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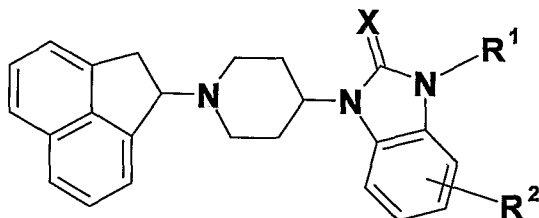
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(54) Title: AGENT FOR PROPHYLAXIS OR TREATMENT OF SUBSTANCE ABUSE AND DEPENDENCE



(I)

(57) Abstract: The present invention provides an agent for the prophylaxis or treatment of substance abuse and dependence, which contains a compound of the formula (I) represented by (R)-2-{3-[1-(ace-naphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimida-zol-1-yl}-N-methylacetamide, or a pharmaceutically acceptable salt

thereof as an active ingredient.



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DESCRIPTION**AGENT FOR PROPHYLAXIS OR TREATMENT OF SUBSTANCE ABUSE AND
DEPENDENCE**

5

Technical Field

The present invention relates to an agent for the prophylaxis or treatment of substance abuse and dependence, which comprises an ORL-1 receptor agonist as an active ingredient.

10

Background Art

After cloning of δ , κ , μ receptors, the opioid receptor-like 1 (ORL-1) receptor was cloned as the forth member of the opioid receptor family in 1994, (FEBS Lett. 347, 284-288, 1994, 15 FEBS Lett. 341, 33-38, 1994). Although ORL-1 receptor has about 60% of homology to other opioid receptors, it is clearly different from other opioid receptors, because non-selective opioid receptor antagonist, naloxone, does not bind to the ORL-1 receptor (FEBS Lett. 341, 33-38, 1994). While the ORL-1 20 receptor is expressed in the periphery organs such as intestine, spleen and so on, it is also widely expressed in the central nervous system, especially in the cortex, hippocampus, hypothalamus, amygdala and spinal cord (Eur. J. Pharmacol. 340, 1-15, 1997, Pharmacol. Rev. 53, 381-415, 2001).

25 In 1995, the endogenous ligand for the ORL-1 receptor was identified by two different research groups in France and Switzerland at the same time, and named as nociceptin (Nature 377, 532-535, 1995) and orphanin FQ (Science 270, 792-794, 1995), respectively. Nociceptin is a 17-amino acid peptide and 30 plays an important role in the function of central nervous system such as learning, memory, anxiety and stress (Br. J. Pharmacol. 129, 1261-1283, 2000).

Substance abuse and dependence involves any of following classes of substances: alcohol, amphetamine, methamphetamine, 35 cannabis (including marijuana, hashish), cocaine, hallucinogens

(including LSD, mescaline, MDMA), nicotine, opioids (including morphine, heroin, codeine, methadone), phencyclidine, ketamine, barbiturates, benzodiazepines (including diazepam, triazolam), inhalants (including toluene, paint thinner).

5 It is known that the nociceptin, an endogenous agonist for the ORL-1 receptor, is effective in alcohol dependence (Ciccocioppo et al., Psychopharmacology (Berl). 141, 220-224, 1999; Ciccocioppo et al., Psychopharmacology (Berl) 172, 170-178, 2004; Martin-Fardon et al., NeuroReport. 11, 1939-1943,
10 2000), morphine or cocaine dependence (Sakoori et al., Psychopharmacology (Berl) 172, 129-136, 2004), methamphetamine dependence (Zhao et al., NeuroReport. 14, 2383-2385, 2003).

Furthermore, buprenorphine, a partial agonist at μ opioid and ORL-1 receptors, has been used in clinical for treatment of
15 heroin dependence in numerous countries including the United States, Australia, Sweden and France (Kakko et al., Lancet 361, 662-668, 2003; Ling et al., Addiction 93, 475-486, 1998). Buprenorphine also reduces cocaine use by dually opiate-dependent and cocaine-dependent outpatients (Montoya et al.,
20 Clin Pharmacol Ther 75, 34-48, 2004; Schottenfeld et al., Biol Psychiatry 34, 66-74, 1993). More recently, evidence has accumulated in support of its efficacy for treatment of alcohol abuse and dependence (Ciccocioppo et al., Biol Psychiatry 61, 4-12, 2007).

25 Therefore a small molecule ORL-1 receptor agonist is expected to be effective in the prophylaxis or treatment of for substance abuse and dependence. However, first synthesized ORL-1 receptor agonist Ro64-6198 failed to decrease alcohol drinking, rather increase it at high dose (Economidou et
30 al., Peptides 27, 3299-3306, 2006). This effect probably induced by its residual agonistic activity at μ opioid receptors.

The compound of represented by the formula (I) mentioned in the below, for example, (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-
35 methylacetamide (same as 2-{3-[1-((1R)-acenaphthen-1-

yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide), is another agonist which possesses highly selective affinity for ORL-1 receptors (WO03/082333).

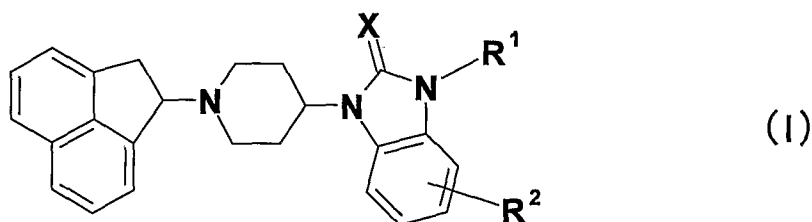
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Disclosure of the Invention

The present inventors have evaluated the effectiveness of the ORL-1 receptor agonist, (R)-2-{3-[1-(acenaphten-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide, in alcohol dependence rat model and found
10 that this compound significantly inhibits alcohol intake of the rat model. Further studies have resulted in the completion of the present invention.

