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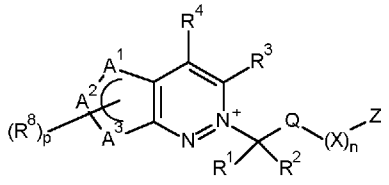
(54) Title: HERBICIDAL FUSED PYRIDAZINE COMPOUNDS

(57) Abstract: Compounds of the formula (I) wherein the substituents are as defined in claim 1, useful as a pesticides, especially as herbicides.



(I)

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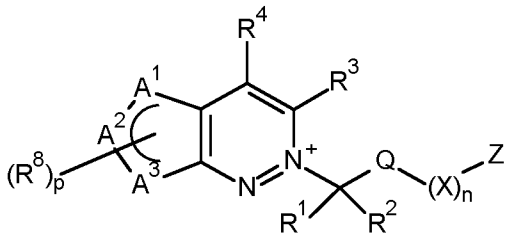
HERBICIDAL FUSED PYRIDAZINE COMPOUNDS

The present invention relates to herbicidally active bicyclic pyridazine derivatives, as well as to processes and intermediates used for the preparation of such derivatives. The invention further extends to herbicidal compositions comprising such derivatives, as well as to the use of such compounds and compositions for controlling undesirable plant growth: in particular the use for controlling weeds, in crops of useful plants.

The present invention is based on the finding that bicyclic pyridazine derivatives of formula (I) as defined herein, exhibit surprisingly good herbicidal activity. Thus, according to the present invention there is provided a compound of formula (I) or an agronomically acceptable salt or zwitterionic species thereof:



(I)

R^1 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_2-C_6alkenyl, C_2-C_6alkynyl, C_3-C_6cycloalkyl, C_1-C_6haloalkyl, -OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$;

R^2 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl and C_1-C_6haloalkyl;

and wherein when R^1 is selected from the group consisting of –OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$, R^2 is selected from the group consisting of hydrogen and C_1-C_6alkyl; or

R^1 and R^2 together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O;

Q is $(CR^{1a}R^{2b})_m$;

m is 0, 1, 2 or 3;

each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, -OH, -OR^7, -OR^{15a}, -NH_2, -NHR^7, -NHR^{15a}, -$N(R^6)CHO$, -$NR^{7b}R^{7c}$ and –$S(O)_rR^{15}$; or

each R^{1a} and R^{2b} together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O;

R^3 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl and C_1-C_6alkoxy and E;

R^4 is selected from the group consisting of E, hydrogen, nitro, cyano, -NH_2, -NR^6R^7, -OH, -OR^7, -$S(O)_rR^{12}$, -$NR^6S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-

C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_1-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, -$C(R^8)$=NOR^8, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents R^9, which may be the same or different; each R^6 is independently selected from hydrogen and C_1-C_6alkyl;

each R^7 is independently selected from the group consisting of C_1-C_6alkyl, -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$ and –$C(O)NR^{16}R^{17}$;

each R^{7a} is independently selected from the group consisting of -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$ –$C(O)NR^{16}R^{17}$ and –$C(O)NR^6R^{15a}$;

R^{7b} and R^{7c} are independently selected from the group consisting of C_1-C_6alkyl, -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$, –$C(O)NR^{16}R^{17}$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different; or

R^{7b} and R^{7c} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S; and

the ring comprising A^1, A^2 and A^3 together with the carbon atoms of the adjacent ring to which A^1 and A^3 are attached is aromatic;

A^1, A^2 and A^3 are independently selected from the group consisting of C, N, O and S;

at least one of A^1, A^2 and A^3 are N, O or S;

when A^1, A^2 and A^3 are C or N, they may each be substituted by R^8 substituents;

p is 0, 1, 2 or 3;

when p is 1 or 2, and R^8 is attached to N then R^8 is independently selected from the group consisting of hydrogen, -OR^7, -$S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_2-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents, which may be the same or different, selected from R^9, or

when p is 1 or 2 and R^8 is attached to C then each R^8 is independently selected from the group consisting of E, hydrogen, halogen, nitro, cyano, -NR^6R^7, -OR^7, -$S(O)_rR^{12}$, -$NR^6S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_1-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-

