml), dry over Na_2SO_4, and concentrate to give the title compound.

4. *[7-(3-Trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine hydrochloride*

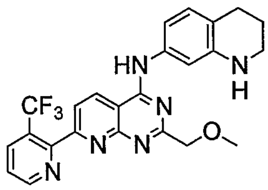
Stir 4-chloro-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-ol (*see* WO 03062209, 0.16 mmol) and 2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-ylamine (0.32 mmol, above) in IPA (4 mL) at 80°C for 6 hours. Cool the mixture and collect the precipitate to obtain [7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine hydrochloride. Mass Spec (M+1) 464.0. The IC_{50} is less than 1 micromolar.

D. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine hydrochloride (compound 4)



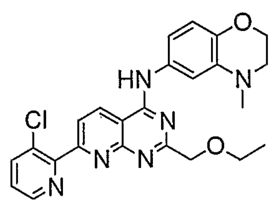
Stir 4-chloro-2-isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidine (*see* WO 03062209, 0.1 mmol) and 7-amino-4,4-dimethyl-1,2,3,4-tetrahydroquinoline (0.1 mmol, prepared according to the method of Elbaum et. al., U.S. Patent Application 2003/0134836) in acetonitrile (1 mL) at 25°C for 20 hours. Filter the solid to afford the title compound. Mass Spec (M+1) 537.34. The IC_{50} is less than 1 micromolar.

E. [2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(1,2,3,4-tetrahydro-quinolin-7-yl)-amine (compound 5)



Stir 4-chloro-2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidine (*see* WO 03062209, 0.1 mmol) and 7-amino-1,2,3,4-tetrahydroquinoline (0.1 mmole, prepared according to US Patent No. 5,283,336) in acetonitrile (1 mL) at 25°C for 20 hours. Filter the solid to afford the title compound. Mass Spec (M+1) 467.2. The IC_{50} is less than 1 micromolar.

F. [[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine (compound 6)



1. 7-Nitro-3,4-dihydro-2H-benzo[1,4]oxazine

Dissolve 2-amino-4-nitrophenol (4.0 g, 26 mmol) in anhydrous DMF (20 mL) under nitrogen atmosphere. Add 1, 2-dibromoethane (2.36 mL, 27.6 mmol) and K_2CO_3 (7.2 g, 52 mmol) to the mixture and stir at 125°C for 3 hours. Cool the reaction mixture to room temperature, dilute with 1.0 N aq. NaOH (250 mL), extract with EtOAc (2 x 200 mL), wash the extract with water (2 x 100 mL) and brine (100 mL), and dry with $MgSO_4$. Filter and concentrate under vacuum to afford orange yellow solid.

2. *1-Methyl-7-nitro-3,4-dihydro-2H-benzo[1,4]oxazine*

Dissolve 7-nitro-3,4-dihydro-2H-benzo[1,4]oxazine(1.8 g, 10 mmol) in anhydrous DMF (30 mL) under nitrogen atmosphere. Add 60 % NaH (480 mg, 12 mmol) and stir for 15 minutes. Add MeI (1.5 mL) to the resulting mixture and stir at room temperature overnight. Quench the reaction mixture with water (100 mL), extract with EtOAc (2 x 200 mL), wash the extract with brine (100 mL) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford brown yellow solid.

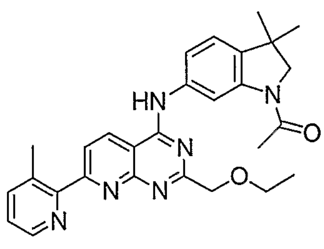
3. *7-amino-1-methyl-3,4-dihydro-2H-benzo[1,4]oxazine*

Dissolve 1-methyl-7-nitro-3,4-dihydro-2H-benzo[1,4]-oxazine(0.5 g) in anhydrous EtOH (50 mL) and then add 10% Pd/C (0.25g). Hydrogenate at 20 psi of H_2 at room temperature for 2 hours. Filter the catalyst and concentrate under vacuum to afford the amino derivative as brown oil.

4. *[[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine hydrochloride*

Stir 4-Chloro-2-ethoxymethyl-7-(3-chloro-pyridin-2-yl)-pyrido[2,3-d]pyrimidine (*see* WO 03/062209, 0.1 mmol) and 7-amino-1-methyl-3,4-dihydro-2H-benzo[1,4]oxazine (0.1 mmole, above) in acetonitrile(1 mL) at 25°C for 20 hours. Filter the solid to afford the title compound. Mass Spec (M+1) 463.2. The IC_{50} is less than 1 micromolar.

G. 1-{6-[2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone (compound 7)



1. *N-(2-Bromo-4-nitro-phenyl)-acetamide*

Dissolve 2-bromo-5-nitroaniline (5.2 g, 24 mmol) in glacial AcOH (150 mL) under nitrogen atmosphere. Add acetic anhydride (2.3 mL, 24 mmol) to the mixture and stir at 25°C for 20 hours. Quench the reaction mixture with water (100 mL), filter the solid, wash the solid with water (2 x 50 mL) and dry under vacuum to afford off-white solid.

2. *N-(2-Bromo-4-nitro-phenyl)-N-(2-methyl-allyl)-acetamide*

Dissolve N-(2-bromo-4-nitro-phenyl)-acetamide (5.6 g, 22 mmol) in anhydrous DMF (100 mL) under nitrogen atmosphere. Add K_2CO_3 (12.1 g, 4 eq) followed by 3-bromo-2-methylpropene (4.5 mL, 2.0 eq.) to the reaction mixture and stir at room temperature overnight. Quench the reaction mixture with water (100 mL), extract with EtOAc (3 x 200 mL), wash the extract with brine (100 mL) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford a solid.

3. *1-(3,3-Dimethyl-5-nitro-2,3-dihydro-indol-1-yl)-ethanone*

Dissolve N-(2-bromo-4-nitro-phenyl)-N-(2-methyl-allyl)-acetamide (6.7 g, 21 mmol) in anhydrous DMF (50 mL) and then add sodium formate (1.75 g, 26 mmol), sodium acetate (4.4 g, 54 mmol), tetraethylammonium chloride hydrate (3.7 g, 21 mmol) and palladium acetate (0.48 g).Heat the resultant mixture at 80°C for 20 hours. Cool the reaction mixture to room temperature, filter the catalyst, dilute the reaction mixture with satd. $NaHCO_3$ (200 mL), extract with EtOAc (2 x 200 mL), wash the extract with brine (100 mL) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford brown solid.

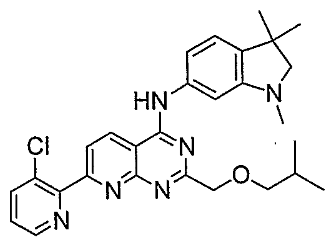
4. *1-(5-Amino-3,3-dimethyl-2,3-dihydro-indol-1-yl)-ethanone*

Dissolve 1-(3,3-dimethyl-5-nitro-2,3-dihydro-indol-1-yl)-ethanone (1.0 g, 4.27 mmol) in anhydrous ether (30 mL) and cool to 0°C. Add tin chloride dihydrate (6.0 g) followed by 12.0 N HCl (3.3 mL) to the mixture and stir at 0°C for 10 minutes. Warm the reaction mixture slowly to room temperature and then stir overnight. Dilute the reaction mixture with EtOAc (100 mL), wash with 10.0 N aq. NaOH (10 ml) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford yellow solid.

5. *1-{6-[2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone*

Stir 4-chloro-2-ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidine (*see* WO 03/062209, 0.1 mmol) and 1-(5-amino-3,3-dimethyl-2,3-dihydro-indol-1-yl)-ethanone (0.1 mmole, above) in acetonitrile (1 mL) at 25°C for 20 hours. Filter the solid to afford the title compound. Mass Spec (M+1) 483.28. The IC_{50} is less than 1 micromolar.

H. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine (compound 8)



1. 3,3-Dimethyl-5-nitro-2,3-dihydro-1H-indole

Dissolve 1-(3,3-dimethyl-5-nitro-2,3-dihydro-indol-1-yl)-ethanone(2.0 g, 8.55 mmol) in anhydrous ethanol (30 mL) and then add 12 N HCl (20 mL). Reflux the mixture for 3 hours followed by room temperature overnight. cool the mixture to 0°C, and filter the solid dry under vacuum to afford off-white solid.

2. 1,3,3-Trimethyl-5-nitro-2,3-dihydro-1H-indole

Dissolve 3,3-Dimethyl-5-nitro-2,3-dihydro-1H-indole (1.5 g, 7.8 mmol) in anhydrous DMF (50 mL) under nitrogen atmosphere. Add 60 % NaH (930 mg, 23 mmol) and stir for 15 minutes. Add MeI (0.53 mL) to the resultant mixture and stir at room temperature for 3h. Quench the reaction mixture with water (100 mL), extract with EtOAc (2 x 200 mL), wash the extract with brine (100 mL) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford a solid.

3. 1,3,3-Trimethyl-2,3-dihydro-1H-indol-5-ylamine

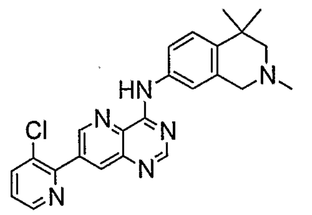
Dissolve 1,3,3-trimethyl-5-nitro-2,3-dihydro-1H-indole (1.6 g, 7.7 mmol) in anhydrous ether (30 mL) and cool to 0°C. Add tin chloride dihydrate (10.6 g) followed by 12.0 N HCl (5.6 mL) to the mixture and stir at 0°C for 10 minutes. Warm the reaction mixture slowly to room temperature and then stir overnight. Dilute the reaction mixture with EtOAc (100 mL), wash with 10.0 N aq. NaOH (10 ml) and dry with $MgSO_4$. Filter and concentrate under vacuum to afford brown oil.

4. *[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine*

Stir 4-chloro-2-isobutoxymethyl-7-(3-chloro-pyridin-2-yl)-pyrido[2,3-d]pyrimidine (*see* WO 03/062209, 0.1 mmol) and 1,3,3-trimethyl-2,3-dihydro-1H-indol-5-ylamine (0.1

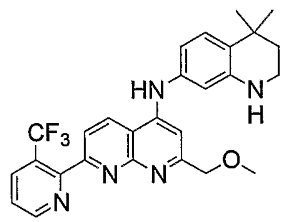
mmole, above) in acetonitrile (1 mL) at 25°C for 20 hours. Filter the solid to afford the title compound. Mass Spec (M+1) 503.28. The IC_{50} is less than 1 micromolar.

I. [7-(3-Chloro-pyridin-2-yl)-pyrido[3,2-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine hydrochloride (compound 9)

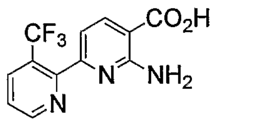


Stir 4-chloro-7-(3-chloro-pyridin-2-yl)-pyrido[3,2-d]pyrimidine (0.16 mmol, *see* WO 03/062209) and 2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-ylamine (0.32 mmol) in IPA (4 mL) at 80°C for 6 hours. Cool the mixture and collect the precipitate to obtain [7-(3-chloro-pyridin-2-yl)-pyrido[3,2-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine hydrochloride. Mass Spec (M+1) 431. The IC_{50} is less than 1 micromolar.