Accordingly, the present invention provides the following.

1. An agent for the prophylaxis or treatment of substance
15 abuse and dependence, which comprises a compound represented by the formula (I)



wherein

R¹ is

- 20 (1) hydrogen,
- (2) lower alkyl,
- (3) lower alkenyl,
- (4) -C(O)-lower alkyl,
- (5) -C(O)O-lower alkyl,
- 25 (6) -C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (7) lower alkyl-carboxyl,
- (8) lower alkyl-C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy
30 or benzyloxy),
- (9) lower alkyl-C(O)O-lower alkyl,

- (10) lower alkenyl-C(O)O-lower alkyl,
(11) lower alkyl-O-lower alkyl,
(12) lower alkyl-C(O)NR³R⁴,
(13) -S(O)₂-lower alkyl,
5 (14) -S(O)₂-phenyl (the phenyl group may be substituted
with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
(15) lower alkyl-S-lower alkyl,
(16) lower alkyl-S(O)-lower alkyl,
(17) lower alkyl-S(O)₂-lower alkyl,
10 (18) lower alkyl-S(O)₂NR³R⁴,
(19) phenyl (the phenyl group may be substituted with
lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy), or
(20) benzyl (the phenyl group may be substituted with
lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
15 R² is hydrogen, lower alkyl, halogen, lower alkoxy, phenoxy,
benzyloxy, trifluoromethyl, nitro, amino or cyano,
R³ and R⁴
may be the same or different, and each is hydrogen, lower
alkyl or lower alkenyl, or R³ and R⁴ may bind with an
20 adjacent nitrogen atom to form a saturated nitrogen-
containing hetero ring (the hetero ring may be
substituted with lower alkyl, halogen, lower alkoxy,
phenoxy or benzyloxy), and
X is O or S.),
25 or a pharmaceutically acceptable salt thereof as an active
ingredient.

2. The agent of above-mentioned 1, wherein the substance abuse
and dependence is abuse of and dependence on alcohol,
30 amphetamine, methamphetamine, cannabis, cocaine, hallucinogens,
nicotine, opioids, phencyclidine, ketamine, barbiturates,
benzodiazepines or inhalants.

3. The agent of above-mentioned 1, wherein the substance abuse
35 and dependence is abuse of and dependence on alcohol.

4. The agent of above-mentioned 1, wherein the compound represented by the formula (I) or a pharmaceutically acceptable salt thereof is a compound selected from

- 5 [1] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
[2] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-5-fluoro-2H-benzimidazol-2-one,
[3] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-6-
10 fluoro-2H-benzimidazol-2-one,
[4] ethyl (RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,
[5] (RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,
15 [6] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,
[7] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-[2-(4-methylpiperazin-1-yl)-2-oxoethyl]-1,3-dihydro-2H-benzimidazol-
20 2-one dihydrochloride,
[8] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-morpholin-4-yl-2-oxoethyl)-1,3-dihydro-2H-benzimidazol-2-one hydrochloride,
[9] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-
25 2H-benzimidazole-2-thione,
[10] (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-3-methyl-2H-benzimidazole-2-thione,
[11] (R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
30 [12] (S)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
[13] (R)-3-acetyl-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
[14] (R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-
35 methanesulfonyl-1,3-dihydro-2H-benzimidazol-2-one,

[15] ethyl (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,

[16] (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,

5 [17] (R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,

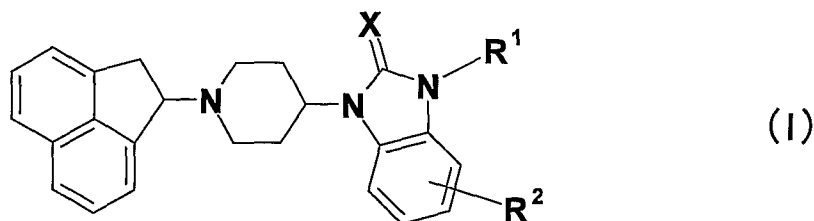
[18] (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide,

10 [19] (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N,N-dimethylacetamide, and

[20] (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetamide.

15 5. The agent of above-mentioned 1, wherein the compound represented by the formula (I) is (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide.

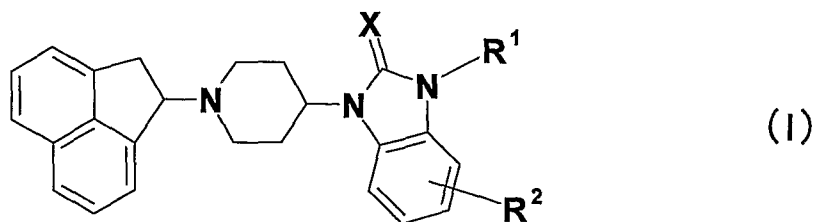
20 The present invention further provides the following.
6. Use of a compound represented by the formula (I)



wherein R^1 , R^2 and X are the same as defined above,

25 or a pharmaceutically acceptable salt thereof for the production of an agent for the prophylaxis or treatment of substance abuse and dependence.

7. A method for the prophylaxis or treatment of substance
30 abuse and dependence, which comprises administering an effective amount of compound represented by the formula (I)



wherein R^1 , R^2 and X are the same as defined above,
or a pharmaceutically acceptable salt thereof.

