



US008809381B2

(12) **United States Patent**
McCurdy et al.(10) **Patent No.:** **US 8,809,381 B2**(45) **Date of Patent:** **Aug. 19, 2014**(54) **HIGHLY SELECTIVE SIGMA RECEPTOR LIGANDS**(75) Inventors: **Christopher R. McCurdy**, Oxford, MS (US); **Christophe Mesangeau**, Oxford, MS (US); **Sanju Narayanan**, San Diego, CA (US); **Rae Reiko Matsumoto**, Morgantown, WV (US); **Jacques Henri Poupaert**, Brussels (BE)(73) Assignees: **The University of Mississippi**, University, MS (US); **L'Universite Catholique de Louvain**, Louvain-la-Neuve (BE)

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(2), (4) Date: **May 12, 2010**(87) PCT Pub. No.: **WO2009/026227**PCT Pub. Date: **Feb. 26, 2009**(65) **Prior Publication Data**

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A61K 31/497 (2006.01)
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A61K 31/55 (2006.01)
C07D 217/00 (2006.01)
C07D 295/00 (2006.01)
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C07D 223/14 (2006.01)
C07D 487/00 (2006.01)
C07D 491/00 (2006.01)
C07D 513/00 (2006.01)

(52) **U.S. Cl.**

USPC **514/367**; 514/212.02; 514/213.01;
 514/317; 514/319; 514/252.13; 548/165;
 544/392; 544/403; 546/17; 546/147; 540/484;
 540/543

(58) **Field of Classification Search**

USPC 514/212.02, 213.01, 317, 319, 252.13,
 514/367; 548/165; 544/392, 403; 546/17,
 546/147; 540/484, 543

See application file for complete search history.

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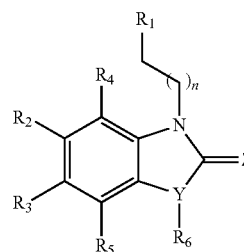
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Primary Examiner — Kendra D Carter(74) *Attorney, Agent, or Firm* — Hershkovitz & Associates, PLLC; Abraham Hershkovitz; Eugene Rzcuidlo(57) **ABSTRACT**

A compound useful for treating subjects in need of therapy involving sigma receptors or for alleviation of affects resulting from drug abuse having the general formula I



in which R₁ can be a radical of an optionally substituted C-4 to C-7 N-containing heterocycle such as, for example, radicals of optionally substituted piperidines, optionally substituted piperazines, optionally substituted tetrahydropyridines, optionally substituted azepanes, tertiary amines (cyclic or acyclic), isoindoline-1,3-dione, or optionally substituted tetrahydroisoquinolones (aromatically substituted); R_{2,3,4,5,6} can each independently be any one or combinations of the following moieties, cyano, nitro, acyl, alkyl, amido, azido, isothiocyanate, isocyanate optionally substituted anilino, halogens, ethers, sulfonamides, thioacyl, nitro, aromatic, heterocyclic, olefinic, acetylene, deuterium, or tritium; Y can be either CH, CH₂, O, S, OCH₂, N—R, N—Ar, C—R, C—Ar; Z can be either H, O, S, S—R or NR. R groups can be either H, aryls, alkyls, or cycloalkyls; "n" can be 1 to 5 carbons in length and stereoisomers, functional analogs, and pharmaceutically acceptable salts thereof and wherein the moiety bridging R₁ and N can be optionally substituted alkylene, optionally substituted alkenylene or optionally substituted alkenylene and where the alkylene group can include an inserted C₃-C₅ cycloalkyl group, aromatic and heterocyclic group.

7 Claims, 5 Drawing Sheets

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Figure 1

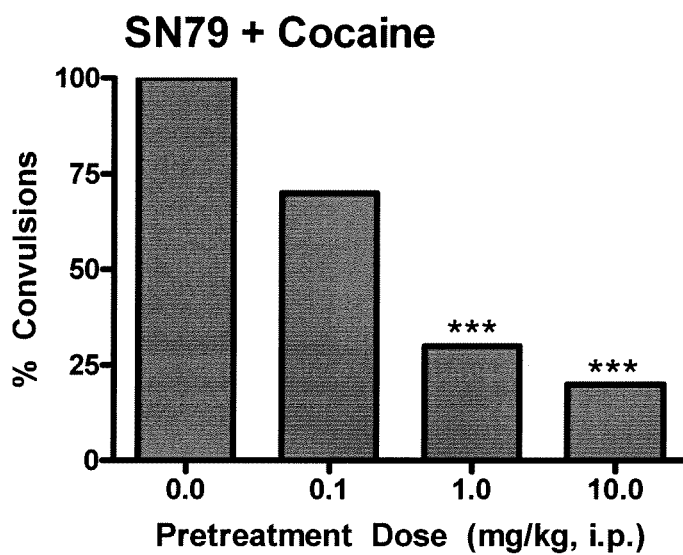


Figure 2

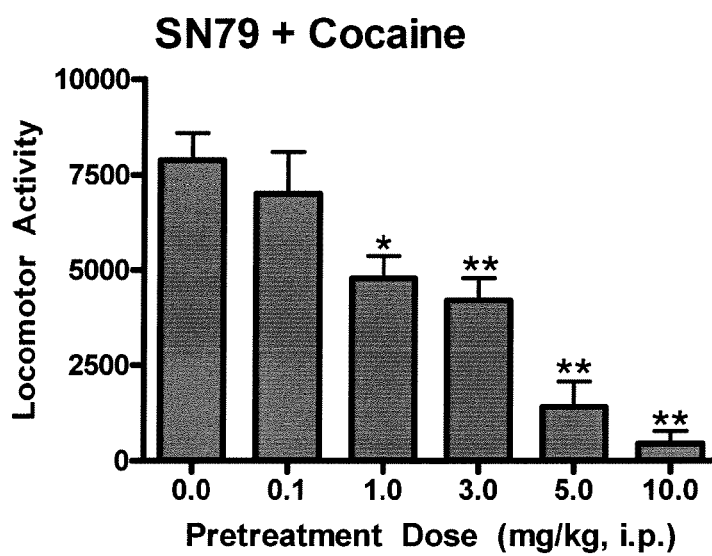


Figure 3

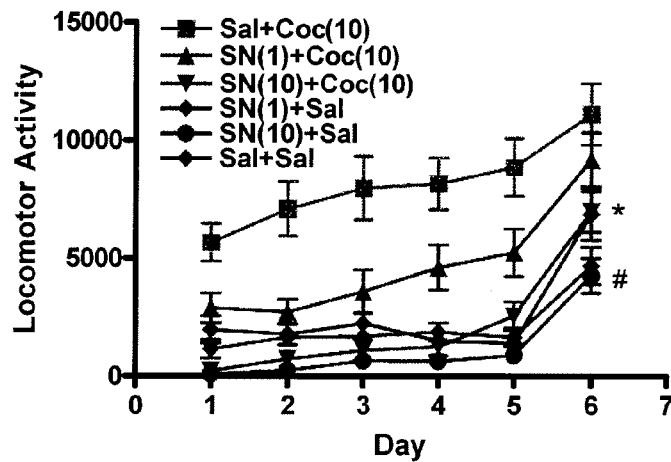


Figure 4

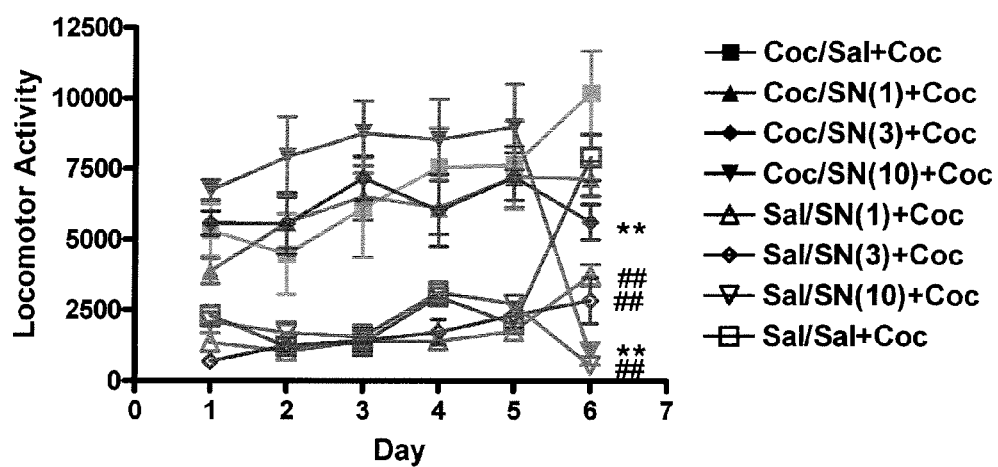


Figure 5

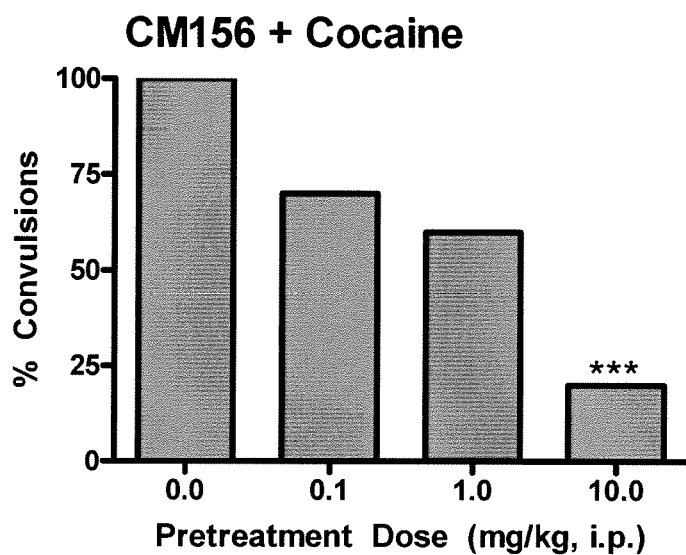


Figure 6

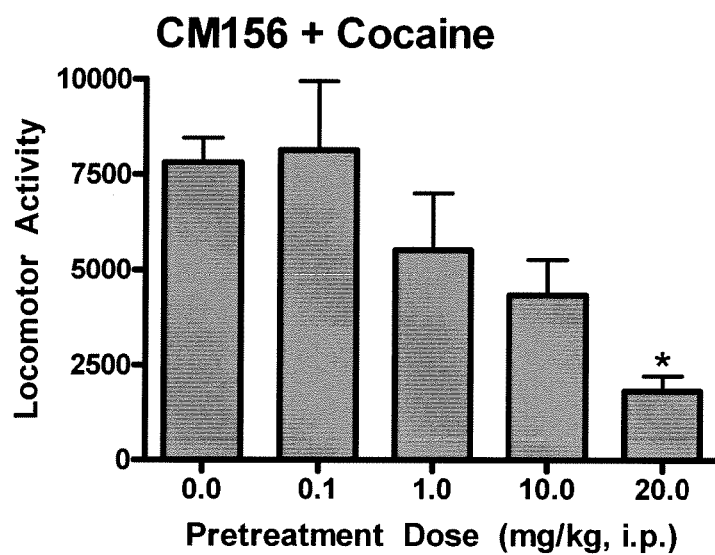


Figure 7

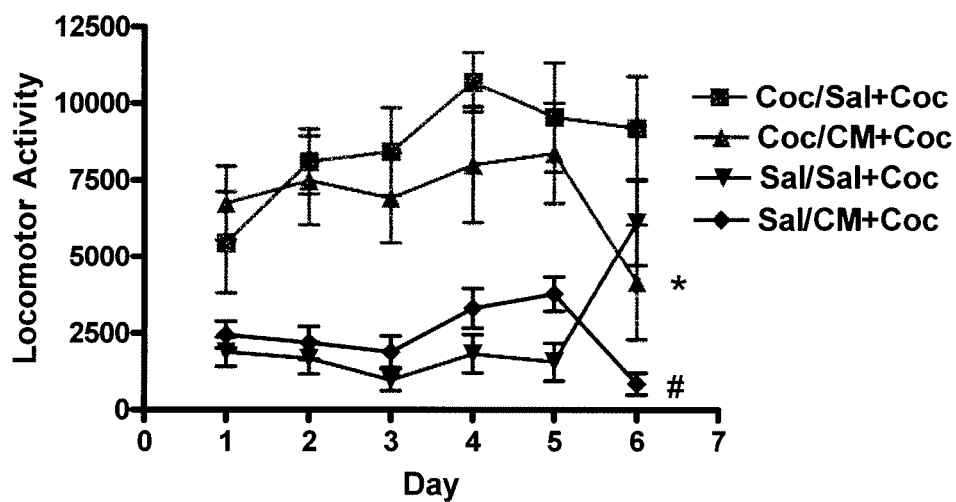


Figure 8

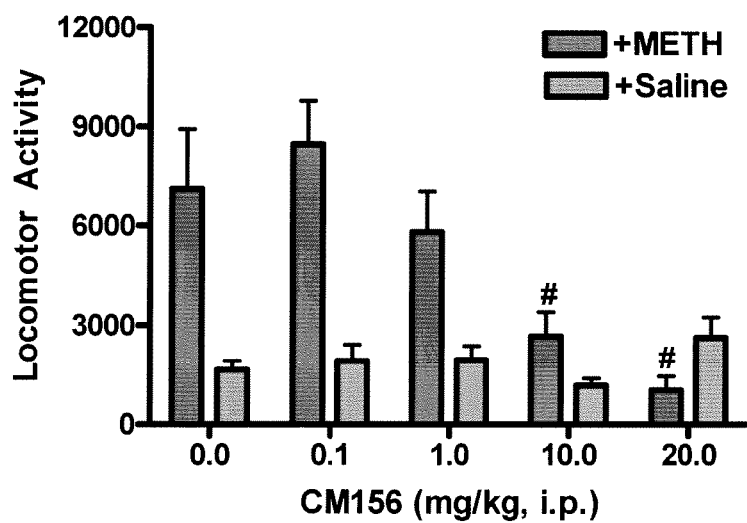
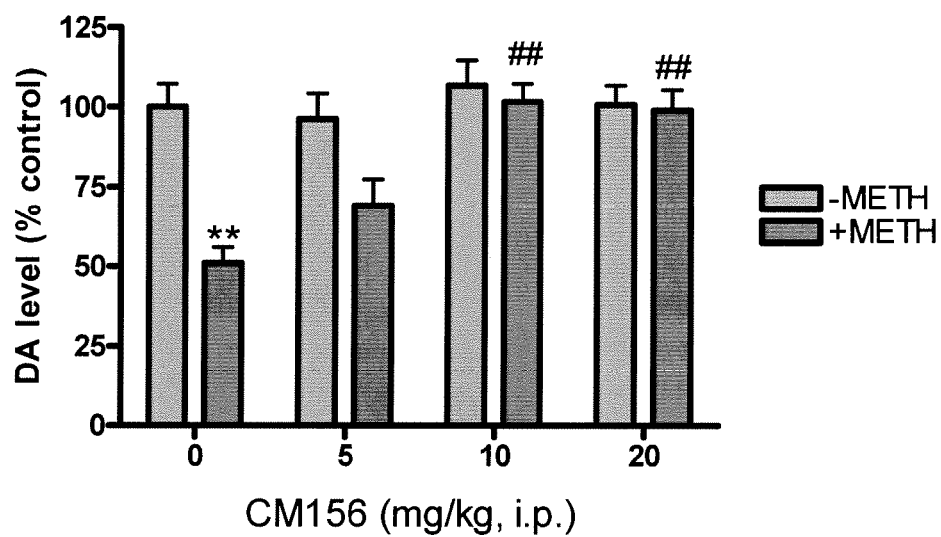


Figure 9



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HIGHLY SELECTIVE SIGMA RECEPTOR LIGANDS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of provisional patent application No. 60/956,249 filed Aug. 16, 2007, the entirety of which is incorporated by reference.

The subject invention was made with government support under a research project supported by the United States Government in NIDA Grant Numbers DA023205, DA011979, DA013978 and NCRR P20 RR021929 and the government has certain rights to this invention.

FIELD OF INVENTION

The present invention relates to the field of compounds which are sigma receptor ligands and methods of use thereof as sigma receptor ligands.

BACKGROUND OF THE INVENTION

Sigma receptors (σ) have received much attention from the drug discovery field due to their possible involvement in schizophrenia, regulation of motor behavior, convulsions, anxiety, and the psychostimulant effects of drugs of abuse including cocaine, methamphetamine and 3,4-methylenedioxymethamphetamine (MDMA).^{1,2} In addition to a host of neurological and psychiatric areas of interest, sigma receptors are promising drug development targets for, oncological, immunological, cardiovascular, ophthalmological, developmental, gastrointestinal and metabolic disorders as well as those affecting the endocrine system. They are structurally unique proteins that are distinct from classical G protein-coupled receptors, ionotropic receptors, or receptor tyrosine kinases. With two subtypes currently known, they modulate cell survival and excitability, and subserve many critical functions in the body. Endogenous ligands for these receptors are unknown, though current clues point to neurosteroids.³

The two subtypes, σ -1 and σ -2, were delineated by studies examining their respective molecular weights, distribution in tissue and drug selectivity profiles. The 223 amino acid σ -1 protein with two transmembrane spanning regions has been purified and cloned from several animal species including mouse, rat, guinea pig, and human.⁴⁻⁸ To date, the σ -1 receptor is well studied and known because of the receptor sequence information and availability of selective σ -1 ligands. But, the protein corresponding to σ -2 sites has not yet been cloned. Also, σ -2 receptor-selective ligands are less common, with tritiated DTG (1,3-di(2-tolyl)guanidine) being accepted as a radioligand in the presence of (+)-pentazocine (to block binding to σ -1 sites). Due to the lack of availability of detailed protein structural information and truly selective σ -2 ligands, the pharmacological characterization of the σ -2 subtype has been very limited. There is clearly a need for a selective σ -2 ligand which can not only act as a probe to explore unknown biochemical mechanisms, but also be used as a radioligand in σ -2 receptor binding assays.