J. 4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)[2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-yl]-amine (compound 10)

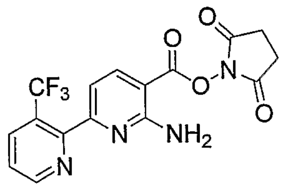


1. 6-Amino-3'-trifluoromethyl-[2,2']bipyridinyl-5-carboxylic acid



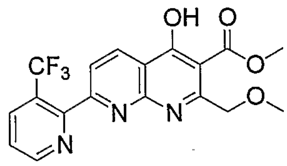
Dissolve 6-amino-3'-trifluoromethyl-[2,2']bypyridinyl-5-carbonitrile (2.33 g, 8.82 mmol, *see* WO 03/062209) in 12M HCl (50 mL) and heat at 110°C overnight. Remove the aqueous acid under reduced pressure to yield the title compound as its hydrochloride salt.

2. *6-Amino-3'-trifluoromethyl-[2,2']bipyridinyl-5-carboxylic acid 2,5-dioxo-pyrrolidin-1-yl ester*



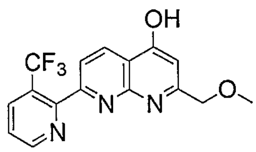
Dissolve 6-amino-3'-trifluoromethyl-[2,2']bipyridinyl-5-carboxylic acid hydrochloride (11.33 g, 35.44 mmol), N-hydroxy-succinimide (8.15 g, 70.9 mmol), and EDCI (10.19 g, 53.16 mmol) in a solution of dry THF (100 mL) and Hunig's base (16.12g, 125 mmol). Stir the reaction mixture overnight at room temperature. Add ethyl acetate (200 mL) and extract the organic phase with water (3 x 100 mL) and brine (100 mL). Dry the organic extract over Na_2SO_4 and remove the solvent under reduced pressure to yield the title compound as a brown foam.

3. *4-Hydroxy-2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridine-3-carboxylic acid methyl ester*



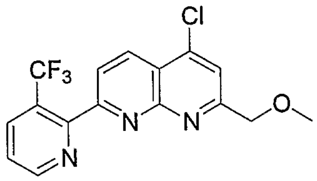
Add a solution of 6-amino-3'-trifluoromethyl-[2,2']bipyridinyl-5-carboxylic acid 2,5-dioxo-pyrrolidin-1-yl ester (10.4 g, 27.3 mmol) in 50 mL dry THF in one portion to a mixture of potassium t-butoxide (7.36g, 65.6 mmol) and methyl 4-methoxy-aceoacetate (8.77 g, 60.7 mmol) in dry THF (100 mL). Stir the reaction overnight at room temperature. Add water (30 mL) and concentrate the solution (~30 mL). Extract the resulting mixture with ether (2 x 50 mL). Acidify the aqueous portion with concentrated hydrochloric acid and extract with CH_2Cl_2 (4 x 100 mL). Dry the combined organic extracts over Na_2SO_4 and remove the solvent under reduced pressure to yield the title compound as a light brown oil that solidifies upon standing.

4. *2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-ol*



Dissolve 4-hydroxy-2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridine-3-carboxylic acid methyl ester (200 mg, 0.508 mmol) in 12 M HCl (20 mL) and heat at 110°C for 6 hours. Pour the reaction mixture onto ice (100 g) and extract with CH_2Cl_2 (4 x 150 mL). Dry the combined organic extracts over Na_2SO_4 and remove the solvent under reduced pressure. Purify the crude product by silica gel preparatory TLC eluting with hexanes/acetone (3:1), yielding the title compound as a white solid.

5. 4-Chloro-2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridine



Dissolve 2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-ol (191 mg, 0.569 mmol) in a solution of chloroform (15 mL), $POCl_3$ (0.212 mL, 2.28 mmol) and 2,6-lutidine (0.256 mL, 2.28 mmol). Heat the reaction at reflux overnight. Concentrate the mixture under reduced pressure. Dissolve the resulting residue in EtOAc (50 mL) and extract with water (50 mL), saturated $NaHCO_3$ (aq) (50 mL) and brine (50 mL). Dry the organic extract over Na_2SO_4 and remove the solvent under reduced pressure. Purify the crude product by column chromatography on silica gel eluting with hexanes/EtOAc (1:1) to yield the title compound as a white solid.

6. 4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)[2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-yl]-amine

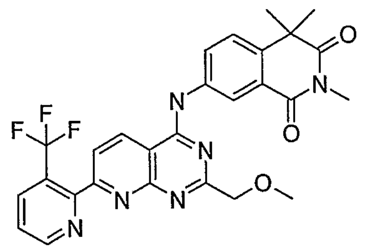
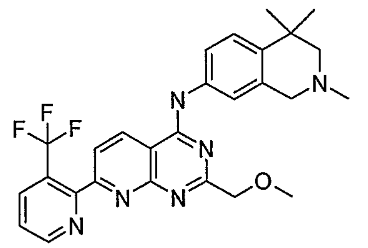
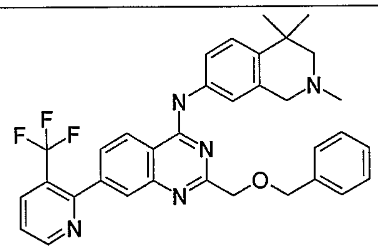
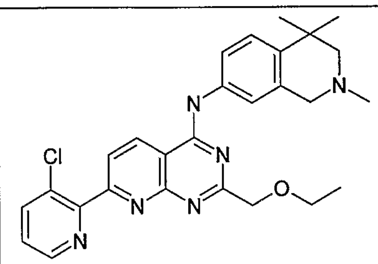
Dissolve 4-chloro-2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridine (100 mg, 0.282 mmol) and 4,4-dimethyl-1,2,3,4-tetrahydro-quinoline (54.8 mg, 0.311 mmol) in a solution of isopropyl alcohol (3 mL) and 2 M HCl (6 drops, ether). Stir the mixture overnight at room temperature. Concentrate the solution under reduced pressure. Dissolve the crude reaction mixture in EtOAc (25 mL) and 1 N NaOH (25 mL). Remove the organic phase and dry over Na_2SO_4. Remove the solvent under reduced pressure. Purify the crude mixture using silica gel preparatory TLC eluting with CH_2Cl_2/MeOH (93:7) to yield the title compound. Mass Spec (M+1) 494.28. The IC_{50} is less than 1 micromolar.

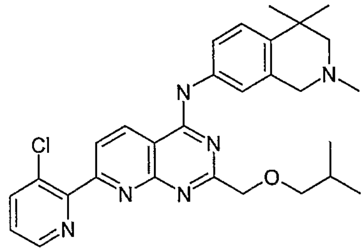
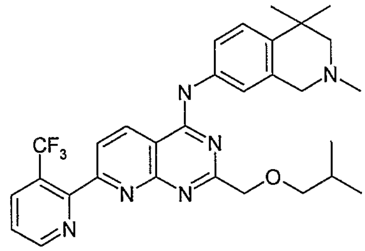
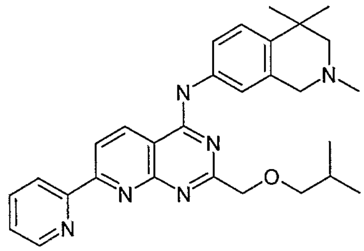
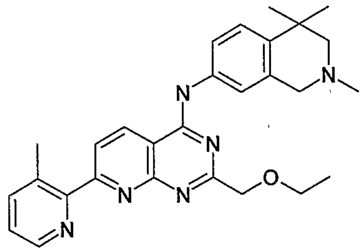
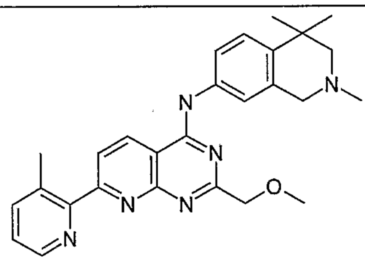
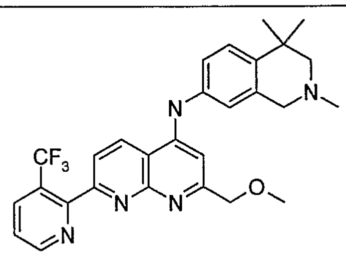
EXAMPLE 3

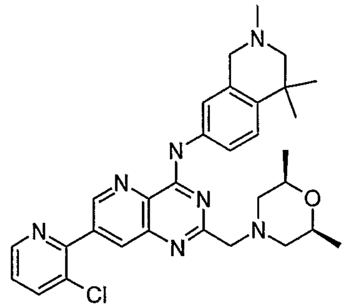
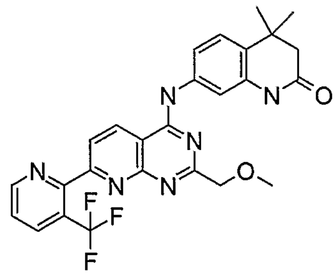
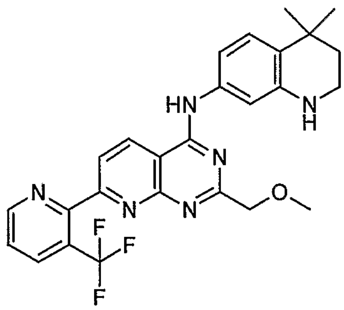
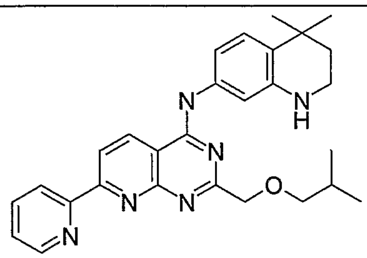
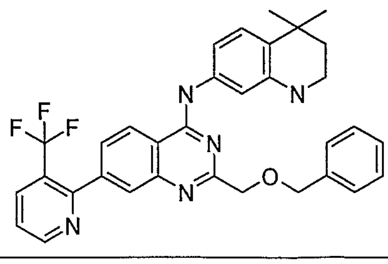
Additional Substituted Bicyclic Quinazoline-4-ylamine Derivatives

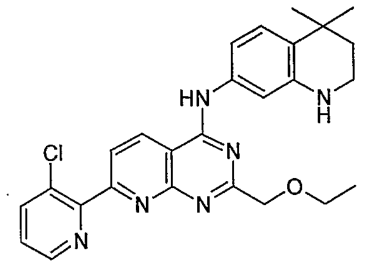
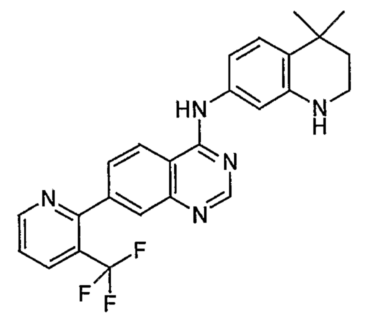
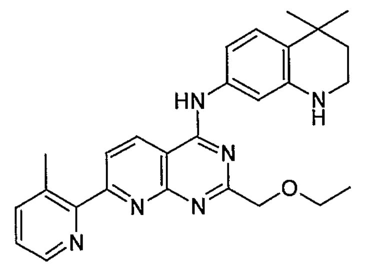
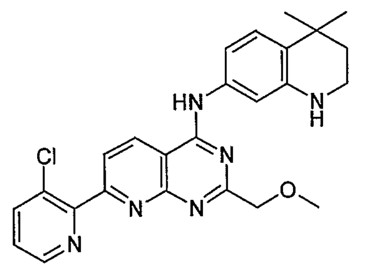
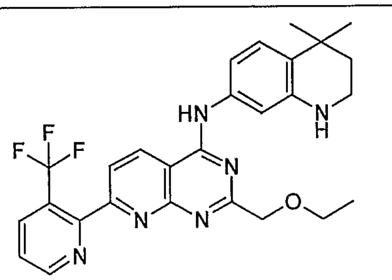
Using the methods provided above, with starting materials and minor variations that will be apparent to those of ordinary skill in the art, the following compounds are prepared. In Table 1, mass spectroscopy data is obtained as described above. In the column labeled "EC_{50}/IC_{50}," a "*" indicates that the EC_{50} or IC_{50}, determined as described in Example 6, herein, is 1 micromolar or less.

