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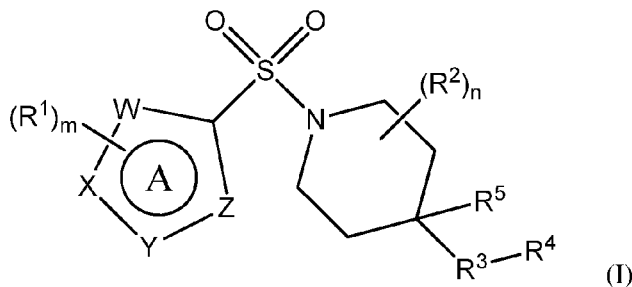
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(54) **Title:** 1-SULFONYL PIPERIDINE DERIVATIVES AS MODULATORS OF PROKINETICIN RECEPTORS



(57) **Abstract:** The present invention provides compounds of formula (I) and pharmaceutically acceptable salts thereof in which m, n, W, X, Y, Z, R¹, R², R³, R⁴ and R⁵ are as defined in the specification, compositions containing them and their use in therapy.

1-SULFONYL PIPERIDINE DERIVATIVES AS MODULATORS OF PROKINETICIN RECEPTORS

The present invention relates to the use of piperidine derivatives in therapy, particularly for the treatment or prevention of psychiatric and neurological conditions.

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Prokineticins are cysteine-rich regulatory peptides that are thought to exert signaling activity via two highly conserved G protein-coupled receptors (GPCR), the prokineticin receptor 1 (PKR1 or PROKR1) and the prokineticin receptor 2 (PKR2 or PROKR2), that belong to the 7-transmembrane domain, G protein-coupled receptor (GPCR) superfamily.

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Prokineticin receptor 1 (also known as GPR73) shows 87% homology to Prokineticin Receptor 2 (also known as GPR73L1). Prokineticins (PK1 and PK2) contain 86 and 81 amino acids respectively, sharing 45% amino acid identity. Both prokineticins activate the two prokineticin receptors, PKR1 and PKR2, with similar potency.

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PKR1 receptors couple to G_q/G_{11} proteins leading to phospholipase C activation, inositol phosphate production and calcium mobilization. In addition, activation of the mitogen-activated protein kinase (MAPK) pathways has also been described.

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PKR1 is broadly distributed throughout peripheral tissues including the intestinal tract, testis, uterus, lung, mouse dorsal root ganglia, macrophage, bone, heart, rectum, white adipose and peripheral blood leukocytes. In addition, the receptor is expressed in the brain particularly in olfactory regions as well as in dorsal root ganglion (DRG) neurons, mouse hippocampus, dentate gyrus, cerebellar cortex, cerebral cortex, human hippocampus, amygdala, medulla oblongata and spinal cord.

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Prokineticins were originally identified as potent agents mediating gut motility, but were later shown to promote angiogenesis in steroidogenic glands (e.g. adrenal gland), heart and reproductive systems. They also modulate neurogenesis, circadian rhythms, nociception, haematopoiesis as well as the immune response. Prokineticins are thought to be associated with pathologies of the reproductive and nervous systems, myocardial infarction and tumorigenesis.

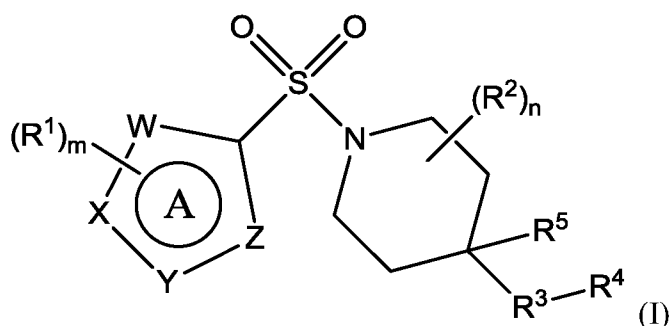
Consequently, antagonism of the functions of the prokineticins may have utility in the treatment of disorders or diseases including gastrointestinal motility, angiogenesis, hematopoiesis, diabetes (e.g. as described in International Patent Application Publication No. WO 2010/077976) and pain (e.g. as described in International Patent Application Publication No. WO 2007/079214).

Certain piperidine derivatives are known chemical library compounds with no known use that are available from commercial suppliers such as Ambinter and Ukrorgsyntez Ltd., in particular the following compounds having Chemical Abstracts Registry Nos. 1436296-61-5, 1172299-59-0, 1171428-14-0 and 1209259-27-7.

Certain other piperidine derivatives which are said to possess pharmaceutical properties are known, for example, from International Patent Application Publication Nos. WO 2006/034341 and WO 2010/080864.

We have now discovered a new class of compounds that are prokineticin receptor modulators which have desirable activity profiles. The compounds of this invention may have beneficial potency, selectivity and/or pharmacokinetic properties.

In a first aspect of the invention, there is provided a compound of formula



or a pharmaceutically acceptable salt thereof, wherein in formula (I)

W, X, Y and Z each independently represent N, NH or CH, with the proviso that W, X, Y and Z do not each simultaneously represent a moiety CH;

m is 2 or 3;

each R¹ independently represents C₃-C₆ cycloalkyl, C₁-C₆ haloalkyl,

or C₁-C₆ alkyl optionally substituted by carboxyl or C₁-C₆ alkoxy carbonyl;

n is 0 or 1;

each R² independently represents C₁-C₆ alkyl;

R³ represents =CR⁶, or, when there is at least one R¹ group present that represents a C₃-C₆ cycloalkyl group, then R³ may additionally represent a group -CR⁷R⁸-;

R⁵ is absent or represents a hydrogen atom;

R⁶ represents a hydrogen or halogen atom or a cyano, C₁-C₆ alkyl or C₁-C₆ alkoxy carbonyl group;

R⁷ and R⁸ each independently represent a hydrogen or halogen atom or cyano, carboxyl, hydroxyl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ alkoxy, C₁-C₆ hydroxyalkyl, C₁-C₆ alkoxy carbonyl, C₁-C₆ alkoxyC₁-C₆ alkyl or a 5- to 9-membered heterocyclic ring system; and

R⁴ represents a 6- to 10-membered aromatic or heteroaromatic ring system, the ring system itself being optionally substituted by at least one substituent selected from halogen, cyano, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ alkoxy, or C₁-C₆ haloalkoxy;

provided that the compound of formula (I) is not:

1-[(1-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethylene)piperidine;

1-[[1-cyclopentyl-3-(1,1-dimethylethyl)-1H-pyrazol-4-yl]sulfonyl]-4-(phenylmethyl)piperidine;

1-[(1-cyclopentyl-3-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethyl)piperidine;

1-[(5-chloro-1-methyl-1H-imidazol-4-yl)sulfonyl]-4-[(3-fluorophenyl)methylene]piperidine; or

4-(1-(4-chlorophenyl)ethylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine.

In a second aspect of the invention, there is provided a compound selected from:

4-(4-Chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine,

Methyl 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate,

2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(2,6-Difluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chloro-2-fluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((3,5-diethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((1,5-dimethyl-3-(trifluoromethyl)-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(2,6-Difluorophenyl)-2-(1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(1-((3,5-Dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)-2-(4-(trifluoromethoxy)phenyl)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)-3-methylpiperidin-4-ylidene)acetonitrile,

4-(4-Chloro-2-fluorobenzylidene)-1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine,

4-(4-Chloro-2-fluorobenzylidene)-1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine,

4-(4-Chlorobenzylidene)-1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine,

2-(4-Chlorophenyl)-2-(1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

4-((4-Chlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((3-Chloro-4-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((2,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((3,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

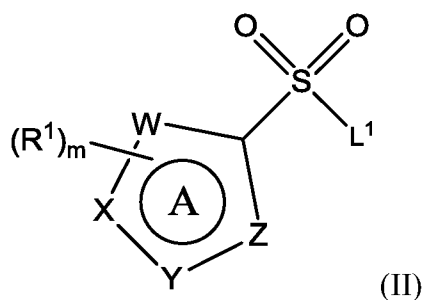
4-((4-Chloro-3-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((4-Chloro-2-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

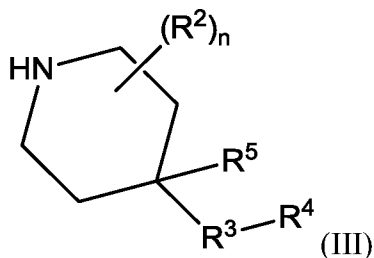
4-((2,4-Difluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

3-((1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)fluoromethyl)quinoline,
and pharmaceutically acceptable salts of any one thereof.

In a third aspect of the invention, there is provided a process for the preparation of a compound of formula (I) as defined in the first aspect of the invention or a pharmaceutically acceptable salt thereof which comprises reacting a compound of formula



wherein L^1 represents a leaving group and m , W , X , Y , Z and R^1 are as defined in formula (I),
with a compound of formula



or a suitable salt thereof, wherein n , R^2 , R^3 , R^4 and R^5 are as defined in formula (I);

and optionally thereafter carrying out one or more of the following procedures:

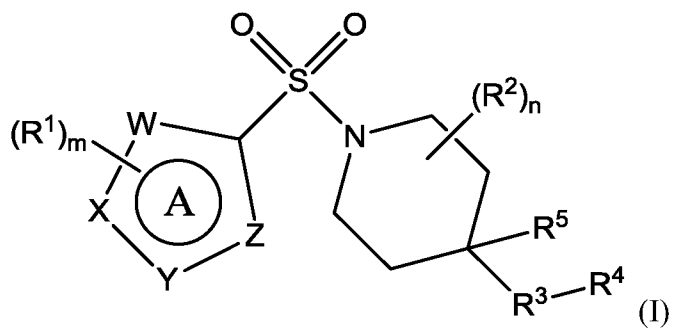
- converting a compound of formula (I) into another compound of formula (I)
- removing any protecting groups
- forming a pharmaceutically acceptable salt.

In a fourth aspect of the invention, there is provided a pharmaceutical composition comprising a compound according to the first or second aspects of the invention in association with a pharmaceutically acceptable adjuvant, diluent or carrier, and optionally one or more other therapeutic agents.

In a fifth aspect of the invention, there is provided a method of treatment of a disease or condition mediated by a prokineticin, the method comprising administering to a patient in need thereof a therapeutically effective amount of a compound according to the first or second aspects of the invention or the pharmaceutical composition accord to the fourth aspect of the invention.

In a sixth aspect of the invention, there is provided use of a compound according to the first or second aspects of the invention for the manufacture of a medicament for treating a disease or condition mediated by a prokineticin.

Disclosed herein is a compound of formula (I)



or a pharmaceutically acceptable salt thereof, wherein in formula (I)

W, X, Y and Z each independently represent N, NH or CH, with the proviso that W, X, Y and Z do not each simultaneously represent a moiety CH;

m is 0, 1, 2 or 3;

each R¹ independently represents halogen, cyano, C₁-C₆ alkoxy, C₃-C₆ cycloalkyl, C₁-C₆ alkoxy carbonyl, C₁-C₆ haloalkyl, C₁-C₆ haloalkoxy, C₁-C₆ alkylthio, C₁-C₆ alkyl carbonyl, or C₁-C₆ alkyl optionally substituted by carboxyl or C₁-C₆ alkoxy carbonyl;

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

each R² independently represents halogen, cyano, carboxyl, hydroxyl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ alkoxy, C₁-C₆ hydroxyalkyl, C₁-C₆ alkoxy carbonyl, C₁-C₆ alkoxy C₁-C₆ alkyl or a 5- to 9-membered heterocyclic ring system;

R³ represents =CR⁶, or, when there is at least one R¹ group present that represents a C₃-C₆ cycloalkyl group, then R³ may additionally represent a group -CR⁷R⁸;

R⁵ is absent or represents a hydrogen atom or a substituent as defined above for R²;

R⁶ represents a hydrogen or halogen atom or a cyano, C₁-C₆ alkyl or

C₁-C₆ alkoxy carbonyl group;

R⁷ and R⁸ each independently represent a hydrogen or halogen atom or cyano, 15 carboxyl, hydroxyl, C₁-C₆ alkyl, C₁-C₆ haloalkyl, C₁-C₆ alkoxy, C₁-C₆ hydroxyalkyl, C₁-C₆ alkoxy carbonyl, C₁-C₆ alkoxy C₁-C₆ alkyl or a 5- to 9-membered heterocyclic ring system;

R⁴ represents a 6- to 10-membered aromatic or heteroaromatic ring system, the ring system itself being optionally substituted by at least one substituent selected from halogen, 20 hydroxyl, cyano, oxo (=O), C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₁-C₆ haloalkyl, C₁-C₆ hydroxyalkyl, C₁-C₆ alkoxy, C₁-C₆ haloalkoxy, C₁-C₆ alkylthio, C₁-C₆ alkylsulphinyl, C₁-C₆ alkylsulphonyl, C₁-C₆ alkyl carbonyl,

C₁-C₆ alkyl carbonyloxy, C₁-C₆ alkoxy carbonyl, amino (-NH₂), -CON(R⁹)₂,

C₁-C₆ alkylamino, di-(C₁-C₆ alkyl)amino, C₃-C₆ cycloalkyl, C₃-C₆ cycloalkyloxy or

25 C₃-C₆ cycloalkylmethyl; and

each R⁹ independently represents a hydrogen atom or a C₁-C₆ alkyl group;

provided that the compound of formula (I) is not:

1-[(1-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethylene)piperidine;

5 1-[[1-cyclopentyl-3-(1,1-dimethylethyl)-1H-pyrazol-4-yl]sulfonyl]-4-(phenylmethyl)piperidine;

1-[(1-cyclopentyl-3-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethyl)piperidine; or

1-[(5-chloro-1-methyl-1H-imidazol-4-yl)sulfonyl]-4-[(3-fluorophenyl)-methylene]piperidine.

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In the context of the present specification, unless otherwise stated, an alkyl, alkenyl or alkynyl substituent group or an alkyl, alkenyl or alkynyl moiety in a substituent group may be linear or branched. Examples of C₁-C₆ alkyl groups/moieties include methyl, ethyl, propyl, 2-methyl-1-propyl, 2-methyl-2-propyl, 2-methyl-1-butyl, 3-methyl-1-butyl, 2-
15 methyl-3-butyl, 2,2-dimethyl-1-propyl, 2--methyl-pentyl, 3-methyl-1-pentyl, 4-methyl-1-pentyl, 2-methyl-2-pentyl, 3-methyl-2-pentyl, 4-methyl-2-pentyl, 2,2-dimethyl-1-butyl, 3,3-dimethyl-1-butyl, 2-ethyl-1-butyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl and n-hexyl. Examples of C₂-C₆ alkenyl groups/moieties include ethenyl, propenyl, 1-butenyl, 2-butenyl, 1-pentenyl, 1-hexenyl, 1,3-butadienyl,
20 1,3-pentadienyl, 1,4-pentadienyl and 1-hexadienyl. Examples of C₂-C₆ alkynyl groups/moieties include ethynyl, propynyl, 1-butylnyl, 2-butylnyl, 1-pentylnyl and 1-hexynyl.

A C₁-C₆ haloalkyl or C₁-C₆ haloalkoxy substituent group/moiety will comprise at least
25 one halogen atom, e.g. one, two, three, four or five halogen atoms, examples of which include trifluoromethyl, trifluoromethoxy or pentafluoroethyl.

A C₁-C₆ hydroxyalkyl substituent group/moiety will comprise at least one hydroxyl group, e.g. one, two, three or four hydroxyl groups, examples of which include -CH₂OH, -CH₂CH₂OH, -CH₂CH₂CH₂OH, -CH(OH)CH₂OH, -CH(CH₃)OH and -CH(CH₂OH)₂.

- 5 The alkyl groups in a di-C₁-C₆ alkylamino group/moiety may be the same as, or different from, one another.

The ring A in formula (I) is a 5-membered heteroaromatic ring containing from 1 to 4 ring nitrogen atoms, examples of which include pyrrolyl, imidazolyl, pyrazolyl, triazolyl and
10 tetrazolyl.

A heterocyclic ring system means a saturated, partially unsaturated or fully unsaturated hydrocarbyl group containing from 5 to 9 ring atoms in which one or more (e.g. one, two, three or four) ring carbon atoms are replaced by a corresponding number of ring
15 heteroatoms independently selected from nitrogen, oxygen and sulphur, particularly nitrogen and oxygen. Examples of heterocyclic ring systems include tetrahydrofuranyl, piperidinyl, pyrrolidinyl, tetrahydropyranyl, morpholinyl, thiamorpholinyl, dihydrobenzofuranyl, dihydrobenzothienyl and indolyl.

- 20 When any chemical moiety or group in formula (I) is described as being optionally substituted, it will be appreciated that the moiety or group may be either unsubstituted or substituted by one or more of the specified substituents. It will be appreciated that the number and nature of substituents will be selected so as to avoid sterically undesirable combinations.