The abuse of drugs is a serious social, economic and health problem worldwide. Some of the opiates, cocaine, amphetamines and phencyclidine (PCP) are the drugs of abuse with

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significant affinities for a receptors. Current treatments for drugs of abuse are limited and there is a need to develop novel and effective agents to combat this problem.

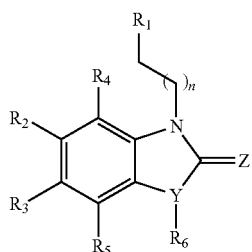
Cocaine use and abuse has been reported as early as the late 1500s.⁹ The historical use has been associated with the chewing of leaves from the *Erythroxylon coca* bush, from which cocaine was isolated in 1860,¹⁰ to eliminate fatigue in workers. Indeed, cocaine is a powerful and addictive psychostimulant. Cocaine abuse is widespread and is responsible for more serious intoxications and deaths than any other illicit drug. However, the invigorating effects of cocaine have caused it to become a major recreational drug of abuse throughout the world with an estimated 13 million people using the drug. In 2004, 34.2 million Americans aged 12 and over reported lifetime use of cocaine with approximately 5.6 million reporting annual use and an estimated 2 million reporting current use of the drug. In 2004 alone, there were an estimated 1 million new users of cocaine amounting to ~2,700 per day. Despite a decline between 2002 and 2003 which is thought to potentially be due to increases in usage of other stimulants such as methamphetamine, data from the National Survey on Drug Use and Health showed near a 70% increase in the number of people receiving treatment for cocaine addiction from 276,000 in 2003 to 466,000 in 2004.¹¹

Currently, there are no approved medications to treat cocaine abuse or addiction. An effective strategy used to develop an anti-cocaine agent was the development of antagonists that compete with cocaine for its target proteins. For years, treatment approaches have targeted the dopaminergic system which is known to be involved in the actions and rewards of cocaine use. Many compounds were generated and tested that targeted the dopamine transporter which was identified as a primary site of action of cocaine. These compounds were met with very limited success as many of them just substituted for cocaine.¹² After many years of investigation at the dopamine transporter as well as the dopamine receptors, researchers have been challenged to envision novel mechanisms that may afford new therapeutic interventions for cocaine addiction.

Although many other mechanisms are under investigation, the a receptor system has been demonstrated and validated as a legitimate target for the attenuation of cocaine effects. The ability of cocaine to bind to the sigma receptors was discovered and first documented in 1988.¹³ It was reported that cocaine had micromolar affinity to the sigma receptor, and this interaction corresponded to micromolar levels that were achievable by cocaine in the body.¹⁴ Additional studies have indicated that reducing brain sigma receptor levels with antisense oligonucleotides attenuates the convulsive and locomotor stimulant actions of cocaine. Synthetic small molecule antagonists for sigma receptors have also been shown to mitigate the actions of cocaine in animal models. From prior work, the role of the σ -1 subtype has been clearly linked to the actions of cocaine. However, the role of the σ -2 receptor has been suggested, but is less clear due to the lack of truly selective ligands for this subtype.

BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to compounds useful as sigma receptors of the following formula I:



Wherein R_1 can be an optionally substituted nitrogen-containing heterocycle radical such as, for example, radicals of optionally substituted piperidines, optionally substituted piperazines, optionally substituted tetrahydropyridines, optionally substituted azepanes, tertiary amines (cyclic or acyclic), isoindoline-1,3-dione, or optionally substituted tetrahydroisoquinolones (aromatically substituted); $R_{2,3,4,5,6}$ can each independently be any one or combinations of the following moieties, such as, for example, cyano, nitro, acyl, alkyl, amido, azido, isothiocyanate, isocyanate anilino (unsubstituted or substituted), halogens (such as fluorine, chlorine, bromine and iodine), ethers, sulfonamides, thioacyl, nitro, aromatic, heterocyclic, olefinic, acetylenic, deuterium, or tritium; Y can be either CH, CH_2 , O, S, OCH_2 , N—R, N—Ar, C—R, C—Ar where Ar is an optionally substituted aryl. Z can be either H, O, S, S—R or NR. R groups can be either H, aryls, alkyls, or cycloalkyls. “n” can be 1 to 5 carbons in length and stereoisomers, analogs, and pharmaceutically acceptable salts thereof as well as compositions comprising said compounds. The moiety bridging R_1 and N in the formula I can be an optionally substituted C_1 – C_6 alkylene, C_1 – C_6 alkenylene or C_1 – C_6 alkynylene group wherein the alkylene group can have inserted into its chain a C_3 – C_5 cycloalkyl group, aromatic, and heterocyclic group.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1—SN79 attenuates the convulsive effects of cocaine (** P <0.005)

FIG. 2—SN79 pretreatment attenuates cocaine-induced locomotor activity (* P <0.05, ** P <0.01)

FIG. 3—SN79 pretreatment attenuates the development of cocaine-induced sensitization (* P <0.05, ## P <0.05)

FIG. 4—SN79 pretreatment attenuates the expression of cocaine-induced sensitization (** P <0.05 vs sensitized, ## P <0.05 vs acute cocaine)

FIG. 5—CM156 attenuates the convulsive effects of cocaine (** P <0.005)

FIG. 6—CM156 pretreatment attenuates cocaine-induced locomotor activity (* P <0.05)

FIG. 7—CM156 pretreatment attenuates the expression of cocaine-induced sensitization (* P <0.05 vs sensitized, # P <0.05 vs acute cocaine)

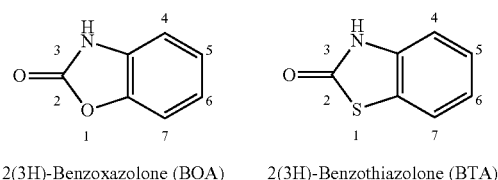
FIG. 8—CM156 pretreatment attenuates methamphetamine-induced locomotor activity (# P <0.05)

FIG. 9—CM156 pretreatment attenuates methamphetamine-induced dopamine depletions (** P <0.05, ## P <0.05)

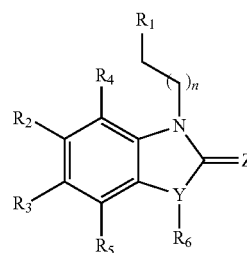
DETAILED DESCRIPTION OF THE INVENTION

The generic structure of Formula I encompasses a diverse range of heterocycles. Embodiments within this genus, for example, include 2(3H)-benzoxazolone (Y=O, Z=O) and 2(3H)-benzothiazolone (Y=S, Z=O) compounds and the sigma receptor affinity shown by these heterocycles. The 2(3H)-benzoxazolone (BOA) and its bioisosteric surrogate 2(3H)-benzothiazolone (BTA) heterocycle is a bicyclic ring system which promotes high versatility in organic synthesis involving N-substitution (either N-alkylation or N-acylation) and aromatic ring electrophilic substitution reactions.

Chemical structures of BOA and BTA



The present invention relates to compounds having the general formula I



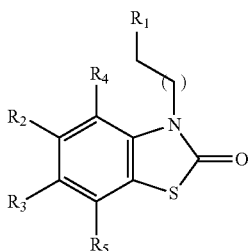
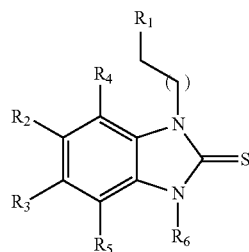
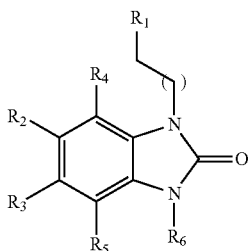
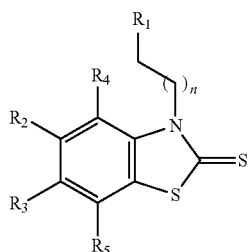
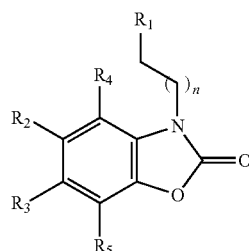
wherein R_1 can be a radical of an optionally substituted C-4 to C-7 N-containing heterocycle or a radical of an optionally substituted cyclic or acyclic tertiary amine, or isoindoline-1,3-dione $R_{2,3,4,5,6}$ can each independently be any one or combinations of the following moieties, cyano, nitro, acyl, alkyl, amido, azido, isothiocyanates, isocyanates, optionally substituted anilino, halogens, ethers, sulfonamides, thioacyl, nitro, aromatic, heterocyclic, olefinic, acetylene, deuterium, or tritium; Y can be either CH, CH_2 , O, S, OCH_2 , N—R, N—Ar, C—R, C—Ar; Z can be either H, O, S, S—R or NR. R groups can be either H, aryls, alkyls, or cycloalkyls; “n” can be 1 to 5 carbons in length and stereoisomers, functional analogs, and pharmaceutically acceptable salts thereof and wherein the moiety bridging R_1 and N can be optionally substituted alkylene, optionally substituted alkenylene or optionally substituted alkynylene and where the alkylene group can include an inserted C_3 – C_5 cycloalkyl group, aromatic and heterocycle group.

The optionally substituted N-containing heterocyclic radical can be for example optionally substituted piperidine, optionally substituted tetrahydropiperidine, optionally sub-

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stituted piperazine, optionally substituted tetrahydropyridine, optionally substituted azepanes or optionally substituted tetrahydroisoquinoline in which the optional substituents are on the aromatic moiety.

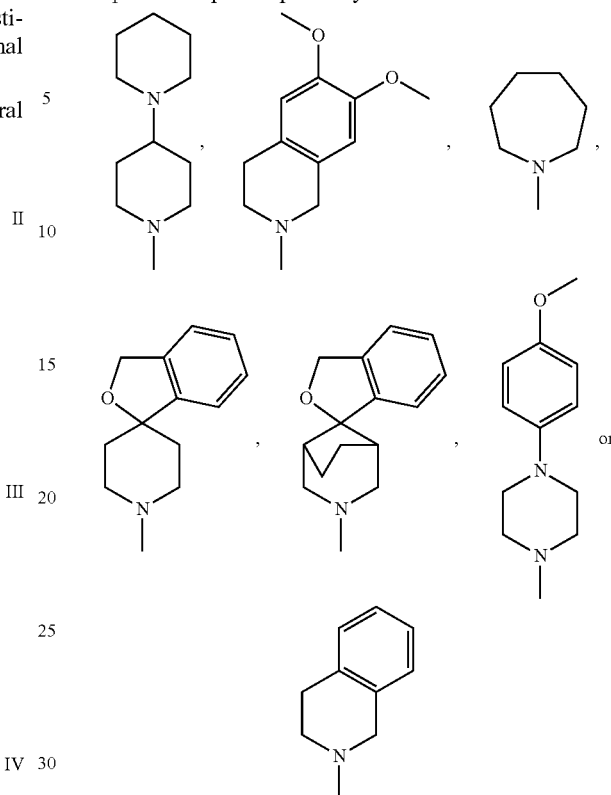
Exemplary compounds of the invention can be the general formulae II, III, IV, V and VI in which $n=1-5$:



Other exemplary compounds of the invention are compounds where $Y=O$ and $Z=O$; or $Y=S$ and $Z=S$; or where $Y=CH_2$ or $Y=CH$

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R_1 for example is optionally substituted



DEFINITIONS OF TERMS

As used herein, the term "lower" refers to a group having between one and six carbons.

As used herein, the term "alkyl" refers to a straight or branched chain hydrocarbon having from one to ten carbon atoms, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, azido, isothiocyanate, isocyanate, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkyl" group may contain one or more O, S, S(O), or S(O)₂ atoms. Examples of "alkyl" as used herein include, but are not limited to, methyl, n-butyl, t-butyl, n-pentyl, isobutyl, and isopropyl, and the like.

As used herein, the term "alkylene" refers to a straight or branched chain divalent hydrocarbon radical having from one to ten carbon atoms, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkylene" group may contain one or more O, S, S(O), or S(O)₂ atoms. Examples of "alkylene" as used herein include, but are not limited to, methylene, ethylene, and the like.

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As used herein, the term "alkenyl" refers to a hydrocarbon radical having from two to ten carbons and at least one carbon-carbon double bond, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkenyl" group may contain one or more O, S, S(O), or S(O)₂, atoms.

As used herein, the term "alkenylene" refers to a straight or branched chain divalent hydrocarbon radical having from two to ten carbon atoms and one or more carbon-carbon double bonds, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, amino-sulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkenylene" group may contain one or more O, S, S(O), or S(O)₂ atoms. Examples of "alkenylene" as used herein include, but are not limited to, ethene-1,2-diyl, propene-1,3-diyl, methylene-1,1-diyl, and the like.

As used herein, the term "alkynyl" refers to a hydrocarbon radical having from two to ten carbons and at least one carbon-carbon triple bond, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfonyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkynyl" group may contain one or more O, S, S(O), or S(O)₂, atoms.

As used herein, the term "alkynylene" refers to a straight or branched chain 5 valent hydrocarbon radical having from two to ten carbon atoms and one or more carbon—carbon triple bonds, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, amino-sulfonyl optionally substituted by alkyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such an "alkynylene" group may contain one or more O, S, S(O), or S(O)₂ atoms. Examples of "alkynylene" as used herein include, but are not limited to, ethyne-1,2-diyl, propyne-1,3-diyl, and the like.

As used herein, "cycloalkyl" refers to an alicyclic hydrocarbon group optionally possessing one or more degrees of unsaturation, having from three to twelve carbon atoms, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, nitro, cyano, halo-

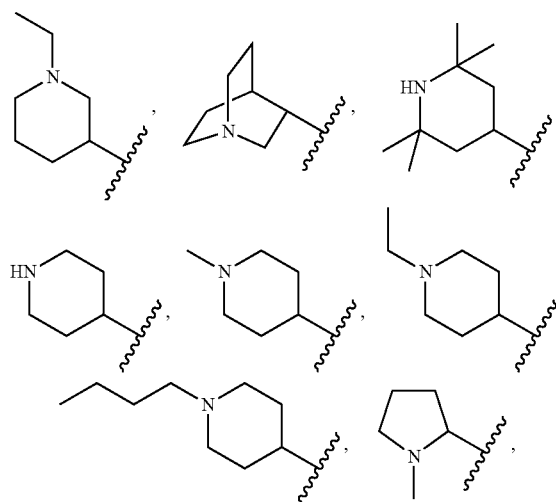
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gen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. "Cycloalkyl" includes by way of example cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, or cyclooctyl, and the like.

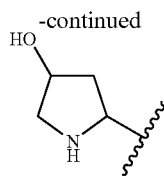
As used herein, the term "cycloalkylene" refers to a non-aromatic alicyclic divalent hydrocarbon radical having from three to twelve carbon atoms and optionally possessing one or more degrees of unsaturation, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Examples of "cycloalkylene" as used herein include, but are not limited to, cyclopropyl-1,1-diyl, cyclopropyl-1,2-diyl, cyclobutyl-1,2-diyl, cyclopentyl 1,3-diyl, cyclohexyl-1,4-diyl, cycloheptyl-1,4-diyl, or cyclooctyl-1,5-diyl. and the like.

As used herein, the term "heterocyclic" or the term "heterocyclyl" refers to a three to twelve-membered heterocyclic ring optionally possessing one or more degrees of unsaturation, containing one or more heteroatomic substitutions selected from S, SO, SO₂, O, or N, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, alinosulfonyl optionally substituted by alkyl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such a ring may be optionally fused to one or more of another "heterocyclic" ring(s) or cycloalkyl ring(s). Examples of "heterocyclic" include, but are not limited to, tetrahydrofuran, 1,4-dioxane, 1,3-dioxane, piperidine, pyrrolidine, morpholine, piperazine, tetrahydroindole, hexahydroazepine and the like.

As used herein, the term "heterocyclyl containing at least one basic nitrogen atom" refers to a "heterocyclic" or "heterocyclyl" group as defined above, wherein said heterocyclyl group contains at least one nitrogen atom flanked by 20 hydrogen, alkyl, alkylene, or alkylyne groups, wherein said alkyl and/or alkylene groups are not substituted by oxo. Examples of "heterocyclyl containing at least one basic nitrogen atom" include, but are not limited to, piperazine-2-yl, pyrrolidine-2-yl, azepine-4-yl,



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and the like.

As used herein, the term “heterocyclylene” refers to a three to twelve-membered heterocyclic ring diradical optionally having one or more degrees of unsaturation containing one or more heteroatoms selected from S, SO, SO₂, O, or N, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Such a ring may be optionally fused to one or more benzene rings or to one or more of another “heterocyclic” rings or cycloalkyl rings. Examples of “heterocyclylene” include, but are not limited to, tetrahydrofuran-2,5-diyl, morpholine-2,3-diyl, pyran-2,4-diyl, 1,4-dioxane-2,3-diyl, 1,3-dioxane-2,4-diyl, piperidine-2,4-diyl, piperidine-1,4-diyl, pyrrolidine-1,3-diyl, morpholine-2,4-diyl, piperazine-1,4-diyl, and the like.

As used herein, the term “aryl” refers to a benzene ring or to an optionally substituted benzene ring system fused to one or more optionally substituted benzene rings, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy optionally substituted by acyl, mercapto, azido, isothiocyanate, isocyanate, amino optionally substituted by alkyl, carboxy, tetrazolyl, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, acyl, aroyl, heteroaroyl, acyloxy, aroyloxy, heteroaroyloxy, alkoxycarbonyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Examples of aryl include, but are not limited to, phenyl, 2-naphthyl, 1-naphthyl, 1-anthracenyl, and the like.

As used herein, the term “arylene” refers to a benzene ring diradical or to a benzene ring system diradical fused to one or more optionally substituted benzene rings, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, tetrazolyl, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, acyl, aroyl, heteroaroyl, acyloxy, aroyloxy, heteroaroyloxy, alkoxycarbonyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. Examples of “arylene” include, but are not limited to, benzene-1,4-diyl, naphthalene-1,8-diyl, and the like.