5 In the present specification, lower alkyl means alkyl having 1 to 6 carbon atoms such as methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, tert-butyl, pentyl, isopentyl or hexyl, lower alkenyl means alkenyl having 2 to 6 carbon atoms such as vinyl, 1-propenyl, 2-propenyl,
10 isopropenyl, 1-butenyl, 2-butenyl or 3-butenyl, lower alkoxy means alkoxy having 1 to 6 carbon atoms such as methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, sec-butoxy, tert-butoxy, pentyloxy, isopentyloxy or hexyloxy, and halogen means chlorine, fluorine, iodine or bromine.

15

Brief Description of the Drawings

Fig. 1 shows a test protocol of alcohol withdrawal.

Fig. 2 shows the action of Compound A on alcohol withdrawal symptoms.

20 Fig. 3 shows a test protocol of ethanol intake measurement in msP rats.

Fig. 4 shows the action of Compound A on the ethanol intake in msP rats.

25 Fig. 5 shows a test protocol of yohimbine-induced reinstatement in msP rats.

Fig. 6 shows the action of Compound A on yohimbine-induced reinstatement in msP rats.

Fig. 7 shows a test protocol of the conditioned place preference in msP rats.

30 Fig. 8 shows the effect of Compound A on the place preference in msP rats.

Effect of the Invention

The present invention provides an agent effective in the prophylaxis or treatment of substance abuse and dependence.

5 More particularly, the present invention provides a pharmaceutical agent useful for the prophylaxis or treatment of excessive alcohol intake, alcohol dependence and the like, as well as a pharmaceutical agent useful for the prophylaxis or treatment of other substance abuse of and dependence on
10 amphetamine, methamphetamine, cannabis, cocaine, hallucinogens, nicotine, opioids, phencyclidine, ketamine, barbiturates, benzodiazepines, inhalants and the like.

Best Mode for Embodiment of the Invention

15 The present invention is explained in detail in the following.

In the present invention, the "substance abuse and dependence" includes abuse of and dependence on alcohol, amphetamine, methamphetamine, cannabis (including marijuana,
20 hashish), cocaine, hallucinogens (including LSD, mescaline, MDMA), nicotine, opioids (including morphine, heroin, codeine, methadone), phencyclidine, ketamine, barbiturates, benzodiazepines (including diazepam, triazolam), inhalants (including toluene, paint thinner) and the like.

25 The agent for the prophylaxis or treatment of substance abuse and dependence of the present invention (hereinafter sometimes to be referred to as the pharmaceutical agent of the present invention) contains a compound represented by the above formula (I) or a pharmaceutically acceptable salt
30 thereof as an active ingredient.

In the compound represented by the formula (I), preferable R^1 is $-C(O)-$ lower alkyl, lower alkyl- $C(O)NR^3R^4$ (either R^3 or R^4 is hydrogen and the other is lower alkyl) or
35 lower alkyl- $C(O)NR^3R^4$ wherein R^3 and R^4 bind with an adjacent

nitrogen atom to form a saturated nitrogen-containing hetero ring (the hetero ring may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy). Preferable R² is hydrogen, and preferable X is O.

5

The following compounds included in the formula (I) are more preferable in the present invention.

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

10 (R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(S)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(R)-3-acetyl-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-
15 dihydro-2H-benzimidazol-2-one,

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide, and

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one.

20

In the present specification, (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide is the most preferable compound.

25 The compound represented by the formula (I) can be synthesized according to the methods described in WO03/082333.

In the present specification, (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide is sometimes to be also referred to as
30 Compound A. As the pharmaceutically acceptable salt, acid addition salts with inorganic acid and organic acid can be mentioned.

The pharmaceutical agent of the present invention can be
35 administered orally or non-orally. Dosage form includes tablet,

capsule, granule, powder, injection, oral tablet, lotion, liniment, ointment, suppository and the like. These can be formulated by generally used techniques.

The amount of compound (I) or a pharmaceutically acceptable salt thereof, an active ingredient in these formulations, is 0.1 to 100% by weight, suitably 1 to 50% by weight. In addition, the dose may be suitably determined depending on symptoms, age, dosage form and the like. For the oral formulation, the dose is usually 0.1 to 5000 mg, preferably 1 to 1000 mg per day, and may be administered in a single dose or divided doses.

Examples

While Example and Experimental Examples are shown in the following, these Examples are given for better understanding of the present invention, and do not limit the scope of the present invention.

The pharmacological action of the pharmaceutical agent of the present invention is explained by way of Experimental Examples.

Experimental Example 1: Effect on alcohol withdrawal symptoms in Wistar rats.

(Experimental method)

Male Wistar rats were used in this study. According to the protocol shown in Figure 1, rats were orally given 12-15 g/kg/body weight of ethanol in 24 hours on day 1 to day 2 and 9-10 g/kg/body weight of ethanol in 12 hours on day 3 to day 5. Compound A was administered p.o. at doses of 0.3 and 1 mg/kg/body weight twice after 2 and 7 hours of last ethanol administration. Four types of alcohol withdrawal symptoms such as vocalization, ventromedial limb retraction, tail rigidity, tail tremors were observed and scored with following 3 rating scales: mild=0, moderate=1, severe=2.

(Results)

As shown in Figure 2, 0.3 and 1 mg/kg/body weight of Compound A significantly and dose-dependently decreased scores of ventromedial limb retraction, tail rigidity and tail tremors, which were observed 8 to 24 hours after the last
5 ethanol administration.

Experimental Example 2: Effect on alcohol intake in msP rats.

(Experimental method)

10 Male genetically selected alcohol-preferring rats known as Marchigian Sardinian alcohol-preferring (msP) rats were used in this study (Addiction Biol. 11, 339-355, 2006). As shown in Figure 3, the rats were housed in reverse light-dark condition (light off at 8:30, light on at 20:30) and ethanol consumption
15 was measured everyday under free choice between water and 10% ethanol. Compound A at doses of 0.3 and 1 mg/kg/body weight was orally administered twice for 9 days at 1 hour before and 8 hours after onset of dark period.