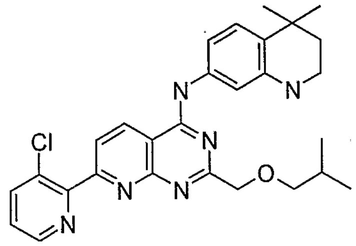
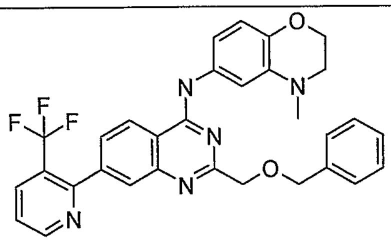
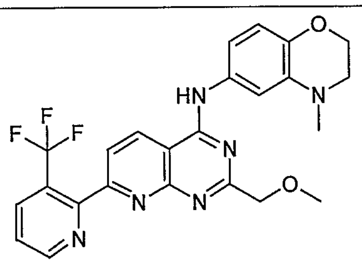
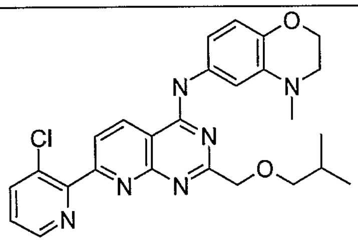
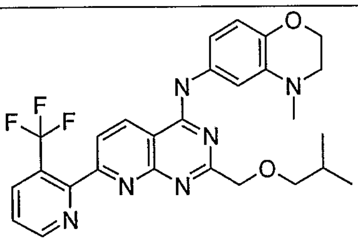
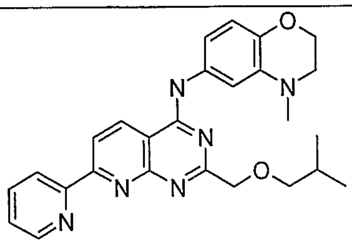
Table 1

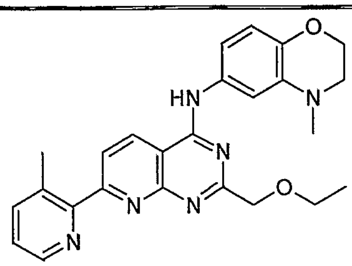
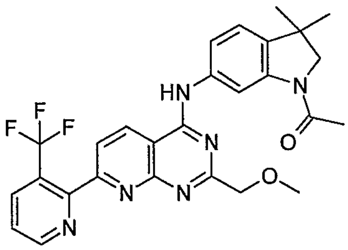
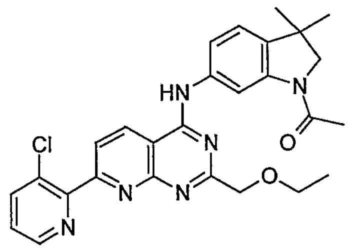
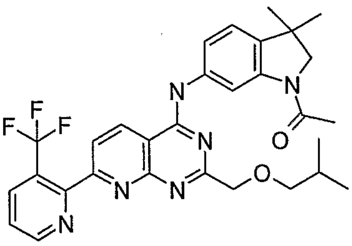
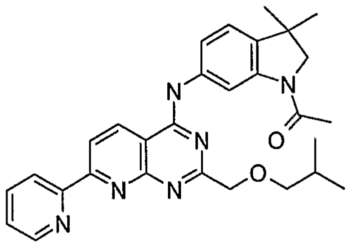
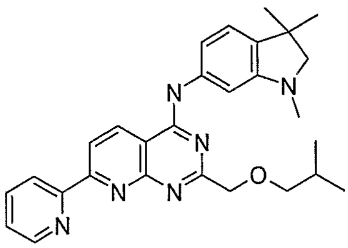
	Compound	Name	MS (M+1)	EC_{50} /IC_{50}
11.		7-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-2,4,4-trimethyl-4H-isoquinoline-1,3-dione	537.17	*
12.		[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	509.23	*
13.		[2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	583	*
14.		[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	488	*

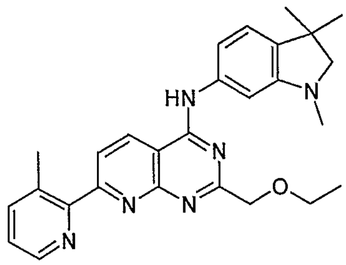
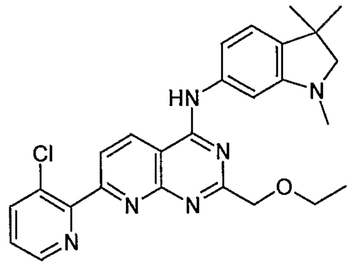
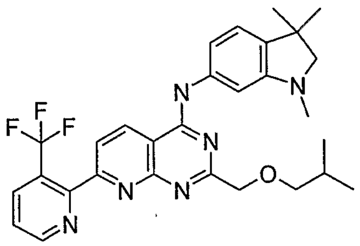
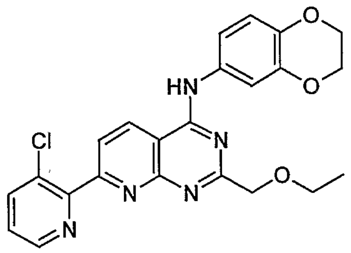
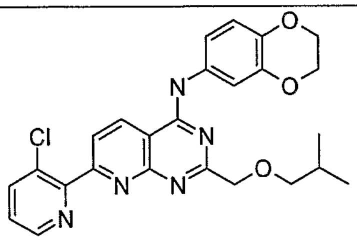
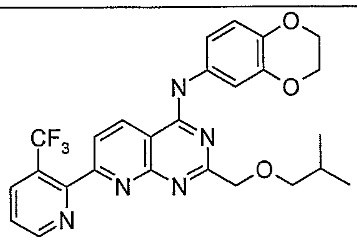
	Compound	Name	MS (M+1)	EC_{50} /IC_{50}
15.		[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	516	*
16.		[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	550	*
17.		(2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	483.3	*
18.		[2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	469.3	*
19.		[2-Methoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	455.3	*
20.		[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	508.3	*

	Compound	Name	MS (M+1)	EC_{50} /IC_{50}
21.		[7-(3-Chloro-pyridin-2-yl)-2-(2,6-dimethyl-morpholin-4-ylmethyl)-pyrido[3,2-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine	558.4	*
22.		7-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-4,4-dimethyl-3,4-dihydro-1H-quinolin-2-one	509.3	*
23.		(4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine	495.2	*
24.		(4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-(2-isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-amine	469.3	*
25.		[2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine	570	*

	Compound	Name	MS (M+1)	EC_{50} /IC_{50}
26.		[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine	475	*
27.		(4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-amine	450	*
28.		(4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine	455.27	*
29.		[7-(3-Chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine	461.2	*
30.		(4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-ethoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine	509.3	*

Compound		Name	MS (M+1)	EC_{50} /IC_{50}
31.		[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine	503.3	*
32.		[2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	558.27	*
33.		[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	483.2	*
34.		[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	491.2	*
35.		[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	525.3	*
36.		(2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	457.25	*

	Compound	Name	MS (M+1)	EC_{50} / IC_{50}
37.		[2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine	443.22	*
38.		1-{6-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone	523.28	*
39.		1-{6-[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone	503.26	*
40.		1-{6-[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone	565.32	*
41.		1-[6-(2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-ylamino)-3,3-dimethyl-2,3-dihydro-indol-1-yl]-ethanone	497.29	*
42.		(2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine	469.3	*

	Compound	Name	MS (M+1)	EC_{50} / IC_{50}
43.		[2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine	455.29	*
44.		[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine	475.25	*
45.		[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine	537.3	*
46.		[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,3-dihydro-benzo[1,4]dioxin-6-yl)-amine	450.12	*
47.		[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,3-dihydro-benzo[1,4]dioxin-6-yl)-amine	478.16	*
48.		(2,3-Dihydro-benzo[1,4]dioxin-6-yl)-[2-isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine	512.18	*

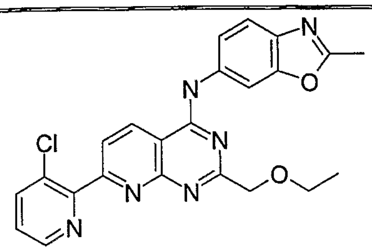
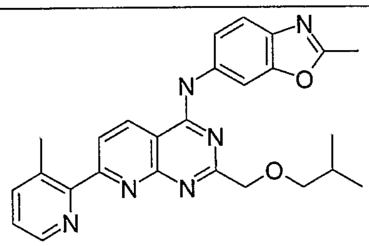
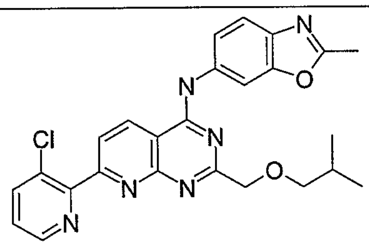
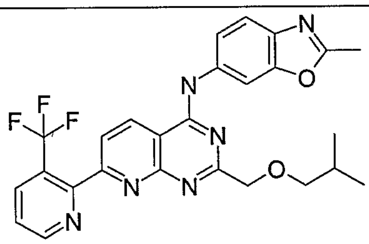
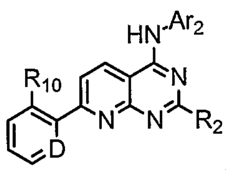
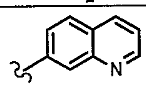
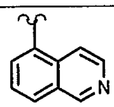
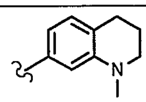
	Compound	Name	MS (M+1)	EC_{50} /IC_{50}
49.		[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine	447.15	*
50.		[2-Isobutoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine	455.22	*
51.		[7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine	475.16	*
52.		[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine	509.20	*

Table 2



Compound	**D**	**R_{10}**	**R_2**	**Ar_2**
53	N	CF_3	CH_2OMe	
54	N	CF_3	CH_2OMe	
55	N	CF_3	CH_2OMe	