As used herein, the term “heteroaryl” refers to a five- to seven-membered aromatic ring, containing one or more nitrogen, oxygen, or sulfur heteroatoms, where N-oxides and sulfur monoxides and sulfur dioxides are permissible heteroaromatic substitutions, optionally substituted with substituents selected from

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the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, tetrazolyl, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, acyl, aroyl, heteroaroyl, acyloxy, aroyloxy, heteroaroyloxy, alkoxycarbonyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. For polycyclic aromatic ring systems, one or more of the rings may contain one or more heteroatoms. Examples of “heteroaryl” used herein are furan, thiophene, pyrrole, imidazole, pyrazole, triazole, tetrazole, thiazole, oxazole, isoxazole, oxadiazole, thiadiazole, isothiazole, pyridine, pyridazine, pyrazine, pyrimidine, quinoline, isoquinoline, quinazoline, benzofuran, benzothiophene, indole, and indazole, and the like.

As used herein, the term “heteroarylene” refers to a five- to seven-membered aromatic ring diradical, or to a polycyclic heterocyclic aromatic ring diradical, containing one or more nitrogen, oxygen, or sulfur heteroatoms, where N-oxides and sulfur monoxides and sulfur dioxides are permissible heteroaromatic substitutions, optionally substituted with substituents selected from the group consisting of lower alkyl, lower alkoxy, lower alkylsulfanyl, lower alkylsulfenyl, lower alkylsulfonyl, oxo, hydroxy, mercapto, amino optionally substituted by alkyl, carboxy, tetrazolyl, carbamoyl optionally substituted by alkyl, aminosulfonyl optionally substituted by alkyl, acyl, aroyl, heteroaroyl, acyloxy, aroyloxy, heteroaroyloxy, alkoxycarbonyl, silyloxy optionally substituted by alkoxy, alkyl, or aryl, silyl optionally substituted by alkoxy, alkyl, or aryl, nitro, cyano, halogen, or lower perfluoroalkyl, multiple degrees of substitution being allowed. For polycyclic aromatic ring system diradicals, one or more of the rings may contain one or more heteroatoms. Examples of “heteroarylene” used herein are furan-2,5-diyl, thiophene-2,4-diyl, 1,3,4-oxadiazole-2,5-diyl, 1,3,4-thiadiazole-2,5-diyl, 1,3-thiazole-2,4-diyl, 1,3-thiazole-2,5-diyl, pyridine-2,4-diyl, pyridine-2,3-diyl, pyridine-2,5-diyl, pyrimidine-2,4-diyl, quinoline-2,3-diyl, and the like.

Initial efforts were focused on incorporating a good directionality by implying side-chains on a rigid template using conventional simple synthetic methodology. Exploring the effects of linker length between two hydrophobic regions for sigma receptor affinity led to the synthesis of 2 to 6 carbon linkers of 2(3H)-benzoxazolones ligands and 2(3H)-benzothiazolones compounds.

The in vitro receptor binding affinities of the initial series of compounds of formulae II and III investigated in rat brain homogenates at σ -1 and σ -2 subtypes are summarized in tables 1 and 2.

II

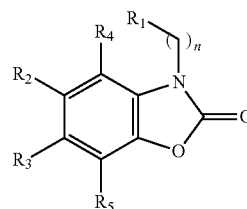
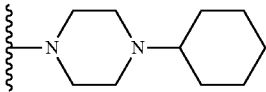
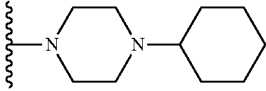
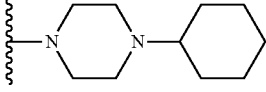
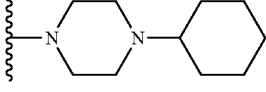
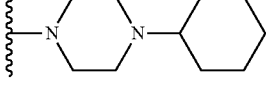
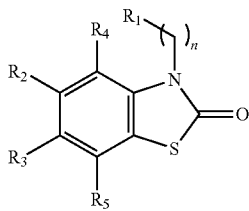


TABLE 1

Initial series 2(3H)-benzoxazolones to explore the effects of linker length on sigma receptor affinity						
Compd.	R ₁	R ₂ ,R ₅	n	σ-1 (K _p , nM)	σ-2 (K _p , nM)	σ-1/σ-2
CM-129		H	2	6.90 ± 0.37	5.43 ± 0.78	1.3
CM-124		H	3	5.22 ± 1.11	8.74 ± 2.30	0.6
CM-121		H	4	11.3 ± 1.25	1.83 ± 0.17	6.2
CM-126		H	5	10.6 ± 2.52	5.89 ± 1.31	1.8
SN-48		H	6	4.60 ± 1.08	3.06 ± 0.45	1.5

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III



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TABLE 2

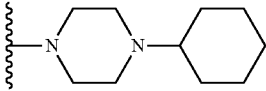
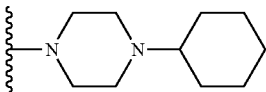
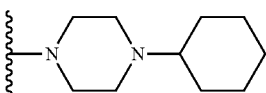
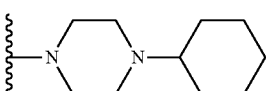
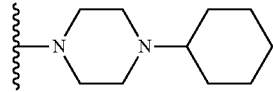
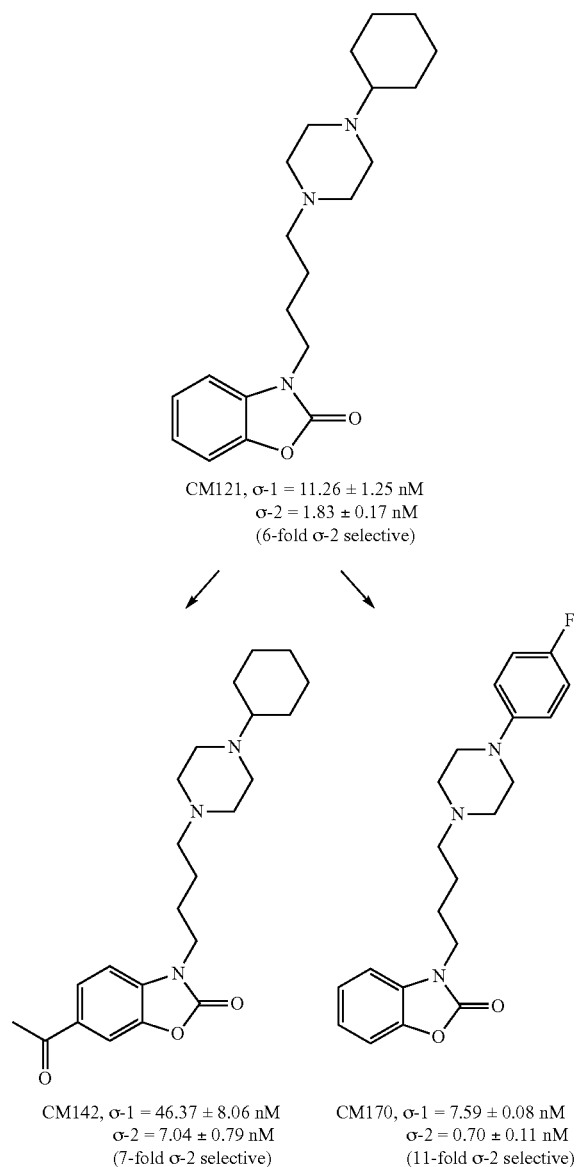
Initial series 2(3H)-benzothiazolones to explore the effects of linker length on sigma receptor affinity						
Compd.	R ₁	R ₂ ,R ₅	n	σ-1 (K _p , nM)	σ-2 (K _p , nM)	σ-1/σ-2
SN-97		H	2	4.66 ± 0.74	2.25 ± 0.37	2.1
SN-98		H	3	5.61 ± 0.74	3.05 ± 0.41	1.84
CM-145		H	4	4.17 ± 0.62	0.39 ± 0.06	10.69
SN-99		H	5	4.98 ± 0.42	2.44 ± 0.26	2.04

TABLE 2-continued

Initial series 2(3H)-benzothiazolones to explore the effects of linker length on sigma receptor affinity						
Compd.	R ₁	R ₂ , R ₅	n	σ-1 (K _s , nM)	σ-2 (K _s , nM)	σ-1/σ-2
SN-102		H	6	6.55 ± 0.25	1.49 ± 0.18	4.40

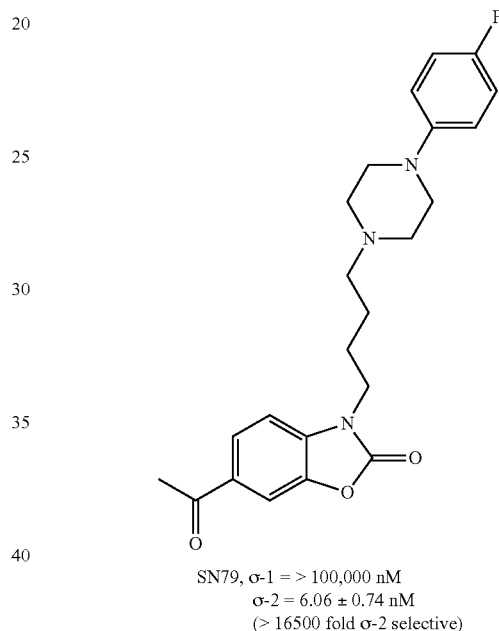
CM121 showed a six fold preference for the σ-2 subtype, suggesting that a four methylene spacer between the piperazine ring and the heterocycle may favor σ-2 affinity (Table 1, Scheme 1). During further SAR studies, compound CM170 was found to have an 11 fold preference for the σ-2 subtype, suggesting a 4-fluoropiperazine moiety may favor σ-2 affinity (Scheme 1). Additionally, CM142 having a 6-acetyl group in the 2(3H)-benzoxazolone heterocycle increased the preference for σ-2 receptors by 7 fold (Scheme 1).

Scheme 1: Sigma-2 selective ligands



Interestingly, SN79 (Scheme 2) showed the highest selectivity (>16,500 fold) for the σ-2 subtype suggesting that a four methylene linker, a 6-acetyl group in the 2(3H)-benzoxazolone heterocycle and a 4-fluoropiperazine moiety favor σ-2 affinity over the σ-1 subtype.

Scheme 2: Compound SN79



When tested on select non-sigma binding sites in rat brain homogenates (Table 3), compound SN79 exhibited weaker interactions, confirming preferential affinity for sigma receptors.

TABLE 3

Non-sigma binding affinity of SN79			
Monoamine transporters	K _i , nM	Other Receptors	K _i , nM
DAT	2615 ± 62	Opioid	>10,000
SERT	159 ± 15	NMDA	>10,000
NET	177 ± 14	Dopamine (D ₂)	>10,000
		5-HT ₂	320 ± 16

Compound SN79 was investigated for in vivo antagonizing effects in cocaine treated mice. Pretreatment of mice with SN79 led to a significant attenuation of cocaine-induced con-

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vulsions, locomotor activity and behavioral sensitization as seen in FIGS. 1-4. These data further demonstrate that compound SN79, acting through σ -2 receptors is able to significantly attenuate both the acute effects of cocaine as well as its chronic effects.

In addition to compounds exhibiting selectivity for the σ -2 receptor, compounds from this same series have demonstrated high affinity for both subtypes. Compound CM156 (Scheme 3), where the 2-oxo is replaced with a sulfur, demonstrated the highest affinity for both subtypes and was therefore examined in several non-sigma binding assays as shown in table 4. CM156 had much weaker affinity for other proteins of interest, confirming preferential affinity for sigma receptors.

Scheme 3: Compound CM156

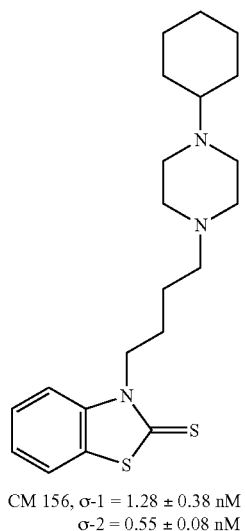


TABLE 4

Non-sigma binding affinity of CM156			
Monoamine transporters	K_i , nM	Other Receptors	K_i , nM
DAT	1175 ± 10	Opioid	$>10,000$
SERT	1402 ± 152	NMDA	$>10,000$
NET	$>10,000$	Dopamine (D_2)	1041 ± 9
		5-HT ₂	1326 ± 159

Compound CM156 was further investigated in vivo for antagonizing effects in cocaine treated mice. Pretreatment of

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mice with CM156 led to a significant attenuation of cocaine-induced convulsions, locomotor activity and behavioral sensitization as seen in FIGS. 5-7. Compound CM156 was additionally investigated for its ability to attenuate methamphetamine-induced locomotor stimulation and neurotoxicity in mice. As seen in FIGS. 8 and 9, CM156 attenuated the locomotor stimulant effects of methamphetamine as well as the neurotoxic effects resulting from methamphetamine exposures. Together, these data demonstrate that CM156 with high affinity for both σ subtypes can mitigate a variety of drug-induced effects, both from cocaine and methamphetamine, in vivo.

The compounds of the present invention are for use as novel radioligands and agents for treatment of drugs of abuse including cocaine- and methamphetamine-induced abuse and toxicities.

EXPERIMENTAL

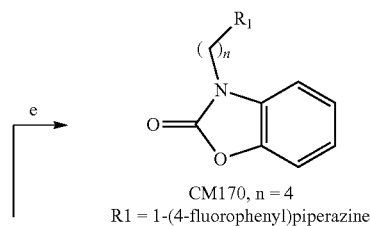
Chemical Synthesis of Novel σ Antagonists

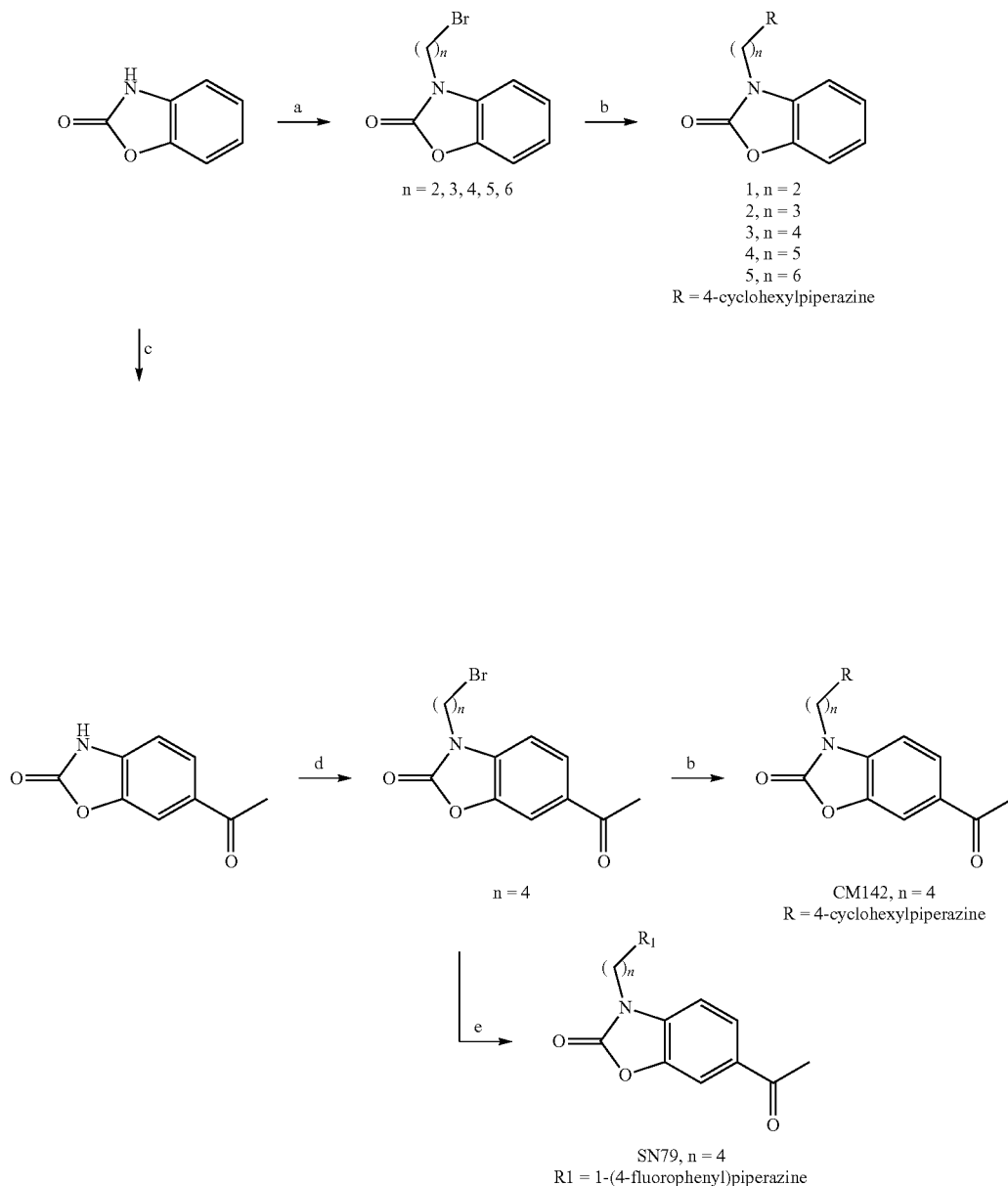
Compounds can be modified in several positions to investigate the effects around the core structure on σ -1 and σ -2 affinities and activities. It has been demonstrated that one can substitute the template molecule through several synthetic routes. These routes which can be easily performed utilizing parallel synthesis methodology, can be easily varied to obtain multiple novel ligands. Initial studies focused on exploring the following changes to the molecules through parallel methodologies: 1) varying the methylene spacer between the tertiary amine and heterocycle; 2) modifying substituents to the piperazine nitrogen above the template; 3) modifying the piperazine ring to substitute piperidines, tetrahydropyridines, azepanes and diazepines; 4) modifying the order of heteroatoms in the heterocycle portion of the molecule as well as the connectivity pattern; and 5) substitution on the benzo portion of the heterocycle to probe the space and physicochemical requirements of the σ receptors.