C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, -$C(R^6)$=NOR^6, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents, which may be the same or different, selected from R^9, or

when p is 3, and R^8 is attached to N then each R^8 is independently selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy;

when p is 3, and R^8 is attached to C then each R^8 is independently selected from the group consisting of E, hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy;

each R^9 is independently selected from the group consisting of halogen, cyano, -OH, -$N(R^6)_2$, C_1-C_4alkyl, C_1-C_4alkoxy, C_1-C_4haloalkyl and C_1-C_4haloalkoxy;

E is selected from the group consisting of of –$C(O)OR^{10}$, -CHO, -$C(O)R^{24}$, -$C(O)NHOR^{11}$, -C(O)NHCN, -$C(O)NHR^{25}$, -$S(O)_2NHR^{25}$, -$C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, -$C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and -$C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$(CR^6_2)_qC(O)OR^{10}$, -$(CR^6_2)_qS(O)_2(OR^{10})$, -$(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$OC(O)NHOR^{11}$, -$O(CR^6_2)_qC(O)OR^{10}$, -OC(O)NHCN, -$O(CR^6_2)_qS(O)_2(OR^{10})$, -$O(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$NR^6C(O)NHOR^{11}$, -$NR^6C(O)NHCN$, -$C(O)NHS(O)_2R^{12}$, -$OC(O)NHS(O)_2R^{12}$, -$NR^6C(O)NHS(O)_2R^{12}$, -$S(O)_2OR^{10}$, -$OS(O)_2OR^{10}$, -$NR^6S(O)_2OR^{10}$, -$NR^6S(O)OR^{10}$, -$NHS(O)_2R^{14}$, -$S(O)OR^{10}$, -$S(CR^6_2)_qC(O)OR^{10}$, -$S(CR^6_2)_qS(O)_2(OR^{10})$, -$S(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$OS(O)OR^{10}$, -$S(O)_2NHCN$, -$S(O)_2NHC(O)R^{18}$, -$S(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHCN$, -$OS(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHC(O)R^{18}$, -$NR^6S(O)_2NHCN$, -$NR^6S(O)_2NHC(O)R^{18}$, –$N(OH)C(O)R^{15}$, –$ONHC(O)R^{15}$, -$NR^6S(O)_2NHS(O)_2R^{12}$, -$P(O)(R^{13})(OR^{10})$, -$P(O)H(OR^{10})$, -$OP(O)(R^{13})(OR^{10})$, -$NR^6P(O)(R^{13})(OR^{10})$ and tetrazole;

q is 1, 2 or 3;

one of R^3, R^4 and R^8 is a group E;

R^8 can only be E if it is attached to C;

X is selected from the group consisting of C_3-C_6cycloalkyl, phenyl, a 5- or 6- membered heteroaryl, which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and a 4- to 6- membered heterocyclyl, which comprises 1, 2 or 3 heteroatoms individually selected from N, O and S, and wherein said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties are optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties;

n is 0 or 1;

Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, C_1-C_6alkoxyC_1-C_6alkyl, nitro, halo, haloalkoxy, cyano, -NH_2, -OH, -OR^7, -$C(O)R^{15}$, -$C(O)NR^{16}R^{17}$, –$C(O)OR^{10}$, -CHO, -$C(O)NHOR^{11}$, -C(O)NHCN, -$OC(O)NHOR^{11}$, -OC(O)NHCN, -$NR^6C(O)NHOR^{11}$, -$NR^6C(O)NHCN$, -$C(O)NHS(O)_2R^{12}$, -$OC(O)NHS(O)_2R^{12}$, -NHR^7, -$N(R^7)_2$, -$NR^6C(O)NHS(O)_2R^{12}$, -$NR^6S(O)_2R^{15}$, -$S(O)_2OR^{10}$, -$OS(O)_2OR^{10}$, -$NR^6S(O)_2OR^{10}$, -$NR^6S(O)OR^{10}$, -$NHS(O)_2R^{14}$, -$S(O)_rR^{15}$, -