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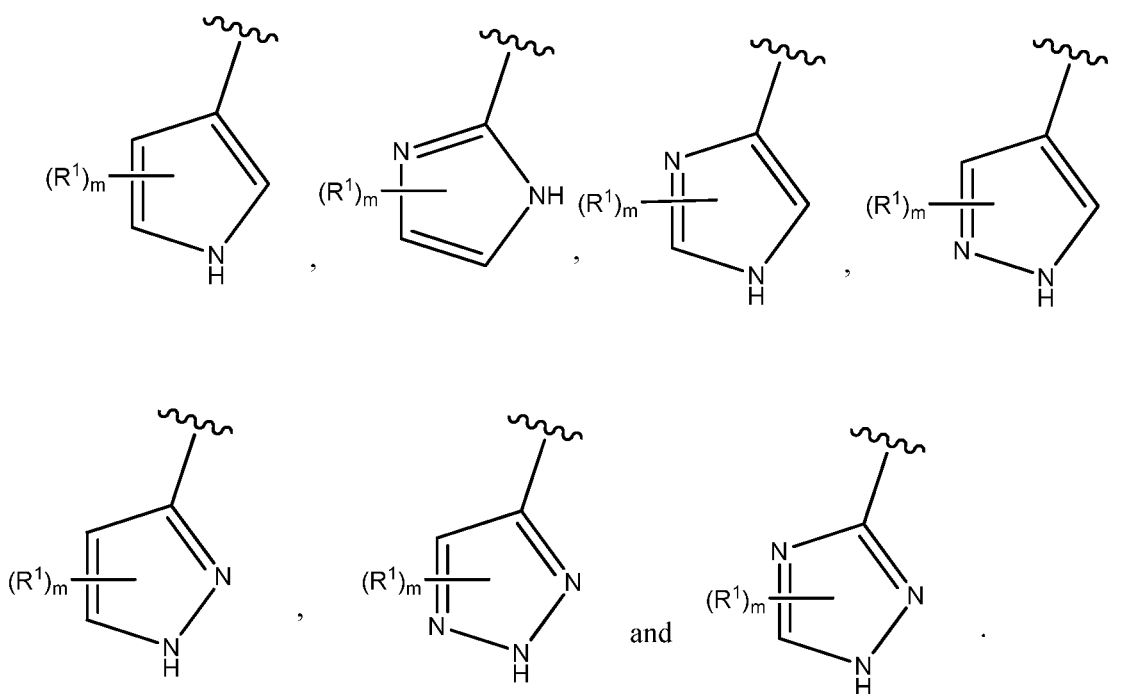
In ring A of the compounds of formula (I), at least one of W, X, Y and Z represents N or NH. In one aspect of the invention, Y represents N or NH and W, X and Z each independently represent N, NH or CH. In a further aspect, Y represents N and W, X and Z each represent CH.

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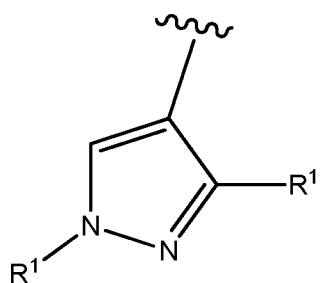
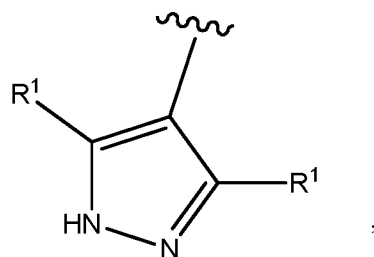
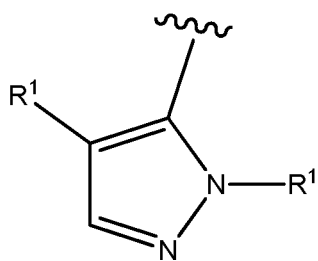
In one embodiment of the invention, at least two of W, X, Y and Z represent N or NH. Particularly advantageous compounds are those in which (i) X and Y each independently represent N or NH and W and Z both represent CH, or (ii) Y and Z each independently represent N or NH and W and X both represent CH, or (iii) W and X each independently represent N or NH and Y and Z both represent CH.

In another embodiment, at least three of W, X, Y and Z independently represent N or NH.

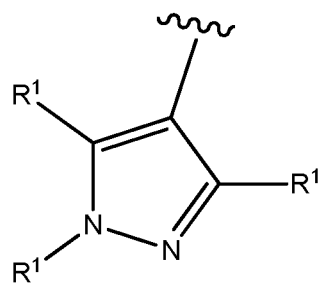
Specific examples of ring A, in which m and R¹ are as previously defined, include:



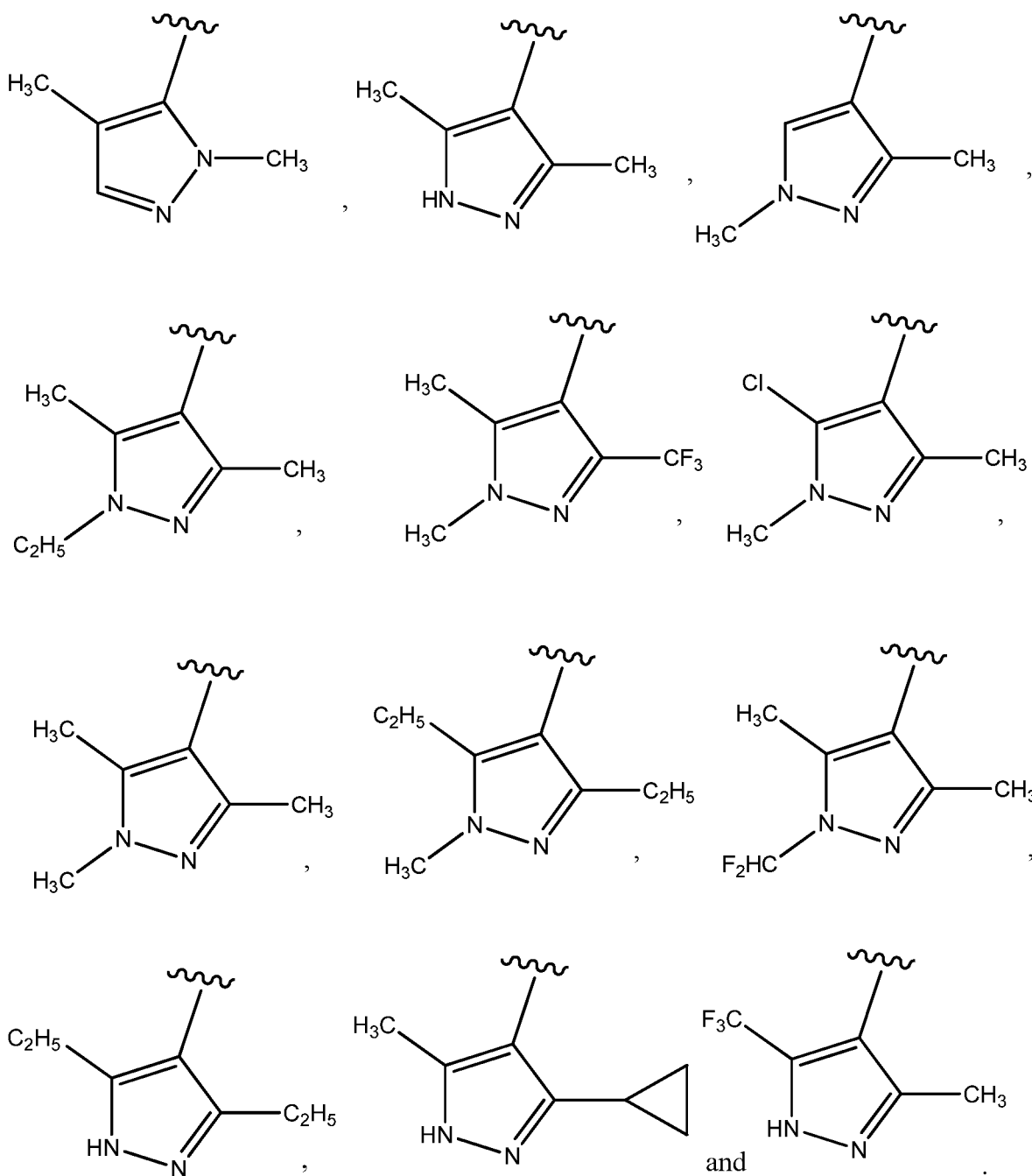
Advantageously, the ring A (where the substituents R¹, which may be the same or different, are as previously defined) is selected from the following moieties:



and



In particular, the ring A may be selected from one of the following moieties:



The number (m) of substituents R¹ on ring A may be 0, 1, 2 or 3, preferably 2 or 3.

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If present on ring A, each R¹ independently represents halogen (e.g. fluorine, chlorine or bromine), cyano, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy, C₃-C₆ or C₃-C₅ cycloalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl, C₁-C₆, or C₁-C₄, or C₁-C₂ haloalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ haloalkoxy, C₁-C₆, or C₁-C₄, or

C₁-C₂ alkylthio, C₁-C₆, or C₁-C₄, or C₁-C₂ alkylcarbonyl, or C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl optionally substituted by one or more (e.g. one, two, three or four) substituents independently selected from carboxyl and C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl.

- 5 In an embodiment of the invention, each R¹ independently represents halogen (e.g. fluorine, chlorine or bromine), cyano, C₁-C₂ alkoxy, C₃-C₅ cycloalkyl (e.g. cyclopropyl), C₁-C₂ alkoxy carbonyl, C₁-C₂ haloalkyl (e.g. difluoromethyl or trifluoromethyl), C₁-C₂ haloalkoxy (e.g. difluoromethoxy or trifluoromethoxy), C₁-C₂ alkylthio, C₁-C₂ alkylcarbonyl, or C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl optionally substituted by one or more (e.g. one, two, three or four) substituents independently selected
10 from carboxyl and C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl.

In another embodiment, each R¹ independently represents halogen (e.g. fluorine, chlorine or bromine, especially chlorine), C₃-C₅ cycloalkyl (e.g. cyclopropyl), C₁-C₂ haloalkyl
15 (e.g. difluoromethyl or trifluoromethyl) or C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl (especially methyl or ethyl).

In still another embodiment, each R¹ independently represents cyclopropyl, C₁-C₂ haloalkyl (e.g. difluoromethyl or trifluoromethyl) or C₁-C₂ alkyl.

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The number (n) of substituents R² on the piperidine ring may be 0, 1, 2, 3 or 4, and is preferably 0 or 1. A substituent R² may be attached at any suitable position on the piperidine ring but is preferably attached at the 3-position (or *meta* position) relative to the ring nitrogen atom.

25

If present, each R^2 independently represents halogen (e.g. fluorine, chlorine or bromine), cyano, carboxyl, hydroxyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ haloalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy, C₁-C₆, or C₁-C₄, or C₁-C₂ hydroxyalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxyC₁-C₆ alkyl or a 5-, 6-, 7-, 8- or 9-membered heterocyclic ring system.

In one embodiment, each R^2 independently represents halogen (e.g. fluorine, chlorine or bromine), cyano, carboxyl, hydroxyl, C₁-C₂ alkyl (especially methyl), C₁-C₂ haloalkyl (e.g. difluoromethyl or trifluoromethyl), C₁-C₂ alkoxy (especially methoxy), C₁-C₂ hydroxyalkyl (e.g. hydroxymethyl), C₁-C₂ alkoxy carbonyl (especially ethoxycarbonyl), C₁-C₂ alkoxyC₁-C₆ alkyl (preferably C₁-C₂ alkoxyC₁-C₂ alkyl) or a 5- to 6-membered heterocyclic ring system containing one or two ring heteroatoms independently selected from nitrogen and oxygen.

In another embodiment, each R^2 independently represents halogen (especially fluorine), cyano, hydroxyl, C₁-C₂ alkyl (especially methyl), C₁-C₂ alkoxy (especially methoxy), C₁-C₂ alkoxy carbonyl (especially ethoxycarbonyl), or C₁-C₂ alkoxyC₁-C₂ alkyl (particularly methoxymethyl).

In still another embodiment, each R^2 independently represents cyano, hydroxyl, C₁-C₂ alkyl (especially methyl), C₁-C₂ alkoxy (especially methoxy), C₁-C₂ alkoxy carbonyl (especially ethoxycarbonyl), or C₁-C₂ alkoxyC₁-C₂ alkyl (particularly methoxymethyl).

In a further embodiment, n is 1 and R^2 is methyl.

R^3 represents $=CR^6$, or, when there is at least one R^1 group present that represents a C₃-C₆ cycloalkyl group, then R^3 may additionally represent a group $-CR^7R^8$.

In one embodiment of the invention, R^3 may represent $=CR^6$ where R^6 represents a hydrogen or halogen (e.g. fluorine, chlorine or bromine) atom or a cyano, C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl or C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl group.

In another embodiment, R^6 represents a hydrogen or fluorine atom or a cyano, C₁-C₂ alkyl (particularly methyl) or C₁-C₂ alkoxy carbonyl (particularly methoxy carbonyl) group.

10

In a preferred aspect, R^6 represents a fluorine atom.

In a further embodiment of the invention, R^3 may represent a group $-CR^7R^8$ - where R^7 and R^8 each independently represent a hydrogen or halogen (e.g. fluorine, chlorine or bromine) atom, cyano, carboxyl, hydroxyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ haloalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy, C₁-C₆, or C₁-C₄, or C₁-C₂ hydroxyalkyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxy carbonyl, C₁-C₆, or C₁-C₄, or C₁-C₂ alkoxyC₁-C₆ alkyl or a 5-, 6-, 7-, 8- or 9-membered heterocyclic ring system.

In one aspect, R^7 and R^8 each independently represent a hydrogen or halogen (e.g. fluorine, chlorine or bromine) atom, cyano, hydroxyl, C₁-C₂ alkyl (preferably methyl), C₁-C₂ haloalkyl (e.g. difluoromethyl or trifluoromethyl), C₁-C₂ alkoxy, C₁-C₂ hydroxyalkyl (e.g. hydroxymethyl), or C₁-C₂ alkoxyC₁-C₂ alkyl (particularly methoxymethyl). In a preferred aspect, R^7 and R^8 each represent a hydrogen atom.

25

In particular, R^3 may represent CH_2 , $=CH$, $=CF$, $=C(CN)$, $=C(CH_3)$ or $=C(CO_2CH_3)$.
Advantageously, R^3 represents $=CF$.

R^5 is absent (i.e. when R^3 represents $=CR^6$) or represents a hydrogen atom or a substituent
5 as defined above for R^2 .

In one aspect, R^5 represents a hydrogen atom.

In another aspect, R^5 is absent.

10

R^4 represents a 6-, 7-, 8-, 9- or 10-membered aromatic or heteroaromatic ring system, the
ring system itself being optionally substituted by at least one substituent (e.g. one, two,
three or four substituents independently) selected from halogen (e.g. fluorine, chlorine or
bromine), hydroxyl, cyano, oxo ($=O$), C_1-C_6 , or C_1-C_4 , or C_1-C_2 alkyl, C_2-C_6 or C_2-C_4
15 alkenyl, C_2-C_6 or C_2-C_4 alkynyl, C_1-C_6 , or C_1-C_4 , or C_1-C_2 haloalkyl, C_1-C_6 , or C_1-C_4 ,
or C_1-C_2 hydroxyalkyl, C_1-C_6 , or C_1-C_4 , or C_1-C_2 alkoxy, C_1-C_6 , or C_1-C_4 , or
 C_1-C_2 haloalkoxy, C_1-C_6 , or C_1-C_4 , or C_1-C_2 alkylthio, C_1-C_6 , or C_1-C_4 , or
 C_1-C_2 alkylsulphinyl, C_1-C_6 , or C_1-C_4 , or C_1-C_2 alkylsulphonyl, C_1-C_6 , or C_1-C_4 , or
 C_1-C_2 alkylcarbonyl, C_1-C_6 , or C_1-C_4 , or C_1-C_2 alkylcarbonyloxy, C_1-C_6 , or C_1-C_4 , or
20 C_1-C_2 alkoxy carbonyl, amino ($-NH_2$), $-CON(R^9)_2$, C_1-C_6 , or C_1-C_4 , or
 C_1-C_2 alkylamino, di- $(C_1-C_6$ alkyl)amino, C_3-C_6 cycloalkyl, C_3-C_6 cycloalkyloxy and
 C_3-C_6 cycloalkylmethyl.

25

The heteroaromatic ring system will comprise at least one ring heteroatom (e.g. one, two,
three or four ring heteroatoms independently) selected from nitrogen, sulphur and oxygen.
Preferably the ring heteroatoms are selected from nitrogen and oxygen.

Examples of 6- to 10-membered aromatic or heteroaromatic ring systems that may be used, which may be monocyclic or polycyclic (e.g. bicyclic) in which the two or more rings are fused, include one or more (in any combination) of phenyl, pyridinyl, naphthyl, benzofuranyl, benzothienyl, quinolinyl, imidazo[1,2-a]pyridinyl, pyrazinyl, indolyl, pyrimidinyl, thiophenyl and benzimidazolyl. Preferred ring systems include phenyl, quinolinyl, naphthyl and pyridinyl.