Compounds were analyzed after purification using standard techniques (NMR, IR, LC/MS, HPLC) and converted into hydrochloride salts for water solubility. Final purity of compounds were achieved through melting points and elemental analysis. When necessary, X-ray crystallography was performed.

Syntheses of 2(3H)-benzoxazolones and 2(3H)-benzothiazolones were accomplished by multistep solution phase synthesis as shown Scheme 4. Synthesis involved simple base-mediated alkylation and Friedel-Craft's alkylation reactions.

Scheme 4.





Reagents and conditions: a) Dibromoalkane, K_2CO_3 , DMF, $60^\circ C$, 2 h; b) 1-cyclohexylpiperazine, K_2CO_3 , DMF, $60^\circ C$, 3 h; c) $(CH_3CO)_2O$, $AlCl_3$, $75^\circ C$, 4 h; d) 1,4-dibromobutane, K_2CO_3 , DMF, $60^\circ C$, 2 h; e) 1-(4-fluorophenyl)piperazine, K_2CO_3 , DMF, $60^\circ C$, 4 h

σ Receptor Assays

Compounds were evaluated for σ -1 and σ -2 binding in rat brain homogenates. Twelve concentrations of each test ligand (0.001-1,000 nM) were incubated for 120 min at $25^\circ C$ in 50 mM Tris-HCl, pH 8.0 with 500 μg membrane protein, and 5 nM [3H](+)-pentazocine (for σ_1 assays) or 3 nM [3H]DTG plus 300 nM (+)-pentazocine (for σ_2 assays); non-specific binding was determined in the presence of 10 μM haloperidol. The assays were terminated with ice-cold 10 mM Tris-HCl, pH 8.0, followed by two washes through glass fiber filters that were pre-soaked for at least 30 min in 0.5% polyethyleneimine

Non- σ Assays

Compounds were tested at various non- σ target sites to evaluate selectivity because cocaine interacts with these sites (dopamine, serotonin and norepinephrine transporters) or historic "sigma" ligands interact with them (opioid, NMDA, dopamine D_2 , 5-HT $_2$ receptors). The compounds were tested in competition binding assays using rat brain homogenates as previously published. Briefly, the radioligands to label the sites of interest and compounds to define non-specific binding were as follows: dopamine transporters (0.5 nM [3H]WIN35, 428, 50 μM cocaine), serotonin transporters (0.2 nM [3H]paroxetine, 1.5 μM imipramine), norepinephrine transporters (0.5 nM [3H]nisoxetine, 4 μM desipramine), opioid receptors

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(2 nM [^3H]bremazocine, 10 μM levallorphan), NMDA receptors (5 nM [^3H]TCP, 10 μM cyclazocine), dopamine D₂ receptors (5 nM [^3H](–)-sulpiride, 1 μM haloperidol), and 5-HT₂ receptors (2 nM [^3H]ketanserin, 1 μM mianserin). The results were reported as K_i in nM. If after three independent replications of the assay, the 10,000 nM concentration of the compound did not display at least 30% inhibition of the radioligand, the affinity of the compound was reported as >10,000 nM.

Cocaine-Induced Convulsions

Male, Swiss Webster mice were pretreated (i.p.) with saline or compound (0.1-10 mg/kg), then challenged 15 min later with a convulsive dose of cocaine (70 mg/kg, i.p.). Mice were observed for the next 30 min for convulsions, which were defined as a loss of righting reflexes for at least 5 sec combined with the presence of clonic limb movements or popcorn jumping. Fisher's exact test was used to determine whether the effect produced by pretreatment with a particular drug dose differed significantly from pretreatment with the saline control.

Cocaine-Induced Locomotor Activity

Male, Swiss Webster mice were acclimated to the treatment room and then to the chambers of the automated activity monitoring system (San Diego Instruments, San Diego, Calif.). They were injected (i.p.) with saline or compound (0.1-20 mg/kg), then challenged 15 min later with cocaine (20 mg/kg, i.p.) or saline (i.p.). The total locomotor activity (ambulatory, fine and rearing movements) of the mice was recorded for the next 30 min as the number of disruptions made by them in the 16×16 photobeam grid of their testing chamber.

Development of Sensitization

Male, Swiss Webster mice were acclimated as detailed above. For five consecutive days (Days 1-5), the mice were pretreated (i.p.) with saline or compound (0.1-20 mg/kg), then challenged 15 min later with cocaine (10 mg/kg, i.p.) or saline (i.p.). The total locomotor activity (ambulatory, fine and rearing movements) of the mice was recorded for the next 30 min as the number of disruptions made by them in the

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16×16 photobeam grids of their testing chamber on each of the five days. A 10 day drug-free period followed. On Day 15, all of the mice were pre-administered (i.p.) saline followed by cocaine (10 mg/kg, i.p.), and locomotor activity quantified for the next 30 min.

Expression of Sensitization

Male, Swiss Webster mice were acclimated as detailed above. For five consecutive days (Days 1-5), the mice were pretreated (i.p.) with saline, then challenged 15 min later with cocaine (10 mg/kg, i.p.). The total locomotor activity (ambulatory, fine and rearing movements) of the mice was recorded for the next 30 min. A 10 day drug free period followed and on Day 15, the mice were administered saline (i.p.) or compound (0.1-20 mg/kg), followed 15 min later with cocaine (10 mg/kg, i.p.). Locomotor activity was then recorded for the next 30 min.

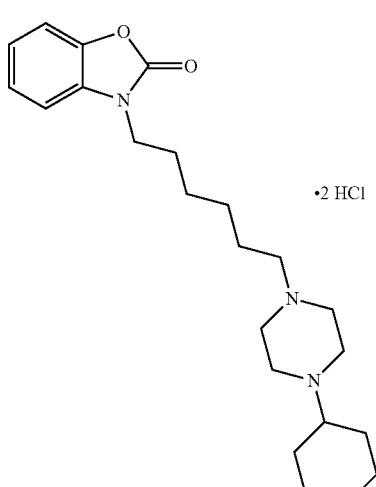
Methamphetamine-Induced Locomotor Activity

Male, Swiss Webster mice were acclimated as detailed above. They were injected (i.p.) with saline or compound (0.1-20 mg/kg), then challenged 15 min later with methamphetamine (1 mg/kg, i.p.) or saline (i.p.). The total locomotor activity (ambulatory, fine and rearing movements) of the mice was recorded for the next 30 min as the number of disruptions made by them in the 16×16 photobeam grids surrounding their testing chambers.

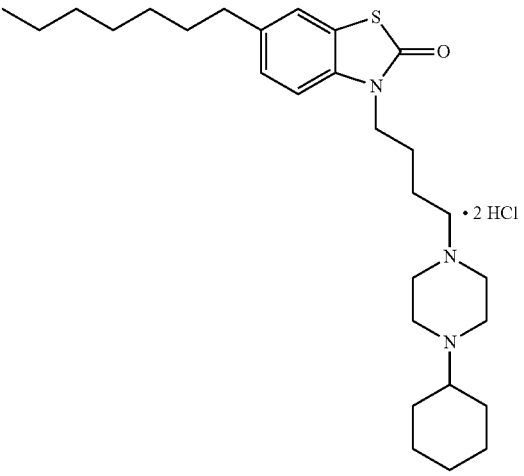
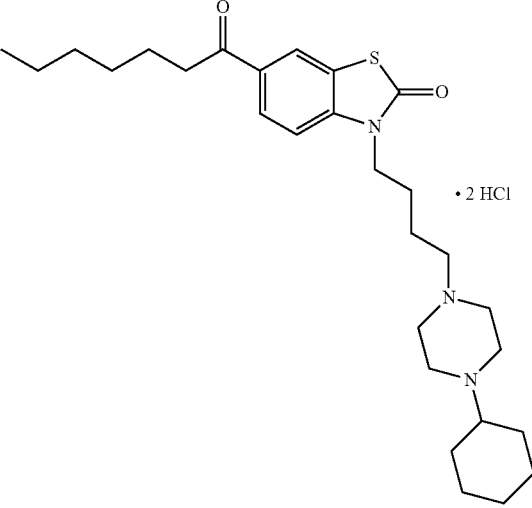
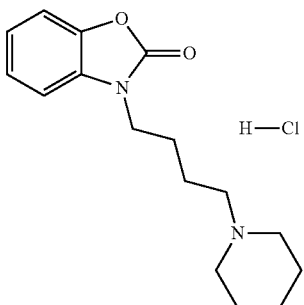
Methamphetamine-Induced Dopamine Depletions

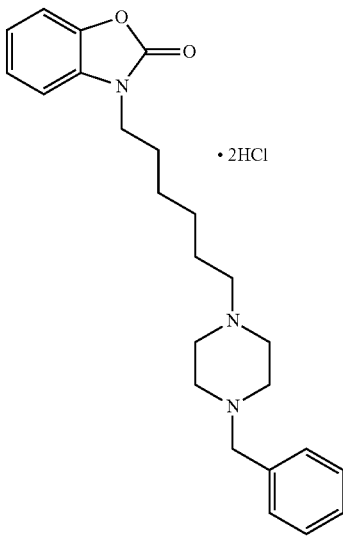
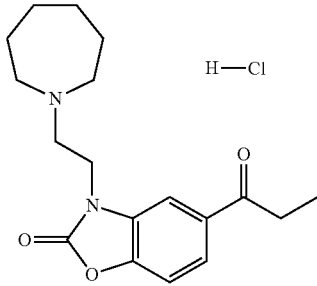
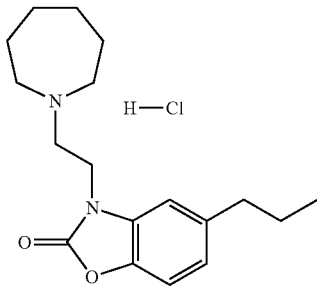
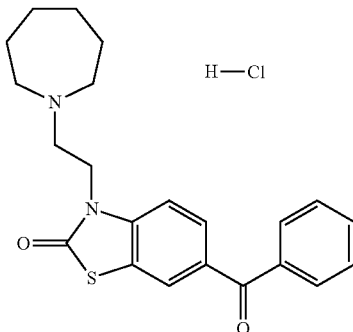
Male, Swiss Webster mice were injected (i.p.) with saline or compound (0-20 mg/kg), followed 15 min later with either saline (–METH) or methamphetamine (5 mg/kg) at 2 hr intervals, a total of four times. Striatal dopamine levels were measured one week later.

The following represents compounds which are within the scope of the invention and which were prepared and tested for activity. Also included are compounds which were prepared but not tested but which are expected to have activity similar to the prepared and tested compounds. Also included in the listing are compounds which can be prepared and which would be expected to have activities similar to those compounds which were prepared and tested.

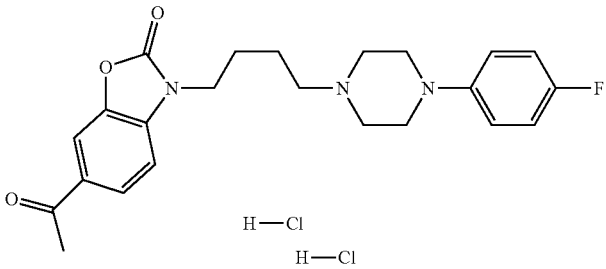
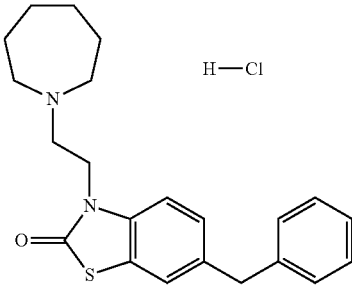
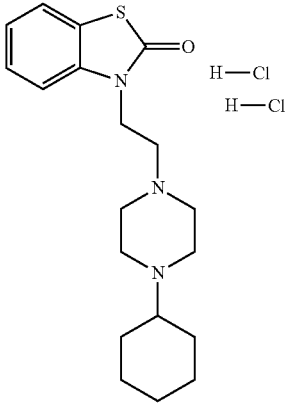
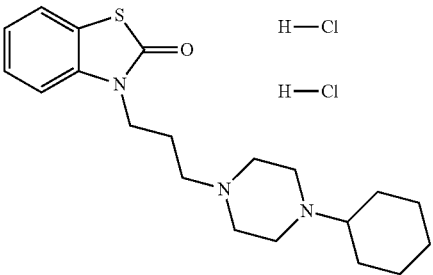
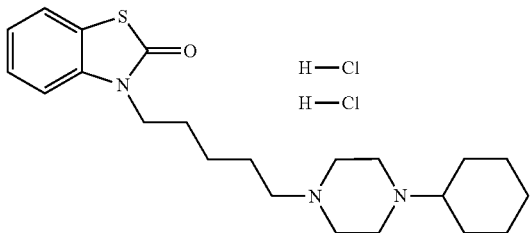
Compd.	Structure	K _i (nM)
SN-48		$\sigma_1 = 4.60 \pm 1.08$ $\sigma_2 = 3.06 \pm 0.45$

-continued

Compd.	Structure	Ki (nM)
SN-55	 <chem>CCCCCCCCc1ccc2c(c1)sc(=O)n2CCCCN3CCN(CC3C4CCCCC4)CCCC5=CC=CC=C5.Cl.Cl</chem>	$\sigma_1 = 34.12 \pm 8.09$ $\sigma_2 = 31.39 \pm 6.87$
SN-57	 <chem>CCCCCCCCC(=O)c1ccc2c(c1)sc(=O)n2CCCCN3CCN(CC3C4CCCCC4)CCCC5=CC=CC=C5.Cl.Cl</chem>	$\sigma_1 = 43.76 \pm 6.12$ $\sigma_2 = 29.29 \pm 2.83$
SN-60	 <chem>CCCCCCCCc1ccc2c(c1)oc(=O)n2CCCCN3CCN(CC3C4CCCCC4)CCCC5=CC=CC=C5.Cl</chem>	$\sigma_1 = 12.06 \pm 1.54$ $\sigma_2 = 212.67 \pm 11.81$

Compd.	Structure	Ki (nM)
SN-61		$\sigma_1 = 4.68 \pm 1.37$ $\sigma_2 = 107.1 \pm 32.59$
SN-71		$\sigma_1 = 114.74 \pm 25.91$ $\sigma_2 = 2342 \pm 229.80$
SN-72		$\sigma_1 = 3.33 \pm 0.41$ $\sigma_2 = 1810.66 \pm 83.76$
SN-78		$\sigma_1 = 88.31 \pm 8.59$ $\sigma_2 = 859.66 \pm 86.59$

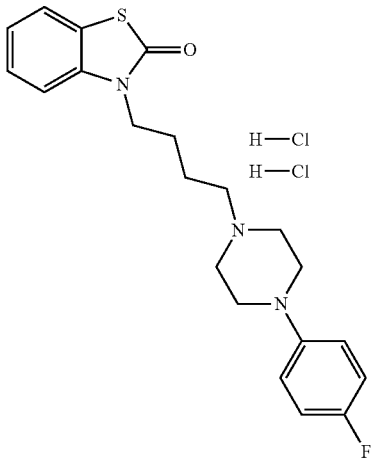
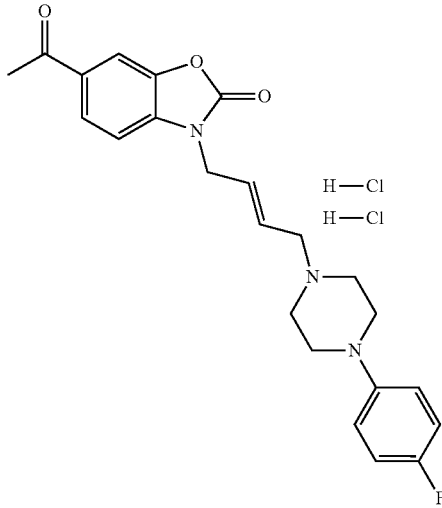
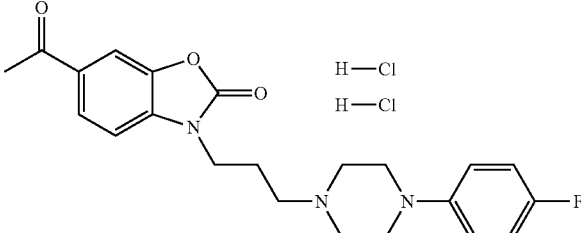
-continued

Compd.	Structure	Ki (nM)
SN-79		$\sigma_1 = >100,000$ $\sigma_2 = 6.06 \pm 0.74$
SN-81		$\sigma_1 = 7.42 \pm 3.21$ $\sigma_2 = 224.56 \pm 46.88$
SN-97		$\sigma_1 = 4.66 \pm 0.74$ $\sigma_2 = 2.25 \pm 0.37$
SN-98		$\sigma_1 = 5.61 \pm 0.74$ $\sigma_2 = 3.05 \pm 0.41$
SN-99		$\sigma_1 = 4.98 \pm 0.42$ $\sigma_2 = 2.44 \pm 0.26$

-continued

Compd.	Structure	Ki (nM)
SN-102	 <chem>ClC1=CC=C(C=C1)N(CCCC1CCN(C1)C2CCCCC2)C3C(=O)SC3=CC=C4C(=O)OCC4</chem>	$\sigma_1 = 6.55 \pm 0.25$ $\sigma_2 = 1.49 \pm 0.18$
SN-123	 <chem>ClC1=CC=C(C=C1)N(C/C=C/C2CCN(C2)C3=CC=C(C=C3)F)C4C(=O)OC4=CC=C5C(=O)OCC5</chem>	
SN-124	 <chem>ClC1=CC=C(C=C1)N(C/C=C/C2CCN(C2)C3CCCCC3)C4C(=O)OC4=CC=C5C(=O)C(=C6C=CC(=C6)C(=O)C)C5</chem>	