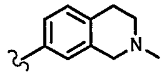
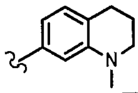
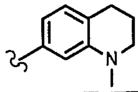
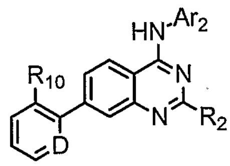
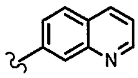
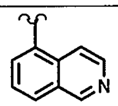
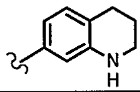
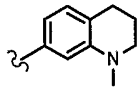
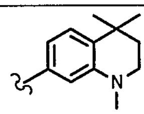
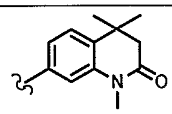
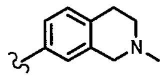
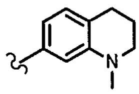
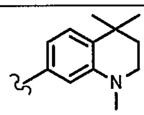
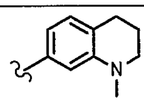
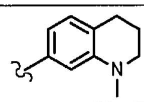
56	N	CF_3	CH_2OMe	
57	N	CF_3	$CH_2OCH_2CH(CH_3)_2$	
58	CH	CF_3	H	

Table 3



Compound	D	R_{10}	R_2	Ar_2
59	N	CF_3	CH_2OMe	
60	N	CF_3	CH_2OMe	
61	N	CF_3	CH_2OMe	
62	N	CF_3	CH_2OMe	
63	N	CF_3	CH_2OMe	
64	N	CF_3	CH_2OMe	
65	N	CF_3	CH_2OMe	
66	N	CF_3	$CH_2OCH_2CH(CH_3)_2$	
67	N	CF_3	$CH_2OCH_2CH(CH_3)_2$	
68	N	Cl	CH_2OMe	
69	CH	CF_3	H	

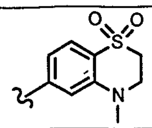
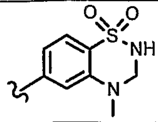
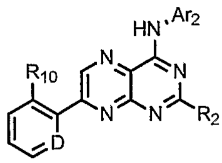
70	N	CF_3	CH_2OMe	
71	N	CF_3	CH_2OMe	

Table 4



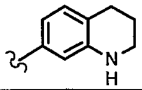
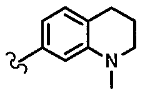
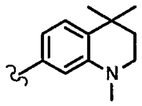
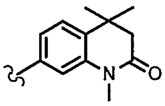
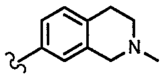
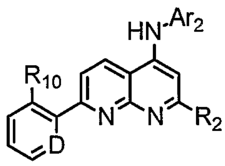
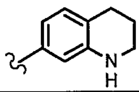
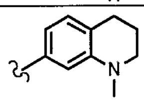
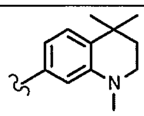
Compound	D	R_{10}	R_2	Ar_2
72	N	CF_3	H	
73	N	CF_3	H	
74	N	CF_3	H	
75	N	CF_3	H	
76	N	CF_3	H	

Table 5



Compound	D	R_{10}	R_2	Ar_2
77	N	CF_3	CH_2OMe	
78	N	CF_3	CH_2OMe	
79	N	CF_3	CH_2OMe	

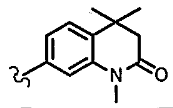
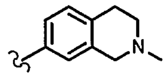
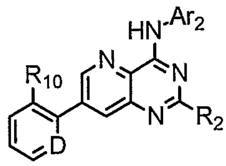
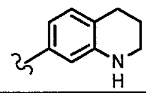
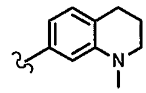
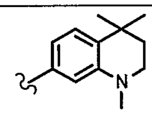
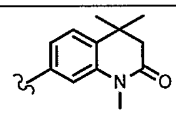
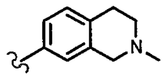
80	N	CF_3	CH_2OMe	
81	N	CF_3	CH_2OMe	

Table 6



Compound	D	R_{10}	R_2	Ar_2
82	N	CF_3	CH_2OMe	
83	N	CF_3	CH_2OMe	
84	N	CF_3	CH_2OMe	
85	N	CF_3	CH_2OMe	
86	N	CF_3	CH_2OMe	

EXAMPLE 4

VR1-Transfected Cells and Membrane Preparations

This Example illustrates the preparation of VR1-transfected cells and membrane preparations for use in binding assays (Example 5) and functional assays (Example 6).

A cDNA encoding full length human capsaicin receptor (SEQ ID NO:1, 2 or 3 of U.S. Patent No. 6,482,611) was subcloned in the plasmid pBK-CMV (Stratagene, La Jolla, CA) for recombinant expression in mammalian cells.

Human embryonic kidney (HEK293) cells were transfected with the pBK-CMV expression construct encoding the full length human capsaicin receptor using standard methods. The transfected cells were selected for two weeks in media containing G418 (400 μg/ml) to obtain a pool of stably transfected cells. Independent clones were isolated from this pool by limiting dilution to obtain clonal stable cell lines for use in subsequent experiments.

For radioligand binding experiments, cells were seeded in T175 cell culture flasks in media without antibiotics and grown to approximately 90% confluency. The flasks were then washed with PBS and harvested in PBS containing 5 mM EDTA. The cells were pelleted by gentle centrifugation and stored at –80°C until assayed.

Previously frozen cells were disrupted with the aid of a tissue homogenizer in ice-cold HEPES homogenization buffer (5mM KCl 5, 5.8mM NaCl, 0.75mM $CaCl_2$, 2mM $MgCl_2$, 320 mM sucrose, and 10 mM HEPES pH 7.4). Tissue homogenates were first centrifuged for 10 minutes at 1000 x g (4°C) to remove the nuclear fraction and debris, and then the supernatant from the first centrifugation is further centrifuged for 30 minutes at 35,000 x g (4°C) to obtain a partially purified membrane fraction. Membranes were resuspended in the HEPES homogenization buffer prior to the assay. An aliquot of this membrane homogenate is used to determine protein concentration via the Bradford method (BIO-RAD Protein Assay Kit, #500-0001, BIO-RAD, Hercules, CA).

EXAMPLE 5

Capsaicin Receptor Binding Assay

This Example illustrates a representative assay of capsaicin receptor binding that may be used to determine the binding affinity of compounds for the capsaicin (VR1) receptor.

Binding studies with [^{3}H] Resiniferatoxin (RTX) are carried out essentially as described by Szallasi and Blumberg (1992) *J. Pharmacol. Exp. Ter. 262*:883-888. In this protocol, non-specific RTX binding is reduced by adding bovine alpha$_1$ acid glycoprotein (100 µg per tube) after the binding reaction has been terminated.

[^{3}H] RTX (37 Ci/mmol) is synthesized by and obtained from the Chemical Synthesis and Analysis Laboratory, National Cancer Institute-Frederick Cancer Research and Development Center, Frederick, MD. [^{3}H] RTX may also be obtained from commercial vendors (*e.g.*, Amersham Pharmacia Biotech, Inc.; Piscataway, NJ).

The membrane homogenate of Example 4 is centrifuged as before and resuspended to a protein concentration of 333µg/ml in homogenization buffer. Binding assay mixtures are set up on ice and contain [^{3}H]RTX (specific activity 2200 mCi/ml), 2 µl non-radioactive test compound, 0.25 mg/ml bovine serum albumin (Cohn fraction V), and 5 x 10^4 - 1 x 10^5 VR1-transfected cells. The final volume is adjusted to 500 µl (for competition binding assays) or 1,000 µl (for saturation binding assays) with the ice-cold HEPES homogenization buffer solution (pH 7.4) described above. Non-specific binding is defined as that occurring in the presence of 1 μM non-radioactive RTX (Alexis Corp.; San Diego, CA). For saturation binding, [^{3}H]RTX is added in the concentration range of 7 - 1,000 pM, using 1 to 2 dilutions. Typically 11 concentration points are collected per saturation binding curve.

Competition binding assays are performed in the presence of 60 pM [^{3}H]RTX and various concentrations of test compound. The binding reactions are initiated by transferring the assay mixtures into a 37°C water bath and are terminated following a 60 minute incubation period by cooling the tubes on ice. Membrane-bound RTX is separated from free, as well as any alpha$_1$-acid glycoprotein-bound RTX, by filtration onto WALLAC glass fiber filters (PERKIN-ELMER, Gaithersburg, MD) which were pre-soaked with 1.0% PEI (polyethyleneimine) for 2 hours prior to use. Filters are allowed to dry overnight then counted in a WALLAC 1205 BETA PLATE counter after addition of WALLAC BETA SCINT scintillation fluid.

Equilibrium binding parameters are determined by fitting the allosteric Hill equation to the measured values with the aid of the computer program FIT P (Biosoft, Ferguson, MO) as described by Szallasi, *et al.* (1993) *J. Pharmacol. Exp. Ther.* 266:678-683. Compounds provided herein generally exhibit K_i values for capsaicin receptor of less than 1 μM, 100 nM, 50 nM, 25 nM, 10 nM or 1nM in this assay.

EXAMPLE 6

Calcium Mobilization Assay

This Example illustrates a representative calcium mobilization assay for use in monitoring the response of cells expressing capsaicin receptor to capsaicin and other vanilloid ligands of the capsaicin receptor, as well as for evaluating test compounds for agonist and antagonist activity.

Cells transfected with expression plasmids (as described in Example 4) and thereby expressing human capsaicin receptor are seeded and grown to 70-90% confluency in FALCON black-walled, clear-bottomed 96-well plates (#3904, BECTON-DICKINSON, Franklin Lakes, NJ). The culture medium is emptied from the 96 well plates and FLUO-3 AM calcium sensitive dye (Molecular Probes, Eugene, OR) is added to each well (dye solution: 1 mg FLUO-3 AM, 440 μL DMSO and 440 μl 20% pluronic acid in DMSO, diluted 1:250 in Krebs-Ringer HEPES (KRH) buffer (25 mM HEPES, 5 mM KCl, 0.96 mM NaH_2PO_4, 1 mM $MgSO_4$, 2 mM $CaCl_2$, 5 mM glucose, 1 mM probenecid, pH 7.4), 50 μl diluted solution per well). Plates are covered with aluminum foil and incubated at 37°C for

1-2 hours in an environment containing 5% CO_2. After the incubation, the dye is emptied from the plates, and the cells are washed once with KRH buffer, and resuspended in KRH buffer.

Agonist (*e.g.*, olvanil, capsaicin or RTX)-induced calcium mobilization is monitored using either FLUOROSKAN ASCENT (Labsystems, Franklin, MA) or FLIPR (fluorometric imaging plate reader system, Molecular Devices, Sunnyvale, CA) instruments. Varying concentrations of the antagonists ruthenium red or capsazepine (RBI; Natick, MA) are added to cells concurrently with agonist (*e.g.*, 25-50 nM capsaicin). For agonist-induced calcium responses, data obtained between 30 and 60 seconds after agonist application are used to generate the IC_{50} values. KALEIDAGRAPH software (Synergy Software, Reading, PA) is used to fit the data to the equation:

$$y=a*(1/(1+(b/x)^c))$$

to determine the IC_{50} for the response. In this equation, y is the maximum fluorescence signal, x is the concentration of the agonist or antagonist, a is the E_{max}, b corresponds to the IC_{50} value and c is the Hill coefficient.