(Results)

20 As shown in Figure 4, 0.3 and 1 mg/kg/body weight of Compound A significantly and dose-dependently decreased ethanol consumption in msP rats. This effect was long-lasting and significant for 9 days after withdrawal of Compound A.

25 Experimental Example 3: Effect on yohimbine-induced reinstatement of alcohol-seeking behavior in msP rats.

(Experimental method)

Male genetically selected alcohol-preferring rats known as msP rats were used in this study (Addiction Biol. 11, 339-
30 355, 2006). As shown in Figure 5, rats were trained to self-administer 10% (w/v) ethanol in 30-min daily sessions under a fixed-ratio 1 (FR 1) schedule of reinforcement, where each response resulted in delivery of 0.1 ml fluid. After acquisition of a stable baseline of 10% ethanol self-
35 administration, rats were subjected to 30-min extinction

sessions for 15 consecutive days. Extinction sessions were identical to 10% ethanol self-administration sessions, however alcohol was no longer available. Beginning on extinction day 10, rats were divided into three groups with similar baseline
5 levels of responding for 10% ethanol. For six consecutive days, 1 hour before the self-administration session and 8 hours later, each group of rats were orally given vehicle, 0.3 mg/kg of Compound A or 1.0 mg/kg of Compound A. After the extinction sessions, rats were given yohimbine (1,25 mg/kg, i.p.) 35 min
10 before the test sessions. The 30-min reinstatement test was conducted under extinction condition.

Yohimbine was used as stressor for this study, because yohimbine is known to produce stress and anxiety-like states in both humans and non-humans (Bremner et al, 1996; Charney et al
15 1983; Holmberg et al 1963).

(Results)

As shown in Figure 6, treatment with 1 mg/kg of Compound A significantly attenuated yohimbine stress-induced reinstatement of alcohol-seeking behavior.

20

Experimental Example 4: Study on dependence elicitation in msP rats.

(Experimental method)

A two-compartment box divided by guillotine door was
25 used. As shown in Figure 7, in the first two days, rats were allowed to explore the box with guillotine door open for 15 min (pre-conditioning). For the following 6 days, the rats were treated on alternate days with three Compound A-pairing administrations (0.3 and 1.0 mg/kg/body weight, p.o.) and
30 three vehicle-pairing administrations immediately before being placed, for 1 hour, into the assigned chamber with guillotine door close for drug-compartment discrimination (conditioning). The day after the last conditioning session, the rats were placed, for 15 min, in the box with door open. The time spent
35 in the drug paired compartment was measured.

(Results)

As shown in Figure 8, Compound A induced place preference at neither 0.3 nor 1 mg/kg/body weight, suggesting Compound A itself does not elicit dependence.

5 Comparison of pharmacological profiles between Compound A and existing medicines for alcohol dependence is summarized in Table 1. Although naltrexone and acamprosate (both have been marketed in Europe and USA) are effective in excessive alcohol intake, these medicines are ineffective in alcohol
10 withdrawal symptoms and stress-induced reinstatement. Benzodiazepines represented by diazepam are used for a treatment of alcohol withdrawal symptoms, but it is known that benzodiazepines themselves have demerit to induce dependence.

Alpha-2 adrenergic agonists represented by clonidine are
15 also effective in alcohol withdrawal symptoms (Dobrydnjov et al., Anesth Analg. 98, 738-744, 2004), but ineffective in excessive alcohol intake and stress-induced reinstatement.

On the other hand, Compound A has not only suppressive effect on excessive alcohol intake, but also ameliorative
20 effect on alcohol withdrawal symptoms and suppressive effect on stress-induced reinstatement. Furthermore, Compound A itself does not elicit dependence. From these results, Compound A is expected to be a good agent for the prophylaxis or treatment of alcohol abuse and dependence and other
25 substance abuse and dependence.

Table 1

	Ameliorative effect on alcohol withdrawal symptoms	Suppressive effect on excessive alcohol intake	Suppressive effect on stress-induced reinstatement	Presence/absence of dependence
Naltrexone	none	yes	none	absent
Acamprosate	none	yes	none	absent
Diazepam	yes	none	none	present
Clonidine	yes	none	none	absent
Compound A	yes	yes	yes	absent

Example 1: formulation example
(tablet)

5 The following ingredients were mixed according to a conventional method in a conventional apparatus and tableted.

Compound A	10 mg
microcrystalline cellulose	180 mg
cornstarch	300 mg
10 lactose	600 mg
magnesium stearate	15 mg

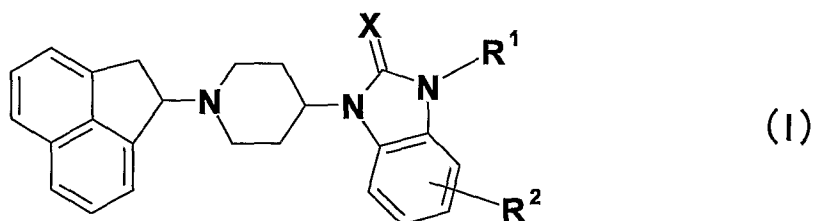
Industrial Applicability

15 The pharmaceutical agent of the present invention can be used as an agent for the prophylaxis or treatment of substance abuse and dependence.

 This application is based on EP patent application No. 06122336.8 filed on October 16, 2006, the contents of which
20 are incorporated in full herein by this reference.