-continued

Compd.	Structure	Ki (nM)
SN-125		
SN-126		
SN-127		

-continued

Compd.	Structure	Ki (nM)
SN-136	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCN3CCN(C3)c4ccc(F)cc4.Cl.Cl</chem>	
SN-137	 <chem>CC(=O)c1ccc2c(c1)sc(=O)n2CCCCN3CCN(C3)c4ccc(F)cc4.Cl.Cl</chem>	
SN-138	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCN3CCN(C3)c4ccccc4F.Cl.Cl</chem>	
SN-139	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCCN3CCN(C3)c4ccc(F)cc4.Cl.Cl</chem>	
SN-140	 <chem>O=C1OC(=O)N1Cc2ccc(cc2)C=C3CCN4CCN(C4)c5ccc(F)cc5Cl.Cl</chem>	

-continued

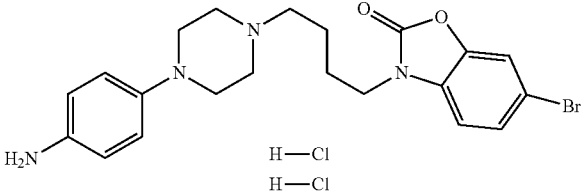
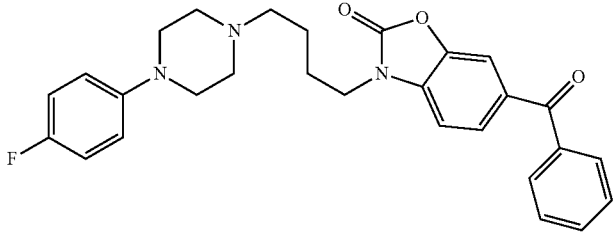
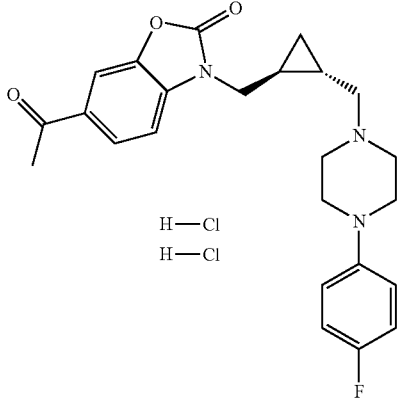
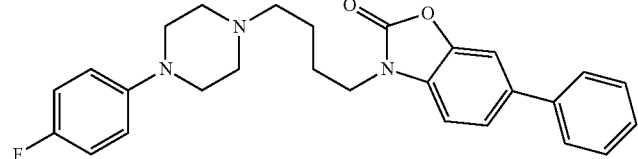
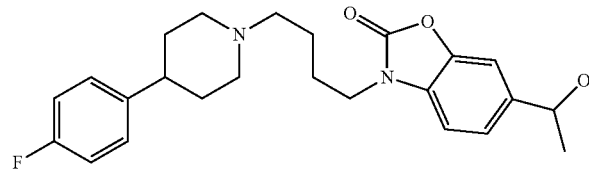
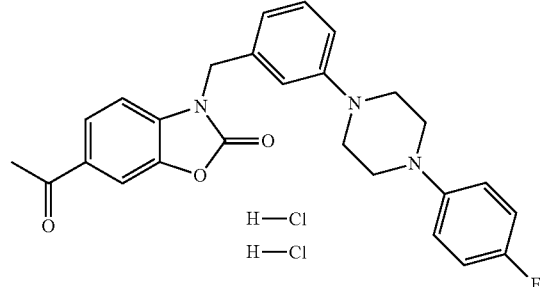
Compd.	Structure	Ki (nM)
SN-147	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCN3CCN(C3)c4ccc(F)cc4</chem> $\text{H}-\text{Cl}$ $\text{H}-\text{Cl}$	
SN-148	 <chem>CC(=O)c1ccc2c(c1)sc(=O)n2CCN3CCN(C3)c4ccc(F)cc4</chem> $\cdot\text{HCl}$	
SN-150	 <chem>O=C1OC(=O)N1CC/C=C/CN2CCN(C2)c3ccccc3</chem> $\text{H}-\text{Cl}$ $\text{H}-\text{Cl}$	
SN-158	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CC/C=C/CN3CCN(C3)c4ccc(F)cc4</chem> $\text{H}-\text{Cl}$ $\text{H}-\text{Cl}$	

-continued

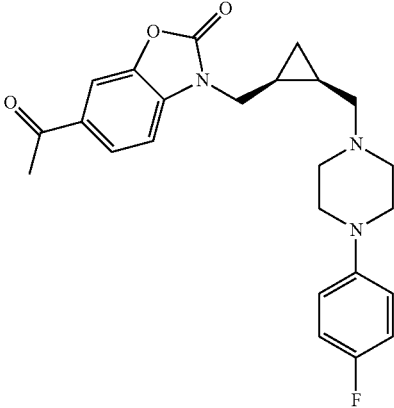
Compd.	Structure	Ki (nM)
SN-167	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCN3CCN(Cc4ccc(F)cc4)CC3</chem> H—Cl H—Cl	
SN-168	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CC#CCN3CCN(Cc4ccc(F)cc4)CC3</chem> H—Cl H—Cl	
SN-169	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCC(=O)N3CCN(Cc4ccc(F)cc4)CC3</chem> H—Cl H—Cl	
SN-170	 <chem>CCc1ccc2c(c1)oc(=O)n2CCCCN3CCN(Cc4ccc(F)cc4)CC3</chem> H—Cl H—Cl	
SN-196	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCN3CCN(Cc4ccc(F)cc4)CC3</chem> H—Cl H—Cl	
SN-197	 <chem>CC(=O)c1ccc2c(c1)oc(=O)n2CCCCN3CCN(Cc4ccc(Cl)cc4)CC3</chem> H—Cl H—Cl	

Compd.	Structure	Ki (nM)
SN-198	 H—Cl H—Cl	
SN-199	 H—Cl H—Cl	
SN-203	 H—Cl H—Cl	
SN-204	 H—Cl H—Cl	
SN-205	 H—Cl H—Cl	
SN-212	 H—Cl H—Cl	
SN-213	 H—Cl H—Cl	

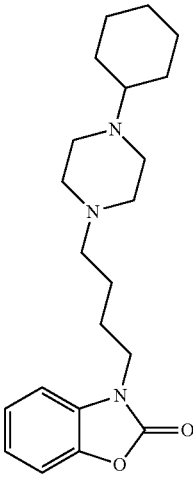
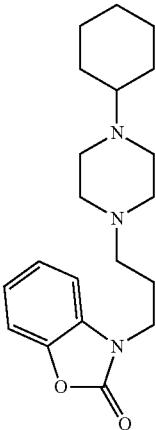
-continued

Compd.	Structure	Ki (nM)
SN-214	 <chem>Nc1ccc(cc1)N2CCN(CC2CCN3CCc4cc(Br)ccc4O3=O)CC5CCc6cc(N)ccc6O5=O.Cl.Cl</chem>	
SN-XXX	 <chem>O=C1C(=O)N2CCc3cc(ccc3O2=O)C(=O)c4ccccc4N2CCN(C2)Cc5ccc(F)cc5</chem>	
SN-XXX	 <chem>CC(=O)c1ccc2c(c1)O[C@H](C2)N3CCc4cc(F)ccc4O3=O[C@H]3C[C@H](N3Cc4cc(F)ccc4O4=O)C5CCc6cc(F)ccc6O5=O.Cl.Cl</chem>	
SN-XXX	 <chem>O=C1C(=O)N2CCc3cc(ccc3O2=O)C(=O)c4ccccc4N2CCN(C2)Cc5ccc(F)cc5</chem>	
SN-XXX	 <chem>CC(=O)c1ccc2c(c1)O[C@H](C2)N3CCc4cc(ccc4O3=O)C(=O)c5ccccc5N3CCN(C3)Cc6ccc(F)cc6</chem>	
SN-XXX	 <chem>CC(=O)c1ccc2c(c1)O[C@H](C2)N3CCc4cc(ccc4O3=O)C(=O)c5ccccc5N3CCN(C3)Cc6ccc(F)cc6</chem>	

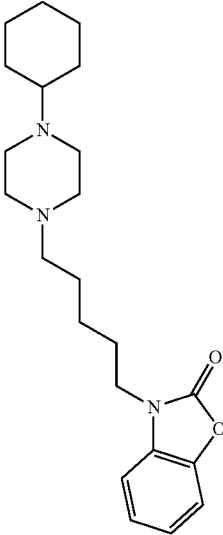
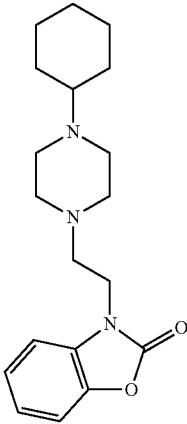
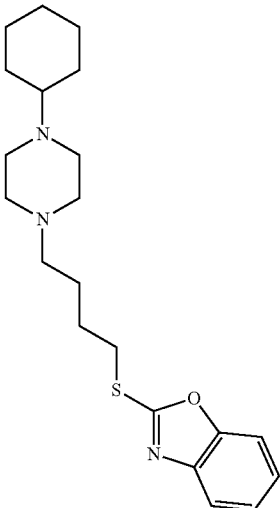
-continued

Compd.	Structure	Ki (nM)
SN-XXX		

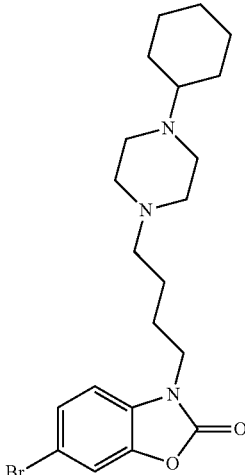
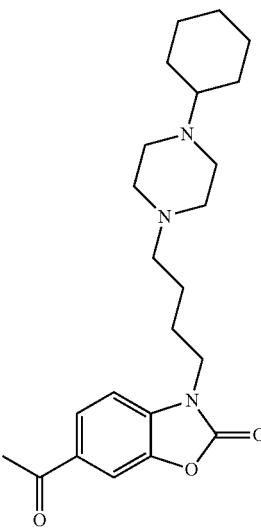
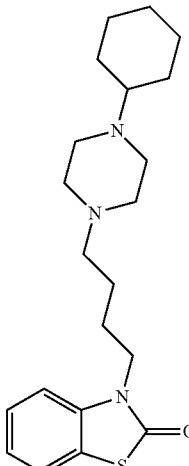
SN-XXX: Synthesis of Compounds in Progress

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 121		11.26 \pm 1.25	1.83 \pm 0.17
CM 124		5.22 \pm 1.11	8.74 \pm 2.30

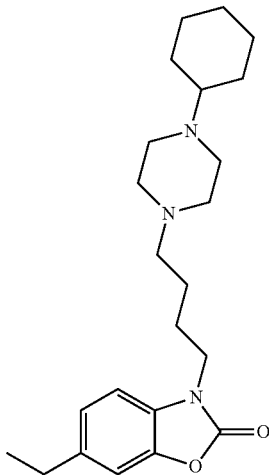
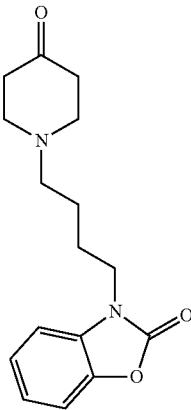
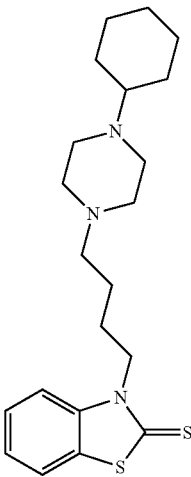
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 126		10.55 ± 2.52	5.89 ± 1.31
CM 129		6.90 ± 0.37	5.43 ± 0.78
CM 135		3.37 ± 0.28	3.77 ± 0.35

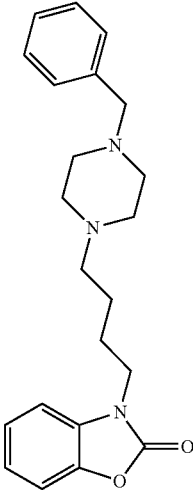
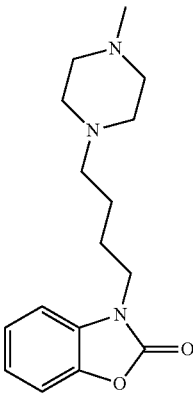
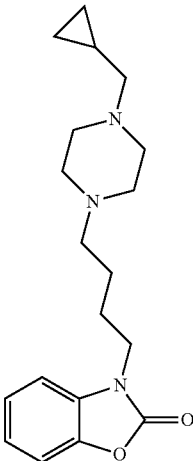
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 138		7.87 ± 0.19	4.47 ± 0.42
CM 142		46.4 ± 8.06	7.04 ± 0.79
CM 145		4.17 ± 0.62	0.39 ± 0.06

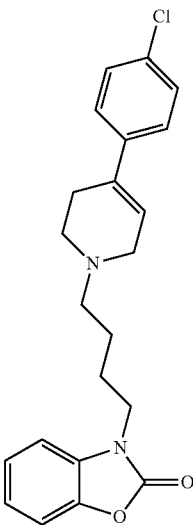
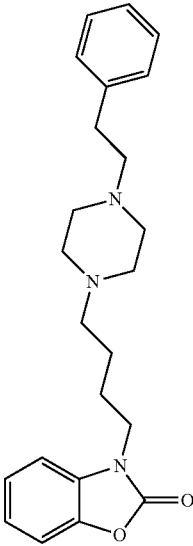
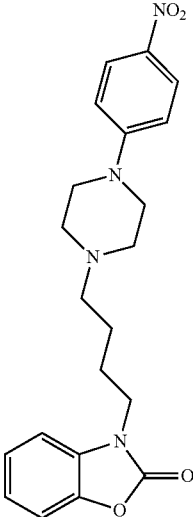
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 146		2.18 ± 0.14	2.56 ± 1.22
CM 152		19.3 ± 0.90	78.5 ± 39.6
CM 156		1.28 ± 0.38	0.55 ± 0.08

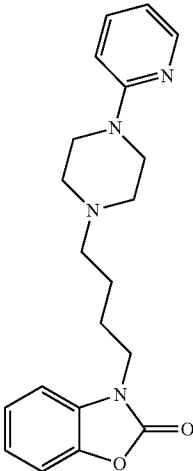
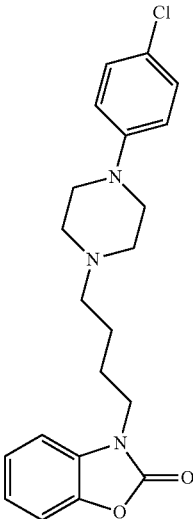
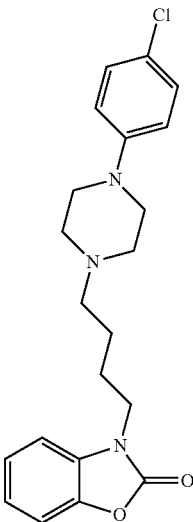
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 159		4.44 ± 0.88	46.41 ± 12.61
CM 160		91.69 ± 11.52	2382.33 ± 142.94
CM 162		10.83 ± 1.00	46.75 ± 10.18

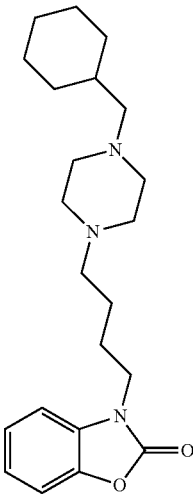
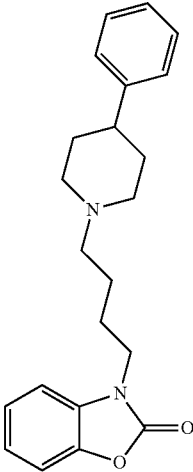
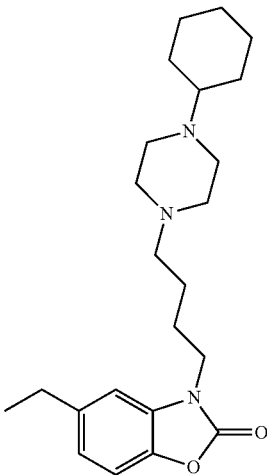
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 165		2.40 ± 0.38	14.44 ± 3.09
CM 166		3.15 ± 0.37	92.71 ± 14.14
CM 167		259.07 ± 33.45	226.00 ± 17.50

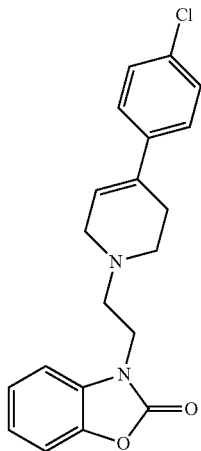
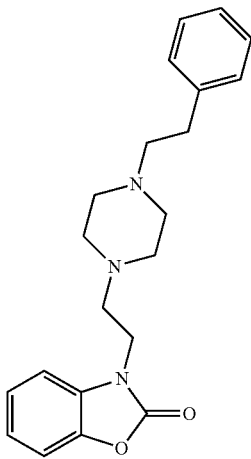
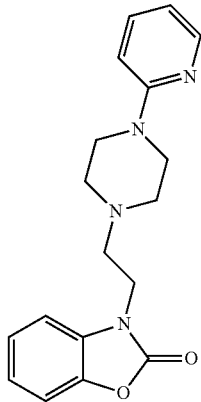
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 168		311.93 \pm 33.22	128.10 \pm 16.26
CM 169		25.44 \pm 4.72	241.5 \pm 28.98
CM 170		7.59 \pm 0.08	0.70 \pm 0.11

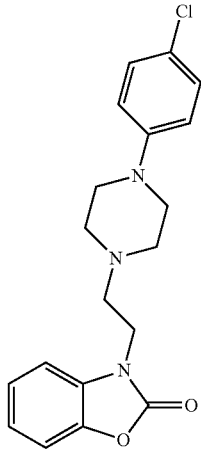
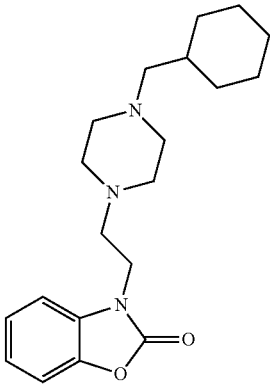
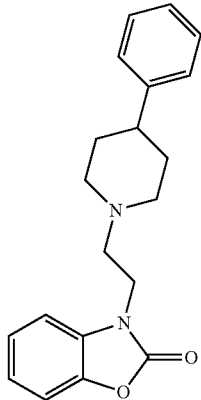
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 171		0.94 ± 0.13	13.94 ± 2.86
CM 172		0.58 ± 0.22	17.22 ± 1.04
CM 174		4.04 ± 0.35	58.24 ± 11.48