$S(O)OR^{10}$, $-S(O)_2NR^{16}R^{17}$ $-OS(O)OR^{10}$, $-S(O)_2NHCN$, $-S(O)_2NHC(O)R^{18}$, $-S(O)_2NHS(O)_2R^{12}$, $-OS(O)_2NHCN$, $-OS(O)_2NHS(O)_2R^{12}$, $-OS(O)_2NHC(O)R^{18}$, $-NR^6S(O)_2NHCN$, $-NR^6S(O)_2NHC(O)R^{18}$, $-N(OH)C(O)R^{15}$, $-ONHC(O)R^{15}$, $-NR^6S(O)_2NHS(O)_2R^{12}$, $-P(O)(R^{13})(OR^{10})$, $-P(O)H(OR^{10})$, $-OP(O)(R^{13})(OR^{10})$, $-NR^6P(O)(R^{13})(OR^{10})$, tetrazole;

R^{10} is selected from the group consisting of hydrogen, C_1-C_6alkyl, phenyl and benzyl, and wherein said phenyl or benzyl are optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{11} is selected from the group consisting of hydrogen, C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{12} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -OH, $-N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{13} is selected from the group consisting of -OH, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, -O-propargyl, –O-allyl and phenyl;

R^{14} is C_1-C_6haloalkyl;

R^{15} is selected from the group consisting of C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{15a} is phenyl, wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{16} and R^{17} are independently selected from the group consisting of hydrogen and C_1-C_6alkyl; or

R^{16} and R^{17} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S;

R^{18} is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, $-N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{24} is a peptide moiety comprising one, two or three amino acid moieties independently selected from the group consisting of Ala, Cys, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp and Tyr, wherein said peptide moiety is bonded to the rest of the molecule via a nitrogen atom in the amino acid moiety;

R^{25} is selected from the group consisting of 5- or 6- membered heteroaromatic moieties, optionally substituted with one or more groups independently selected from R^2 or;

R^{25} is selected from the group consisting of 5- or 6- membered heteroaromatic moieties, containing at least two N atoms, optionally substituted with one or more groups independently selected from R^9;

and

r is 0, 1 or 2.

According to a second aspect of the invention, there is provided an agrochemical composition comprising a herbicidally effective amount of a compound of formula (I) and an agrochemically-acceptable diluent or carrier. Such an agricultural composition may further comprise at least one additional active ingredient.

According to a third aspect of the invention, there is provided a method of controlling or preventing undesirable plant growth, wherein a herbicidally effective amount of a compound of formula (I), or a composition comprising this compound as active ingredient, is applied to the plants, to parts thereof or the locus thereof.

According to a fourth aspect of the invention, there is provided the use of a compound of formula (I) as a herbicide.

According to a fifth aspect of the invention, there is provided a process for the preparation of compounds of formula (I).

As used herein, the term "halogen" or “halo” refers to fluorine (fluoro), chlorine (chloro), bromine (bromo) or iodine (iodo), preferably fluorine, chlorine or bromine.

As used herein, cyano means a -CN group.

As used herein, hydroxy means an -OH group.

As used herein, nitro means an $–NO_2$ group.

As used herein, the term "C_1-C_6alkyl" refers to a straight or branched hydrocarbon chain radical consisting solely of carbon and hydrogen atoms, containing no unsaturation, having from one to six carbon atoms, and which is attached to the rest of the molecule by a single bond. C_1-C_4alkyl and C_1-C_2alkyl are to be construed accordingly. Examples of C_1-C_6alkyl include, but are not limited to, methyl (Me), ethyl (Et), *n*-propyl, 1-methylethyl (iso-propyl), *n*-butyl, and 1-dimethylethyl (*t*-butyl).