Claims

1. An agent for the prophylaxis or treatment of substance
abuse and dependence, which comprises a compound represented
5 by the formula (I)



wherein

R¹ is

- (1) hydrogen,
- 10 (2) lower alkyl,
- (3) lower alkenyl,
- (4) -C(O)-lower alkyl,
- (5) -C(O)O-lower alkyl,
- (6) -C(O)-phenyl (the phenyl group may be substituted
- 15 with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (7) lower alkyl-carboxyl,
- (8) lower alkyl-C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- 20 (9) lower alkyl-C(O)O-lower alkyl,
- (10) lower alkenyl-C(O)O-lower alkyl,
- (11) lower alkyl-O-lower alkyl,
- (12) lower alkyl-C(O)NR³R⁴,
- (13) -S(O)₂-lower alkyl,
- 25 (14) -S(O)₂-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (15) lower alkyl-S-lower alkyl,
- (16) lower alkyl-S(O)-lower alkyl,
- (17) lower alkyl-S(O)₂-lower alkyl,
- 30 (18) lower alkyl-S(O)₂NR³R⁴,
- (19) phenyl (the phenyl group may be substituted with

lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy), or
(20) benzyl (the phenyl group may be substituted with
lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),

R² is hydrogen, lower alkyl, halogen, lower alkoxy, phenoxy,

5 benzyloxy, trifluoromethyl, nitro, amino or cyano,

R³ and R⁴

may be the same or different, and each is hydrogen, lower

alkyl or lower alkenyl, or R³ and R⁴ may bind with an

adjacent nitrogen atom to form a saturated nitrogen-

10 containing hetero ring (the hetero ring may be

substituted with lower alkyl, halogen, lower alkoxy,

phenoxy or benzyloxy), and

X is O or S.),

or a pharmaceutically acceptable salt thereof as an active

15 ingredient.

2. The agent of claim 1, wherein the substance abuse and
dependence is abuse of and dependence on alcohol, amphetamine,
methamphetamine, cannabis, cocaine, hallucinogens, nicotine,
20 opioids, phencyclidine, ketamine, barbiturates,
benzodiazepines or inhalants.

3. The agent of claim 1, wherein the substance abuse and
dependence is abuse of and dependence on alcohol.

25

4. The agent of claim 1, wherein the compound represented by
the formula (I) or a pharmaceutically acceptable salt thereof
is a compound selected from

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-
30 benzimidazol-2-one,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-5-
fluoro-2H-benzimidazol-2-one,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-6-
fluoro-2H-benzimidazol-2-one,

35 ethyl (RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-

dihydro-2-oxo-benzimidazol-1-yl}acetate,

(RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one
5 dihydrochloride,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-[2-(4-methylpiperazin-1-yl)-2-oxoethyl]-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,

10 (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-morpholin-4-yl-2-oxoethyl)-1,3-dihydro-2H-benzimidazol-2-one hydrochloride,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazole-2-thione,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-3-methyl-2H-benzimidazole-2-thione,
15

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(S)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

20 (R)-3-acetyl-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-methanesulfonyl-1,3-dihydro-2H-benzimidazol-2-one,

ethyl (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,
25

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one
30 dihydrochloride,

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide,

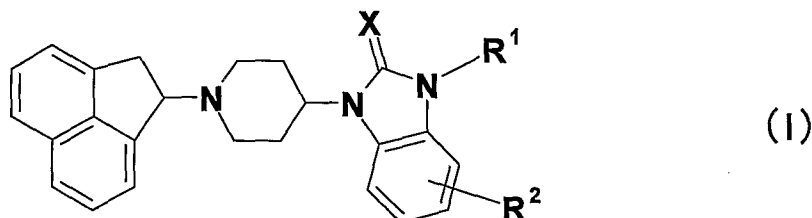
(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N,N-dimethylacetamide, and

35 (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-

oxo-benzimidazol-1-yl}acetamide.

5 5. The agent of claim 1, wherein the compound represented by the formula (I) is (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide.

6. Use of a compound represented by the formula (I)



10 wherein

R¹ is

- (1) hydrogen,
- (2) lower alkyl,
- (3) lower alkenyl,
- 15 (4) -C(O)-lower alkyl,
- (5) -C(O)O-lower alkyl,
- (6) -C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (7) lower alkyl-carboxyl,
- 20 (8) lower alkyl-C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (9) lower alkyl-C(O)O-lower alkyl,
- (10) lower alkenyl-C(O)O-lower alkyl,
- 25 (11) lower alkyl-O-lower alkyl,
- (12) lower alkyl-C(O)NR³R⁴,
- (13) -S(O)₂-lower alkyl,
- (14) -S(O)₂-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- 30 (15) lower alkyl-S-lower alkyl,
- (16) lower alkyl-S(O)-lower alkyl,

(17) lower alkyl-S(O)₂-lower alkyl,

(18) lower alkyl-S(O)₂NR³R⁴,

(19) phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy), or

5 (20) benzyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),

R² is hydrogen, lower alkyl, halogen, lower alkoxy, phenoxy, benzyloxy, trifluoromethyl, nitro, amino or cyano,

R³ and R⁴

10 may be the same or different, and each is hydrogen, lower alkyl or lower alkenyl, or R³ and R⁴ may bind with an adjacent nitrogen atom to form a saturated nitrogen-containing hetero ring (the hetero ring may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy), and

15 X is O or S.),

or a pharmaceutically acceptable salt thereof for the production of an agent for the prophylaxis or treatment of substance abuse and dependence.

20

7. The use of claim 6, wherein the substance abuse and dependence is abuse of and dependence on alcohol, amphetamine, methamphetamine, cannabis, cocaine, hallucinogens, nicotine, opioids, phencyclidine, ketamine, barbiturates, benzodiazepines or inhalants.