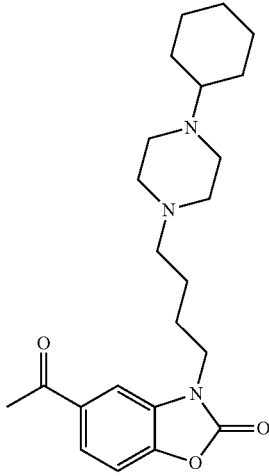
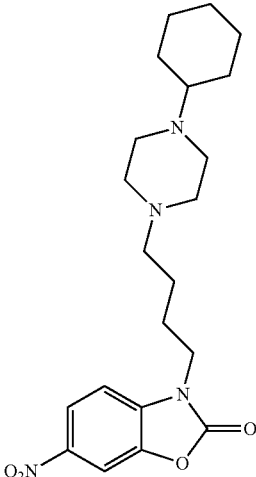
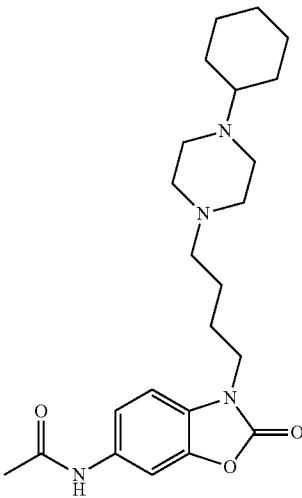
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 175		21.37 \pm 3.68	616.33 \pm 77.47
CM 176		1.43 \pm 0.26	21.73 \pm 2.79
CM 178		>10,000	>10,000

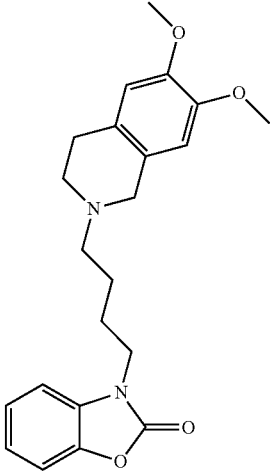
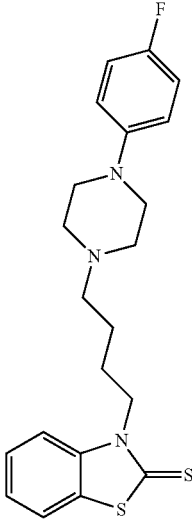
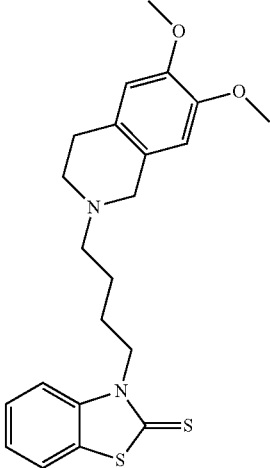
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 179		1426.33 \pm 185.09	2260 \pm 96.08
CM 181		2.36 \pm 0.38	8.83 \pm 1.17
CM 182		14.08 \pm 2.84	777.26 \pm 72.47

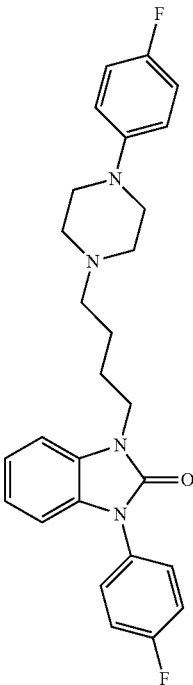
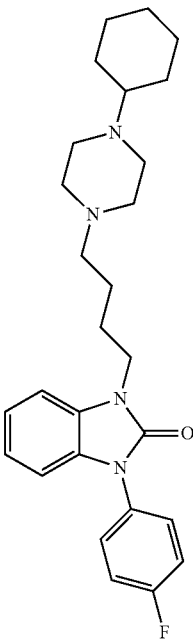
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 184		40.82 ± 6.21	10.41 ± 1.54
CM 188		11.11 ± 1.61	2.46 ± 0.18
CM 191		213.87 ± 55.33	77.37 ± 14.22

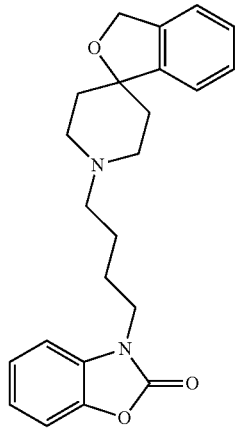
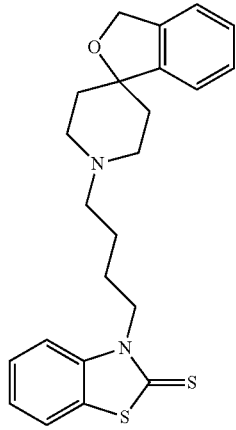
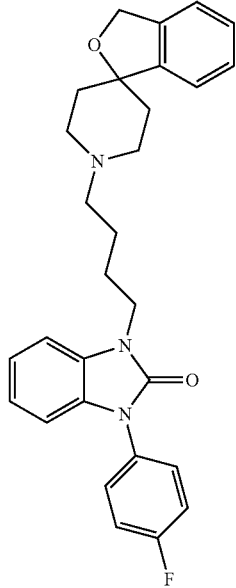
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 295		74.31 ± 3.77	1.52 ± 0.64
CM 307		6.27 ± 0.78	6.61 ± 1.42
CM 308		9.11 ± 1.31	0.56 ± 0.12

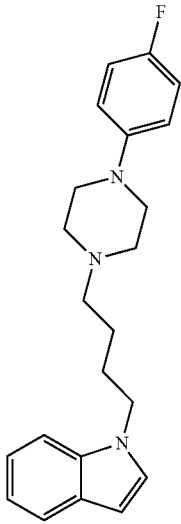
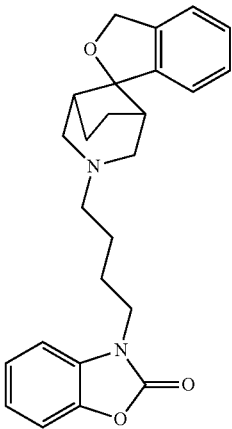
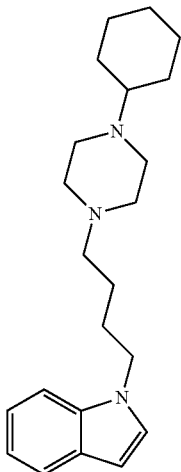
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 322		118.46 \pm 48.37	1.67 \pm 0.16
CM 325		5.04 \pm 0.66	2.12 \pm 0.75

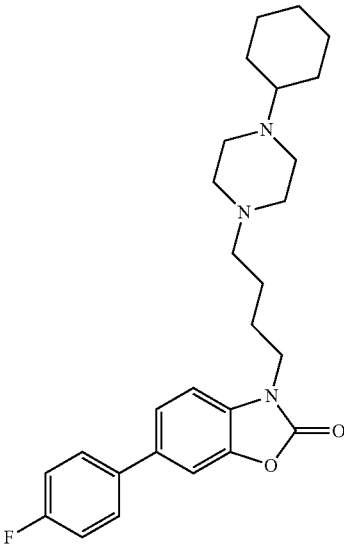
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 328			
CM 329			
CM 330			

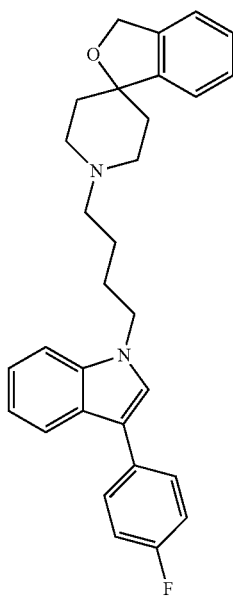
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 338		169.8 \pm 5.68	1.09 \pm 0.03
CM 339			
CM 341		3.28 \pm 0.32	1.90 \pm 0.16

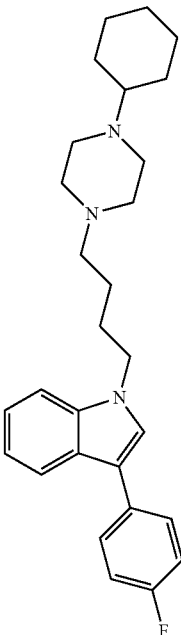
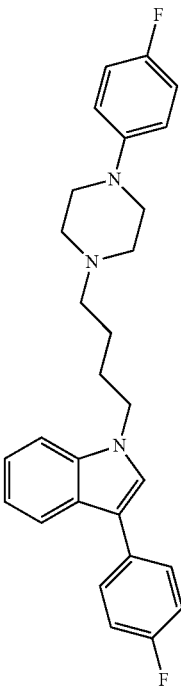
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 343		17.6 ± 0.82	38.13 ± 1.42

CM 347



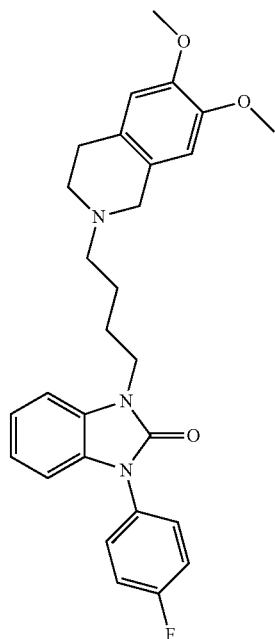
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 349		90.87 ± 12.30	22.55 ± 1.13
CM 350		1202 ± 73.89	83.33 ± 3.96

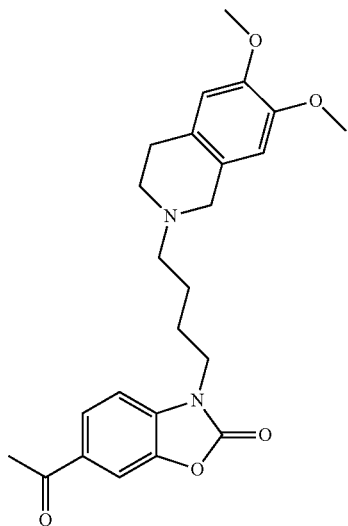
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
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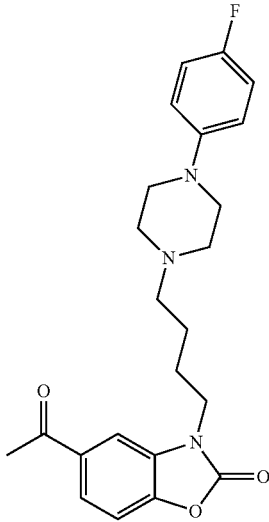
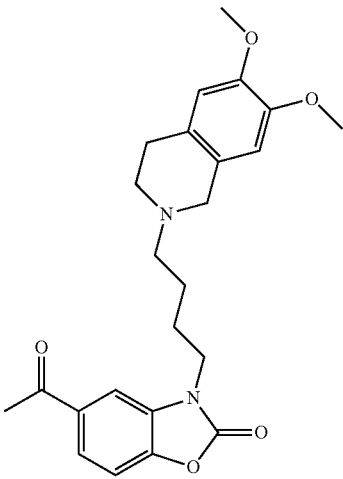
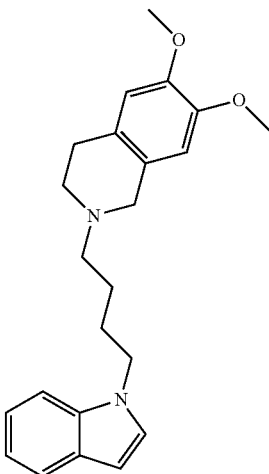
CM 353



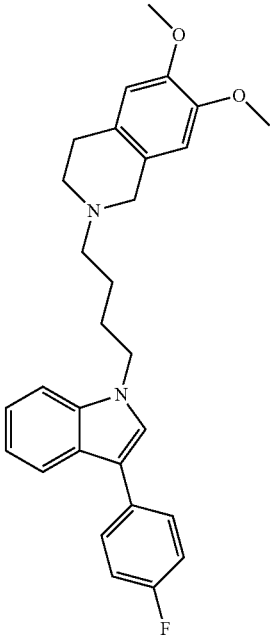
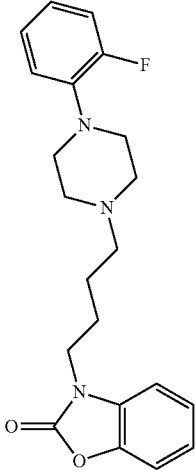
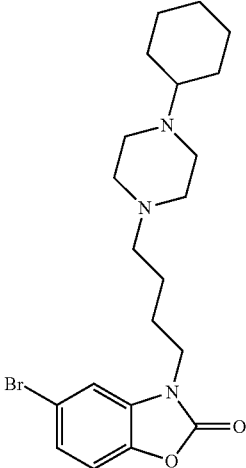
CM 355



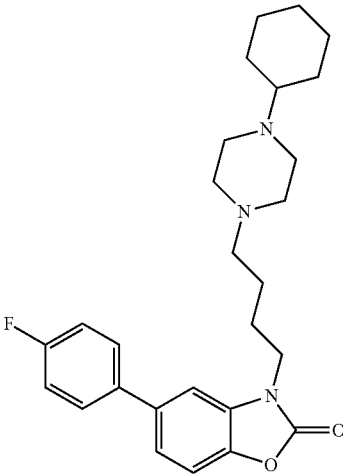
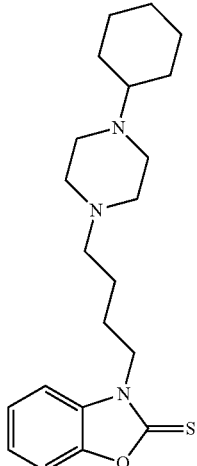
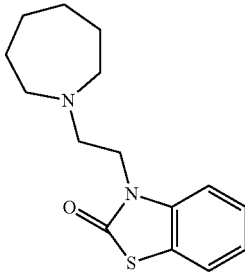
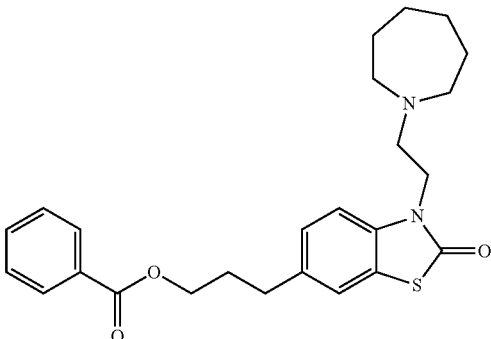
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 356		27.82 \pm 4.14	1.21 \pm 0.20
CM 357			
CM 360		73.25 \pm 5.58	0.21 \pm 0.020

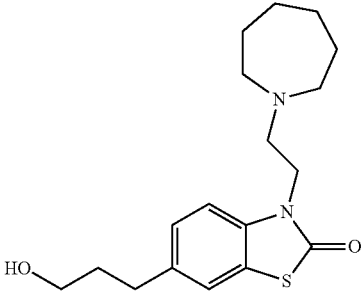
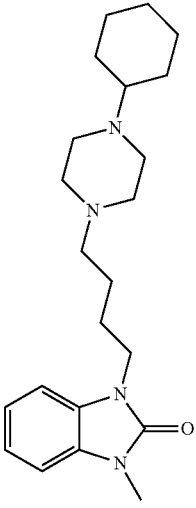
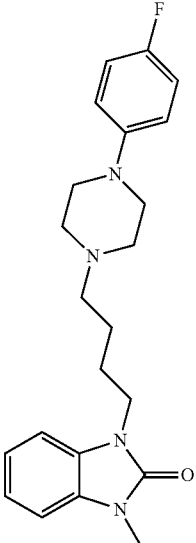
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 361		4713 \pm 449.50	4.37 \pm 0.33
CM 362		17.64 \pm 3.34	2.79 \pm 0.49
CM 365		5.94 \pm 0.35	0.055 \pm 0.0063

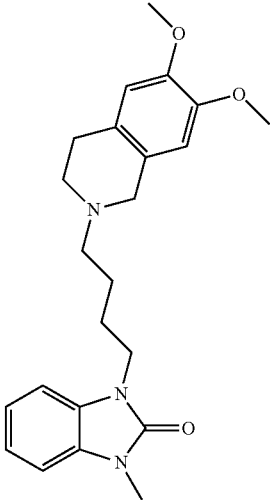
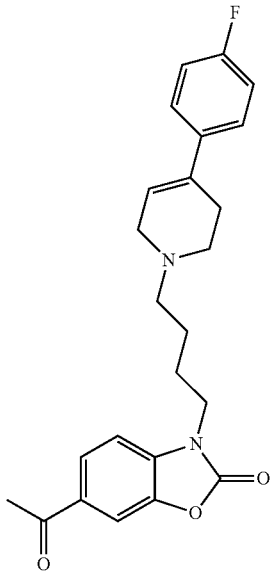
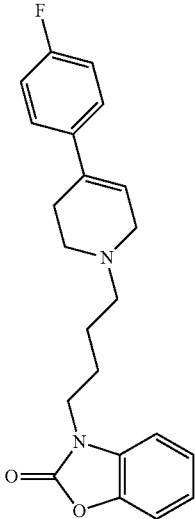
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 366		22.55 ± 1.14	0.0061 ± 0.00096
CM 372		4.90 ± 1.70	0.77 ± 0.06
CM 373			
CM 393			