As used herein, the term "C_1-C_6alkoxy" refers to a radical of the formula $-OR_a$ where R_a is a C_1-C_6alkyl radical as generally defined above. C_1-C_4alkoxy is to be construed accordingly. Examples of C_{1-4}alkoxy include, but are not limited to, methoxy, ethoxy, propoxy, iso-propoxy and *t*-butoxy.

As used herein, the term "C_1-C_6haloalkyl" refers to a C_1-C_6alkyl radical as generally defined above substituted by one or more of the same or different halogen atoms. C_1-C_4haloalkyl is to be construed accordingly. Examples of C_1-C_6haloalkyl include, but are not limited to chloromethyl, fluoromethyl, fluoroethyl, difluoromethyl, trifluoromethyl and 2,2,2-trifluoroethyl.

As used herein, the term "C_2-C_6alkenyl" refers to a straight or branched hydrocarbon chain radical group consisting solely of carbon and hydrogen atoms, containing at least one double bond that can be of either the (*E*)- or (*Z*)-configuration, having from two to six carbon atoms, which is attached to the rest of the molecule by a single bond. C_2-C_4alkenyl is to be construed accordingly. Examples of C_2-C_6alkenyl include, but are not limited to, prop-1-enyl, allyl (prop-2-enyl) and but-1-enyl.

As used herein, the term “C_2-C_6haloalkenyl” refers to a C_2-C_6alkenyl radical as generally defined above substituted by one or more of the same or different halogen atoms. Examples of C_2-C_6haloalkenyl

include, but are not limited to chloroethylene, fluoroethylene, 1,1-difluoroethylene, 1,1-dichloroethylene and 1,1,2-trichloroethylene.

As used herein, the term "C_2-C_6alkynyl" refers to a straight or branched hydrocarbon chain radical group consisting solely of carbon and hydrogen atoms, containing at least one triple bond, having from two to six carbon atoms, and which is attached to the rest of the molecule by a single bond. C_2-C_4alkynyl is to be construed accordingly. Examples of C_2-C_6alkynyl include, but are not limited to, prop-1-ynyl, propargyl (prop-2-ynyl) and but-1-ynyl.

As used herein, the term "C_1-C_6haloalkoxy" refers to a C_1-C_6alkoxy group as defined above substituted by one or more of the same or different halogen atoms. C_1-C_4haloalkoxy is to be construed accordingly. Examples of C_1-C_6haloalkoxy include, but are not limited to, fluoromethoxy, difluoromethoxy, fluoroethoxy, trifluoromethoxy and trifluoroethoxy.

As used herein, the term "C_1-C_3haloalkoxyC_1-C_3alkyl" refers to a radical of the formula R_b-O-R_a- where R_b is a C_1-C_3haloalkyl radical as generally defined above, and R_a is a C_1-C_3alkylene radical as generally defined above.

As used herein, the term "C_1-C_3alkoxyC_1-C_3alkyl" refers to a radical of the formula R_b-O-R_a- where R_b is a C_1-C_3alkyl radical as generally defined above, and R_a is a C_1-C_3alkylene radical as generally defined above.

As used herein, the term " C_1-C_3alkoxyC_1-C_3alkoxy-" refers to a radical of the formula R_b-O-R_a-O- where R_b is a C_1-C_3alkyl radical as generally defined above, and R_a is a C_1-C_3alkylene radical as generally defined above.

As used herein, the term "C_3-C_6alkenyloxy" refers to a radical of the formula -OR_a where R_a is a C_3-C_6alkenyl radical as generally defined above.

As used herein, the term "C_3-C_6alkynyloxy" refers to a radical of the formula -OR_a where R_a is a C_3-C_6alkynyl radical as generally defined above.

As used herein, the term “hydroxyC_1-C_6alkyl” refers to a C_1-C_6alkyl radical as generally defined above substituted by one or more hydroxy groups.

As used herein, the term "C_1-C_6alkylcarbonyl" refers to a radical of the formula -C(O)R_a where R_a is a C_1-C_6alkyl radical as generally defined above.

As used herein, the term "C_1-C_6alkoxycarbonyl" refers to a radical of the formula -C(O)OR_a where R_a is a C_1-C_6alkyl radical as generally defined above.