In one embodiment of the invention, R^4 represents a 6-, 7-, 8-, 9- or 10-membered aromatic or heteroaromatic ring system, the ring system itself being optionally substituted by at least one substituent (e.g. one, two, three or four substituents independently) selected from halogen (e.g. fluorine, chlorine or bromine), hydroxyl, cyano, oxo, C_1 - C_4 alkyl (e.g. methyl or ethyl), C_2 - C_4 alkenyl (e.g. ethenyl), C_2 - C_4 alkynyl (e.g. ethynyl), C_1 - C_2 haloalkyl (e.g. trifluoromethyl), C_1 - C_2 hydroxyalkyl (e.g. hydroxymethyl), C_1 - C_4 alkoxy (e.g. methoxy or ethoxy), C_1 - C_2 haloalkoxy (e.g. trifluoromethoxy), C_1 - C_4 alkylthio (e.g. methylthio or ethylthio), C_1 - C_4 alkylsulphinyl (e.g. methylsulphinyl or ethylsulphinyl), C_1 - C_4 alkylsulphonyl (e.g. methylsulphonyl or ethylsulphonyl), C_1 - C_4 alkylcarbonyl (e.g. methylcarbonyl or ethylcarbonyl), C_1 - C_4 alkylcarbonyloxy (e.g. methylcarbonyloxy), C_1 - C_4 alkoxy carbonyl (e.g. methoxycarbonyl), amino, $-\text{CON}(\text{R}^9)_2$, C_1 - C_4 alkylamino (e.g. methylamino or ethylamino), di- $(C_1$ - C_4 alkyl)amino (e.g. dimethylamino), C_3 - C_5 cycloalkyl, C_3 - C_5 cycloalkyloxy and C_3 - C_5 cycloalkylmethyl.

In another embodiment of the invention, R^4 represents a 6-, 7-, 8-, 9- or 10-membered, particularly 6-membered, aromatic or heteroaromatic ring system (particularly a nitrogen-containing heteroaromatic ring system containing 1, 2, 3 or 4 ring nitrogen atoms and optionally one or more further ring heteroatoms), the ring system itself being optionally substituted by at least one substituent (e.g. one, two, three or four substituents independently) selected from halogen (e.g. fluorine, chlorine or bromine), cyano, C_1 -

C₄ alkyl (e.g. methyl or ethyl), C₁-C₂ haloalkyl (e.g. trifluoromethyl), C₁-C₄ alkoxy (e.g. methoxy or ethoxy) and C₁-C₂ haloalkoxy (e.g. trifluoromethoxy).

In still another embodiment of the invention, R⁴ represents a 6-, 7-, 8-, 9- or 10-membered, particularly 6-membered, aromatic or heteroaromatic (particularly a nitrogen-containing heteroaromatic) ring system, the ring system itself being optionally substituted by at least one substituent (preferably up to three, most preferably one or two, substituents independently) selected from halogen (e.g. fluorine, chlorine or bromine), cyano, methyl, trifluoromethyl, methoxy and trifluoromethoxy.

In a still further embodiment of the invention, R⁴ represents phenyl optionally substituted by at least one substituent (preferably up to three, most preferably one or two, substituents independently) selected from halogen (particularly fluorine or chlorine) and trifluoromethoxy.

Each R⁹ independently represents a hydrogen atom or a C₁-C₆, or C₁-C₄, or C₁-C₂ alkyl, particularly methyl, group.

In a preferred embodiment of the invention, subject to the above provisos, compounds of formula (I) are those in which:

W, X, Y and Z each independently represent a nitrogen atom or a moiety NH or CH, with the proviso that W, X, Y and Z do not each simultaneously represent a moiety CH;

m is 2 or 3;

each R¹ independently represents C₃-C₆ cycloalkyl, C₁-C₆ haloalkyl or C₁-C₆ alkyl;

n is 0 or 1;

R² represents C₁-C₆ alkyl;

R³ represents =CR⁶, or, when there is at least one R¹ group present that represents a C₃-C₆ cycloalkyl group, then R³ may additionally represent a group -CR⁷R⁸;

R⁵ is absent or represents a hydrogen atom;

R⁶ represents a hydrogen or fluorine atom or a cyano, C₁-C₂ alkyl or

C₁-C₂ alkoxy carbonyl group;

R⁷ and R⁸ each represent a hydrogen atom; and

R⁴ represents a 6- to 10-membered aromatic or heteroaromatic ring system, the ring
5 system itself being optionally substituted by at least one substituent selected from halogen
and C₁-C₆ haloalkoxy.

Examples of compounds of the invention include:

- 4-(4-Chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1*H*-pyrazol-4-
10 yl)sulfonyl)piperidine,
Methyl 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-
ylidene)acetate,
2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-
ylidene)acetonitrile,
15 2-(2,6-Difluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-
ylidene)acetonitrile,
2-(4-Chloro-2-fluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-
4-ylidene)acetonitrile,
2-(4-Chlorophenyl)-2-(1-((3,5-diethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-
20 ylidene)acetonitrile,
2-(4-Chlorophenyl)-2-(1-((1,5-dimethyl-3-(trifluoromethyl)-1*H*-pyrazol-4-
yl)sulfonyl)piperidin-4-ylidene)acetonitrile,
2-(2,6-Difluorophenyl)-2-(1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-
ylidene)acetonitrile,
25 2-(1-((3,5-Dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)-2-(4-
(trifluoromethoxy)phenyl)acetonitrile,
2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)-3-methylpiperidin-
4-ylidene)acetonitrile,
4-(4-Chloro-2-fluorobenzylidene)-1-((3,5-dimethyl-1*H*-pyrazol-4-
30 yl)sulfonyl)piperidine,

4-(4-Chloro-2-fluorobenzylidene)-1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-(1-(4-Chlorophenyl)ethylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

5 4-(4-Chlorobenzylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

2-(4-Chlorophenyl)-2-(1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

4-((4-Chlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

10 4-((3-Chloro-4-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((2,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

15 4-((3,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((4-Chloro-3-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((4-Chloro-2-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

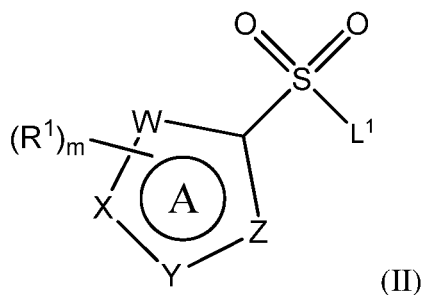
20 4-((2,4-Difluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

3-((1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)fluoromethyl)quinoline,

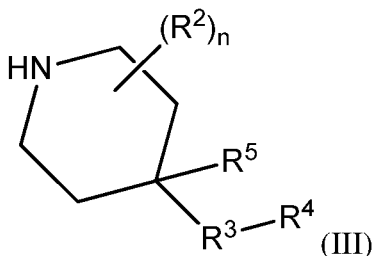
25 and pharmaceutically acceptable salts of any one thereof.

It should be noted that each of the chemical compounds listed above represents a particular and independent aspect of the invention.

30 Compounds of formula (I) and pharmaceutically acceptable salts thereof as defined above may be prepared by a process comprising reacting a compound of formula



wherein L^1 represents a leaving group (e.g. a halogen atom) and m , W , X , Y , Z and R^1 are as defined in formula (I), with a compound of formula



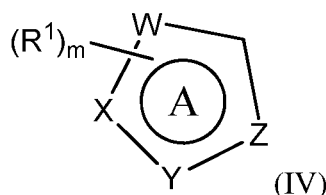
or a suitable salt (e.g. a hydrochloride salt) thereof, wherein n , R^2 , R^3 , R^4 and R^5 are as defined in formula (I);

and optionally thereafter carrying out one or more of the following procedures:

- converting a compound of formula (I) into another compound of formula (I)
- removing any protecting groups
- forming a pharmaceutically acceptable salt.

The process may conveniently be carried out in the presence of an organic solvent such as dichloromethane, acetonitrile or tetrahydrofuran and a suitable base such as triethylamine, pyridine or diisopropylethylamine, at a temperature in the range from 20°C to 40°C, e.g. at ambient temperature (20°C).

Compounds of formula (II) in which L^1 represents a halogen atom may be prepared by reacting a compound of formula



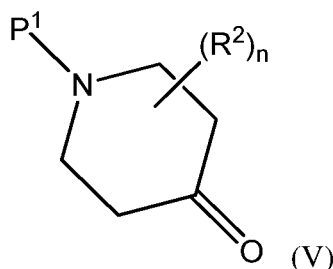
wherein m , W , X , Y , Z and R^1 are as defined in formula (I), with sulphur dioxide in the present of an organometallic reagent (e.g. an organolithium reagent such as *n*-butyl lithium), followed by reaction with a halogenating agent, e.g. *N*-chlorosuccinimide.

5

The first step of the process is conveniently carried out in the presence of an organic polar solvent such as ether, chloroform or dichloromethane under a nitrogen atmosphere at low temperature, e.g. from 0°C to -70°C . The second step of the process may be carried out using a biphasic solvent mixture, e.g. dichloromethane/water mixture, at ambient

10 temperature (20°C).

Compounds of formula (III) in which R^3 represents $=\text{CR}^6$, R^6 represents cyano or $\text{C}_1\text{-C}_6$ alkoxy carbonyl and R^5 is absent may be prepared by reacting a compound of formula

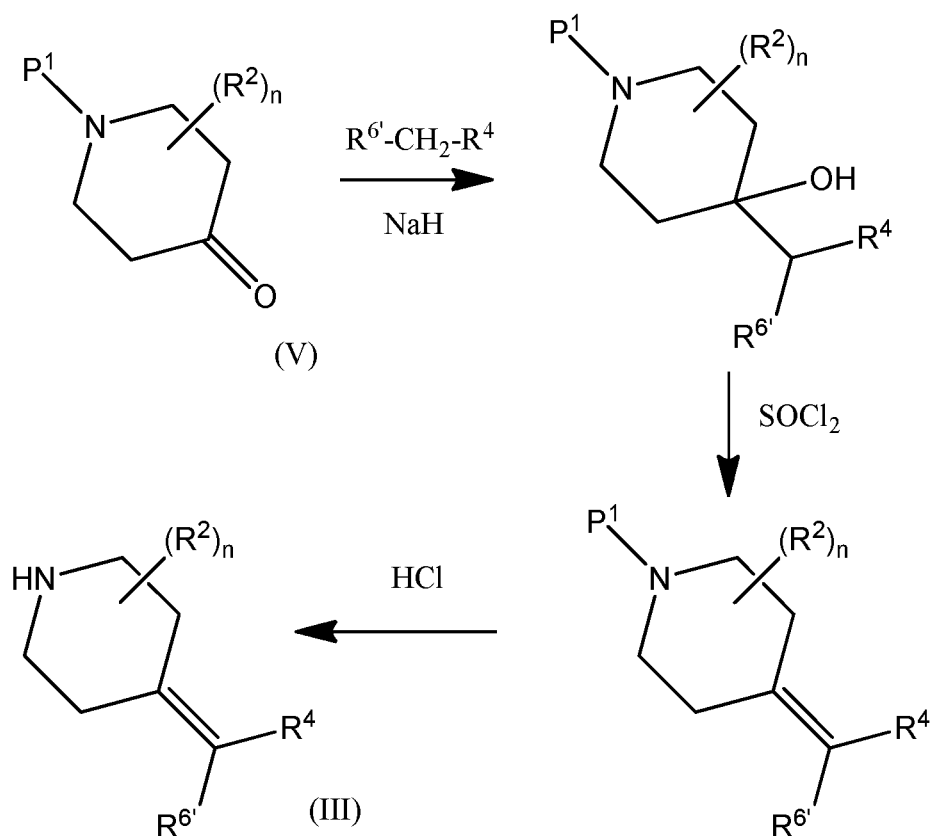


15

wherein P^1 represents a nitrogen-protecting group (e.g. *tert*-butoxy carbonyl group) and n and R^2 are as defined in formula (I), with a compound of formula (VI), $R^{6'}\text{-CH}_2\text{-R}^4$, wherein $R^{6'}$ represents cyano or $\text{C}_1\text{-C}_6$ alkoxy carbonyl and R^4 is as defined in formula (I), in the presence of a strong base (e.g. sodium hydride), followed by an activation and

20 elimination step (e.g. in the presence of thionyl chloride) and removal of the protecting group P^1 (e.g. in the presence of an acid such as hydrochloric acid) (see Scheme 1 below).

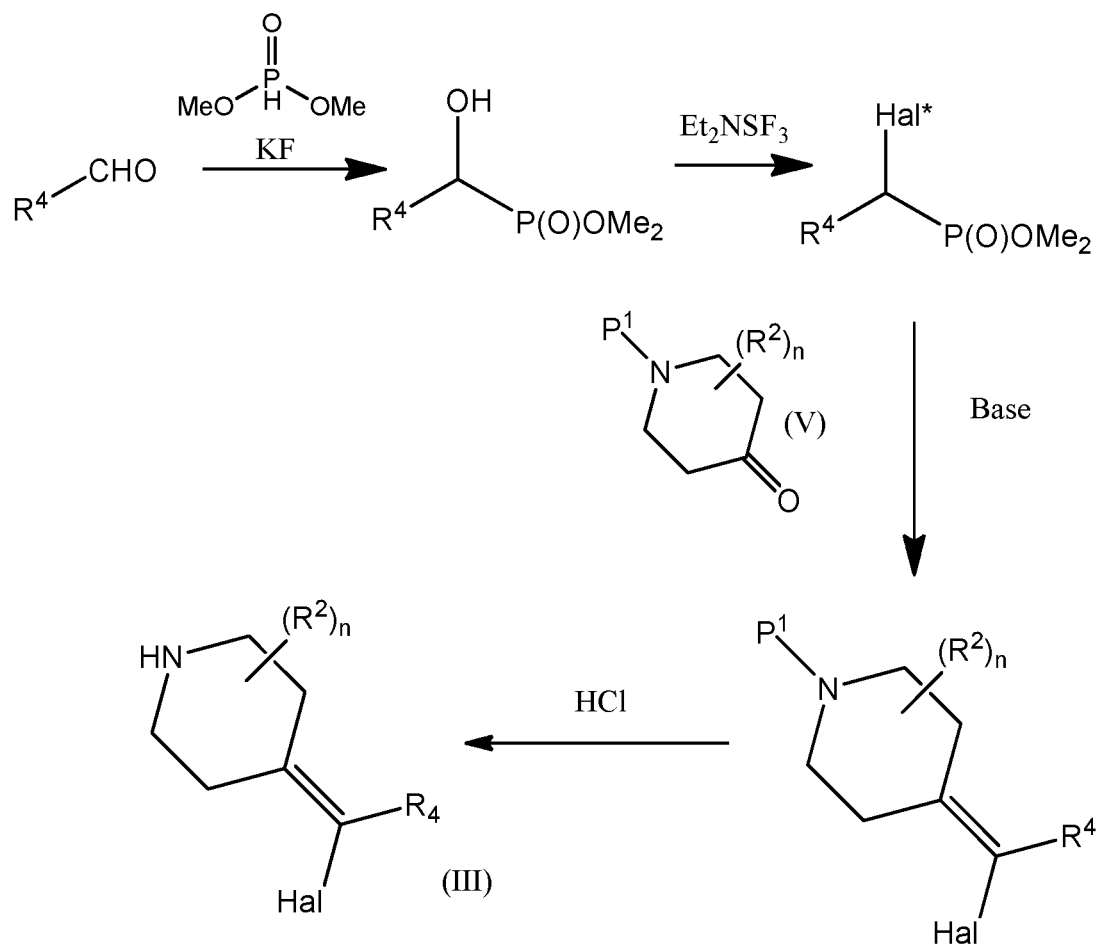
Scheme 1



Alternatively, compounds of formula (III) in which R^3 represents $=\text{CR}^6$, R^6 represents a halogen atom and R^5 is absent may be prepared by a modified Arbamov reaction as illustrated in Scheme 2 below. Details of the Arbamov reaction can be found, for example, in the following literature references:

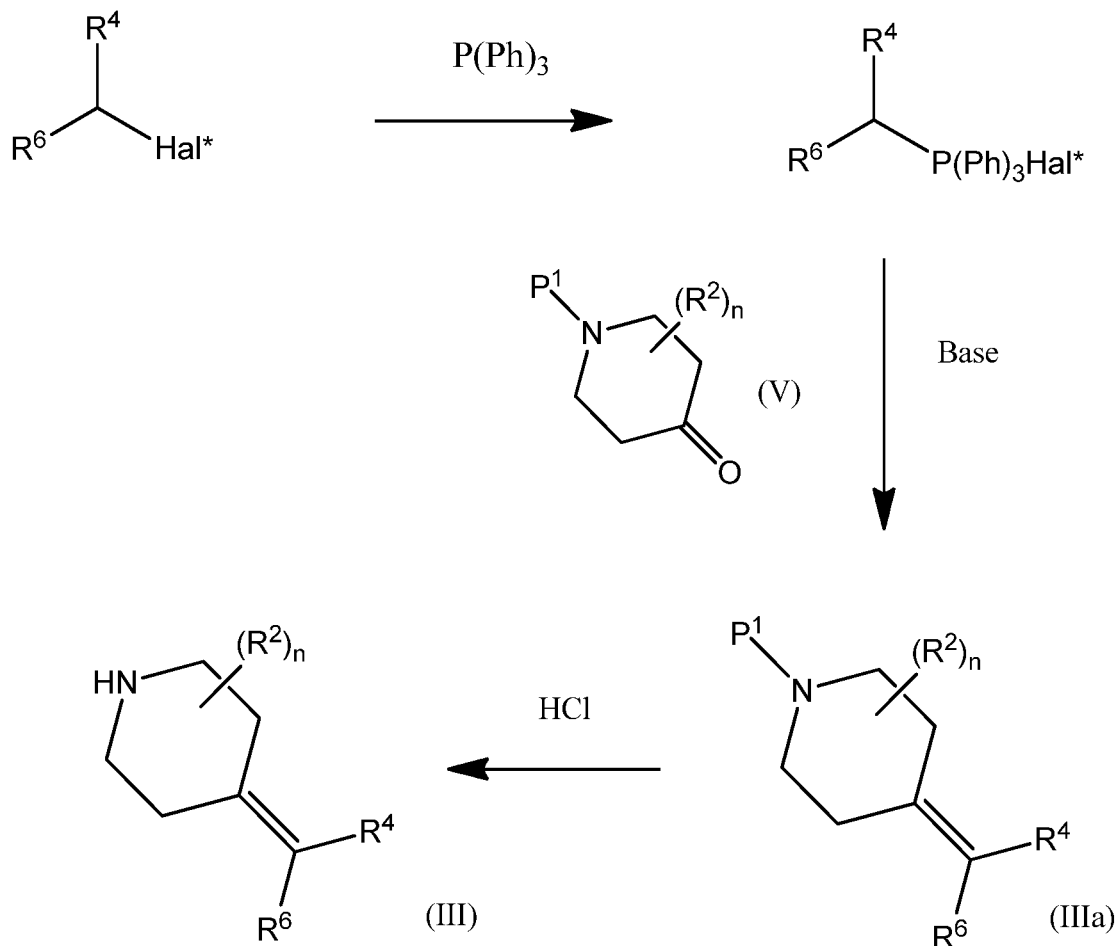
- (1) Azizi, Najmedin and Saidi, Mohammad R., *Phosphorus, Sulfur and Silicon and the Related Elements*, 178(6), 1255-1259; 2003;
- (2) Naresh S. Tulsi, A. Michael Downey, Christopher W. Cairo, *Bioorganic & Medicinal Chemistry*, 18 (2010), 8679–8686; and
- (3) Blackburn, G. Michael and Kent, David E., *Journal of the Chemical Society, Perkin Transactions 1: Organic and Bio-Organic Chemistry* (1972-1999), (6), 913-17; 1986.

Scheme 2



Compounds of formula (III) in which R^3 represents $=CR^6$, R^6 represents a hydrogen atom or a C_1 - C_6 alkyl group and R^5 is absent may be prepared via generation of a phosphonium salt as illustrated in Scheme 3 following:

Scheme 3



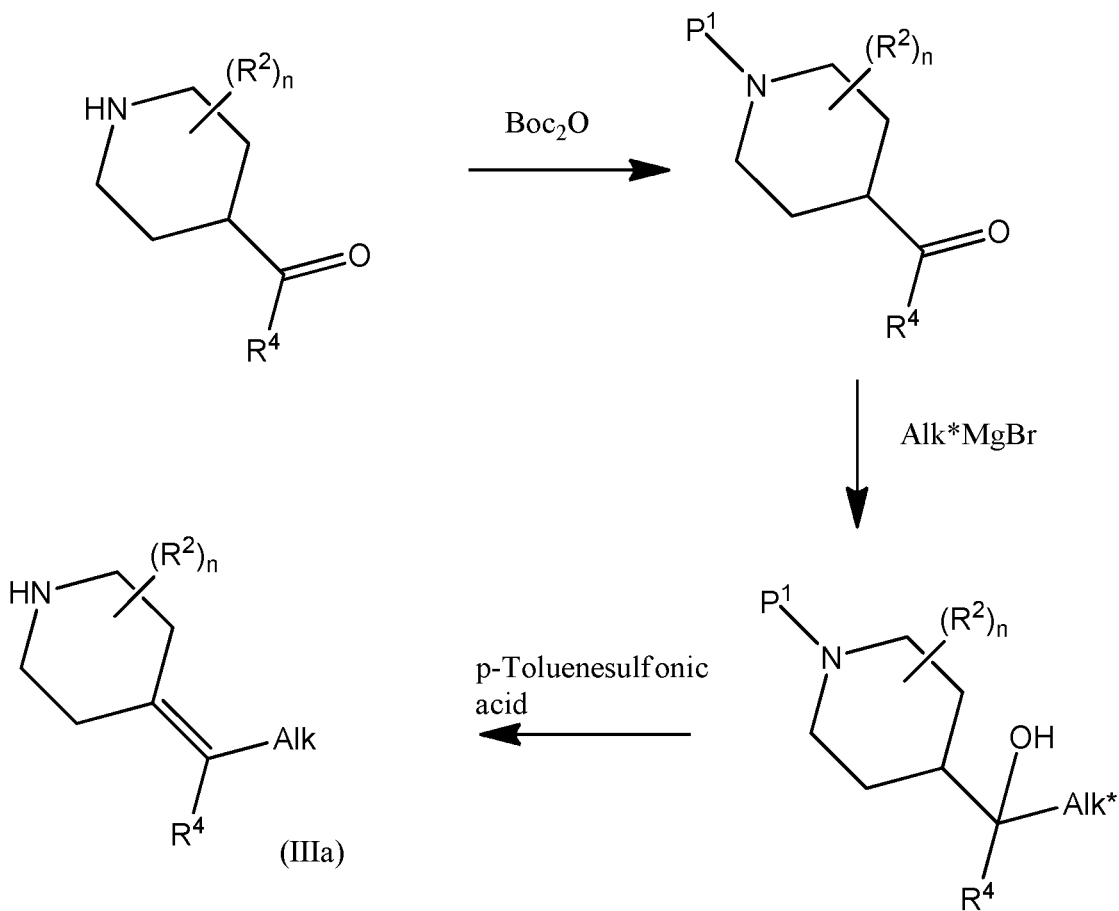
* Hal denotes a halogen atom

The base used in Scheme 3 is preferably a strong base such as n-butyl lithium.

Compounds of formula (IIIa) in which R⁶ represents a C₁-C₆ alkyl group may be

5 synthesised according to Scheme 4 below:

Scheme 4



* Alk denotes C₁-C₆ alkyl

Compounds of formula (III) in which R³ represents a group -CR⁷R⁸ - and R⁷ and R⁸ each represent a hydrogen atom may be prepared by reducing a compound of formula (IIIa) in which R⁶ represents a hydrogen atom, in a suitable solvent (e.g. an alcoholic solvent or ethyl acetate) in the presence of a metal catalyst (e.g. platinum (IV) oxide) under a hydrogen atmosphere, followed by removal of the protecting group, P¹, under acid conditions.

10 Compounds of formulae (III), (IV), (V) and (VI) are either commercially available, are well known in the literature or may be prepared using known techniques.

It will be appreciated by those skilled in the art that in the above processes certain functional groups such as phenol, hydroxyl or amino groups in the reagents may need to be protected by protecting groups. Thus, the preparation of compounds of formula (I) may
5 involve, at an appropriate stage, the removal of one or more protecting groups.

The protection and deprotection of functional groups is described in 'Protective Groups in Organic Chemistry', edited by J.W.F. McOmie, Plenum Press (1973) and 'Protective Groups in Organic Synthesis', 3rd edition, T.W. Greene and P.G.M. Wuts, Wiley-
10 Interscience (1999).

The compounds of formula (I) above may be converted to a pharmaceutically acceptable salt thereof, preferably an acid addition salt such as a formate, hemi-formate, hydrochloride, hydrobromide, benzenesulphonate (besylate), saccharin (e.g.
15 monosaccharin), trifluoroacetate, sulphate, nitrate, phosphate, acetate, fumarate, maleate, tartrate, lactate, citrate, pyruvate, succinate, valerate, propanoate, butanoate, malonate, oxalate, 1-hydroxy-2-napthoate (xinafoate), methanesulphonate or *p*-toluenesulphonate salt.

In one aspect of the invention, compounds of formula (I) defined above may bear one or
20 more radiolabels. Such radiolabels may be introduced by using radiolabel-containing reagents in the synthesis of the compounds of formula (I) or may be introduced by coupling the compounds of formula (I) to chelating moieties capable of binding to a radioactive metal atom. Such radiolabeled versions of the compounds may be used, for
25 example, in diagnostic imaging studies.

Compounds of formula (I) and their salts may be in the form of hydrates or solvates which form an aspect of the present invention. Such solvates may be formed with common organic solvents, including but not limited to, alcoholic solvents e.g. methanol, ethanol or
30 isopropanol.

Compounds of formula (I) above are capable of existing in stereoisomeric forms. It will be understood that the invention encompasses the use of all geometric and optical isomers (including atropisomers) of the compounds of formula (I) and mixtures thereof including racemates. The use of tautomers and mixtures thereof also form an aspect of the present invention. Enantiomerically pure forms are particularly desired.

The compounds of formula (I) and their pharmaceutically acceptable salts have activity as pharmaceuticals, in particular as prokineticin receptor modulators, and thus may be used in the treatment of schizophrenia and other psychotic disorders (*e.g.*, psychotic disorder, psychosis), dementia and other cognitive disorders, anxiety disorders (*e.g.*, generalized anxiety disorder), mood disorders (*e.g.*, depressive disorders, major depressive disorders, bipolar disorders including bipolar I and II, bipolar mania, bipolar depression), sleep disorders, disorders usually first diagnosed in infancy, childhood, or adolescence (*e.g.*, attention-deficit disorder and disruptive behaviour disorders), pain (*e.g.* neuropathic pain), inflammatory conditions and neurodegenerative disorders (*e.g.* Parkinson's or Alzheimer's disease).

In the context of the present specification, the term "therapy" also includes "prophylaxis" unless there are specific indications to the contrary. The terms "therapeutic" and "therapeutically" should be construed accordingly.

Prophylaxis is expected to be particularly relevant to the treatment of persons who have suffered a previous episode of, or are otherwise considered to be at increased risk of, the disorder or condition in question. Persons at risk of developing a particular disorder or condition generally include those having a family history of the disorder or condition, or those who have been identified by genetic testing or screening to be particularly susceptible to developing the disorder or condition or those in the prodromal phase of a disorder.

In particular, the compounds of formula (I) and their pharmaceutically acceptable salts as defined above may be used in the treatment of the positive symptoms of schizophrenia, schizophreniform disorder or schizoaffective disorder (*e.g.* voices or hallucinations),

cognitive disorders (such as dementia and impaired learning) and also pain (such as neuropathic pain).

The invention also provides a method of treating at least one symptom or condition associated with schizophrenia, schizophreniform disorder, schizoaffective disorder and other psychotic disorders (e.g., psychotic disorder, psychosis), dementia and other cognitive disorders, anxiety disorders (e.g., generalized anxiety disorder), mood disorders (e.g., depressive disorders, major depressive disorders, bipolar disorders including bipolar I and II, bipolar mania, bipolar depression), sleep disorders, disorders usually first diagnosed in infancy, childhood, or adolescence (e.g., attention-deficit disorder, autistic spectrum disorders and disruptive behaviour disorders), pain (e.g. neuropathic pain) and neurodegenerative disorders (e.g. Parkinson's or Alzheimer's disease) which comprises administering to a patient in need thereof a therapeutically effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof as hereinbefore defined.

Such symptoms and conditions include, but are not limited to, anxiety, agitation, hostility, panic, an eating disorder, an affective symptom, a mood symptom, a negative and positive psychotic symptom commonly associated with psychosis and neurodegenerative disorder.

For the above-mentioned therapeutic uses the dosage administered will, of course, vary with the compound employed, the mode of administration, the treatment desired and the disorder indicated. For example, the daily dosage of a compound according to the invention (i.e. a compound of formula (I) or a pharmaceutically acceptable salt thereof), if inhaled, may be in the range from 0.05 micrograms per kilogram body weight ($\mu\text{g}/\text{kg}$) to 100 micrograms per kilogram body weight ($\mu\text{g}/\text{kg}$). Alternatively, if the compound is administered orally, then the daily dosage of the compound of the invention may be in the range from 0.01 micrograms per kilogram body weight ($\mu\text{g}/\text{kg}$) to 100 milligrams per kilogram body weight (mg/kg).

The compounds of formula (I) and pharmaceutically acceptable salts thereof may be used on their own but will generally be administered in the form of a pharmaceutical

composition in which the formula (I) compound/salt (active ingredient) is in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

Therefore the present invention further provides a pharmaceutical composition comprising
5 a compound of formula (I) or a pharmaceutically acceptable salt thereof as hereinbefore defined, in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

The invention still further provides a process for the preparation of a pharmaceutical composition of the invention which comprises mixing a compound of formula (I) or a
10 pharmaceutically acceptable salt thereof as hereinbefore defined with a pharmaceutically acceptable adjuvant, diluent or carrier.

Conventional procedures for the selection and preparation of suitable pharmaceutical formulations are described in, for example, "Pharmaceuticals - The Science of Dosage
15 Form Designs", M. E. Aulton, Churchill Livingstone, 1988.

Pharmaceutically acceptable adjuvants, diluents or carriers that may be used in the pharmaceutical compositions of the invention are those conventionally employed in the field of pharmaceutical formulation, and include, but are not limited to, sugars, sugar
20 alcohols, starches, ion exchangers, alumina, aluminium stearate, lecithin, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycerine, sorbic acid, potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulphate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate,
25 polyvinyl pyrrolidone, cellulose-based substances, polyethylene glycol, sodium carboxymethylcellulose, polyacrylates, waxes, polyethylene- polyoxypropylene-block polymers, polyethylene glycol and wool fat.

The pharmaceutical compositions of the present invention may be administered orally,
30 parenterally, by inhalation spray, rectally, nasally, buccally, vaginally or via an implanted reservoir. Oral administration is preferred. The pharmaceutical compositions of the invention may contain any conventional non-toxic pharmaceutically acceptable adjuvants,

diluents or carriers. The term parenteral as used herein includes subcutaneous, intracutaneous, intravenous, intramuscular, intra-articular, intrasynovial, intrasternal, intrathecal, intralesional and intracranial injection or infusion techniques.

5 The pharmaceutical compositions may be in the form of a sterile injectable preparation, for example, as a sterile injectable aqueous or oleaginous suspension. The suspension may be formulated according to techniques known in the art using suitable dispersing or wetting agents (such as, for example, Tween 80) and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic
10 parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable diluents and solvents that may be employed are mannitol, water, Ringer's solution and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose, any bland fixed oil may be employed including synthetic mono- or diglycerides. Fatty acids, such as
15 oleic acid and its glyceride derivatives are useful in the preparation of injectables, as are natural pharmaceutically acceptable oils, such as olive oil or castor oil, especially in their polyoxyethylated versions. These oil solutions or suspensions may also contain a long-chain alcohol diluent.

20 The pharmaceutical compositions of this invention may be orally administered in any orally acceptable dosage form including, but not limited to, capsules, tablets, powders, granules, and aqueous suspensions and solutions. These dosage forms are prepared according to techniques well-known in the art of pharmaceutical formulation. In the case of tablets for oral use, carriers which are commonly used include lactose and corn starch.
25 Lubricating agents, such as magnesium stearate, are also typically added. For oral administration in a capsule form, useful diluents include lactose and dried corn starch. When aqueous suspensions are administered orally, the active ingredient is combined with emulsifying and suspending agents. If desired, certain sweetening and/or flavouring and/or colouring agents may be added.

30

The pharmaceutical compositions of the invention may also be administered in the form of suppositories for rectal administration. These compositions can be prepared by mixing the

active ingredient with a suitable non-irritating excipient which is solid at room temperature but liquid at the rectal temperature and therefore will melt in the rectum to release the active ingredient. Such materials include, but are not limited to, cocoa butter, beeswax and polyethylene glycols.

5

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

10 bioavailability, fluorocarbons, and/or other solubilising or dispersing agents known in the art.

Depending on the mode of administration, the pharmaceutical composition will preferably comprise from 0.05 to 99 %w (per cent by weight), more preferably from 0.05 to 80 %w, still more preferably from 0.10 to 70 %w, and even more preferably from 0.10 to 50 %w, of active ingredient, all percentages by weight being based on total composition.

15

The compounds of formula (I) and pharmaceutically acceptable salts thereof as defined above may also be administered in conjunction with other compounds used for the

20 treatment of the above conditions.