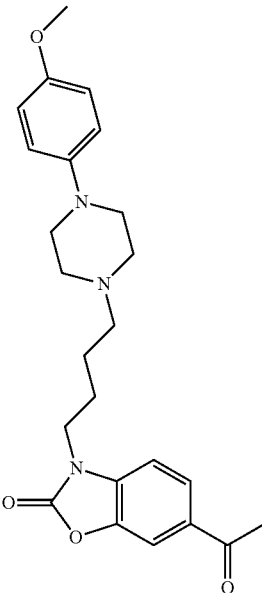
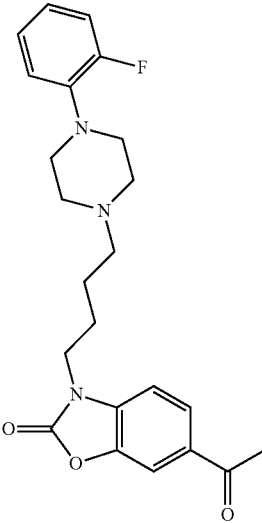
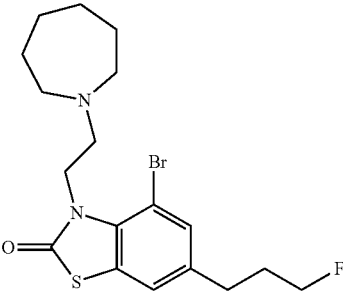
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 394			
CM 396		50.22 ± 7.59	2.57 ± 0.47
CM 397		414.83 ± 26.12	0.46 ± 0.03

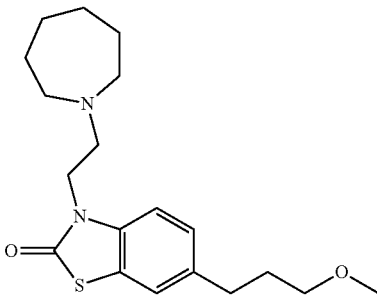
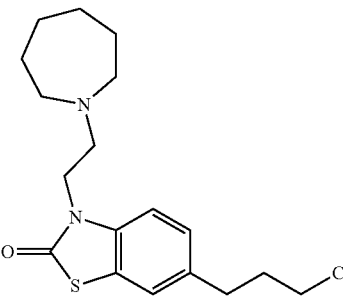
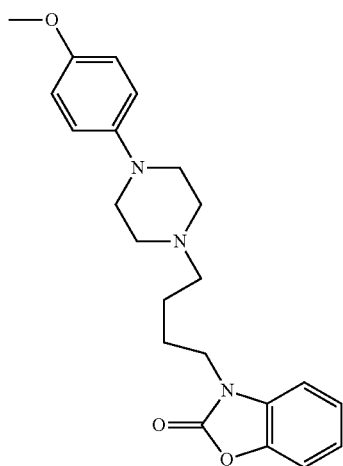
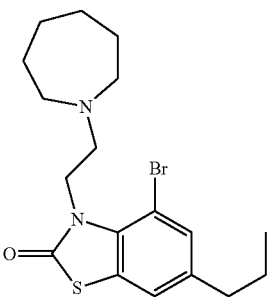
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 398			
CM 401		2.89 ± 0.23	0.66 ± 0.08
CM 406			

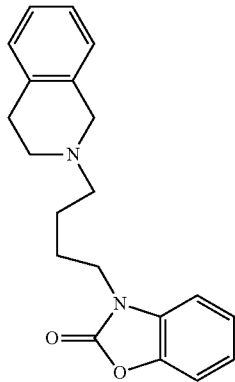
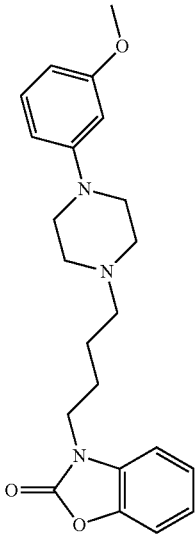
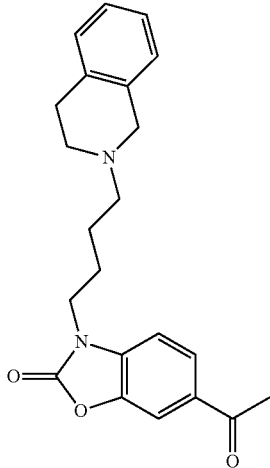
-continued

CMPD	STRUCTURE	K _i (nM) σ_1	K _i (nM) σ_2
CM 407	 <chem>COc1ccc(cc1)N2CCN(CC2)CCCN3C(=O)Oc4ccc(cc4N3)C(=O)C</chem>		
CM 408	 <chem>Fc1ccccc1N2CCN(CC2)CCCN3C(=O)Oc4ccc(cc4N3)C(=O)C</chem>		
CM 418	 <chem>Brc1cc(ccc1Sc2c(=O)n(CCN2C3CCCCC3)CC4=CC=C(C=C4)F)C5=CC=CC=C5F</chem>		

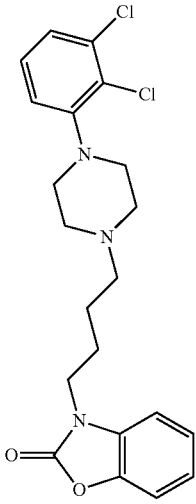
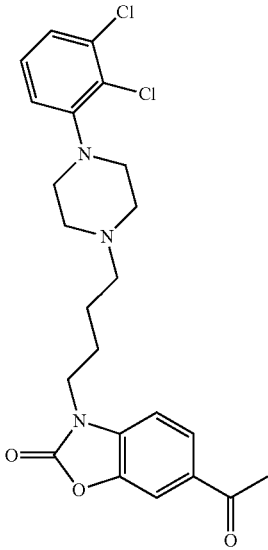
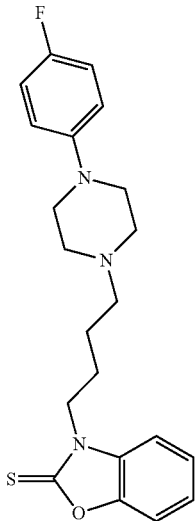
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 422			
CM 423			
CM 433			
CM 435			

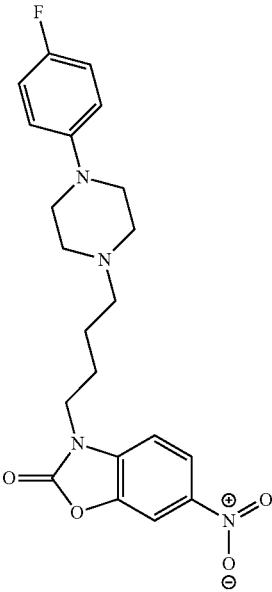
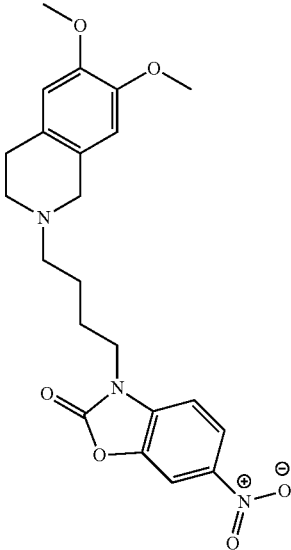
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM436			
CM 442			
CM 444			

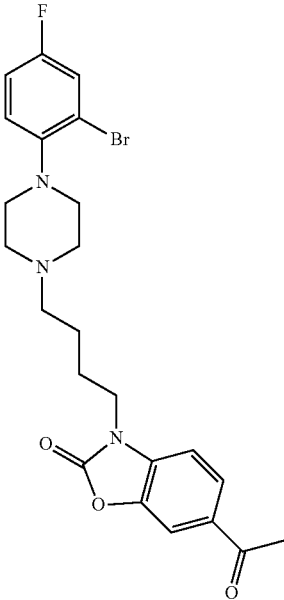
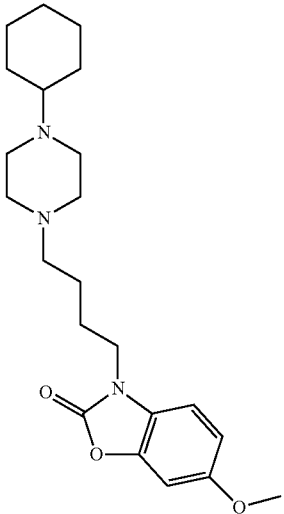
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 449			
CM 450			
CM 454			

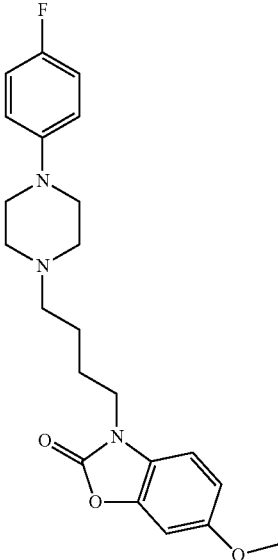
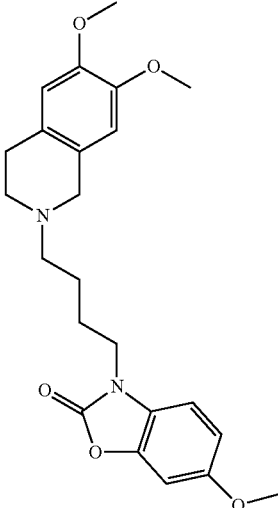
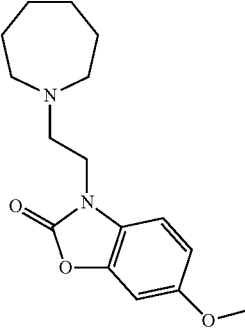
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 458			
CM 459			

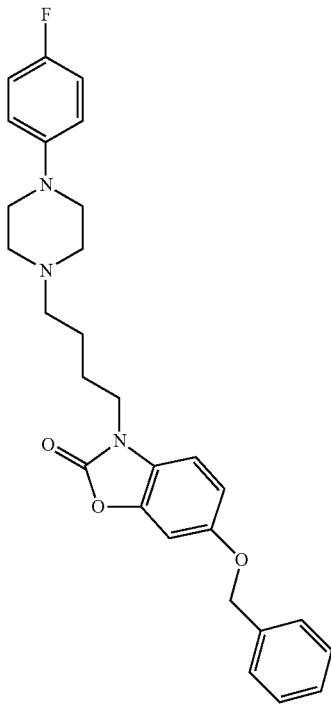
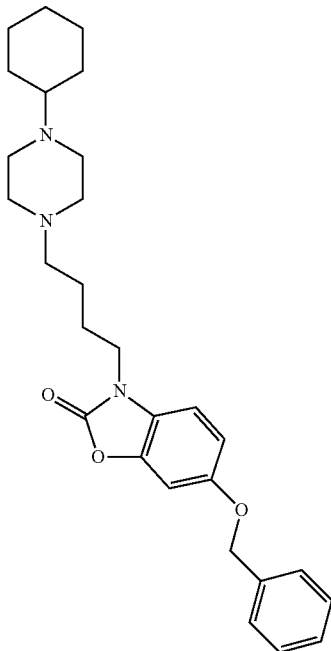
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 461			
CM 464			

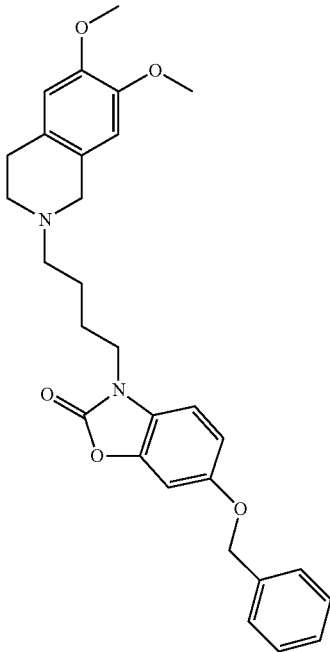
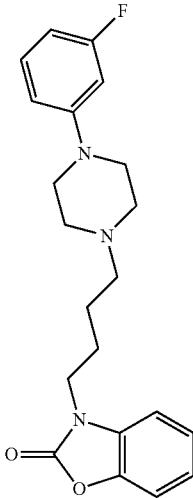
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 465			
CM 466			
CM 471			

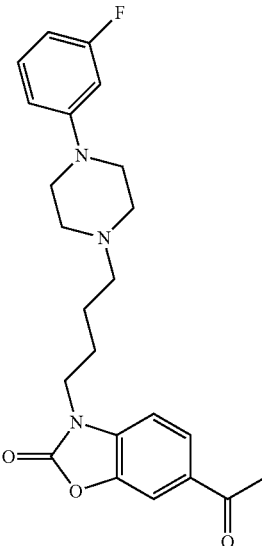
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 483			
CM 484			

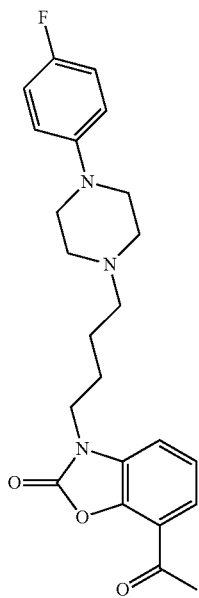
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 485			
CM 490			

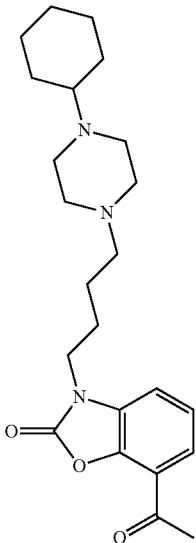
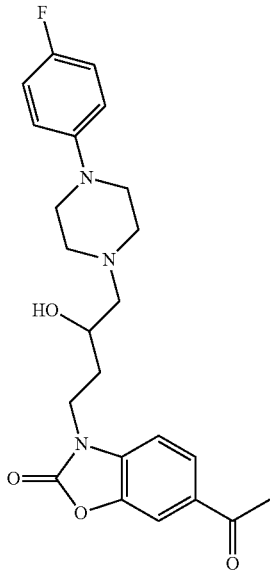
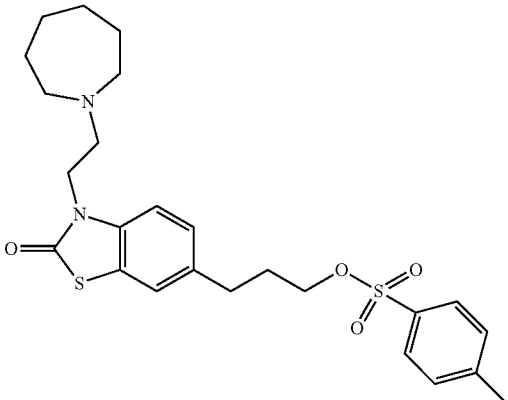
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 491			

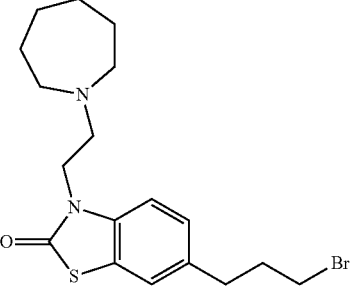
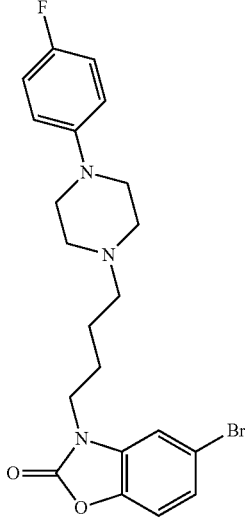
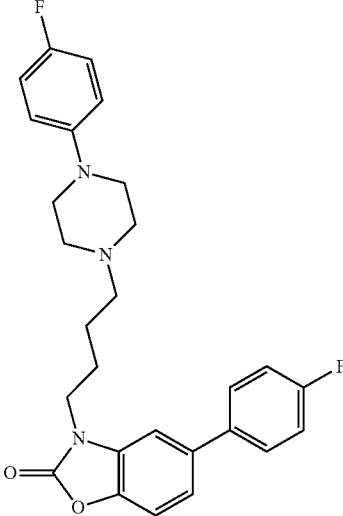
CM 498



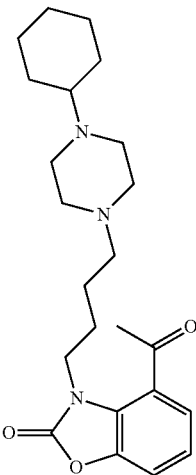
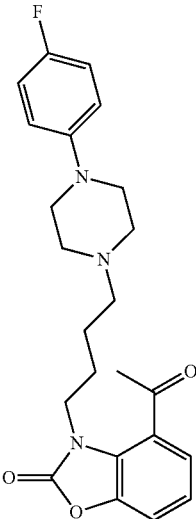
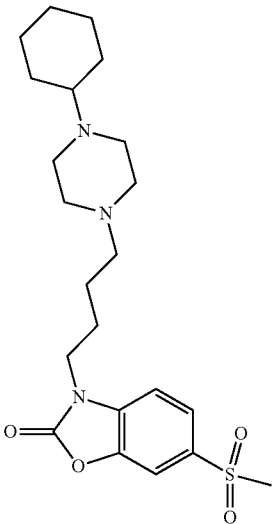
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 500			
CM 504			
CM 528			

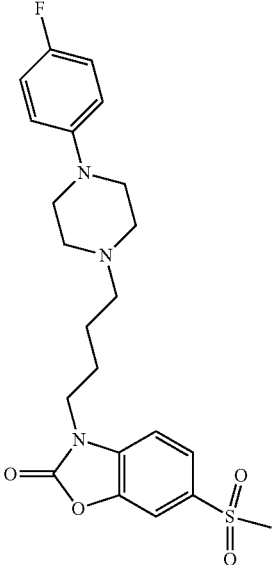
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 538			
CM 539			
CM 540			

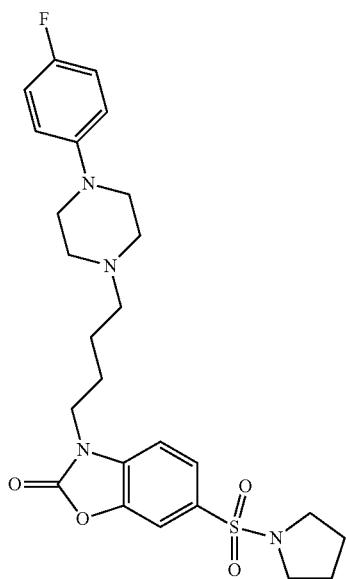
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CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 563			
CM 564			
CM 566			

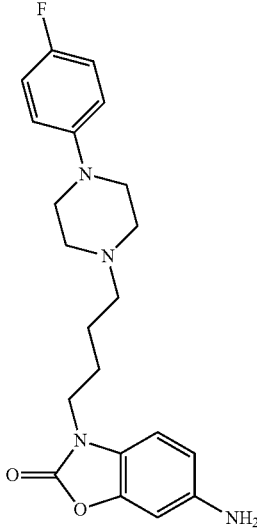
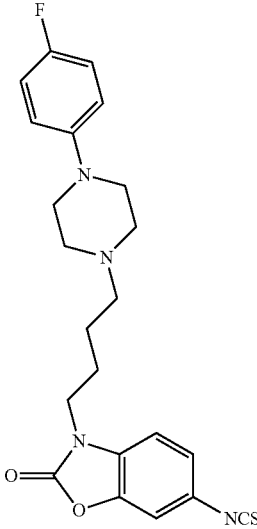
-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 567			

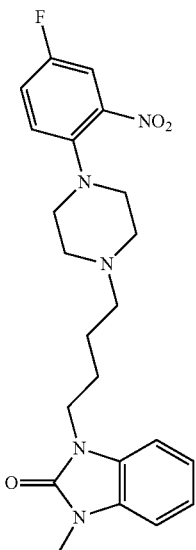
CM 569



-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 571	 <chem>Fc1ccc(cc1)N2CCN(CC2)CCCN3C(=O)Oc4cc(N)ccc4N3</chem>		
CM 572	 <chem>Fc1ccc(cc1)N2CCN(CC2)CCCN3C(=O)Oc4cc(N=C=S)ccc4N3</chem>		

-continued

CMPD	STRUCTURE	Ki (nM) σ_1	Ki (nM) σ_2
CM 585			

The present invention comprises a method of treating a subject for alleviation of affects in the subject resulting from drug intake or drug abuse by the subject comprising administering to the subject a therapeutically effective amount of at least one compound according to the invention.