As used herein, the term “aminocarbonyl” refers to a radical of the formula -C(O)NH_2.

As used herein, the term "C_3-C_6cycloalkyl" refers to a stable, monocyclic ring radical which is saturated or partially unsaturated and contains 3 to 6 carbon atoms. C_3-C_4cycloalkyl is to be construed accordingly. Examples of C_3-C_6cycloalkyl include, but are not limited to, cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl.

As used herein, the term "C_3-C_6halocycloalkyl" refers to a C_3-C_6cycloalkyl radical as generally defined above substituted by one or more of the same or different halogen atoms. C_3-C_4halocycloalkyl is to be construed accordingly.

As used herein, the term "C_3-C_6cycloalkoxy" refers to a radical of the formula $–OR_a$ where R_a is a C_3-C_6cycloalkyl radical as generally defined above.

As used herein, the term "N-C_3-C_6cycloalkylamino" refers to a radical of the formula $-NHR_a$ where R_a is a C_3-C_6cycloalkyl radical as generally defined above.

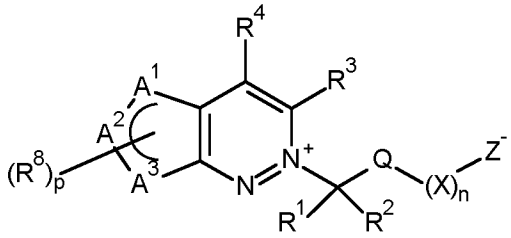
As used herein, except where explicitly stated otherwise, the term "heteroaryl" refers to a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from nitrogen, oxygen and sulfur. The heteroaryl radical may be bonded to the rest of the molecule *via* a carbon atom or heteroatom. Examples of heteroaryl include, furyl, pyrrolyl, imidazolyl, thienyl, pyrazolyl, thiazolyl, isothiazolyl, oxazolyl, isoxazolyl, triazolyl, tetrazolyl, pyrazinyl, pyridazinyl, pyrimidyl or pyridyl.

As used herein, except where explicitly stated otherwise, the term "heterocyclyl" or "heterocyclic" refers to a stable 4- to 6-membered non-aromatic monocyclic ring radical which comprises 1, 2, or 3 heteroatoms individually selected from nitrogen, oxygen and sulfur. The heterocyclyl radical may be bonded to the rest of the molecule via a carbon atom or heteroatom. Examples of heterocyclyl include, but are not limited to, pyrrolinyl, pyrrolidyl, tetrahydrofuryl, tetrahydrothienyl, tetrahydrothiopyranyl, piperidyl, piperazinyl, tetrahydropyranyl, dihydroisoxazolyl, dioxolanyl, morpholinyl or δ-lactamyl.

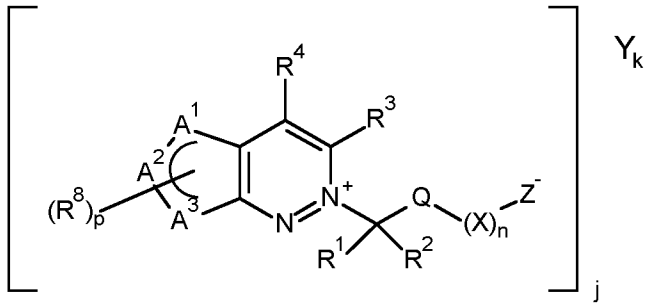
The presence of one or more possible asymmetric carbon atoms in a compound of formula (I) means that the compounds may occur in chiral isomeric forms, i.e., enantiomeric or diastereomeric forms. Also atropisomers may occur as a result of restricted rotation about a single bond. Formula (I) is intended to include all those possible isomeric forms and mixtures thereof. The present invention includes all those possible isomeric forms and mixtures thereof for a compound of formula (I). Likewise, formula (I) is intended to include all possible tautomers (including lactam-lactim tautomerism and keto-enol tautomerism) where present. The present invention includes all possible tautomeric forms for a compound of formula (I). Similarly, where there are di-substituted alkenes, these may be present in *E* or *Z* form or as mixtures of both in any proportion. The present invention includes all these possible isomeric forms and mixtures thereof for a compound of formula (I).