The invention therefore further relates to combination therapies wherein a compound of formula (I) or a pharmaceutically acceptable salt thereof as previously defined or a pharmaceutical composition or formulation comprising a compound of formula (I) or a pharmaceutically acceptable salt thereof as previously defined is administered with another

25 therapeutic agent or agents, for the treatment of one or more of the conditions previously indicated. Such therapeutic agents may be selected from the following:

(i) **antidepressants** such as, for example, amitriptyline, amoxapine, bupropion, citalopram, clomipramine, desipramine, doxepin duloxetine, elzasonan, escitalopram, fluvoxamine, fluoxetine, gepirone, imipramine, ipsapirone, maprotiline, nortriptyline, nefazodone, paroxetine, phenelzine, protriptyline, reboxetine, robaizotan, sertraline, sibutramine,

30

thionisoxetine, tranlycypromaine, trazodone, trimipramine, venlafaxine, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(ii) **atypical antipsychotics** including, for example, quetiapine and pharmaceutically
5 active isomer(s) and/or metabolite(s) thereof;

(iii) **antipsychotics** including, for example, amisulpride, aripiprazole, asenapine, benisoxidil, bifeprunox, carbamazepine, clozapine, chlorpromazine, debenzapine, divalproex, duloxetine, eszopiclone, haloperidol, iloperidone, lamotrigine, loxapine,
10 mesoridazine, olanzapine, paliperidone, perlapine, perphenazine, phenothiazine, phenylbutylpiperidine, pimozide, prochlorperazine, risperidone, sertindole, sulpiride, suproclonidine, suriclone, thioridazine, trifluoperazine, trimetozine, valproate, valproic acid, zopiclone, zotepine, ziprasidone, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

15

(iv) **anxiolytics** including, for example, alnespirone, azapirone, benzodiazepines, barbiturates, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof. Example anxiolytics include adinazolam, alprazolam, balezepam, bentazepam, bromazepam, brotizolam, buspirone, clonazepam, clorazepate, chlordiazepoxide,
20 cyprazepam, diazepam, diphenhydramine, estazolam, fenobam, flunitrazepam, flurazepam, fosazepam, lorazepam, lormetazepam, meprobamate, midazolam, nitrazepam, oxazepam, prazepam, quazepam, reclazepam, tracazolate, trepipam, temazepam, triazolam, uldazepam, and zolazepam; and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

25

(v) **anticonvulsants** including, for example, carbamazepine, valproate, lamotrigine, and gabapentin, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(vi) **Alzheimer's therapies** including, for example, donepezil, memantine, tacrine, and
30 equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(vii) **Parkinson's therapies** including, for example, deprenyl, L-dopa, Requip, Mirapex, MAOB inhibitors such as selegine and rasagiline, comP inhibitors such as Tasmar, A-2 inhibitors, dopamine reuptake inhibitors, NMDA antagonists, Nicotine agonists, and Dopamine agonists and inhibitors of neuronal nitric oxide synthase, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(viii) **migraine therapies** including, for example, almotriptan, amantadine, bromocriptine, butalbital, cabergoline, dichloralphenazone, eletriptan, frovatriptan, lisuride, naratriptan, pergolide, pramipexole, rizatriptan, ropinirole, sumatriptan, zolmitriptan, and zomitriptan, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(ix) **stroke therapies** including, for example, abciximab, activase, NXY-059, citicoline, crobenetine, desmoteplase, repinotan, traxoprodil, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(x) **urinary incontinence therapies** including, for example, darafenacin, falvoxate, oxybutynin, propiverine, robalzotan, solifenacin, and tolterodine, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(xi) **neuropathic pain therapies** including, for example, gabapentin, lidoderm, and pregablin, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(xii) **nociceptive pain therapies** such as, for example, celecoxib, etoricoxib, lumiracoxib, rofecoxib, valdecoxib, diclofenac, loxoprofen, naproxen, and paracetamol, and equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(xiii) **insomnia therapies** including, for example, allobarbital, alonimid, amobarbital, benzoctamine, butabarbital, capuride, chloral, cloperidone, clorethate, dexclamol, ethchlorvynol, etomidate, glutethimide, halazepam, hydroxyzine, mecloqualone, melatonin, mephobarbital, methaqualone, midaflur, nisobamate, pentobarbital, phenobarbital, propofol, roletamide, triclofos, secobarbital, zaleplon, and Zolpidem, and

equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(xiv) **mood stabilizers** including, for example, carbamazepine, divalproex, gabapentin, lamotrigine, lithium, olanzapine, quetiapine, valproate, valproic acid, and verapamil, and
5 equivalents and pharmaceutically active isomer(s) and/or metabolite(s) thereof;

(xv) 5HT1B ligands such as, for example, compounds disclosed in WO 99/05134 and
WO 02/08212;

10 (xvi) mGluR2 agonists;

(xvii) alpha 7 nicotinic agonists such as, for example, compounds disclosed in
WO 96/006098, WO 97/030998, WO 99/003859, WO 00/042044, WO 01/029034,
WO 01/60821, WO 01/36417, WO 02/096912, WO 03/087102, WO 03/087103,
15 WO 03/087104, WO 2004/016617, WO 2004/016616, and WO 2004/019947;

(xviii) chemokine receptor CCR1 inhibitors; and

(xix) delta opioid agonists such as, for example, compounds disclosed in WO 97/23466
20 and WO 02/094794.

Such combination products employ the compound of formula (I) or a pharmaceutically
acceptable salt thereof as previously defined within the dosage range described herein and
the other pharmaceutically active agent within approved dosage ranges and/or the dosage
25 such as described in the publication reference.

In a further aspect the present invention provides a combination (for example for the
treatment of schizophrenia, cognitive disorders or pain) of a compound of formula (I) or a
pharmaceutically acceptable salt thereof as hereinbefore defined and one or more agents
30 independently selected from carbamazepine, olanzapine, quetiapine, verapamil,
lamotrigine, oxcarbazepine, risperidone, aripiprazol, ziprasidone and lithium.

The invention also provides a pharmaceutical product comprising, in combination, a preparation of a first active ingredient which is a compound of formula (I) or a pharmaceutically acceptable salt thereof as hereinbefore defined, and a preparation of a second active ingredient which is carbamazepine, olanzapine, quetiapine, verapamil, lamotrigine, oxcarbazepine, risperidone, aripiprazol, ziprasidone or lithium,
5 for simultaneous, sequential or separate use in therapy.

In another aspect, the invention provides a kit comprising a preparation of a first active ingredient which is a compound of formula (I) or a pharmaceutically acceptable salt thereof as hereinbefore defined, and a preparation of a second active ingredient which is carbamazepine, olanzapine, quetiapine, verapamil, lamotrigine, oxcarbazepine, risperidone, aripiprazol, ziprasidone or lithium, and instructions for the simultaneous,
10 sequential or separate administration of the preparations to a patient in need thereof.

15 The present invention will now be further explained by reference to the following illustrative examples.

The methods used for synthesis of the compounds of the invention are illustrated by the general schemes below and the preparative examples that follow. The starting materials and reagents used in preparing these compounds are available from commercial suppliers.
20 These general schemes are merely illustrative of methods by which the compounds of this invention can be synthesised, and various modifications to these schemes can be made and will be suggested to one skilled in the art having referred to this disclosure.

25 Nuclear magnetic resonance (NMR) spectra were recorded at 400MHz; the chemical shifts (δ) are reported in parts per million. Spectra were recorded using a Bruker 400 Avance instrument fitted with a 5mm BBFO probe or DUL probe. Instrument control was by Bruker TopSpin 2.1 software, unless stated otherwise.

30 Purity was assessed using UPLC with UV (photodiode array) detection over a wide range of wavelengths, normally 220-450nm, using a Waters Acquity UPLC system equipped with Acquity UPLC BEH or HSS C18 columns (2.1mm id x 50mm long) operated at 50 or

60°C. Mobile phases typically consisted of acetonitrile or methanol mixed with water containing either 0.05% formic acid or 0.025% ammonia. Mass spectra were recorded with a Waters SQD single quadrupole mass spectrometer using atmospheric pressure ionisation, unless stated otherwise.

5

Compounds were purified using normal phase chromatography on silica or alumina, or by reverse phase chromatographic methods, using Biotage or Isolute KPNH Cartridge, SCX cartridge and SCX-2 solid phase extraction cartridges.

10 Preparative HPLC was performed using an Agilent Technologies 1100 Series system or a Waters autopurification LC/MS system typically using Waters 19mm id x 100mm long C18 columns such as XBridge or SunFire 5µm materials at room temperature. Mobile phases typically consisted of acetonitrile or methanol mixed with water containing either 0.1% formic acid or 0.1% ammonia, unless stated otherwise.

15

Room temperature in the following schemes means the temperature ranging from 20°C to 25°C.

The following abbreviations are used in the Examples:

20

n-BuLi n-Butyllithium

DCM Dichloromethane

DMSO Dimethyl sulfoxide

d₆-DMSO Deuterated dimethyl sulfoxide

25

EtOAc Ethyl acetate

H₂O Water

HCl Hydrochloric acid

HPLC High performance liquid chromatography

LCMS Liquid chromatography-mass spectrometry

30

MeOH Methanol

MS Mass spectrum

NaOH Sodium hydroxide

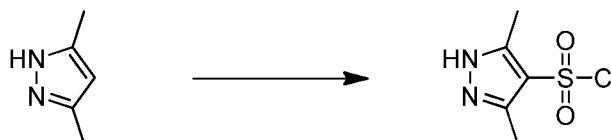
Na₂SO₄ Sodium sulphate

NMR Nuclear magnetic resonance

THF Tetrahydrofuran

5 1. Intermediates

Intermediate 1: 3,5-Dimethyl-1H-pyrazole-4-sulfonyl chloride

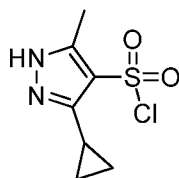


3,5-Dimethyl-1H-pyrazole (3.0g, 1.0eq) dissolved in chloroform (5 mL) was added drop-
10 wise to a solution of chlorosulfonic acid (19.95g, 5.5eq.) in chloroform(20 mL) under a
nitrogen atmosphere at 0°C with continuous stirring. The reaction was heated at 60°C for
15 hours under continuous stirring. The reaction was cooled to room temperature and
thionyl chloride (4.0g, 1.1 eq) was gradually added. The reaction was heated at 60°C for a
further 2 hours. The reaction was cooled to room temperature and added to a stirred
15 mixture of dichloromethane (50mL) and ice cold water (70 mL). The organic layer was
separated and the aqueous layer was extracted with dichloromethane (2 x 70 mL). The
combined organic layer was dried over sodium sulfate and evaporated under vacuum to
obtain the title compound, 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (2.0 g, 42%), as a
white solid.

20 ¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 2.40 (s, 6 H)

MS ES⁺: 195

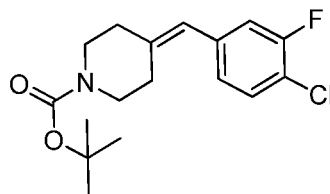
Intermediate 2 3-Cyclopropyl-5-methyl-1H-pyrazole-4-sulfonyl chloride



25 Hydrazine hydrate (7.93 g, 0.158 mol) was added to a solution of 1-cyclopropyl-1,3-
butanedione (10 g, 0.079 mol) in ethanol (100 mL) and the reaction was heated to reflux
for two hours then concentrated to afford 5-cyclopropyl-3-methyl-1H-pyrazole (9.59 g,

98% yield). This was reacted with chlorosulfonic acid as described in the preparation of 3,5-dimethyl-1*H*-pyrazole-4-sulfonyl chloride (Intermediate 1) to afford 5-cyclopropyl-3-methyl-1*H*-pyrazole-4-sulfonyl chloride.

5 **Intermediate 3:** *tert*-Butyl 4-(4-chloro-3-fluorobenzylidene)piperidine-1-carboxylate



A suspension of triphenylphosphine (2.347 g, 8.95 mmol) and 4-(bromomethyl)-1-chloro-2-fluorobenzene (2 g, 8.95 mmol) in ether (25 mL) was stirred at room temperature overnight. The suspension was concentrated to give (4-chloro-3-fluorobenzyl)-

10 triphenylphosphonium bromide (quantitative) as a white solid that was used crude.

Butyl lithium (1.6 M in hexanes) (6.03 mL, 9.65 mmol) was added slowly to a suspension of (4-chloro-3-fluorobenzyl)triphenylphosphonium bromide (4.26 g, 8.77 mmol) in THF (40 mL) under inert atmosphere at 0 °C. The resulting suspension was stirred at 0 °C for

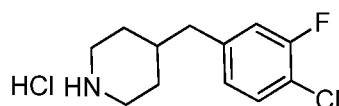
15 15 minutes, then warmed to room temperature for two hours. *tert*-Butyl 4-oxopiperidine-1-carboxylate (1.922 g, 9.65 mmol) as a solution in THF (5 mL) was added and the suspension was stirred at room temperature overnight. Petroleum ether was added, the precipitate (O=PPh₃) was filtered and the filtrate concentrated. The crude product was purified by silica chromatography eluted with 0-100% DCM / petroleum ether to give *tert*-

20 butyl 4-(4-chloro-3-fluorobenzylidene)piperidine-1-carboxylate (2.03 g, 6.23 mmol, 71% yield) as a colourless oil that solidified on standing.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 1.42 (s, 9H) 2.28-2.30 (m, 2H) 2.39-2.40 (m, 2H) 3.27-3.34 (m, 2H) 3.36-3.47 (m, 2H) 6.35 (s, 1H) 7.06-7.13 (m, 1H) 7.25-7.28 (m, 1H) 7.51-7.55 (m, 1H)

25

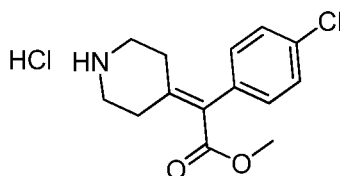
Intermediate 4: 4-(4-Chloro-3-fluorobenzyl)piperidine hydrochloride



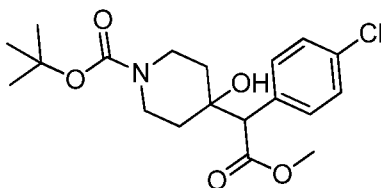
A flask charged with *tert*-butyl 4-(4-chloro-3-fluorobenzylidene)piperidine-1-carboxylate (2.03 g, 6.23 mmol, Intermediate 3) and platinum(IV)oxide (0.141 g, 0.623 mmol) was evacuated and flushed with argon three times. The flask was evacuated again and ethanol (20 mL) and ethyl acetate (20 mL) were added, then the suspension stirred under an atmosphere of hydrogen for two hours. The suspension was filtered through diatomaceous earth and the filtrate concentrated to give *tert*-butyl 4-(4-chloro-3-fluorobenzyl)piperidine-1-carboxylate (2.01 g, 6.13 mmol, 98 % yield) as a yellow oil that was used without further purification. Hydrogen chloride (4M in dioxane) (3.05 mL, 12.20 mmol) was added to a solution of *tert*-butyl 4-(4-chloro-3-fluorobenzyl)piperidine-1-carboxylate (2 g, 6.10 mmol) in methanol (20 mL) and stirred overnight. The solution was concentrated and azeotroped with toluene to give 4-(4-chloro-3-fluorobenzyl)piperidine hydrochloride (1.56 g, 5.91 mmol, 97% yield) as a white solid.

$^1\text{H NMR}$ (400 MHz, $\text{DMSO-}d_6$) δ ppm 1.28 - 1.44 (m, 2 H) 1.60 - 1.73 (m, 2 H) 1.74 - 1.88 (m, 1 H) 2.54 - 2.60 (m, 2 H) 2.69 - 2.86 (m, 2 H) 3.15 - 3.25 (m, 2 H) 7.05 - 7.12 (m, 1 H) 7.24 - 7.32 (m, 1 H) 7.46 - 7.54 (m, 1 H) 8.80 (br. s., 1 H) 9.06 (br. s., 1 H)

Intermediate 5: Methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride



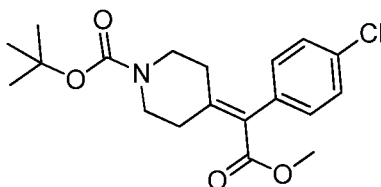
Step (i): *tert*-Butyl 4-(1-(4-chlorophenyl)-2-methoxy-2-oxoethyl)-4-hydroxypiperidine-1-carboxylate



A flask was charged with nitrogen and methyl 2-(4-chlorophenyl)acetate (2g, 13.19 mmol) in tetrahydrofuran to give a colourless solution cooled to $-78\text{ }^{\circ}\text{C}$. *n*-Butyl lithium was added dropwise over 20 mins via a syringe pump and stirred for 30 minutes. *tert*-Butyl 4-oxopiperidine-1-carboxylate (2.63 g, 13.19 mmol) in THF was added dropwise via a

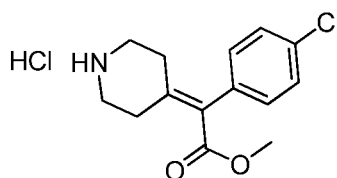
syringe pump over 20 mins and stirred for a further 2.5 hours. While still cold the reaction was quenched with NH_4Cl and allowed to warm to room temperature overnight. The organic phase was separated, dried and evaporated to leave an oil. The crude product was purified by column chromatography on silica, eluted with EtOAc/petroleum ether 0-30% to afford the product as an oil (2.77g, 60%).