To measure the ability of a test compound to antagonize (inhibit) the response of cells expressing capsaicin receptors to capsaicin or other vanilloid agonist, the IC_{50} of capsaicin is first determined. An additional 20 μl of KRH buffer and 1 μl DMSO is added to each well of cells, prepared as described above. 100 μl capsaicin in KRH buffer is automatically transferred by the FLIPR instrument to each well. An 8-point concentration response curve, with final capsaicin concentrations of 1 nM to 3 μM, is used to determine capsaicin IC_{50}.

Test compounds are dissolved in DMSO, diluted in 20 μl KRH buffer so that the final concentration of test compounds in the assay well is between 1 μM and 5 μM, and added to cells prepared as described above. The 96 well plates containing prepared cells and test compounds are incubated in the dark, at room temperature for 0.5 to 6 hours. It is important that the incubation not continue beyond 6 hours. Just prior to determining the fluorescence response, 100 μl capsaicin in KRH buffer at twice the IC_{50} concentration determined from the concentration response curve is automatically added by the FLIPR instrument to each well of the 96 well plate for a final sample volume of 200 μl and a final capsaicin concentration equal to the IC_{50}. The final concentration of test compounds in the assay wells is between 1 μM and 5 μM. Typically cells exposed to one IC_{50} of capsaicin exhibit a fluorescence response of about 10,000 Relative Fluorescence Units. Antagonists of the capsaicin receptor decrease this response by at least about 20%, preferably by at least about 50%, and most preferably by at least 80% as compared to matched control. The concentration of antagonist required to provide a 50% decrease is the IC_{50} for the antagonist, and is preferably below 1 micromolar, 100 nanomolar, 10 nanomolar or 1 nanomolar.

The ability of a compound to act as an agonist of the capsaicin receptor is determined by measuring the fluorescence response of cells expressing capsaicin receptors, using the methods described above, in the absence of capsaicin, RTX or other capsaicin receptor agonists. Compounds that cause cells to exhibit fluorescence above background are capsaicin receptor agonists. Certain preferred compounds of the present invention are antagonists that are essentially free of agonist activity as demonstrated by the absence of detectable agonist activity in such an assay at compound concentrations below 4 nM, more preferably at concentrations below 10 μM and most preferably at concentrations less than or equal to 100 μM.

EXAMPLE 7

Microsomal *in vitro* half-life

This Example illustrates the evaluation of compound half-life values ($t_{1/2}$ values) using a representative liver microsomal half-life assay.

Pooled human liver microsomes are obtained from XenoTech LLC, 3800 Cambridge St., Kansas City, Kansas 66103 (catalog # H0610). Such liver microsomes may also be obtained from In Vitro Technologies (Baltimore, MD) or Tissue Transformation Technologies (Edison, NJ). Six test reactions are prepared, each containing 25 μL microsomes, 5 μL of a 100 μM solution of test compound, and 399 μL 0.1 M phosphate buffer (19 mL 0.1 M NaH_2PO_4, 81 mL 0.1 M Na_2HPO_4, adjusted to pH 7.4 with H_3PO_4). A seventh reaction is prepared as a positive control containing 25 μL microsomes, 399 μL 0.1 M phosphate buffer, and 5 μL of a 100 μM solution of a compound with known metabolic properties (*e.g.*, DIAZEPAM or CLOZAPINE). Reactions are preincubated at 39°C for 10 minutes.

CoFactor Mixture is prepared by diluting 16.2 mg NADP and 45.4 mg Glucose-6-phosphate in 4 mL 100 mM $MgCl_2$. Glucose-6-phosphate dehydrogenase solution is prepared by diluting 214.3 μL glucose-6-phosphate dehydrogenase suspension (Boehringer-Manheim catalog no. 0737224, distributed by Roche Molecular Biochemicals, Indianapolis, IN) into 1285.7 μL distilled water. 71 μL Starting Reaction Mixture (3 mL CoFactor Mixture; 1.2 mL Glucose-6-phosphate dehydrogenase solution) is added to 5 of the 6 test reactions and to the positive control. 71 µL 100 mM $MgCl_2$ is added to the sixth test reaction, which is used as a negative control. At each time point (0, 1, 3, 5, and 10 minutes), 75 µL of each reaction mix is pipetted into a well of a 96-well deep-well plate containing 75 µL ice-cold acetonitrile. Samples are vortexed and centrifuged 10 minutes at 3500 rpm (Sorval T 6000D centrifuge, H1000B rotor). 75 µL of supernatant from each reaction is transferred to a well of a 96-well plate containing 150 µL of a 0.5 µM solution of a compound with a known LCMS profile (internal standard) per well. LCMS analysis of each sample is carried out and the amount of unmetabolized test compound is measured as AUC, compound concentration vs. time is plotted, and the $t_{1/2}$ value of the test compound is extrapolated.

Preferred compounds of the present invention exhibit *in vitro* $t_{1/2}$ values of greater than 10 minutes and less than 4 hours, preferably between 30 minutes and 1 hour, in human liver microsomes.

EXAMPLE 8

MDCK Toxicity Assay

This Example illustrates the evaluation of compound toxicity using a Madin Darby canine kidney (MDCK) cell cytotoxicity assay.

1 µL of test compound is added to each well of a clear bottom 96-well plate (PACKARD, Meriden, CT) to give final concentration of compound in the assay of 10 micromolar, 100 micromolar or 200 micromolar. Solvent without test compound is added to control wells.

MDCK cells, ATCC no. CCL-34 (American Type Culture Collection, Manassas, VA), are maintained in sterile conditions following the instructions in the ATCC production information sheet. Confluent MDCK cells are trypsinized, harvested, and diluted to a concentration of 0.1 x 10^6 cells/ml with warm (37°C) medium (VITACELL Minimum Essential Medium Eagle, ATCC catalog # 30-2003). 100 µL of diluted cells is added to each well, except for five standard curve control wells that contain 100 µL of warm medium without cells. The plate is then incubated at 37°C under 95% O_2, 5% CO_2 for 2 hours with constant shaking. After incubation, 50 µL of mammalian cell lysis solution is added per well, the wells are covered with PACKARD TOPSEAL stickers, and plates are shaken at approximately 700 rpm on a suitable shaker for 2 minutes.

Compounds causing toxicity will decrease ATP production, relative to untreated cells. The PACKARD, (Meriden, CT) ATP-LITE-M Luminescent ATP detection kit, product no. 6016941, is generally used according to the manufacturer's instructions to measure ATP production in treated and untreated MDCK cells. PACKARD ATP LITE-M reagents are allowed to equilibrate to room temperature. Once equilibrated, the lyophilized substrate solution is reconstituted in 5.5 mls of substrate buffer solution (from kit). Lyophilized ATP standard solution is reconstituted in deionized water to give a 10 mM stock. For the five control wells, 10 µL of serially diluted PACKARD standard is added to each of the standard curve control wells to yield a final concentration in each subsequent well of 200 nM, 100 nM, 50 nM, 25 nM and 12.5 nM. PACKARD substrate solution (50 µL) is added to all wells, which are then covered, and the plates are shaken at approximately 700 rpm on a suitable shaker for 2 minutes. A white PACKARD sticker is attached to the bottom of each plate and samples are dark adapted by wrapping plates in foil and placing in the dark for 10 minutes. Luminescence is then measured at 22°C using a luminescence counter (*e.g.*, PACKARD TOPCOUNT Microplate Scintillation and Luminescence Counter or TECAN SPECTRAFLUOR PLUS), and ATP levels calculated from the standard curve. ATP levels in cells treated with test compound(s) are compared to the levels determined for untreated cells. Cells treated with 10 µM of a preferred test compound exhibit ATP levels that are at least 80%, preferably at least 90%, of the untreated cells. When a 100 µM concentration of the test compound is used, cells treated with preferred test compounds exhibit ATP levels that are at least 50%, preferably at least 80%, of the ATP levels detected in untreated cells.

EXAMPLE 9

Dorsal Root Ganglion Cell Assay

This Example illustrates a representative dorsal root ganglian cell assay for evaluating VR1 antagonist activity of a compound.

DRG are dissected from neonatal rats, dissociated and cultured using standard methods (Aguayo and White (1992) *Brain Research 570*:61-67). After 48 hour incubation, cells are washed once and incubated for 30-60 minutes with the calcium sensitive dye Fluo 4 AM (2.5-10 ug/ml; TefLabs, Austin, TX). Cells are then washed once, and various concentrations of compound is added to the cells. Addition of capsaicin to the cells results in a VR1-dependent increase in intracellular calcium levels which is monitored by a change in Fluo-4 fluorescence with a fluorometer. Data are collected for 60-180 seconds to determine the maximum fluorescent signal. Fluorescent signal is then plotted as a function of compound concentration to identify the concentration required to achieve a 50% inhibition of the capsaicin-activated response, or IC_{50}. Antagonists of the capsaicin receptor preferably have an IC_{50} below 1 micromolar, 100 nanomolar, 10 nanomolar or 1 nanomolar.

EXAMPLE 10

Animal Models for Determining Pain Relief

This Example illustrates representative methods for assessing the degree of pain relief provided by a compound.

A. Pain Relief Testing

The following methods may be used to assess pain relief.

MECHANICAL ALLODYNIA

Mechanical allodynia (an abnormal response to an innocuous stimulus) is assessed essentially as described by Chaplan *et al.* (1994) *J. Neurosci. Methods* 53:55-63 and Tal and Eliav (1998) *Pain* 64(3):511-518. A series of von Frey filaments of varying rigidity (typically 8-14 filaments in a series) are applied to the plantar surface of the hind paw with just enough force to bend the filament. The filaments are held in this position for no more than three seconds or until a positive allodynic response is displayed by the rat. A positive allodynic response consists of lifting the affected paw followed immediately by licking or shaking of the paw. The order and frequency with which the individual filaments are applied are determined by using Dixon up-down method. Testing is initiated with the middle hair of the series with subsequent filaments being applied in consecutive fashion, ascending or descending, depending on whether a negative or positive response, respectively, is obtained with the initial filament.

Compounds are effective in reversing or preventing mechanical allodynia-like symptoms if rats treated with such compounds require stimulation with a Von Frey filament of higher rigidity strength to provoke a positive allodynic response as compared to control untreated or vehicle treated rats. Alternatively, or in addition, testing of an animal in chronic pain may be done before and after compound administration. In such an assay, an effective compound results in an increase in the rigidity of the filament needed to induce a response after treatment, as compared to the filament that induces a response before treatment or in an animal that is also in chronic pain but is left untreated or is treated with vehicle. Test compounds are administered before or after onset of pain. When a test compound is administered after pain onset, testing is performed 10 minutes to three hours after administration.

MECHANICAL HYPERALGESIA

Mechanical hyperalgesia (an exaggerated response to painful stimulus) is tested essentially as described by Koch et al. (1996) *Analgesia* 2(3):157-164. Rats are placed in individual compartments of a cage with a warmed, perforated metal floor. Hind paw withdrawal duration (*i.e.,* the amount of time for which the animal holds its paw up before placing it back on the floor) is measured after a mild pinprick to the plantar surface of either hind paw.