The compounds of formula (I) will typically be provided in the form of an agronomically acceptable salt, a zwitterion or an agronomically acceptable salt of a zwitterion. This invention covers all such agronomically acceptable salts, zwitterions and mixtures thereof in all proportions.

For example a compound of formula (I) wherein Z comprises an acidic proton, may exist as a zwitterion, a compound of formula (I-I), or as an agronomically acceptable salt, a compound of formula (I-II) as shown below:



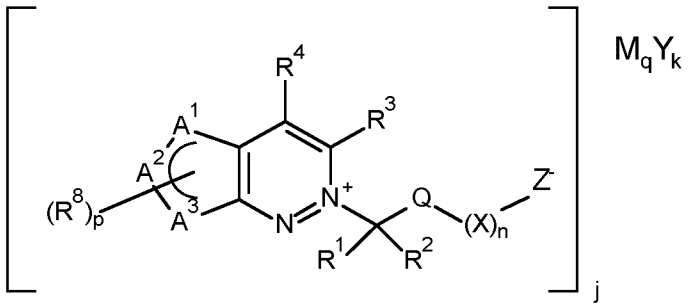
(I-I)



(I-II)

wherein, Y represents an agronomically acceptable anion and j and k represent integers that may be selected from 1, 2 or 3, dependent upon the charge of the respective anion Y.

A compound of formula (I) may also exist as an agronomically acceptable salt of a zwitterion, a compound of formula (I-III) as shown below:



(I-III)

wherein, Y represents an agronomically acceptable anion, M represents an agronomically acceptable cation (in addition to the pyridazinium cation) and the integers j, k and q may be selected from 1, 2 or 3, dependent upon the charge of the respective anion Y and respective cation M.

Thus where a compound of formula (I) is drawn in protonated form herein, the skilled person would appreciate that it could equally be represented in unprotonated or salt form with one or more relevant counter ions.

In one embodiment of the invention there is provided a compound of formula (I-II) wherein k is 2, j is 1 and Y is selected from the group consisting of halogen, trifluoroacetate and pentafluoropropionate. In this embodiment a nitrogen atom comprised in R^1, R^2, R^8, Q or X may be protonated.

Suitable agronomically acceptable salts of the present invention, represented by an anion Y, include but are not limited chloride, bromide, iodide, fluoride, 2-naphthalenesulfonate, acetate, adipate, methoxide, ethoxide, propoxide, butoxide, aspartate, benzenesulfonate, benzoate, bicarbonate, bisulfate, bitartrate, butylsulfate, butylsulfonate, butyrate, camphorate, camsylate, caprate, caproate, caprylate, carbonate, citrate, diphosphate, edetate, edisylate, enanthate, ethanedisulfonate, ethanesulfonate, ethylsulfate, formate, fumarate, gluceptate, gluconate, glucoronate, glutamate, glycerophosphate, heptadecanoate, hexadecanoate, hydrogen sulfate, hydroxide, hydroxynaphthoate, isethionate, lactate, lactobionate, laurate, malate, maleate, mandelate, mesylate, methanedisulfonate, methylsulfate, mucate, myristate,

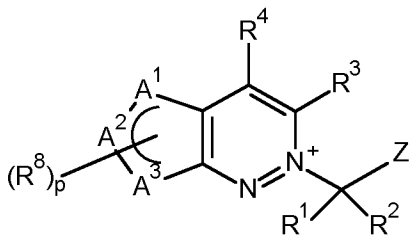
napsylate, nitrate, nonadecanoate, octadecanoate, oxalate, pelargonate, pentadecanoate, pentafluoropropionate, perchlorate, phosphate, propionate, propylsulfate, propylsulfonate, succinate, sulfate, tartrate, tosylate, tridecylate, triflate, trifluoroacetate, undecylinate and valerate.