8. The use of claim 6, wherein the substance abuse and dependence is abuse of and dependence on alcohol.

30 9. The use of claim 6, wherein the compound represented by the formula (I) or a pharmaceutically acceptable salt thereof is a compound selected from

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

35 (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-5-

fluoro-2H-benzimidazol-2-one,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-6-fluoro-2H-benzimidazol-2-one,

ethyl (RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,

(RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one

10 dihydrochloride,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-[2-(4-methylpiperazin-1-yl)-2-oxoethyl]-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-morpholin-4-yl-2-oxoethyl)-1,3-dihydro-2H-benzimidazol-2-one hydrochloride,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazole-2-thione,

(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-3-methyl-2H-benzimidazole-2-thione,

20 (R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(S)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(R)-3-acetyl-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-methanesulfonyl-1,3-dihydro-2H-benzimidazol-2-one,

ethyl (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,

30 (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,

(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,

35 (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-

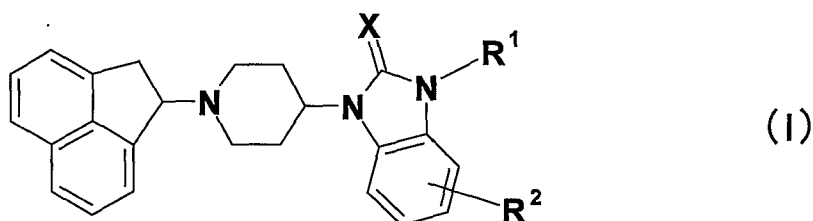
oxo-benzimidazol-1-yl}-N-methylacetamide,

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N,N-dimethylacetamide, and

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetamide.

10. The use of claim 6, wherein the compound represented by the formula (I) is (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide.

11. A method for the prophylaxis or treatment of substance abuse and dependence, which comprises administering an effective amount of compound represented by the formula (I)



15 wherein

R¹ is

- (1) hydrogen,
- (2) lower alkyl,
- (3) lower alkenyl,
- 20 (4) -C(O)-lower alkyl,
- (5) -C(O)O-lower alkyl,
- (6) -C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (7) lower alkyl-carboxyl,
- 25 (8) lower alkyl-C(O)-phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
- (9) lower alkyl-C(O)O-lower alkyl,
- (10) lower alkenyl-C(O)O-lower alkyl,
- 30 (11) lower alkyl-O-lower alkyl,
- (12) lower alkyl-C(O)NR³R⁴,

- (13) $-S(O)_2$ -lower alkyl,
(14) $-S(O)_2$ -phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
(15) lower alkyl-S-lower alkyl,
5 (16) lower alkyl-S(O)-lower alkyl,
(17) lower alkyl-S(O)₂-lower alkyl,
(18) lower alkyl-S(O)₂NR³R⁴,
(19) phenyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy), or
10 (20) benzyl (the phenyl group may be substituted with lower alkyl, halogen, lower alkoxy, phenoxy or benzyloxy),
R² is hydrogen, lower alkyl, halogen, lower alkoxy, phenoxy, benzyloxy, trifluoromethyl, nitro, amino or cyano,
R³ and R⁴
15 may be the same or different, and each is hydrogen, lower alkyl or lower alkenyl, or R³ and R⁴ may bind with an adjacent nitrogen atom to form a saturated nitrogen-containing hetero ring (the hetero ring may be substituted with lower alkyl, halogen, lower alkoxy,
20 phenoxy or benzyloxy), and
X is O or S.),
or a pharmaceutically acceptable salt thereof.

12. The method of claim 11, wherein the substance abuse and
25 dependence is abuse of and dependence on alcohol, amphetamine, methamphetamine, cannabis, cocaine, hallucinogens, nicotine, opioids, phencyclidine, ketamine, barbiturates, benzodiazepines or inhalants.

30 13. The method of claim 11, wherein the substance abuse and dependence is abuse of and dependence on alcohol.

14. The method of claim 11, wherein the compound represented by the formula (I) or a pharmaceutically acceptable salt
35 thereof is a compound selected from (RS)-1-[1-(acenaphthen-1-

yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-5-fluoro-2H-benzimidazol-2-one,
(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-6-fluoro-2H-benzimidazol-2-one,
5 ethyl (RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,
(RS)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,
10 (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,
(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-[2-(4-methylpiperazin-1-yl)-2-oxoethyl]-1,3-dihydro-2H-benzimidazol-2-one dihydrochloride,
15 (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-morpholin-4-yl-2-oxoethyl)-1,3-dihydro-2H-benzimidazol-2-one hydrochloride,
(RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazole-2-thione,
20 (RS)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-3-methyl-2H-benzimidazole-2-thione,
(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
(S)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
25 (R)-3-acetyl-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-1,3-dihydro-2H-benzimidazol-2-one,
(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-methanesulfonyl-1,3-dihydro-2H-benzimidazol-2-one,
30 ethyl (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetate,
(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetic acid,
(R)-1-[1-(acenaphthen-1-yl)piperidin-4-yl]-3-(2-oxo-2-piperazin-1-ylethyl)-1,3-dihydro-2H-benzimidazol-2-one
35

dihydrochloride,

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide,

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N,N-dimethylacetamide, and

(R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}acetamide.

15. The method of claim 11, wherein the compound represented
10 by the formula (I) is (R)-2-{3-[1-(acenaphthen-1-yl)piperidin-4-yl]-2,3-dihydro-2-oxo-benzimidazol-1-yl}-N-methylacetamide.