Compounds produce a reduction in mechanical hyperalgesia if there is a statistically significant decrease in the duration of hindpaw withdrawal. Test compound may be administered before or after onset of pain. For compounds administered after pain onset, testing is performed 10 minutes to three hours after administration.

THERMAL HYPERALGESIA

Thermal hyperalgesia (an exaggerated response to noxious thermal stimulus) is measured essentially as described by Hargreaves *et al.* (1988) *Pain.* 32(1):77-88. Briefly, a constant radiant heat source is applied the animals' plantar surface of either hind paw. The time to withdrawal *(i.e.,* the amount of time that heat is applied before the animal moves its paw), otherwise described as thermal threshold or latency, determines the animal's hind paw sensitivity to heat.

Compounds produce a reduction in thermal hyperalgesia if there is a statistically significant increase in the time to hindpaw withdrawal (*i.e.,* the thermal threshold to response or latency is increased). Test compound may be administered before or after onset of pain. For compounds administered after pain onset, testing is performed 10 minutes to three hours after administration.

B. Pain Models

Pain may be induced using any of the following methods, to allow testing of analgesic efficacy of a compound. In general, compounds provided herein result in a statistically significant reduction in pain as determined by at least one of the previously described testing methods, using male SD rats and at least one of the following models.

ACUTE INFLAMMATORY PAIN MODEL

Acute inflammatory pain is induced using the carrageenan model essentially as described by Field *et al.* (1997) *Br. J. Pharmacol.* 121(8):1513-1522. 100-200 µl of 1-2% carrageenan solution is injected into the rats' hind paw. Three to four hours following injection, the animals' sensitivity to thermal and mechanical stimuli is tested using the methods described above. A test compound (0.01 to 50 mg/kg) is administered to the animal, prior to testing, or prior to injection of carrageenan. The compound can be administered orally or through any parenteral route, or topically on the paw. Compounds that relieve pain in this model result in a statistically significant reduction in mechanical allodynia and/or thermal hyperalgesia.

CHRONIC INFLAMMATORY PAIN MODEL

Chronic inflammatory pain is induced using one of the following protocols:

1. Essentially as described by Bertorelli *et al.* (1999) *Br. J. Pharmacol.* 128(6):1252-1258, and Stein *et al.* (1998) *Pharmacol. Biochem. Behav.* 31(2):455-51, 200 µL Complete Freund's Adjuvant (0.1 mg heat killed and dried *M. Tuberculosis*) is injected to the rats' hind paw: 100 µL into the dorsal surface and 100 µL into the plantar surface.
2. Essentially as described by Abbadie *et al.* (1994) *J Neurosci.* 14(10):5865-5871 rats are injected with 150 µL of CFA (1.5 mg) in the tibio-tarsal joint.

Prior to injection with CFA in either protocol, an individual baseline sensitivity to mechanical and thermal stimulation of the animals' hind paws is obtained for each experimental animal.

Following injection of CFA, rats are tested for thermal hyperalgesia, mechanical allodynia and mechanical hyperalgesia as described above. To verify the development of symptoms, rats are tested on days 5, 6, and 7 following CFA injection. On day 7, animals are treated with a test compound, morphine or vehicle. An oral dose of morphine of 1-5 mg/kg is suitable as positive control. Typically, a dose of 0.01-50 mg/kg of test compound is used. Compounds can be administered as a single bolus prior to testing or once or twice or three times daily, for several days prior to testing. Drugs are administered orally or through any parenteral route, or applied topically to the animal.

Results are expressed as Percent Maximum Potential Efficacy (MPE). 0% MPE is defined as analgesic effect of vehicle, 100% MPE is defined as an animal's return to pre-CFA baseline sensitivity. Compounds that relieve pain in this model result in a MPE of at least 30%.

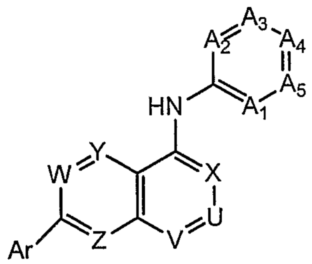
CHRONIC NEUROPATHIC PAIN MODEL

Chronic neuropathic pain is induced using the chronic constriction injury (CCI) to the rat's sciatic nerve essentially as described by Bennett and Xie (1988) *Pain* 33:87-107. Rats are anesthetized (*e.g.* with an intraperitoneal dose of 50-65 mg/kg pentobarbital with additional doses administered as needed). The lateral aspect of each hind limb is shaved and disinfected. Using aseptic technique, an incision is made on the lateral aspect of the hind limb at the mid thigh level. The biceps femoris is bluntly dissected and the sciatic nerve is exposed. On one hind limb of each animal, four loosely tied ligatures are made around the sciatic nerve approximately 1-2 mm apart. On the other side the sciatic nerve is not ligated and is not manipulated. The muscle is closed with continuous pattern and the skin is closed with wound clips or sutures. Rats are assessed for mechanical allodynia, mechanical hyperalgesia and thermal hyperalgesia as described above.

Compounds that relieve pain in this model result in a statistically significant reduction in mechanical allodynia, mechanical hyperalgesia and/or thermal hyperalgesia when administered (0.01-50 mg/kg, orally, parenterally or topically) immediately prior to testing as a single bolus, or for several days: once or twice or three times daily prior to testing.

What is claimed is:

1. A compound of the formula:



or a pharmaceutically acceptable salt thereof, wherein:

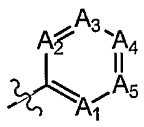
A_2, V, X, W, Y and Z are each independently N or CR_1, such that at least one of V and X is N;

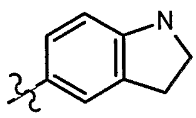
A_3 is N or CR_9;

Either:

(i) A_4 is joined to A_5 to form a fused 5- to 7-membered carbocyclic or heterocyclic ring, each of which is substituted with from 0 to 6 substituents independently chosen from R_8; and A_1 is N or CR_1;

such the group designated



is not


that is substituted with C_1-C_6alkylsulfonyl; or

(ii) A_1 is joined to A_5 to form a fused 5- to 7-membered carbocyclic or heterocyclic ring that is substituted with from 0 to 6 substituents independently chosen from R_8, and A_4 is N or CR_9;

R_1 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy and mono- and di-(C_1-C_6alkyl)amino;

R_8 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, oxo, -COOH, C_1-C_6alkyl, C_1-C_6alkenyl, C_1-C_6alkynyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6aminoalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_6alkanoyl, mono- and di-(C_1-C_6alkyl)aminoC_0-C_6alkyl, (5- to 7-membered heterocycloalkyl)C_0-C_6alkyl, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

R_9 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

U is N or CR_2, with the proviso that if V and X are both N, then U is CR_2;

R_2 is:

(i) hydrogen, halogen, cyano or –COOH; or

(ii) a group of the formula –R_c-M-A-R_y, wherein:

R_c is C_0-C_3alkylene or is joined to R_y or R_z to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 2 substituents independently selected from R_b;

M is absent, a single covalent bond, O, S, SO, SO_2, C(=O), OC(=O), C(=O)O, O-C(=O)O, C(=O)N(R_z), OC(=O)N(R_z), N(R_z)C(=O), N(R_z)SO_2, SO_2N(R_z) or N(R_z);

A is absent, a single covalent bond or C_1-C_8alkylene substituted with from 0 to 3 substituents independently selected from R_b; and

R_y and R_z, if present, are:

(a) independently hydrogen, C_1-C_8alkyl, C_2-C_8alkanone, C_2-C_8alkyl ether, C_2-C_8alkenyl, a 4- to 10-membered carbocycle or heterocycle, or joined to R_c to form a 4- to 10-membered carbocycle or heterocycle, wherein each R_y and R_z is independently substituted with from 0 to 6 substituents independently selected from R_b; or

(b) joined to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 6 substituents independently selected from R_b;

Ar is selected from 5- to 10-membered aromatic carbocycles and heterocycles, each of which is substituted with from 0 to 3 substituents independently selected from R_1, such that Ar is not thiophene; and

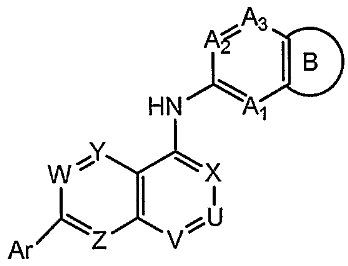
R_b is independently chosen at each occurrence from:

(i) hydroxy, halogen, amino, aminocarbonyl, cyano, nitro, oxo and –COOH; and

(ii) C_1-C_8alkyl, C_1-C_8alkoxy, C_1-C_8alkanoyl, C_2-C_8alkoxycarbonyl, C_2-C_8alkanoyloxy, C_1-C_8alkylthio, C_2-C_8alkyl ether, phenylC_0-C_8alkyl, phenylC_1-C_8alkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_8alkylsulfonyl, and (4- to 7-membered heterocycle)C_0-C_8alkyl;

wherein each of (ii) is substituted with from 0 to 3 substituents independently chosen from hydroxy, halogen, amino and cyano.

2. A compound of the formula:

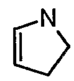


or a pharmaceutically acceptable salt thereof, wherein:

A_1, A_2, V, X, W, Y and Z are each independently N or CR_1, such that at least one of V and X is N;

A_3 is N or CR_9;

U is N or CR_2, such that if V and X are both N, then U is CR_2;

 is a 5- to 7-membered aromatic or partially saturated carbocyclic or heterocyclic ring, each of which is substituted with from 0 to 6 substituents independently chosen from R_8, such that  is not  that is substituted with C_1-C_6alkylsulfonyl;

R_1 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy and mono- and di-(C_1-C_6alkyl)amino;

R_2 is:

(i) hydrogen, halogen, cyano or –COOH; or

(ii) a group of the formula $-R_c$-M-A-R_y, wherein:

R_c is C_0-C_3alkylene or is joined to R_y or R_z to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 2 substituents independently selected from R_b;

M is absent, a single covalent bond, O, S, SO, SO_2, C(=O), OC(=O), C(=O)O, O-C(=O)O, C(=O)N(R_z), OC(=O)N(R_z), N(R_z)C(=O), N(R_z)SO_2, SO_2N(R_z) or N(R_z);

A is absent, a single covalent bond or C_1-C_8alkylene substituted with from 0 to 3 substituents independently selected from R_b; and

R_y and R_z, if present, are:

(a) independently hydrogen, C_1-C_8alkyl, C_2-C_8alkanone, C_2-C_8alkyl ether, C_2-C_8alkenyl, a 4- to 10-membered carbocycle or heterocycle, or joined to R_c to form a 4- to 10-membered carbocycle or heterocycle, wherein each R_y and R_z is independently substituted with from 0 to 6 substituents independently selected from R_b; or

(b) joined to form a 4- to 10-membered carbocycle or heterocycle that is substituted with from 0 to 6 substituents independently selected from R_b;

R_8 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, oxo, -COOH, C_1-C_6alkyl, C_1-C_6alkenyl, C_1-C_6alkynyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6aminoalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_6alkanoyl, mono- and di-(C_1-C_6alkyl)aminoC_0-C_6alkyl, (5- to 7-membered heterocycloalkyl)C_0-C_6alkyl, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

R_9 is independently selected at each occurrence from hydrogen, halogen, hydroxy, cyano, amino, nitro, -COOH, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkylsulfonyl and mono- or di-(C_1-C_6alkyl)sulfonamido;

Ar is selected from phenyl and 6-membered aromatic heterocycles, each of which is substituted with from 0 to 3 substituents independently selected from R_1; and

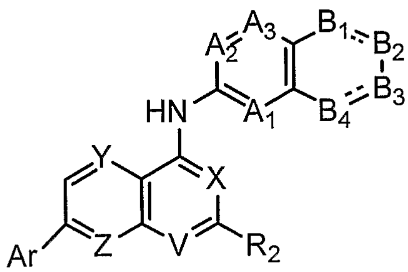
R_b is independently chosen at each occurrence from:

(i) hydroxy, halogen, amino, aminocarbonyl, cyano, nitro, oxo and –COOH; and

(ii) C_1-C_8alkyl, C_1-C_8alkoxy, C_1-C_8alkanoyl, C_2-C_8alkoxycarbonyl, C_2-C_8alkanoyloxy, C_1-C_8alkylthio, C_2-C_8alkyl ether, phenylC_0-C_8alkyl, phenylC_1-C_8alkoxy, mono- and di-(C_1-C_6alkyl)amino, C_1-C_8alkylsulfonyl, (4- to 7-membered heterocycle)C_0-C_8alkyl;

wherein each of (ii) is substituted with from 0 to 3 substituents independently chosen from hydroxy, halogen, amino and cyano.