Suitable cations represented by M include, but are not limited to, metals, conjugate acids of amines and organic cations. Examples of suitable metals include aluminium, calcium, cesium, copper, lithium, magnesium, manganese, potassium, sodium, iron and zinc. Examples of suitable amines include allylamine, ammonia, amylamine, arginine, benethamine, benzathine, butenyl-2-amine, butylamine, butylethanolamine, cyclohexylamine, decylamine, diamylamine, dibutylamine, diethanolamine, diethylamine, diethylenetriamine, diheptylamine, dihexylamine, diisoamylamine, diisopropylamine, dimethylamine, dioctylamine, dipropanolamine, dipropargylamine, dipropylamine, dodecylamine, ethanolamine, ethylamine, ethylbutylamine, ethylenediamine, ethylheptylamine, ethyloctylamine, ethylpropanolamine, heptadecylamine, heptylamine, hexadecylamine, hexenyl-2-amine, hexylamine, hexylheptylamine, hexyloctylamine, histidine, indoline, isoamylamine, isobutanolamine, isobutylamine, isopropanolamine, isopropylamine, lysine, meglumine, methoxyethylamine, methylamine, methylbutylamine, methylethylamine, methylhexylamine, methylisopropylamine, methylnonylamine, methyloctadecylamine, methylpentadecylamine, morpholine, N,N-diethylethanolamine, N-methylpiperazine, nonylamine, octadecylamine, octylamine, oleylamine, pentadecylamine, pentenyl-2-amine, phenoxyethylamine, picoline, piperazine, piperidine, propanolamine, propylamine, propylenediamine, pyridine, pyrrolidine, sec-butylamine, stearylamine, tallowamine, tetradecylamine, tributylamine, tridecylamine, trimethylamine, triheptylamine, trihexylamine, triisobutylamine, triisodecylamine, triisopropylamine, trimethylamine, tripentylamine, tripropylamine, tris(hydroxymethyl)aminomethane, and undecylamine. Examples of suitable organic cations include benzyltributylammonium, benzyltrimethylammonium, benzyltriphenylphosphonium, choline, tetrabutylammonium, tetrabutylphosphonium, tetraethylammonium, tetraethylphosphonium, tetramethylammonium, tetramethylphosphonium, tetrapropylammonium, tetrapropylphosphonium, tributylsulfonium, tributylsulfoxonium, triethylsulfonium, triethylsulfoxonium, trimethylsulfonium, trimethylsulfoxonium, tripropylsulfonium and tripropylsulfoxonium.

Preferred compounds of formula (I), wherein Z comprises an acidic proton, can be represented as either (I-I) or (I-II). For compounds of formula (I-II) emphasis is given to salts when Y is chloride, bromide, iodide, hydroxide, bicarbonate, acetate, pentafluoropropionate, triflate, trifluoroacetate, methylsulfate, tosylate and nitrate, wherein j and k are 1. Preferably, Y is chloride, bromide, iodide, hydroxide, bicarbonate, acetate, trifluoroacetate, methylsulfate, tosylate and nitrate, wherein j and k are 1. For compounds of formula (I-II) emphasis is also given to salts when Y is carbonate and sulfate, wherein j is 2 and k is 1, and when Y is phosphate, wherein j is 3 and k is 1.

Where appropriate compounds of formula (I) may also be in the form of (and/or be used as) an N-oxide.

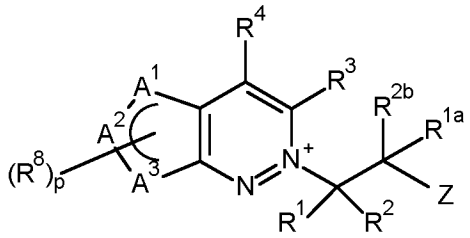
Compounds of formula (I) wherein m is 0 and n is 0 may be represented by a compound of formula (I-Ia) as shown below:



(I-Ia)

wherein R^1, R^2, R^3, R^4, R^8, A^1, A^2, A^3, p and Z are as defined for compounds of formula (I).