FIG. 1

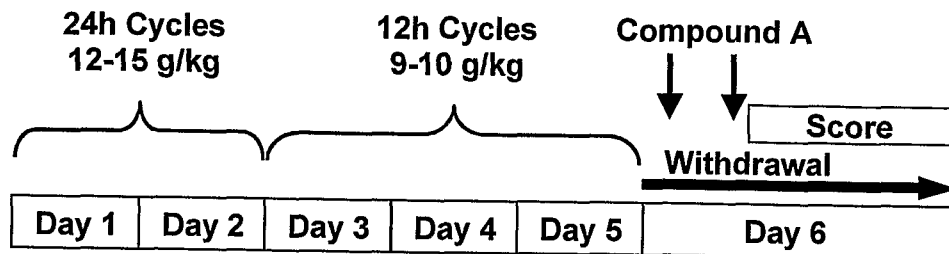


FIG. 2

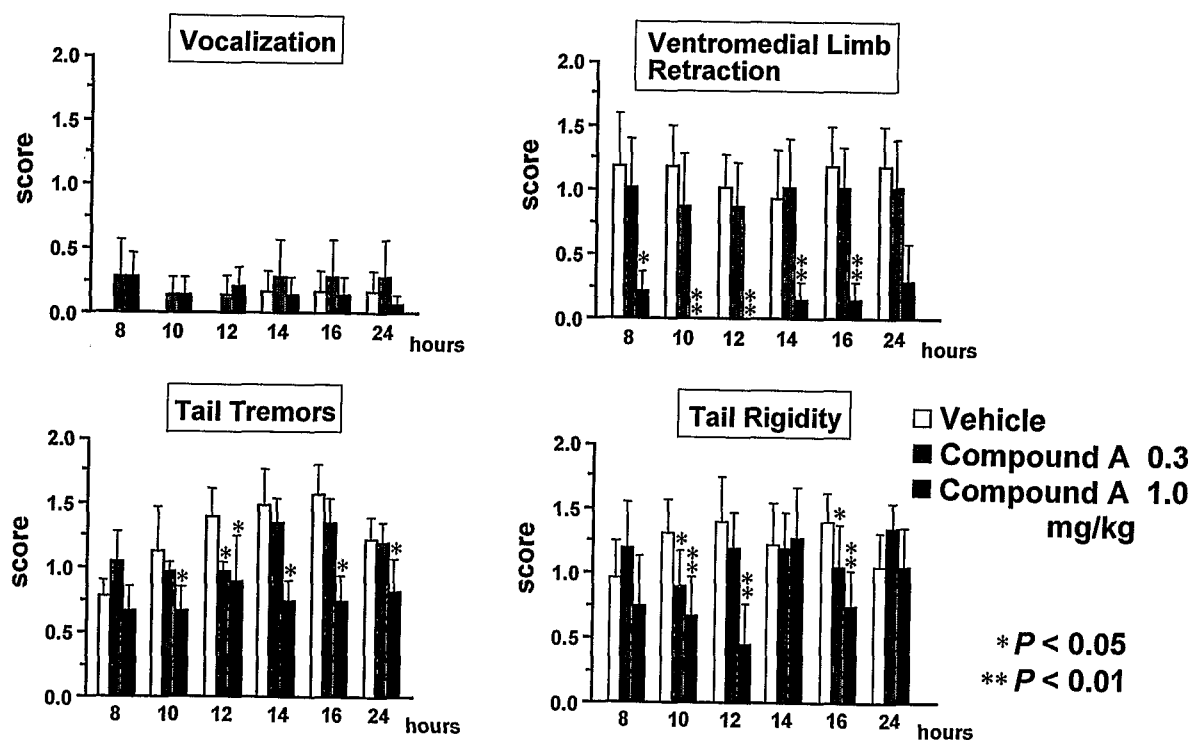


FIG. 3

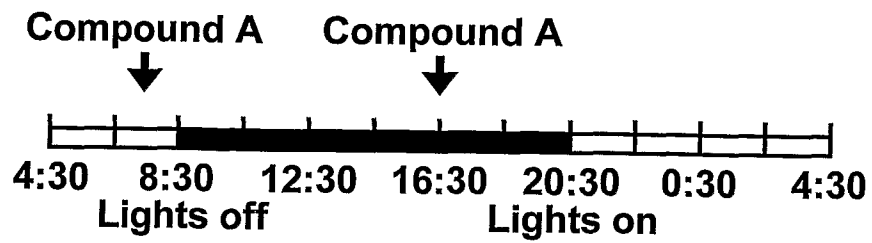


FIG. 4