Step (ii) : *tert*-Butyl 4-(1-(4-chlorophenyl)-2-methoxy-2-oxoethylidene)piperidine-1-carboxylate



A flask was charged with *tert*-butyl 4-(1-(4-chlorophenyl)-2-methoxy-2-oxoethyl)-4-hydroxypiperidine-1-carboxylate (from step (i), 1.29g, 3.68 mmol) in pyridine (2 mL) to give a colourless solution. Thionyl chloride (1.334 mL, 18.38 mmol) was added and the reaction stirred for 10 mins, then evaporated to dryness. The crude product was purified by column chromatography on silica, eluted with 10-50% Hexane/EtOAc to afford the product (0.78g, 58%).

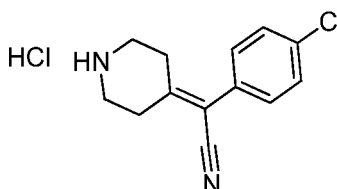
Step (iii): Methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride



tert-Butyl 4-(1-(4-chlorophenyl)-2-methoxy-2-oxoethylidene)piperidine-1-carboxylate (from step (ii), 0.78g, 2.14 mmol) was treated with 4N HCl in dioxane and stirred for one hour then evaporated to leave a white solid, (0.21g, 33%).

MS: ES+266

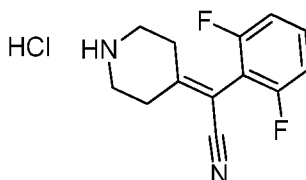
Intermediate 6: 2-(4-Chlorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride



Prepared in a similar manner to methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5) using 2-(4-chlorophenyl) acetonitrile.

MS: ES+233

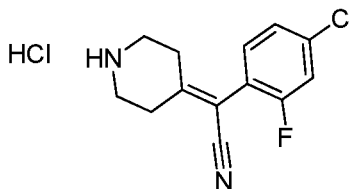
5 **Intermediate 7:** **2-(2,6-Difluorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride**



Prepared in a similar manner to methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5) using 2-(2,6-difluorophenyl) acetonitrile.

10 MS: ES+235

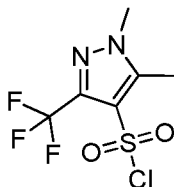
Intermediate 8: **2-(4-Chloro-2-fluorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride**



15 Prepared in a similar manner to methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5) using 2-(2-fluoro-4-chlorophenyl) acetonitrile.

MS: ES+251

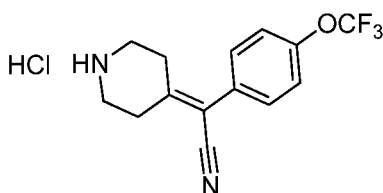
20 **Intermediate 9:** **1,5-Dimethyl-3-(trifluoromethyl)-1H-pyrazole-4-sulfonyl chloride**



Prepared in a similar manner to 3-cyclopropyl-5-methyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 2) from 1,1,1-trifluoropentane-2,4-dione and methylhydrazine.

^1H NMR (400 MHz, CDCl_3) δ ppm 2.63 (s, 3H), 3.91 (s, 3H)

Intermediate 10: 2-(Piperidin-4-ylidene)-2-(4-(trifluoromethoxy)phenyl)acetonitrile hydrochloride

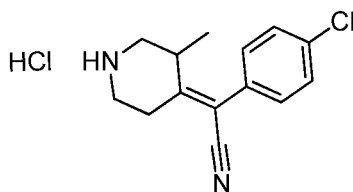


5

Prepared in a similar manner to methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5) using 2-(4-(trifluoromethoxy)phenyl)acetonitrile.

MS: ES+283

10 **Intermediate 11:** 2-(4-Chlorophenyl)-2-(3-methylpiperidin-4-ylidene)acetonitrile hydrochloride

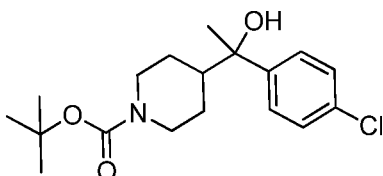


15

Prepared in a similar manner to methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5) using 2-(4-chlorophenyl) acetonitrile and *tert*-butyl 3-methyl-4-oxopiperidine-1-carboxylate.

MS: ES+247

Intermediate 12: *tert*-Butyl 4-(1-(4-chlorophenyl)-1-hydroxyethyl)piperidine-1-carboxylate



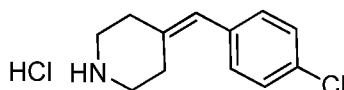
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Di-*tert*-butyl dicarbonate (0.923 g, 4.23 mmol) was added to a solution of (4-chlorophenyl)(piperidin-4-yl)methanone hydrochloride (1 g, 3.84 mmol) and triethylamine (1.179 mL, 8.46 mmol) in methanol (20 mL) under nitrogen. The reaction was stirred at

room temperature overnight. The suspension was concentrated *in vacuo*. The residue was taken up in ethyl acetate and water and the phases separated. The organic was washed with brine, dried (phase separator) and concentrated to give *tert*-butyl 4-(4-chlorobenzoyl)piperidine-1-carboxylate (1.22 g, 3.77 mmol, 98% yield) as a white solid.
5 ¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 1.33 - 1.46 (m, 11 H) 1.72 - 1.81 (m, 2 H) 2.83 - 3.00 (m, 2 H) 3.62 (s, 1 H) 3.92 - 4.02 (m, 2 H) 7.58 - 7.65 (m, 2 H) 7.98 - 8.04 (m, 2 H).

Methylmagnesium bromide (3M in ether) (3.09 mL, 9.26 mmol) was added slowly to a solution of *tert*-butyl 4-(4-chlorobenzoyl)piperidine-1-carboxylate (0.5 g, 1.544 mmol) in THF (10 mL) at 0 °C under nitrogen. The reaction was stirred at room temperature for 2 hours. The reaction was quenched with 2M HCl and partitioned between ethyl acetate and 2M HCl. The phases were separated and the aqueous phase was extracted with ethyl acetate. The combined organics were washed with saturated brine, dried (phase separator) and concentrated *in vacuo* to afford *tert*-butyl 4-(1-(4-chlorophenyl)-1-hydroxyethyl)piperidine-1-carboxylate (0.481 g, 1.415 mmol, 92 % yield) as a colourless oil. MS: ES- 338.
15

Intermediate 13: 4-(4-Chlorobenzylidene)piperidine hydrochloride

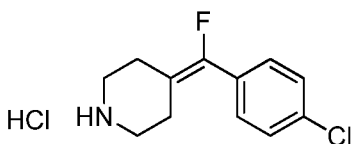


(4-Chlorobenzyl)triphenylphosphonium bromide (prepared in an analogous manner to (4-chloro-3-fluorobenzyl)triphenylphosphonium bromide described in the synthesis of Intermediate 3) (20 g, 42.8 mmol) was added to THF (200 mL) and *n*-BuLi (6.03 g, 94 mmol) added at 0 °C. The reaction was stirred at room temperature for two hours. *tert*-Butyl 4-oxopiperidine-1-carboxylate (8.52 g, 42.8 mmol) was added and the reaction was stirred at room temperature overnight. The reaction mixture was poured onto saturated aqueous ammonium chloride solution and extracted with ethyl acetate. The combined organic layers were dried (Na₂SO₄), filtered and concentrated under reduced pressure. The crude product was purified by column chromatography on silica, eluted with 0-10% ethyl acetate/petroleum ether to afford *tert*-butyl 4-(4-chlorobenzylidene)piperidine-1-carboxylate (7 g, 53%). Hydrogen chloride (4M in dioxane) (0.609 mL, 2.437 mmol) was added to a solution of *tert*-butyl 4-(4-chlorobenzylidene)piperidine-1-carboxylate (0.25 g,
30

0.812 mmol) in methanol (5 mL). The reaction was stirred at room temperature overnight. A further portion of hydrogen chloride (4M in dioxane) (0.609 mL, 2.437 mmol) was added and the solution stirred for three hours. The solution was concentrated and azeotroped with toluene to give 4-(4-chlorobenzylidene)piperidine hydrochloride (0.196 g, 0.803 mmol, 99 % yield) as a white solid.

MS: ES+ 208

Intermediate 14: 4-((4-Chlorophenyl)fluoromethylene)piperidine hydrochloride



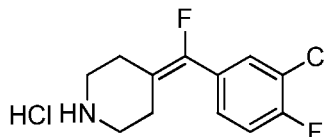
Diethyl ((4-chlorophenyl)fluoromethyl)phosphonate (prepared as described by Azizi *et.al.* Phosphorus, Sulfur and Silicon and the Related Elements, 178(6), 1255-1259; 2003 followed by Blackburn *et.al.* Journal of the Chemical Society, Perkin Transactions 1: Organic and Bio-Organic Chemistry (1972-1999), (6), 913-17; 1986) (0.61 g, 2.173 mmol) and *tert*-butyl 4-oxopiperidine-1-carboxylate (0.433 g, 2.173 mmol) in THF (20 mL) at 0 °C was treated with sodium hydride (60% in mineral oil, 0.229 g, 4.78 mmol). The reaction mixture was allowed to reach room temperature and stirred for 18 hours, then quenched with water and evaporated. To the reaction mixture was added DCM/H₂O and the organic layer dried (phase separator) and concentrated *in vacuo* to yield an oil. The crude product was purified by column chromatography on silica, eluted with EtOAc/petroleum ether 0-50% to afford *tert*-butyl 4-((4-chlorophenyl)fluoromethylene)piperidine-1-carboxylate (0.41g, 58%).

¹H NMR (400 MHz, CD₂Cl₂) δ ppm 1.48 (s, 9H) 2.30-2.36 (m, 2 H) 2.48-2.54 (m, 2H) 3.42-3.48 (m, 2H) 3.51-3.55 (m, 2H) 7.38-7.45 (m, 4H)

tert-Butyl 4-((4-chlorophenyl)fluoromethylene)piperidine-1-carboxylate (0.39g, 1.19 mmol) was treated with 4N HCl in dioxane and stirred for one hour then evaporated to leave a white solid (quantitative) that was used without purification.

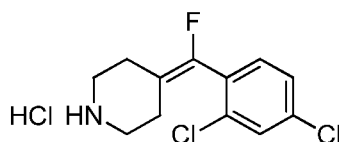
MS: ES+226

Intermediate 15: 4-((3-Chloro-4-fluorophenyl)fluoromethylene)piperidine
hydrochloride



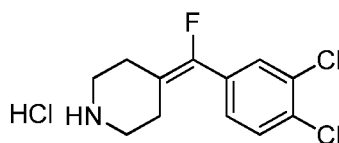
Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine
5 hydrochloride (Intermediate 14).

Intermediate 16: 4-((2,4-Dichlorophenyl)fluoromethylene)piperidine
hydrochloride



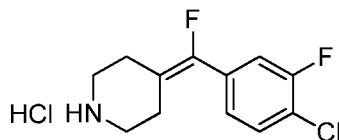
10 Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine
hydrochloride (Intermediate 14).

Intermediate 17: 4-((3,4-Dichlorophenyl)fluoromethylene)piperidine
hydrochloride



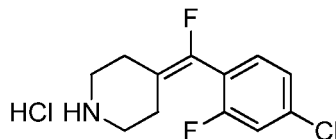
15 Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine
hydrochloride (Intermediate 14).

Intermediate 18: 4-((4-Chloro-3-fluorophenyl)fluoromethylene)piperidine
20 hydrochloride



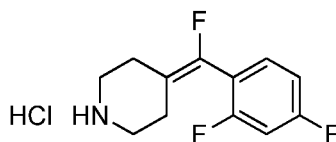
Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine
hydrochloride (Intermediate 14).

Intermediate 19: 4-((4-Chloro-2-fluorophenyl)fluoromethylene)piperidine hydrochloride



Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 14).

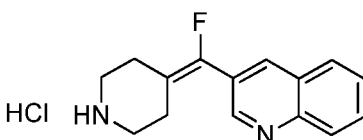
Intermediate 20: 4-((2,4-Difluorophenyl)fluoromethylene)piperidine hydrochloride



10

Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 14).

Intermediate 21: 3-(Fluoro(piperidin-4-ylidene)methyl)quinoline hydrochloride



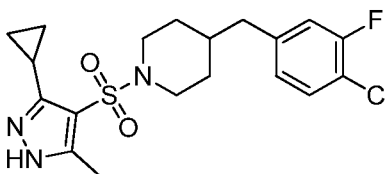
15

Prepared in a similar manner to 4-((4-chlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 14).

2. Examples

20

Example 1 4-(4-Chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1H-pyrazol-4-yl)sulfonyl)piperidine

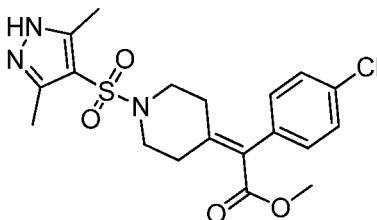


The title compound was prepared from 5-cyclopropyl-3-methyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 2, 150mg, 0.68mmol) and 4-(4-chloro-3-fluorobenzyl)piperidine hydrochloride (Intermediate 4, 176mg, 0.68mmol). The reaction was stirred at room temperature for two hours. To the reaction mixture was added DCM/H₂O and the organic layer dried (phase separator) and concentrated *in vacuo* to yield an oil. The crude product was purified by column chromatography on silica, eluted with EtOAc/petroleum ether 0-100% to afford the title compound, 0.14g, 50% yield.

¹H NMR (400 MHz, ACETONITRILE-*d*₃) δ ppm 0.58 - 0.77 (m, 3 H) 0.97 - 1.12 (m, 2 H) 1.27 - 1.40 (m, 1 H) 1.41 - 1.49 (m, 2 H) 1.71 - 1.76 (m, 3 H) 2.06 - 2.15 (m, 4 H) 2.28 - 2.36 (m, 2 H) 3.43 - 3.51 (m, 2 H) 6.72 - 6.78 (m, 1 H) 6.81 - 6.87 (m, 1 H) 7.12 - 7.18 (m, 1 H) 10.89 - 11.03 (m, 1 H)

MS: ES+ 412

Example 2 Methyl 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate



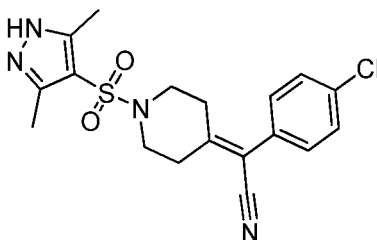
A flask was charged with nitrogen and methyl 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetate hydrochloride (Intermediate 5, 210 mg, 0.790 mmol) in DCM (10 mL) to give a colourless solution. 3,5-Dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1; 114 mg, 0.586 mmol) and triethylamine (0.330 mL , 2.371 mmol) were added. The reaction was stirred at room temperature for two hours. To the reaction mixture was added DCM/H₂O and the organic layer dried (phase separator) and concentrated *in vacuo* to yield an oil. The crude product was purified by column chromatography on silica, eluted with EtOAc/petroleum ether 0-100%, EtOAc/ MeOH 0-20% to afford the title compound.

¹H NMR (400 MHz, DMSO- *d*₆) δ ppm 2.25-2.28 (m, 2 H) 2.34 (s, 6 H) 2.75 - 2.78 (m, 2 H) 2.96-2.96 (m, 2 H) 3.01-3.03 (s, 2 H) 3.60 (s, 3 H) 7.16 - 7.29 (m, 2 H) 7.38 - 7.41 (m, 2 H)

MS: ES+ 424

Example 3 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile

5



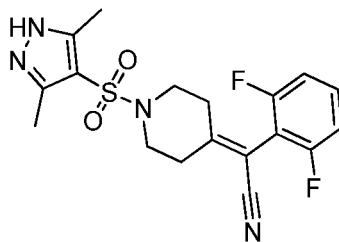
Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.32g, 1.67mmol) and 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 6, 0.39g, 1.67mmol) to give the title compound (0.49g, 76%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25-2.38 (m, 8 H) 2.75 - 2.78 (m, 2 H) 3.01-3.03 (s, 2 H) 3.18-3.20 (m, 2H) 7.32 - 7.36 (m, 2 H) 7.52 - 7.56 (m, 2 H) 13.0 (s, 1H)

MS: ES+ 391

15

Example 4 2-(2,6-Difluorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile



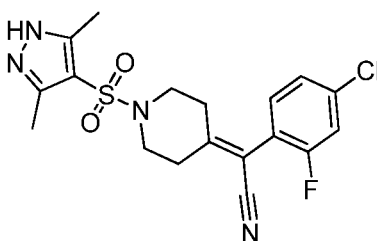
Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.12g, 0.58mmol) and 2-(2,6-difluorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 7, 0.21g, 0.89mmol) to give the title compound (0.23g, 67%).