The drug abuse or drug intake can result from methamphetamine intake or methamphetamine abuse by the subject or from cocaine abuse or cocaine intake by the subject.

The present invention further comprises a method of treating a subject having a need for therapy involving sigma receptors comprising administering to the subject an effective amount of at least one compound of the present invention and additionally comprises treating a subject to prevent neurotoxic effects resulting from drug abuse or drug intake by the subject comprising administering to the subject a therapeutically effective amount of at least one compound according to the invention.

The invention further comprises radioligand compositions comprising at least one compound according to the invention wherein at least one compound contains a radioactive element.

Pharmaceutical compositions according to the invention are those which are suitable for enteral, such as oral, administration and for parenteral, such as subcutaneous, administration to warm-blooded animals, especially humans, and which contain the pharmacologically active substance on its own or together with a pharmaceutically acceptable carrier. The dosage of the active substance depends on the species of warm-blooded animal and on the age and individual condition, the illness to be treated and also on the mode of administration. Such dosage can be readily determined by those practicing in the relevant art area.

The novel pharmaceutical preparations contain from approximately 10% to approximately 95%, and preferably from approximately 20% to approximately 90%, of the active substance. Pharmaceutical compositions according to the invention can, for example, be in unit dose form, such as dragees, tablets, capsules, suppositories or ampoules.

The pharmaceutical compositions of the present invention are manufactured in a manner known per se, for example, by

means of conventional mixing, granulating, confectioning, dissolving or lyophilizing processes. Pharmaceutical compositions for oral use can be obtained by combining the active substance with one or more solid carriers, if desired, granulating a resulting mixture and processing the mixture or granulate, if desired or necessary after the addition of suitable adjuncts, to form tablets or dragee cores. In so doing, they can also be incorporated into plastics carriers which release the active substances or allow them to diffuse in controlled amounts.

Suitable carriers are especially fillers such as sugars, for example, lactose, saccharose, mannitol or sorbitol, cellulose preparations and/or calcium phosphates, for example, tricalcium phosphate or calcium hydrogen phosphate, also binders such as starches, for example, corn, wheat, rice or potato starch, gelatine, tragacanth, methylcellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose and/or polyvinylpyrrolidone, and/or, if desired, disintegrators such as the above-mentioned starches, also carboxymethyl starch, cross-linked polyvinylpyrrolidone, agar, alginic acid or a salt thereof such as sodium alginate. Adjuncts are especially flow-regulating and lubricating agents, for example, silica, talc, stearic acid or salts thereof such as magnesium or calcium stearate, and/or polyethylene glycol. Dragee cores are provided with suitable coatings that are, if desired, resistant to gastric juice, there being used, inter alia, concentrated sugar solutions which optionally contain gum arabic, talc, polyvinylpyrrolidone, polyethylene glycol and/or titanium dioxide, lacquer solutions in suitable organic solvents or solvent mixtures or, for the manufacture of coatings that are resistant to gastric juice, solutions of suitable cellulose preparations such as acetylcellulose phthalate or hydroxypropylmethylcellulose phthalate. Coloring substances or pigments can be added to the tablets or dragee coatings, for example for the purpose of identification or for indicating different doses of active substance.

Other orally administrable pharmaceutical compositions are dry-filled capsules made of gelatin and also soft, sealed

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capsules made of gelatin and a plasticizer such as glycerol or sorbitol. The dry-filled capsules may contain the active ingredient in the form of a granulate, for example, in admixture with fillers such as corn starch, binders and/or glidants such as talc or magnesium stearate and optionally stabilizers. In soft capsules, the active ingredient is preferably dissolved or suspended in suitable liquids or wax-like substances such as fatty oils, paraffin oil or polyethylene glycols, it being possible also for stabilizers to be added.

Other forms of oral administration are, for example, syrups prepared in a customary manner that contain the active ingredient in, for example, suspended form in a concentration that provides a suitable single dose when administered.

Further suitable dosage forms for parenteral administration are sterile aqueous solutions of an active ingredient in water-soluble form, for example, a water-soluble salt, or sterile aqueous injection suspensions which contain substances increasing the viscosity, for example, sodium, carboxymethyl cellulose, sorbitol and/or dextran, and optionally stabilizers. In addition, the active ingredient, with or without adjuvants, can also be in lyophilized form and brought into solution prior to parenteral administration by the addition of suitable solvents.

The invention also relates to a method of treatment of pathological conditions in a mammal, especially human, which as has been described hereinabove, which method comprises administering, a therapeutically effective amount of a compound of the formula I or of a pharmaceutically acceptable salt thereof.

The examples provided in the present application serve to illustrate the invention, but should not be construed as a limitation thereof.

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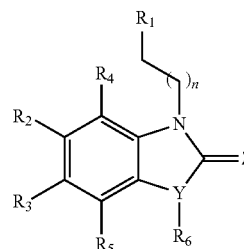
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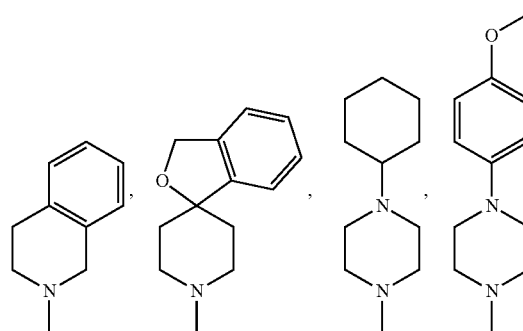
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The invention claimed is:

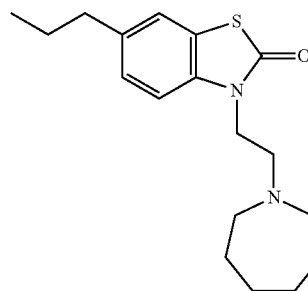
1. A compound having the general formula I



wherein R₁ can be an optionally substituted

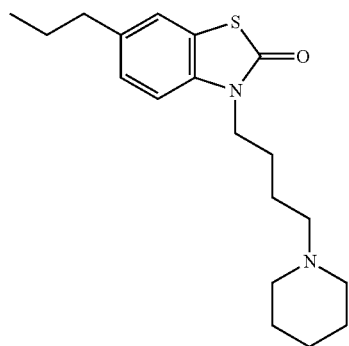
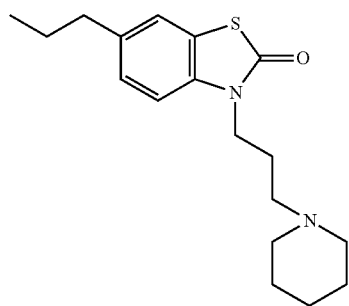
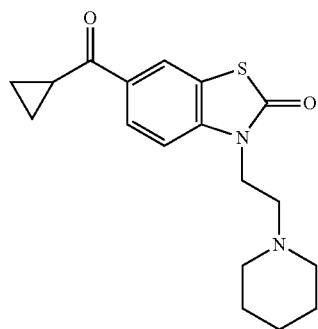
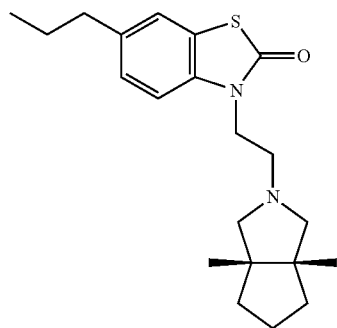
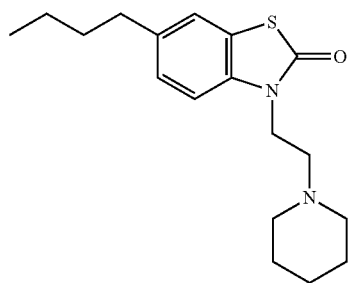


an optionally substituted tetrahydropyridine, an optionally substituted azepane or an optionally substituted tetrahydroisoquinoline in which the optional substituents are on the aromatic moiety or an optionally substituted isoindoline-1,3-dione; R_{2,3,4,5} can each independently be any one or combinations of the following moieties, hydrogen, cyano, nitro, acyl, alkyl, amido, azido, isothiocyanate, isocyanate, optionally substituted anilino, ethers, sulfonamides, thioacyl, nitro, aromatic, heterocyclic, olefinic, acetylene, deuterium, or tritium; "n" can be 1 to 5 carbons in length and wherein the moiety bridging R₁ and N can be optionally substituted alkylene, optionally substituted alkenylene or optionally substituted alkynylene with the exclusion of the following compounds:



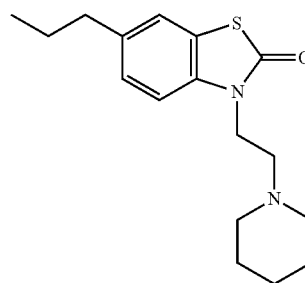
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**122**

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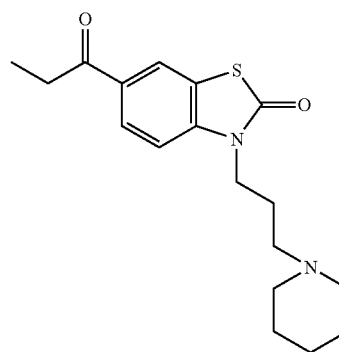


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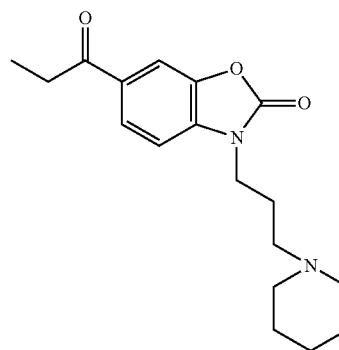
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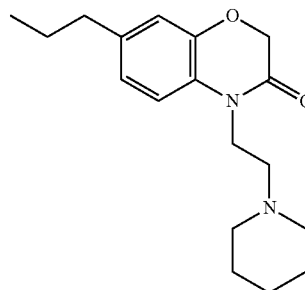
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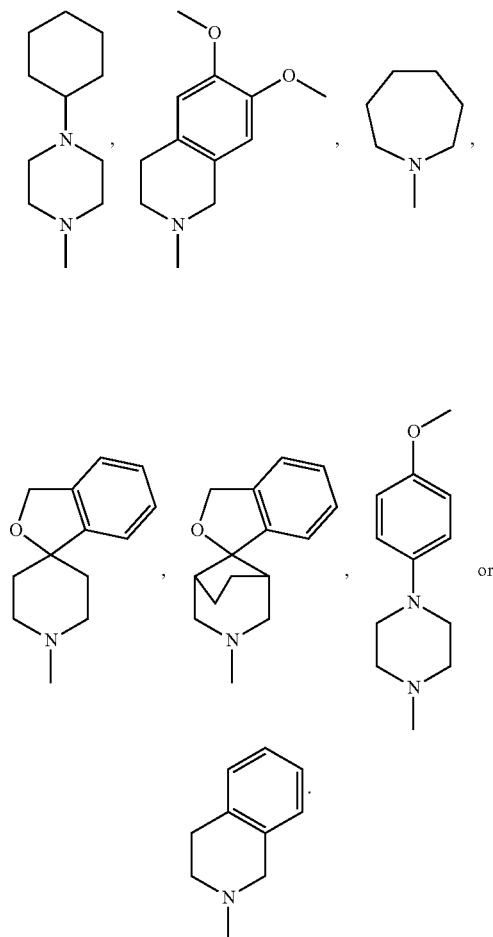
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and stereoisomers, or pharmaceutically acceptable salts thereof.

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2. The compound of claim 1, where R₁ is optionally substituted

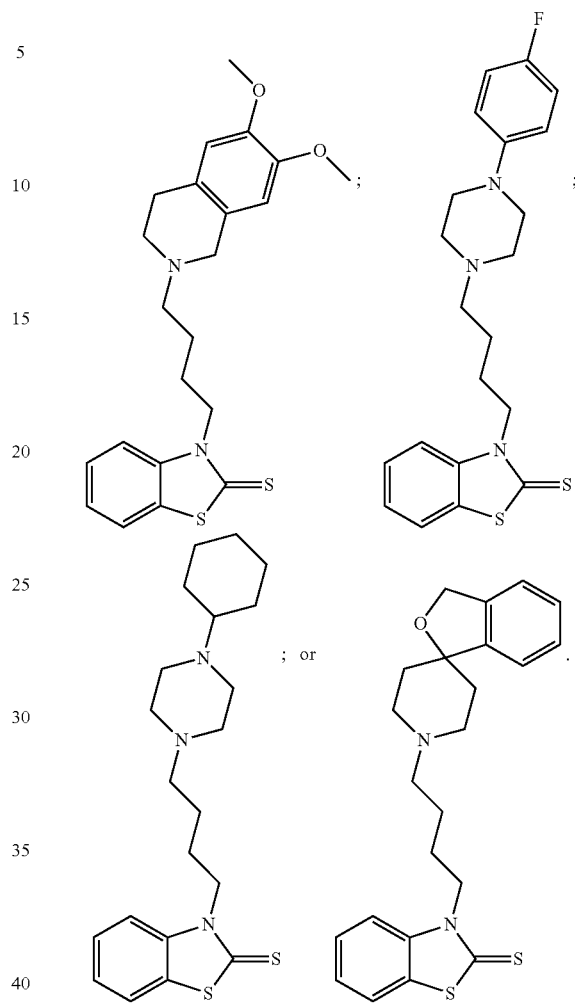


3. A radioligand composition comprising at least one compound according to claim 1 wherein at least one compound contains a radioactive element.

4. A pharmaceutical composition comprising at least one compound according to claim 1 and an acceptable carrier or excipient.

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5. The compound of claim 1 of the formula:



6. A radioligand composition comprising at least one compound according to claim 5 wherein at least one compound contains a radioactive element.

7. A pharmaceutical composition comprising at least one compound according to claim 5 and an acceptable carrier or excipient.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 8,809,381 B2
APPLICATION NO. : 12/673486
DATED : August 19, 2014
INVENTOR(S) : Christopher R. McCurdy et al.

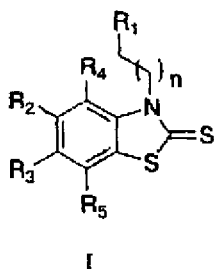
Page 1 of 2

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

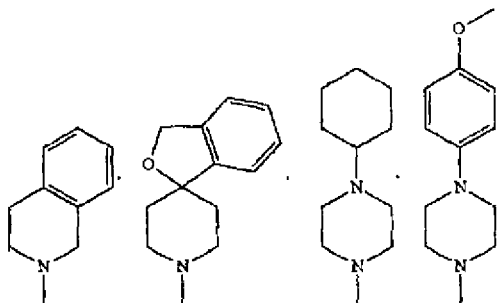
In the Claims

Col. 120, lines 6-37, Please replace Claim 1 as follows:

1. A compound having the general formula I



wherein R₁ can be an optionally substituted



an optionally substituted tetrahydropyridine, an optionally substituted azepane or an optionally substituted tetrahydroisoquinoline in which the optional substituents are on the aromatic moiety or an optionally substituted isoindoline-1,3-dione; R_{2,3,4,5} can each independently be any one or combinations of the following moieties, hydrogen, cyano, nitro, acyl, alkyl, amido, azido, isothiocyanate, isocyanate, optionally substituted anilino, ethers, sulfonamides, thioacyl, nitro, aromatic, heterocyclic, olefinic, acetylene, deuterium, or tritium; "n" can be 1 to 5 carbons in length

Signed and Sealed this
Twenty-first Day of April, 2015

Michelle K. Lee
Director of the United States Patent and Trademark Office

and wherein the moiety bridging R₁ and N can be optionally substituted alkylene, optionally substituted alkenylene or optionally substituted alkynylene and stereoisomers, or pharmaceutically acceptable salts thereof.