3. A compound or salt according to claim 2, wherein the compound has the formula:



wherein:

Ar is phenyl or a 6-membered aromatic heterocycle, each of which is substituted with from 0 to 3 substituents independently chosen from R_1; and

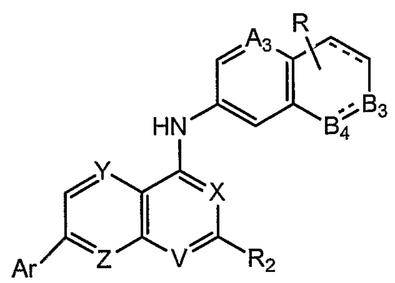
B_1, B_2, B_3 and B_4 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O.

4. A compound or salt according to claim 3, wherein B_1 is $C(CH_3)_2$ or SO_2, B_2 is $C(R_8)$ or $N(R_8)$, and B_3 and B_4 are independently $C(R_8)$, $C(R_8)(R_8)$ or $N(R_8)$.

5. A compound or salt according to claim 4, wherein B_1 is $C(CH_3)_2$, B_2 and B_3 are $C(R_8)$ and B_4 is NH or N-CH_3.

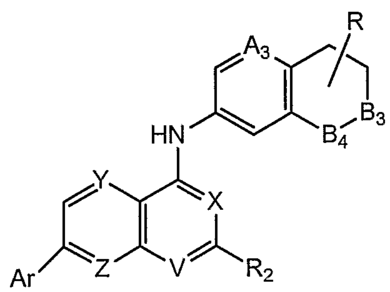
6. A compound or salt according to claim 3, wherein B_1 is O, B_2 and B_3 are $C(R_8)$ and B_4 is NH or N-CH_3.

7. A compound or salt according to claim 3, wherein the compound has the formula:

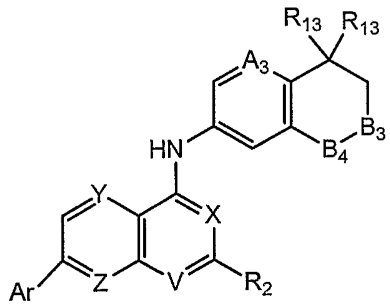


wherein R represents from 0 to 5 substituents independently chosen from halogen, hydroxy, oxo, cyano, amino, C_1-C_6alkyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy or C_1-C_6alkanoyl.

8. A compound or salt according to claim 7, wherein the compound has the formula:

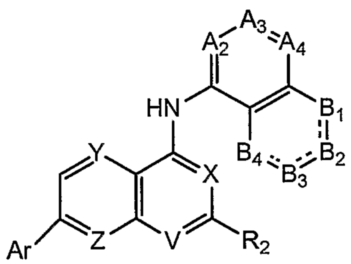


9. A compound or salt according to claim 7, wherein the compound has the formula:



wherein each R_{13} is independently chosen from hydrogen, halogen, C_1-C_4alkyl and C_1-C_4haloalkyl.

10. A compound or salt according to claim 1, wherein the compound has the formula:

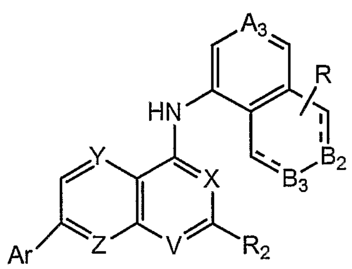


wherein:

Ar is phenyl or a 6-membered aromatic heterocycle, each of which is substituted with from 0 to 3 substituents independently chosen from R_1; and

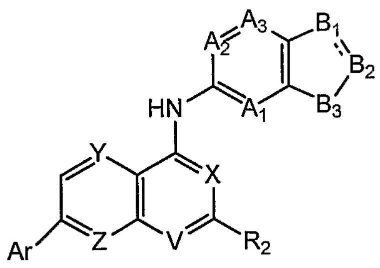
B_1, B_2, B_3 and B_4 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O.

11. A compound or salt according to claim 10, wherein the compound has the formula:



wherein R represents from 0 to 5 substituents independently chosen from halogen, hydroxy, oxo, cyano, amino, C_1-C_6alkyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy or C_1-C_6alkanoyl.

12. A compound or salt according to claim 2, wherein the compound has the formula:

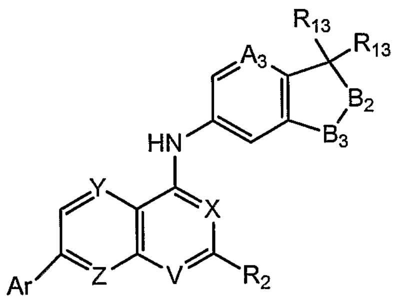


wherein:

Ar is phenyl or a 6-membered aromatic heterocycle, each of which is substituted with from 0 to 3 substituents independently chosen from R_1; and

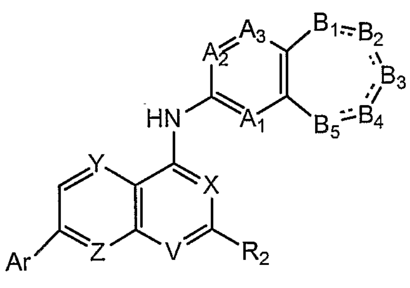
B_1, B_2 and B_3 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O.

13. A compound or salt according to claim 12, wherein the compound has the formula:



wherein each R_{13} is independently chosen from hydrogen and C_1-C_4alkyl.

14. A compound or salt according to claim 2, wherein the compound has the formula:



wherein:

Ar is phenyl or a 6-membered aromatic heterocycle, each of which is substituted with from 0 to 3 substituents independently chosen from R_1; and

B_1, B_2, B_3, B_4 and B_5 are independently chosen from $C(R_8)$, $C(R_8)(R_8)$, S, SO, SO_2, N, $N(R_8)$ and O.

15. A compound or salt according to any one of claims 1-14, wherein Ar is phenyl or pyridyl, optionally substituted with one substituent chosen from halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy or C_1-C_6haloalkoxy.

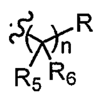
16. A compound or salt according to claim 15, wherein Ar is pyridin-2-yl, 3-methyl-pyridin-2-yl, 3-trifluoromethyl-pyridin-2-yl or 3-halo-pyridin-2-yl.

17. A compound or salt according to any of claims 1-14, wherein U is CR_2.

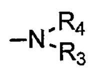
18. A compound or salt according to claim 17, wherein R_2 is:

(i) hydrogen or halogen; or

(ii) a group of the formula:



wherein

R is -O-R_7 or 

;

R_7 is selected from:

(i) hydrogen;

(ii) C_1-C_8alkyl, C_2-C_8alkenyl, C_2-C_8alkynyl, C_2-C_8alkanoyl, C_3-C_8alkanone, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl and (5- to 10-membered heterocycle)C_0-C_8alkyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b; and

(iii) groups that are joined to an R_5 or R_6 to form a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b;

R_3 and R_4 are:

(i) each independently selected from:

(a) hydrogen;

(b) C_1-C_8alkyl, C_2-C_8alkenyl, C_2-C_8alkynyl, C_1-C_8alkoxy, C_3-C_8alkanone, C_2-C_8alkanoyl, C_1-C_8alkoxycarbonyl, C_2-C_8alkyl ether, (C_6-C_{10}aryl)C_0-C_8alkyl, (5- to 10-membered heterocycle)C_0-C_8alkyl and C_1-C_8alkylsulfonyl, each of which is substituted with from 0 to 9 substituents independently selected from R_b; and

(c) groups that are joined to an R_5 or R_6 to form a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b; or

(ii) joined to form, with the N to which they are bound, a 4- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b, C_1-C_8alkanoyl, (4- to 7-membered heterocycloalkyl)C_0-C_4alkyl, and mono- and di-(C_1-C_6alkyl)aminoC_1-C_6alkyl; and

R_5 and R_6 are, independently at each occurrence:

(i) each independently selected from:

(a) hydrogen or hydroxy;

(b) C_1-C_8alkyl, substituted with 0, 1 or 2 substituents independently selected from R_b; and

(c) groups that are joined to R_3 or R_7 to form a 5- to 10-membered heterocyclic group that is substituted with from 0 to 6 substituents independently selected from R_b;

(ii) taken together to form a keto group -(C=O)-; or

(iii) joined to form a 3- to 7-membered carbocyclic or heterocyclic ring, each of which is substituted with from 0 to 4 substituents selected from R_b; and

n is 1, 2 or 3.

19. A compound or salt according to claim 18, wherein R_2 is:

(i) hydrogen or halogen; or

(ii) C_1-C_6alkyl, -$(CH_2)_nNH_2$, -$(CH_2)_nNH$(C_1-C_8alkyl), -$(CH_2)_nN$(C_1-C_8alkyl)$_2$, -$(CH_2)_n$(5- to 8-membered heterocycloalkyl), -$(CH_2)_nOH$ or -$(CH_2)_nO$(C_1-C_6alkyl), wherein each n is 0, 1, 2 or 3, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl and C_1-C_6haloalkyl.

20. A compound or salt according claim 19 wherein R_2 is C_1-C_6alkyl, C_2-C_6alkyl ether, mono- or di-(C_1-C_6alkyl)amino, morpholino, benzyloxymethyl, piperazinyl, piperidinyl, phenyl or pyridyl, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl and C_1-C_6haloalkyl.

21. A compound or salt according to any of claims 1-14, wherein X is N.

22. A compound or salt according to any of claims 1-14, wherein X and V are both N.

23. A compound or salt according to any of claims 1-14, wherein X is CH and V is N.

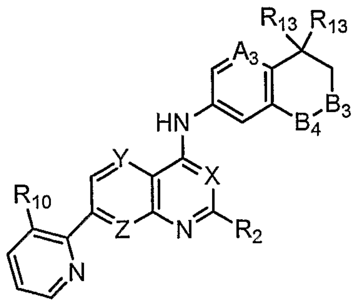
24. A compound or salt according to claim 1 or claim 2, wherein W is CH.