20

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25-2.38 (m, 8 H) 2.82-2.90 (m, 2 H) 2.93-3.03 (m, 2 H) 3.18-3.20 (m, 2H) 7.25-7.33 (m, 2 H) 7.58-7.63 (m, 1 H) 13.0 (s, 1H)

MS: ES+ 393

5 **Example 5** 2-(4-Chloro-2-fluorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile



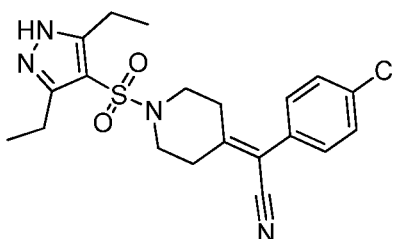
Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.3g, 1.54mmol) and 2-(4-chloro-2-fluorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 8, 0.44g, 1.54mmol) to give the title compound (0.54g, 86%).

15 ^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25-2.38 (m, 8 H) 2.80 - 2.88 (m, 2 H) 2.96-3.03 (m, 2 H) 3.18-3.20 (m, 2H) 7.41 - 7.48 (m, 2 H) 7.60 - 7.63 (m, 1 H) 13.0 (s, 1 H)

MS: ES+ 409

Example 6 2-(4-Chlorophenyl)-2-(1-((3,5-diethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile

20



A solution of 3,5-heptanedione (12.5 g, 97.5 mmol) in ethanol (50 mL) was treated dropwise with hydrazine hydrate (60%, 5.72 g, 107 mmol) whilst cooling in an ice bath. The reaction was stirred for 1.5 hours at room temperature. The reaction was concentrated

under reduced pressure. The reaction mixture was partitioned between DCM and brine, the aqueous layer was extracted with DCM. The combined organic layers were dried (Na_2SO_4), filtered and concentrated under reduced pressure to afford 3,5-diethyl-1H-pyrazole that was used crude. 3,5-diethyl-1H-pyrazole (6.0 g, 0.048 mol) was added dropwise to chlorosulfonic acid (30.9g, 17.7mL, 0.265 mol) at 0 °C with stirring. The reaction was heated to 80 °C for 30 minutes. The reaction was cooled and thionyl chloride (6.32 g, 3.8 mL, 53.1 mol) was added dropwise. The reaction was heated to 65°C for 4 hours. The reaction mixture was cooled to room temperature and carefully poured onto ice (100g) with stirring. The resultant solid was filtered and dried under vacuum to afford 3,5-diethyl-1H-pyrazole-4-sulfonyl chloride as a brown solid (9.15 g, 85% yield).

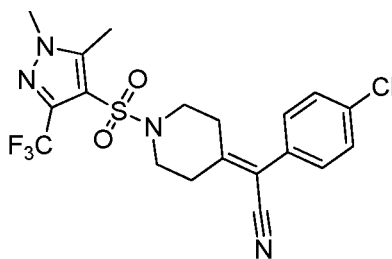
The title compound was prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-diethyl-1H-pyrazole-4-sulfonyl chloride (0.11 g, 0.47mmol) and 2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 6, 0.11g, 0.47mmol) in the following yield: 0.072g (38%).

^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ ppm 1.15-1.21 (m, 6 H) 2.40-2.50 (m, 2 H) 2.71-2.78 (m, 2 H) 2.78-2.82 (m, 4 H) 2.98-3.03 (m, 2 H) 3.18-3.22 (m, 2 H) 7.34-7.40 (m, 2 H) 7.50-7.62 (m, 2 H) 13.0 (s, 1 H)

MS: ES+ 419

20

Example 7 2-(4-Chlorophenyl)-2-(1-((1,5-dimethyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile



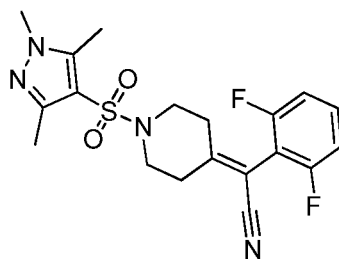
25 Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 1,5-dimethyl-3-(trifluoromethyl)-1H-pyrazole-4-sulfonyl chloride (Intermediate 9, 0.11g, 0.47mmol) and

2-(4-chlorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 6, 0.12g, 0.47mmol) to give the title compound (0.11g, 50%).

$^1\text{H NMR}$ (400 MHz, DMSO- d_6) δ ppm 2.42-2.50 (m, 5H) 2.75-2.80 (m, 2H) 3.12-3.18 (m, 2H) 3.30-3.40 (m, 2 H) 3.85 (s, 3H) 7.42-7.48 (m, 2 H) 7.52-7.60 (m, 2H)

5 MS: ES+ 459

Example 8 2-(2,6-Difluorophenyl)-2-(1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile

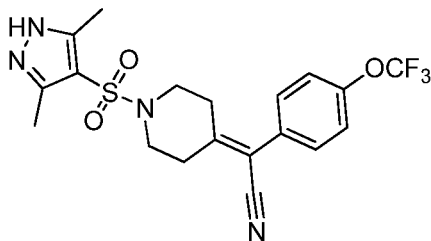


10 Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 1,3,5-trimethyl-1H-pyrazole-4-sulfonyl chloride (0.14g, 0.58mmol) and 2-(2,6-difluorophenyl)-2-(piperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 7, 0.11g, 0.89 mmol) to give the title compound (0.05 g, 26%).

15 $^1\text{H NMR}$ (400 MHz, DMSO- d_6) δ ppm 2.20 (s, 3H) 2.20-2.34 (m, 2H) 2.40 (s, 3H) 2.82-2.90 (m, 2H) 2.98-3.00 (m, 2H) 3.18-3.24 (m, 2 H) 3.70 (s, 3H) 7.24-7.30 (m, 2 H) 7.58-7.63 (m, 1H)

MS: ES+ 407

20 **Example 9** 2-(1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)-2-(4-(trifluoromethoxy)phenyl)acetonitrile

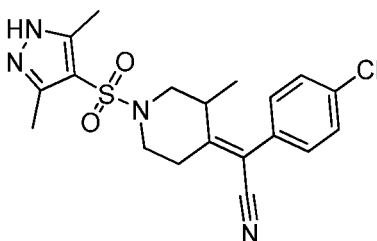


Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.12g, 0.62mmol) and 2-(piperidin-4-ylidene)-2-(4-(trifluoromethoxy)phenyl)acetonitrile hydrochloride (Intermediate 10, 0.2g, 0.62 mmol) to give the title compound (0.14g, 50%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25-2.32 (m, 6H) 2.45-2.30 (m, 2H) 2.80-2.85 (m, 2H) 2.98-3.05 (m, 2H) 3.18-3.22 (m, 2 H) 7.42-7.52 (m, 4H) 13.0 (s, 1H)

MS: ES+ 441

Example 10 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)-3-methylpiperidin-4-ylidene)acetonitrile

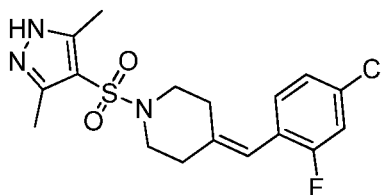


Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.085g, 0.43mmol) and 2-(4-chlorophenyl)-2-(3-methylpiperidin-4-ylidene)acetonitrile hydrochloride (Intermediate 11, 0.12g, 0.43mmol) to give the title compound (0.055g, 31%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 1.20 (m, 3H) 2.20-2.25 (m, 2H) 2.42-2.60 (m, 3H) 2.60 (s, 6H) 3.18-3.22 (m, 2 H) 7.25-7.60 (m, 4H) 13 (s, 1H)

MS: ES+ 405

Example 11 4-(4-Chloro-2-fluorobenzylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



tert-Butyl 4-(4-chloro-2-fluorobenzylidene)piperidine-1-carboxylate was prepared as described for *tert*-butyl 4-(4-chloro-3-fluorobenzylidene)piperidine-1-carboxylate

(Intermediate 3) from 4-(bromomethyl)-1-chloro-3-fluorobenzene. Hydrogen chloride

(4M in dioxane) (0.384 mL, 1.535 mmol) was added to a suspension of *tert*-butyl 4-(4-chloro-2-fluorobenzylidene)piperidine-1-carboxylate (0.25 g, 0.767 mmol) in methanol (5 mL). The reaction was stirred at room temperature overnight. The solution was concentrated *in vacuo* and azeotroped with toluene to give 4-(4-chloro-2-

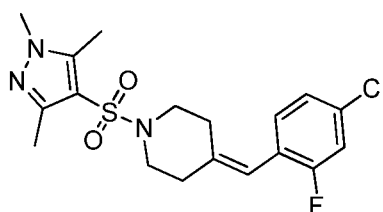
fluorobenzylidene)piperidine hydrochloride (0.2 g, 0.763 mmol, 99 % yield) as a white

solid. The title compound was prepared as described for 4-(4-chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine (Example 1) from 3,5-dimethyl-1*H*-pyrazole-4-sulfonyl chloride (Intermediate 1) and 4-(4-chloro-2-fluorobenzylidene)piperidine hydrochloride.

¹H NMR (400 MHz, DMSO-*d*₆) δ ppm 2.25 - 2.39 (m, 8 H) 2.41 - 2.47 (m, 2 H) 2.89 - 2.99 (m, 2 H) 3.00 - 3.09 (m, 2 H) 6.22 (s, 1 H) 7.19 - 7.32 (m, 2 H) 7.37 - 7.45 (m, 1 H) 13.05 (br. s., 1 H)

MS : ES+ 384

Example 12 4-(4-Chloro-2-fluorobenzylidene)-1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine



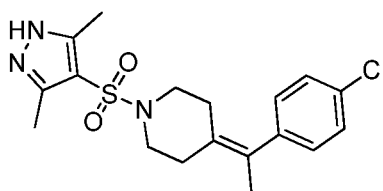
Prepared as described for 4-(4-chloro-2-fluorobenzylidene)-1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine (Example 11) using 1,3,5-trimethyl-1*H*-pyrazole-4-sulfonyl chloride.

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.24 (s, 3 H) 2.33 - 2.41 (m, 5 H) 2.42 - 2.48 (m, 2 H) 2.90 - 2.96 (m, 2 H) 3.00 - 3.07 (m, 2 H) 3.70 (s, 3 H) 6.22 (s, 1 H) 7.23 - 7.32 (m, 2 H) 7.38 - 7.44 (m, 1 H)

MS: ES+ 398

5

Example 13 4-(1-(4-Chlorophenyl)ethylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



p-Toluenesulfonic acid monohydrate (0.963 g, 5.06 mmol) was added to a solution of *tert*-butyl 4-(1-(4-chlorophenyl)-1-hydroxyethyl)piperidine-1-carboxylate (Intermediate 12, 0.43 g, 1.265 mmol) in toluene (15 ml) under nitrogen. Magnesium sulfate was added and the reaction was heated to reflux for 5 hours then cooled overnight. The reaction was quenched with 2M NaOH and the mixture was partitioned between ethyl acetate and water. The phases were separated and the aqueous extracted with ethyl acetate (2 x 200 ml). The combined organics were washed with saturated brine (2 x 100 ml), dried (phase separator) and concentrated in vacuo to afford 4-(1-(4-chlorophenyl)ethylidene)piperidine 4-methylbenzenesulfonate, which was taken on without further purification.

MS: ES+ 222

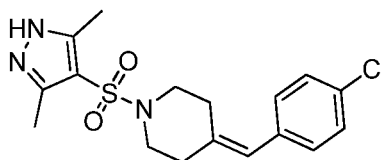
Triethylamine (0.386 ml, 2.77 mmol) was added to a suspension of 4-(1-(4-chlorophenyl)ethylidene)piperidine 4-methylbenzenesulfonate (0.364 g, 0.924 mmol) and 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 0.216 g, 1.109 mmol) in DCM (10 ml). The reaction was stirred at room temperature for 4 hours. The mixture was diluted with DCM, washed with water (1 x 25 ml), dried (phase separator) and concentrated *in vacuo*. The crude product was purified by column chromatography on silica, eluted with 0-100% ethyl acetate/petroleum ether. LCMS/NMR shows mixture of products. The crude product was purified by reverse phase preparative HPLC eluted with acetonitrile / water (with 0.1% ammonia) to afford 4-(1-(4-chlorophenyl)ethylidene)-1-

((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine (0.057 g, 0.150 mmol, 16.24 % yield) as a white solid.

¹H NMR (400 MHz, DMSO- *d*₆) δ ppm 1.90 (s, 3 H) 2.07 - 2.17 (m, 2 H) 2.30 (br. s., 6 H) 2.42 - 2.48 (m, 2 H) 2.78 - 2.87 (m, 2 H) 2.97 - 3.03 (m, 2 H) 7.07 - 7.17 (m, 2 H) 7.32 - 7.40 (m, 2 H) 13.04 (br. s., 1 H)

MS: ES+ 380

Example 14 4-(4-Chlorobenzylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine

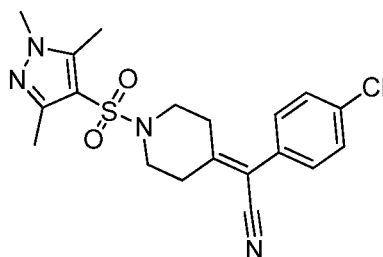


Prepared as described for 4-(4-chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1H-pyrazol-4-yl)sulfonyl)piperidine (Example 1) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1) and 4-(4-Chlorobenzylidene)piperidine hydrochloride (Intermediate 13).

¹H NMR (400 MHz, DMSO- *d*₆) δ ppm 2.30 (br. s., 6 H) 2.36 - 2.43 (m, 2 H) 2.45 - 2.48 (m, 2 H) 2.90 - 2.97 (m, 2 H) 3.00 - 3.06 (m, 2 H) 6.32 (s, 1 H) 7.17 - 7.23 (m, 2 H) 7.33 - 7.40 (m, 2 H) 13.03 (br. s., 1 H)

MS: ES- 364

Example 15 2-(4-Chlorophenyl)-2-(1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile

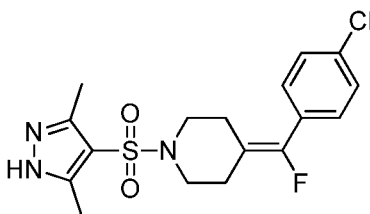


Prepared as described for 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile (Example 3) using 1,3,5-trimethyl-1H-pyrazole-4-sulfonyl chloride.

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.08-2.20 (m, 4H) 2.48-2.50 (m, 4 H) 2.78 (s, 3H)
3.70 (s, 3 H) 7.32-7.38 (m, 2 H) 7.48-7.52 (m, 2 H)

MS: ES+ 405

5 **Example 16** 4-((4-Chlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine

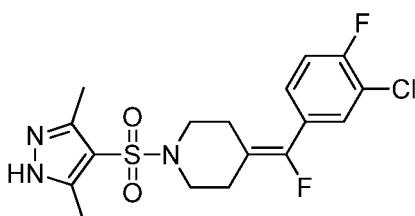


Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 232 mg, 1.194 mmol) and 4-((4-chlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 14, 313 mg, 1.194 mmol) to afford the title compound (0.31g, 67%).

10 ^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25 - 2.42 (m, 10 H) 2.96 - 3.08 (m, 4 H) 7.40 - 7.46 (m, 2 H) 7.48 - 7.52 (m, 2 H) 13.0 (s, 1 H)

15 MS: ES+ 384

Example 17 4-((3-Chloro-4-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



20

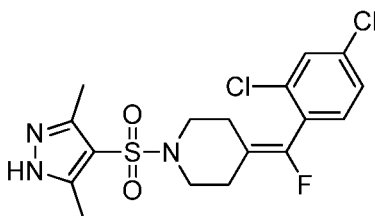
Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 217 mg, 1.11 mmol) and 4-((3-chloro-4-fluorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 15, 312 mg, 1.11 mmol) to afford the title compound (0.19g, 42%).

25

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.20 - 2.35 (m, 10 H) 2.86 - 3.10 (m, 4 H) 7.40 - 7.50 (m, 2 H) 7.64 - 7.70 (m, 1 H) 13.0 (s, 1 H)

MS: ES+ 402

5 **Example 18** 4-((2,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine

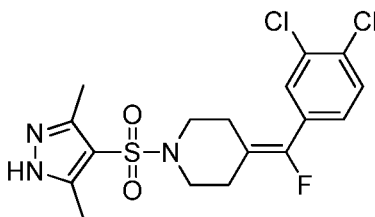


Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 260 mg, 1.33 mmol) and 4-((2,4-dichlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 16, 480 mg, 1.33 mmol) to afford the title compound (0.26g, 48%).