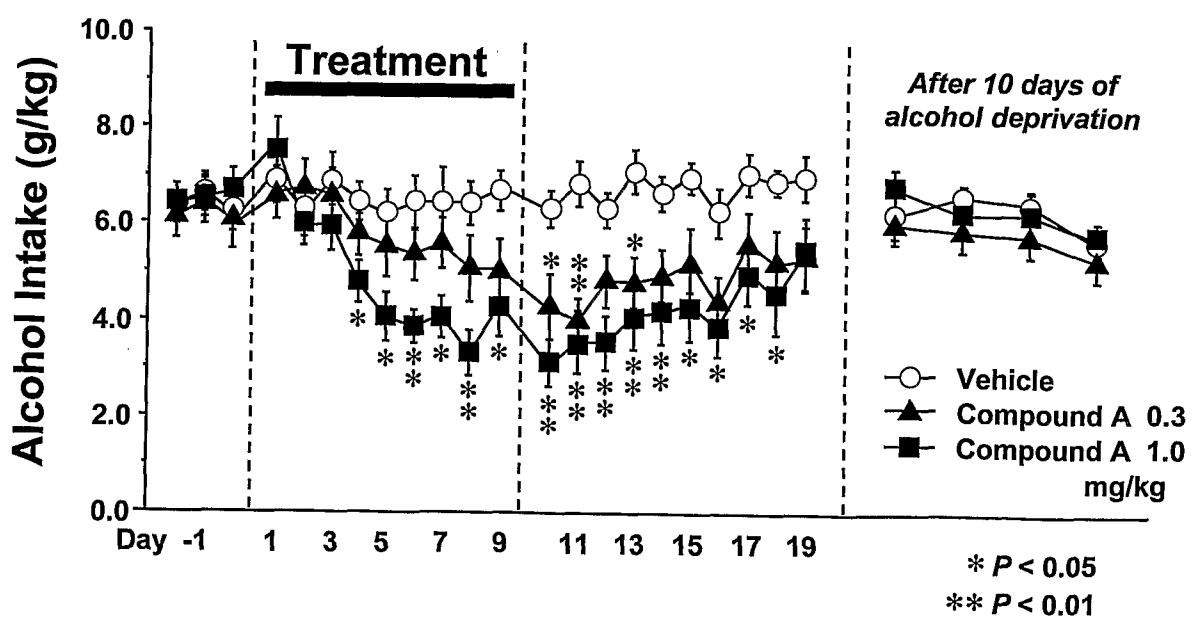


FIG. 5

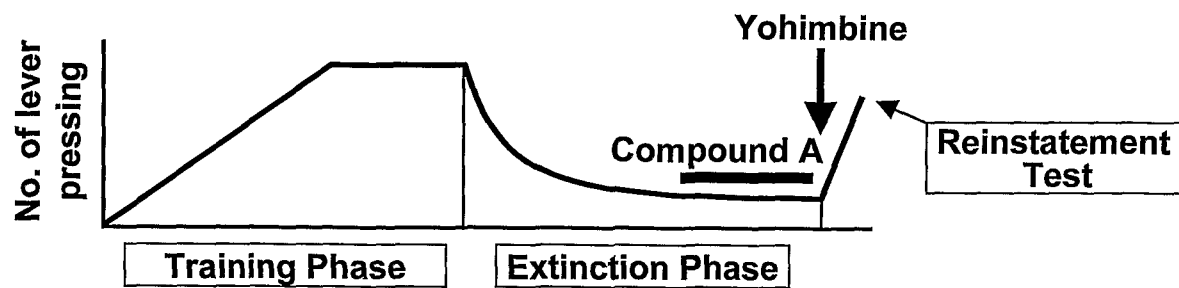


FIG. 6

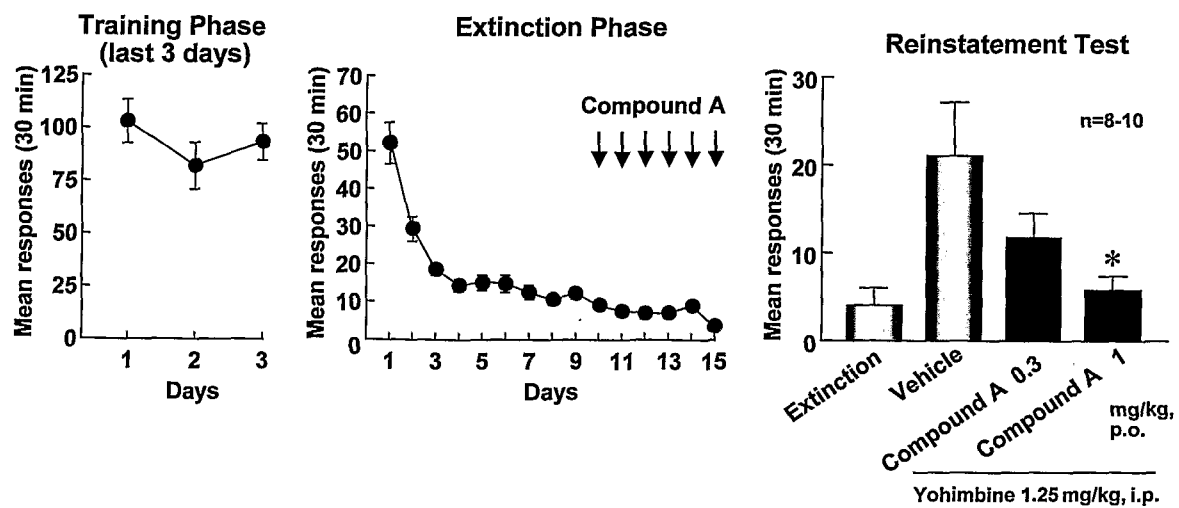
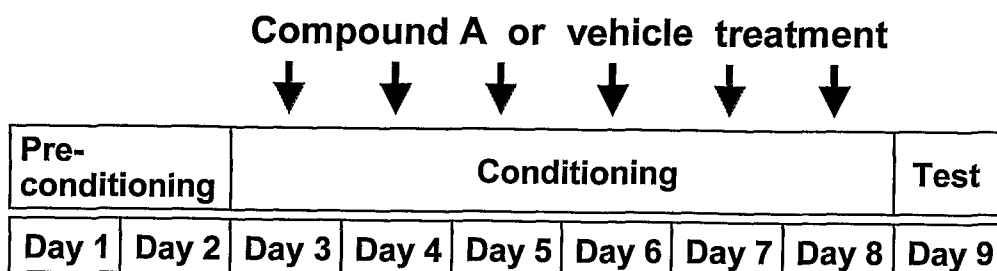


FIG. 7**FIG. 8**