25. A compound or salt according to any of claims 3-14 or 24, wherein Y is N and Z is CH.

26. A compound or salt according to claim 25, wherein Y and Z are both CH.

27. A compound or salt according to claim 26, wherein Z is N and Y is CH.

28. A compound or salt according to claim 2, wherein the compound has the formula:



wherein

X, Y, Z and A_3 are independently N or CH;

R_{10} is hydrogen, halogen, methyl, mono-, di- or tri-fluoromethyl or cyano;

each R_{13} is independently hydrogen or methyl;

one of B_3 and B_4 is $CH(R_8)$ and the other of B_3 and B_4 is $N(R_8)$; and

R_2 is:

(i) hydrogen or halogen; or

(ii) C_1-C_6alkyl, -$(CH_2)_nNH_2$, -$(CH_2)_nN(H)C_1$-C_8alkyl, -$(CH_2)_nN(C_1$-C_8alkyl$)_2$, -$(CH_2)_n$(4- to 8-membered heterocycloalkyl), -$(CH_2)_nOH$, -$(CH_2)_nOC_1$-C_6alkyl or -$(CH_2)_n$O-benzyl, each of which is substituted with from 0 to 4 substituents independently chosen from halogen, cyano, hydroxy, amino, mono- and di-(C_1-C_6alkyl)amino, C_1-C_6alkyl, and C_1-C_6haloalkyl, wherein each n is 0, 1, 2 or 3.

29. A compound or salt according to claim 2, wherein each R_8 is independently hydrogen, C_1-C_6alkyl, C_1-C_6alkyl ether, C_1-C_6hydroxyalkyl, C_1-C_6haloalkyl, C_1-C_6alkanoyl, mono- or di-(C_1-C_6alkyl)aminoC_0-C_6alkyl or (5- to 7-membered heterocycloalkyl)C_0-C_6alkyl.

30. A compound or salt according to any of claims 1-29, wherein the compound exhibits no detectable agonist activity an *in vitro* assay of capsaicin receptor agonism.

31. A compound or salt according to any of claims 1-29, wherein the compound has an EC_{50} or IC_{50} value of 1 micromolar or less in a capsaicin receptor calcium mobilization assay.

32. A compound or salt according to any of claims 1-29, wherein the compound has an EC_{50} or IC_{50} value of 100 nanomolar or less in a capsaicin receptor calcium mobilization assay.

33. A compound or salt according to any of claims 1-29, wherein the compound has an EC_{50} or IC_{50} value of 10 nanomolar or less in a capsaicin receptor calcium mobilization assay.

34. A pharmaceutical composition, comprising at least one compound or pharmaceutically acceptable salt according to any of claims 1-29, in combination with a physiologically acceptable carrier or excipient.

35. A method for reducing calcium conductance of a cellular capsaicin receptor, comprising contacting a cell expressing a capsaicin receptor with at least one compound or salt according to any of claims 1-29, and thereby reducing calcium conductance of the capsaicin receptor.

36. A method according to claim 35, wherein the cell is a neuronal cell that is contacted *in vivo* in an animal.

37. A method according to claim 36, wherein during contact the compound is present within a body fluid of the animal.

38. A method according to claim 37, wherein the compound is present in the blood of the animal at a concentration of 1 micromolar or less.

39. A method according to claim 37, wherein the animal is a human.

40. A method according to claim 37, wherein the compound is administered orally.

41. A method for inhibiting binding of vanilloid ligand to a capsaicin receptor *in vitro*, the method comprising contacting capsaicin receptor with at least one compound or salt according to any of claims 1-29, under conditions and in an amount sufficient to detectably inhibit vanilloid ligand binding to capsaicin receptor.

42. A method for inhibiting binding of vanilloid ligand to capsaicin receptor in a patient, comprising contacting cells expressing capsaicin receptor with at least one compound or salt according to any of claims 1-29, in an amount sufficient to detectably inhibit vanilloid ligand binding to cells expressing a cloned capsaicin receptor *in vitro*, and thereby inhibiting binding of vanilloid ligand to the capsaicin receptor in the patient.

43. A method according to claim 42, wherein the compound is present in the blood of the patient at a concentration of 1 micromolar or less.

44. A method for treating a condition responsive to capsaicin receptor modulation in a patient, comprising administering to the patient a therapeutically effective amount of at least one compound or salt according to any of claims 1-29, and thereby alleviating the condition in the patient.

45. A method according to claim 44, wherein the patient is suffering from (i) exposure to capsaicin, (ii) burn or irritation due to exposure to heat, (iii) burns or irritation due to exposure to light, (iv) burn, bronchoconstriction or irritation due to exposure to tear gas, air pollutants or pepper spray, or (v) burn or irritation due to exposure to acid.

46. A method according to claim 44, wherein the compound is present in the blood of the animal at a concentration of 1 micromolar or less.

47. A method according to claim 44, wherein the condition is asthma or chronic obstructive pulmonary disease.

48. A method for treating pain in a patient, comprising administering to a patient suffering from pain a therapeutically effective amount of at least one compound or salt according to any of claims 1-29, and thereby alleviating pain in the patient.

49. A method according to claim 48, wherein the compound is present in the blood of the animal at a concentration of 1 micromolar or less.

50. A method according to claim 48, wherein the patient is suffering from neuropathic pain.

51. A method according to claim 48, wherein the pain is associated with a condition selected from: postmastectomy pain syndrome, stump pain, phantom limb pain, oral neuropathic pain, toothache, postherpetic neuralgia, diabetic neuropathy, reflex sympathetic dystrophy, trigeminal neuralgia, osteoarthritis, rheumatoid arthritis, fibromyalgia, Guillain-Barre syndrome, meralgia paresthetica, burning-mouth syndrome, bilateral peripheral neuropathy, causalgia, neuritis, neuronitis, neuralgia, AIDS-related neuropathy, MS-related neuropathy, spinal cord injury-related pain, surgery-related pain, musculoskeletal pain, back pain, headache, migraine, angina, labor, hemorrhoids, dyspepsia, Charcot's pains, intestinal gas, menstruation, cancer, venom exposure, irritable bowel syndrome, inflammatory bowel disease, and/or trauma.

52. A method according to claim 44, wherein the patient is a human.

53. A method for treating itch in a patient, comprising administering to a patient a therapeutically effective amount of a compound or salt according to any of claims 1-14, 28 or 29, and thereby alleviating itch in the patient.

54. A method for treating cough or hiccup in a patient, comprising administering to a patient a therapeutically effective 1-29, and thereby alleviating cough or hiccup in the patient.

55. A method promoting weight loss in an obese patient, comprising administering to a patient a therapeutically effective amount of a compound or salt according to any of claims 1-29, and thereby promoting weight loss in the patient.

56. A compound or salt according to any of claims 1-14, 28 or 29, wherein the compound or salt is radiolabeled.

57. A method for determining the presence or absence of capsaicin receptor in a sample, comprising the steps of:

(a) contacting a sample with a compound or salt according to any of claims 1-29, under conditions that permit binding of the compound to capsaicin receptor; and

(b) detecting a level of the compound bound to capsaicin receptor, and therefrom determining the presence or absence of capsaicin receptor in the sample.

58. A method according to claim 57, wherein the compound is a radiolabeled compound, and wherein the step of detection comprises the steps of:

(i) separating unbound compound from bound compound; and

(ii) detecting the presence or absence of bound compound in the sample.

59. A packaged pharmaceutical preparation, comprising:

(a) a pharmaceutical composition according to claim 34 in a container; and

(b) instructions for using the composition to treat pain.

60. A packaged pharmaceutical preparation, comprising:

(a) a pharmaceutical composition according to claim 34 in a container; and

(b) instructions for using the composition to treat cough or hiccup.

61. A packaged pharmaceutical preparation, comprising:

(a) a pharmaceutical composition according to claim 34 in a container; and

(b) instructions for using the composition to treat obesity.

62. 7-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-2,4,4-trimethyl-4H-isoquinoline-1,3-dione or a pharmaceutically acceptable salt thereof.

63. (2,3-Dihydro-benzo[1,4]dioxin-6-yl)-[2-isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine or a pharmaceutically acceptable salt thereof.

64. (2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

65. (2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

66. (2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

67. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-(2-isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-yl)-amine or a pharmaceutically acceptable salt thereof.

68. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine or a pharmaceutically acceptable salt thereof.

69. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-ethoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine or a pharmaceutically acceptable salt thereof.

70. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[2-methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-amine or a pharmaceutically acceptable salt thereof.

71. (4,4-Dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-[7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-amine or a pharmaceutically acceptable salt thereof.

72. [2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

73. [2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

74. [2-Benzyloxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-quinazolin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

75. [2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

76. [2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

77. [2-Ethoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

78. [2-Isobutoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

79. [2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

80. [2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

81. [2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

82. [2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

83. [2-Methoxymethyl-7-(3-methyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

84. [2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-[1,8]naphthyridin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

85. [2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

86. [2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

87. [7-(3-Chloro-pyridin-2-yl)-2-(2,6-dimethyl-morpholin-4-ylmethyl)-pyrido[3,2-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

88. [7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

89. [7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

90. [7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(1,3,3-trimethyl-2,3-dihydro-1H-indol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

91. [7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,3-dihydro-benzo[1,4]dioxin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

92. [7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

93. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,4,4-trimethyl-1,2,3,4-tetrahydro-isoquinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

94. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

95. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4-methyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

96. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2,3-dihydro-benzo[1,4]dioxin-6-yl)-amine or a pharmaceutically acceptable salt thereof.

97. [7-(3-Chloro-pyridin-2-yl)-2-isobutoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(2-methyl-benzooxazol-6-yl)-amine or a pharmaceutically acceptable salt thereof.

98. [7-(3-Chloro-pyridin-2-yl)-2-methoxymethyl-pyrido[2,3-d]pyrimidin-4-yl]-(4,4-dimethyl-1,2,3,4-tetrahydro-quinolin-7-yl)-amine or a pharmaceutically acceptable salt thereof.

99. 1-[6-(2-Isobutoxymethyl-7-pyridin-2-yl-pyrido[2,3-d]pyrimidin-4-ylamino)-3,3-dimethyl-2,3-dihydro-indol-1-yl]-ethanone or a pharmaceutically acceptable salt thereof.

100. 1-{6-[2-Isobutoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone or a pharmaceutically acceptable salt thereof.

101. 1-{6-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone or a pharmaceutically acceptable salt thereof.

102. 1-{6-[7-(3-Chloro-pyridin-2-yl)-2-ethoxymethyl-pyrido[2,3-d]pyrimidin-4-ylamino]-3,3-dimethyl-2,3-dihydro-indol-1-yl}-ethanone or a pharmaceutically acceptable salt thereof.

103. 7-[2-Methoxymethyl-7-(3-trifluoromethyl-pyridin-2-yl)-pyrido[2,3-d]pyrimidin-4-ylamino]-4,4-dimethyl-3,4-dihydro-1H-quinolin-2-one or a pharmaceutically acceptable salt thereof.