15 ^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.00 - 2.15 (m, 2 H) 2.20- 2.40 (br s, 6H) 2.50- 2.55 (m, 2H) 2.85-2.96 (m, 2H) 3.08 - 3.12 (m, 2 H) 7.40 - 7.44 (m, 2 H) 7.55 (s, 1 H) 13.0 (s, 1 H)

MS: ES+ 418

20 **Example 19** 4-((3,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 385 mg, 1.97 mmol) and 4-((3,4-

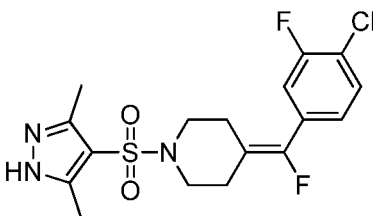
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dichlorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 17; 712 mg, 1.97 mmol) to afford the title compound (0.57g, 69%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.20 - 2.40 (m, 10 H) 2.90 - 3.10 (m, 4 H) 7.39 - 7.45 (m, 1 H) 7.70 - 7.80 (m, 2 H) 13.0 (s, 1 H)

5 MS: ES+ 418

Example 20 4-((4-Chloro-3-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



10

Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 178 mg, 0.91 mmol) and 4-((4-chloro-3-fluorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 18, 256 mg, 0.91

15

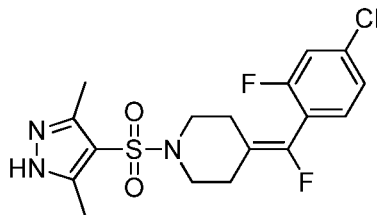
mmol) to afford the title compound (0.23g, 61%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.20 - 2.50 (m, 10 H) 2.95 - 3.12 (m, 4 H) 7.25 - 7.31 (m, 1 H) 7.42 - 7.48 (m, 1 H) 7.58 - 7.67 (m, 1H) 13.0 (s, 1 H)

MS: ES+ 402

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Example 21 4-((4-Chloro-2-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine



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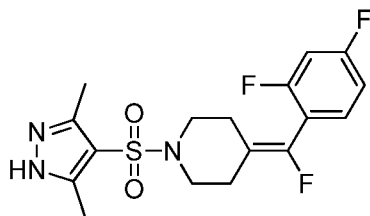
Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-

sulfonyl chloride (Intermediate 1, 25 mg, 0.13 mmol) and 4-((4-chloro-2-fluorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 19, 45 mg, 0.13 mmol) to afford the title compound (0.036g, 68%).

¹H NMR (400 MHz, DMSO- *d*₆) δ ppm 2.14 - 2.18 (m, 2 H) 2.26 (s, 3H) 2.36 (s, 3H) 2.48-
 5 2.53 (m, 2H) 2.96 - 3.08 (m, 2 H) 3.10 - 3.16 (m, 2H) 7.36 - 7.41 (m, 1 H) 7.47 - 7.52 (m,
 1 H) 7.58 – 7.67 (m, 1H) 13.0 (s, 1 H)

MS: ES+ 402

Example 22 4-((2,4-Difluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-
 10 4-yl)sulfonyl)piperidine

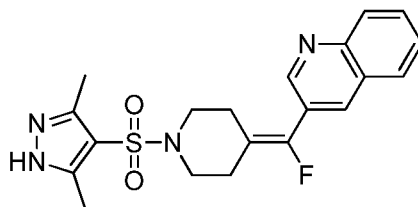


Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-
 15 sulfonyl chloride (Intermediate 1, 892 mg, 4.58 mmol) and 4-((2,4-difluorophenyl)fluoromethylene)piperidine hydrochloride (Intermediate 20, 1039 mg, 4.58 mmol) to afford the title compound (1.2g, 68%).

¹H NMR (400 MHz, DMSO- *d*₆) δ ppm 2.16 - 2.22 (m, 2 H) 2.34-2.45 (m, 6H) 2.55 – 2.60
 (m, 2H) 2.91 - 3.08 (m, 2 H) 3.10 – 3.22 (m, 2H) 7.14 - 7.22 (m, 1 H) 7.31 - 7.38 (m, 1 H)
 20 7.38 – 7.55n (m, 1H) 13.0 (s, 1 H)

MS: ES+ 400

Example 23 3-((1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)fluoromethyl)quinoline



Prepared as described for methyl 2-(4-chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate (Example 2) from 3,5-dimethyl-1H-pyrazole-4-sulfonyl chloride (Intermediate 1, 117 mg, 0.59 mmol) and 3-(fluoro(piperidin-4-ylidene)methyl)quinoline hydrochloride (Intermediate 21, 167 mg, 0.59 mmol) to afford the title compound (0.045g, 18%).

^1H NMR (400 MHz, DMSO- d_6) δ ppm 2.25 - 2.41 (m, 6 H) 2.45 - 3.50 (m, 2 H) 2.62 - 2.65 (m, 2H) 2.99 - 3.05 (m, 2H) 3.08 - 3.12 (m, 2H) 7.67 - 7.71 (m, 1 H) 7.80 - 7.90 (m, 1 H) 8.05 - 8.10 (m, 2H) 8.45 (s, 1H) 8.90 (s, 1H) 13.0 (s, 1 H)

MS: ES+ 401

3. Biological Assay

Prokineticin receptor 1 (PKR1) antagonists may be functionally assessed by measurement of change in intracellular calcium levels induced by Gq mediated increase in inositol triphosphate (IP3) levels. The ability of a compound to block the intracellular release of calcium mediated by PK1 in RBL2H3 cells expressing human PKR1 receptors is determined as a measure of the compound's antagonist activity in vitro.

Approximately 10,000 cells per assay well are seeded in normal culture medium in a 384 well plate (Corning). Twenty-four hours after seeding, the cells are loaded with a calcium sensitive fluorescent dye by replacing the culture medium with assay buffer (1x Hanks buffered saline, 25mM HEPES, 0.1% w/v fatty acid free BSA (bovine serum albumin), pH 7.4) containing 1mM probenecid and 1x Calcium 5 Reagent (Molecular Devices). Cells are incubated at 37°C for 1 hour to allow for dye uptake.

To test for antagonist activity, test compounds at a final concentration range between 0.32nM - 10 μ M (diluted in assay buffer) are added to the assay wells and allowed to incubate for 10 minutes prior to stimulation with PK1. After incubation with test compounds the assay plate is placed in a FLIPR Tetra (Molecular Devices) and PK1 (diluted in assay buffer) is added at the determined EC80 concentration (final). Ligand-dependent changes in intracellular calcium levels are determined by measuring changes in fluorescence of the dye at 525nm following excitation at 485nm. Readings from wells

that do not contain antagonist enable percentage inhibition curves to be plotted using 4-parameter fit algorithm and IC₅₀ values are calculated for each test compound.

Results

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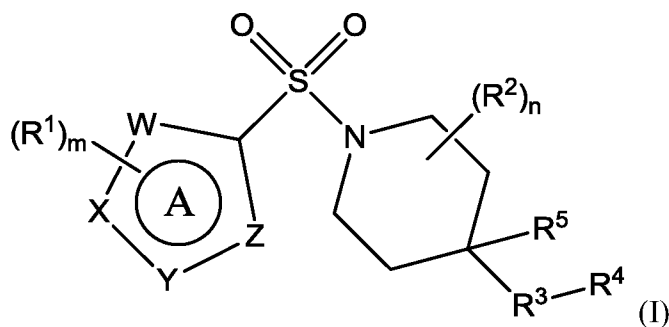
Compound of Example No.	Mean IC₅₀ (μM)	Compound of Example No.	Mean IC₅₀ (μM)
1	1.37	2	3.10
3	0.04	4	3.68
5	0.18	6	0.05
7	0.21	8	5.43
9	0.15	10	0.47
11	0.60	12	0.55
13	0.76	14	0.76
15	0.04	16	0.16
17	1.88	18	0.26
19	0.52	20	0.19
21	0.40	22	1.63
23	0.06		

The compounds tested above exhibit IC₅₀ values significantly less than 10 μM, with the most potent compounds showing antagonist activity at the prokineticin receptor with IC₅₀ values < 1 μM. Accordingly, the compounds of the invention are expected to be useful in the prevention or treatment of conditions in which prokineticin receptor modulation is implicated.

10

CLAIMS:

1. A compound of formula



or a pharmaceutically acceptable salt thereof, wherein in formula (I)

W, X, Y and Z each independently represent N, NH or CH, with the proviso that W, X, Y and Z do not each simultaneously represent a moiety CH;

m is 2 or 3;

each R^1 independently represents C_3 - C_6 cycloalkyl, C_1 - C_6 haloalkyl, or C_1 - C_6 alkyl optionally substituted by carboxyl or C_1 - C_6 alkoxy carbonyl;

n is 0 or 1;

each R^2 independently represents C_1 - C_6 alkyl;

R^3 represents $=CR^6$, or, when there is at least one R^1 group present that represents a C_3 - C_6 cycloalkyl group, then R^3 may additionally represent a group $-CR^7R^8-$;

R^5 is absent or represents a hydrogen atom;

R^6 represents a hydrogen or halogen atom or a cyano, C_1 - C_6 alkyl or C_1 - C_6 alkoxy carbonyl group;

R^7 and R^8 each independently represent a hydrogen or halogen atom or cyano, carboxyl, hydroxyl, C_1 - C_6 alkyl, C_1 - C_6 haloalkyl, C_1 - C_6 alkoxy, C_1 - C_6 hydroxyalkyl, C_1 - C_6 alkoxy carbonyl, C_1 - C_6 alkoxy C_1 - C_6 alkyl or a 5- to 9-membered heterocyclic ring system; and

R^4 represents a 6- to 10-membered aromatic or heteroaromatic ring system, the ring system itself being optionally substituted by at least one substituent selected from halogen, cyano, C_1 - C_6 alkyl, C_1 - C_6 haloalkyl, C_1 - C_6 alkoxy, or C_1 - C_6 haloalkoxy;

provided that the compound of formula (I) is not:

1-[(1-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethylene)piperidine;

1-[[1-cyclopentyl-3-(1,1-dimethylethyl)-1H-pyrazol-4-yl]sulfonyl]-4-(phenylmethyl)piperidine;

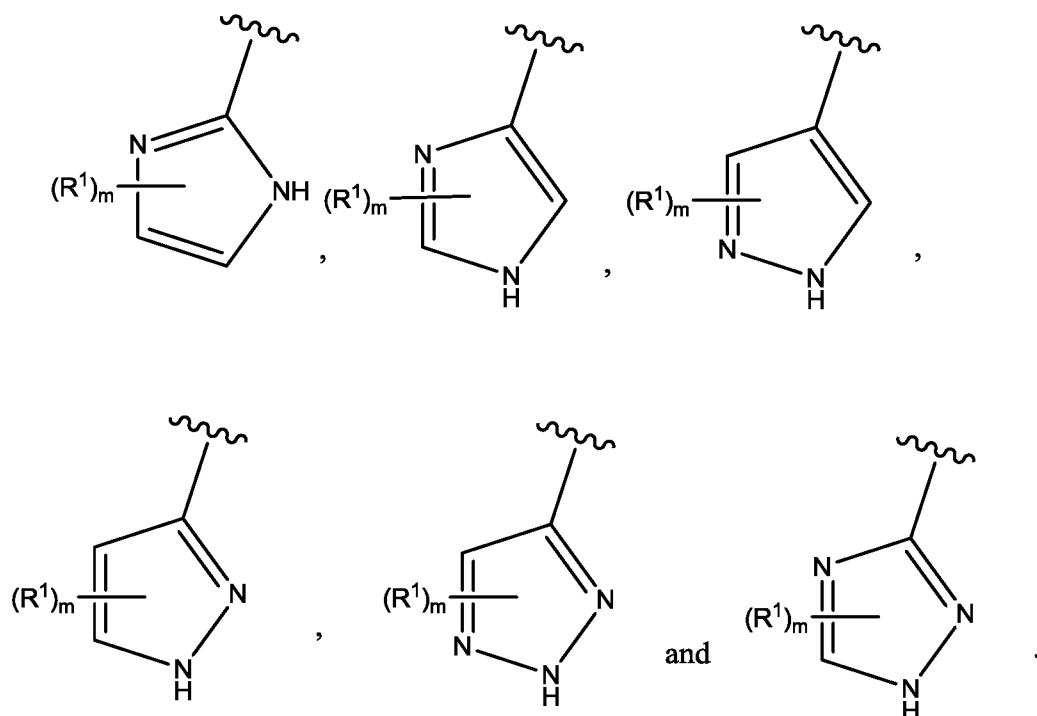
1-[(1-cyclopentyl-3-methyl-1H-pyrazol-4-yl)sulfonyl]-4-(phenylmethyl)piperidine;

1-[(5-chloro-1-methyl-1H-imidazol-4-yl)sulfonyl]-4-[(3-fluorophenyl)-methylene]piperidine; or

4-(1-(4-chlorophenyl)ethylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine.

2. A compound according to claim 1, wherein at least two of W, X, Y and Z represent N or NH.

3. A compound according to claim 1 or claim 2, wherein the ring A is selected from the group consisting of:



4. A compound according to any one of the preceding claims, wherein each R¹ independently represents C₃-C₆ cycloalkyl, C₁-C₆ haloalkyl or C₁-C₆ alkyl.
5. A compound according to any one of the preceding claims, wherein R³ represents =CR⁶.
6. A compound according to claim 5, wherein R⁶ represents a hydrogen or fluorine atom or a cyano, C₁-C₂ alkyl or C₁-C₂ alkoxy carbonyl group.
7. A compound according to any one of claims 1 to 4, wherein R³ represents -CR⁷R⁸.
8. A compound according to any one of the preceding claims, wherein the ring system is aromatic.
9. A compound selected from:

4-(4-Chloro-3-fluorobenzyl)-1-((3-cyclopropyl-5-methyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine,

Methyl 2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetate,

2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(2,6-Difluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chloro-2-fluorophenyl)-2-(1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((3,5-diethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((1,5-dimethyl-3-(trifluoromethyl)-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(2,6-Difluorophenyl)-2-(1-((1,3,5-trimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

2-(1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)-2-(4-(trifluoromethoxy)phenyl)acetonitrile,

2-(4-Chlorophenyl)-2-(1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)-3-methylpiperidin-4-ylidene)acetonitrile,

4-(4-Chloro-2-fluorobenzylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-(4-Chloro-2-fluorobenzylidene)-1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-(4-Chlorobenzylidene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

2-(4-Chlorophenyl)-2-(1-((1,3,5-trimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)acetonitrile,

4-((4-Chlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((3-Chloro-4-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((2,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((3,4-Dichlorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((4-Chloro-3-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

4-((4-Chloro-2-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

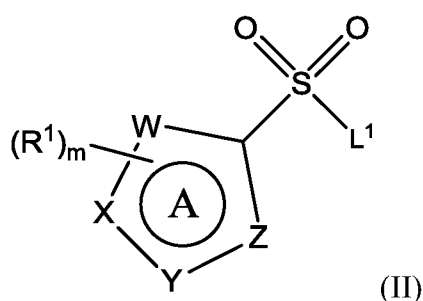
4-((2,4-Difluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidine,

3-((1-((3,5-Dimethyl-1H-pyrazol-4-yl)sulfonyl)piperidin-4-ylidene)fluoromethyl)quinoline,
and pharmaceutically acceptable salts of any one thereof.

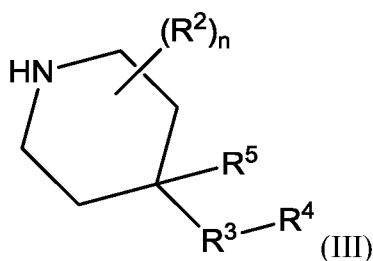
10. A compound according to claim 1, wherein the compound is 4-((4-chloro-3-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine, or a pharmaceutically acceptable salt thereof.

11. A compound according to claim 1, wherein the compound is 4-((4-chloro-2-fluorophenyl)fluoromethylene)-1-((3,5-dimethyl-1*H*-pyrazol-4-yl)sulfonyl)piperidine, or a pharmaceutically acceptable salt thereof.

12. A process for the preparation of a compound of formula (I) as defined in claim 1 or a pharmaceutically acceptable salt thereof which comprises reacting a compound of formula



wherein L^1 represents a leaving group and m , W , X , Y , Z and R^1 are as defined in formula (I), with a compound of formula



or a suitable salt thereof, wherein n , R^2 , R^3 , R^4 and R^5 are as defined in formula (I);

and optionally thereafter carrying out one or more of the following procedures:

- converting a compound of formula (I) into another compound of formula (I)
- removing any protecting groups
- forming a pharmaceutically acceptable salt.

13. A pharmaceutical composition comprising a compound according to any one of claims 1 to 11 in association with a pharmaceutically acceptable adjuvant, diluent or carrier, and optionally one or more other therapeutic agents.

14. A method of treatment of a disease or condition mediated by a prokineticin, the method comprising administering to a patient in need thereof a therapeutically effective amount of a compound according to any one of claims 1 to 11 or the pharmaceutical composition according to claim 13.

15. The method of claim 14, wherein the disease or condition is selected from the group consisting of schizophrenia, schizophreniform disorder, schizoaffective disorder and cognitive disorders.

16. The method of claim 14, wherein the disease or condition is pain.

17. Use of a compound according to any one of claims 1 to 11 for the manufacture of a medicament for treating a disease or condition mediated by a prokineticin.

18. The use of claim 17, wherein the disease or condition is selected from the group consisting of schizophrenia, schizophreniform disorder, schizoaffective disorder and cognitive disorders.

19. The use of claim 17, wherein the disease or condition is pain.

Takeda Pharmaceutical Company Limited
Patent Attorneys for the Applicant/Nominated Person
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