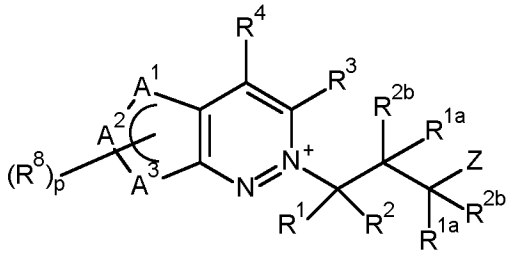
Compounds of formula (I) wherein m is 1 and n is 0 may be represented by a compound of formula (I-Ib) as shown below:



(I-Ib)

wherein R^1, R^2, R^{1a}, R^{2b}, R^3, R^4, R^8, A^1, A^2, A^3, p and Z are as defined for compounds of formula (I).

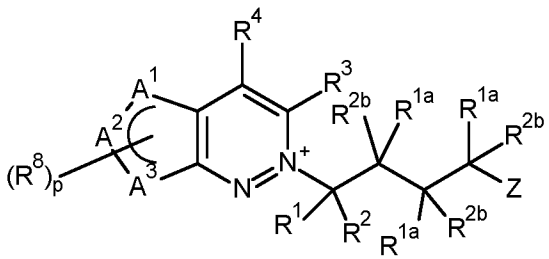
Compounds of formula (I) wherein m is 2 and n is 0 may be represented by a compound of formula (I-Ic) as shown below:



(I-Ic)

wherein R^1, R^2, R^{1a}, R^{2b}, R^3, R^4, R^8, A^1, A^2, A^3, p and Z are as defined for compounds of formula (I).

Compounds of formula (I) wherein m is 3 and n is 0 may be represented by a compound of formula (I-Id) as shown below:



(I-Id)

wherein R^1, R^2, R^{1a}, R^{2b}, R^3, R^4, R^8, A^1, A^2, A^3, p and Z are as defined for compounds of formula (I).

The following list provides definitions, including preferred definitions, for substituents n, m, p, A^1, A^2, A^3, E, Q, X, Z, R^1, R^2, R^{1a}, R^{2b}, R^3, R^4, R^6, R^7, R^{7a}, R^{7b}, R^{7c}, R^8, R^9, R^{10}, R^{11}, R^{12}, R^{13}, R^{14}, R^{15}, R^{15a}, R^{16}, R^{17} and R^{18} with reference to the compounds of formula (I) according to the invention. For any one of these substituents, any of the definitions given below may be combined with any definition of any other substituent given below or elsewhere in this document.

R^1 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_2-C_6alkenyl, C_2-C_6alkynyl, C_3-C_6cycloalkyl, C_1-C_6haloalkyl, -OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$. Preferably, R^1 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6fluoroalkyl, -OR^7, -$NHS(O)_2R^{15}$, -$NHC(O)R^{15}$, -$NHC(O)OR^{15}$, -$NHC(O)NR^{16}R^{17}$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$. More preferably, R^1 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6fluoroalkyl, -OR^7 and -$N(R^{7a})_2$. Even more preferably, R^1 is selected from the group consisting of hydrogen, C_1-C_6alkyl, -OR^7 and -$N(R^{7a})_2$. Even more preferably still, R^1 is hydrogen or C_1-C_6alkyl. Yet even more preferably still, R^1 is hydrogen or methyl. Most preferably R^1 is hydrogen.

R^2 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl and C_1-C_6haloalkyl. Preferably, R^2 is selected from the group consisting of hydrogen, C_1-C_6alkyl and C_1-C_6fluoroalkyl. More preferably, R^2 is hydrogen or C_1-C_6alkyl. Even more preferably, R^2 is hydrogen or methyl. Most preferably R^2 is hydrogen.

Wherein when R^1 is selected from the group consisting of –OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$, then R^2 is selected from the group consisting of hydrogen and C_1-C_6alkyl. Preferably, when R^1 is selected from the group consisting of –OR^7, -$NHS(O)_2R^{15}$, -$NHC(O)R^{15}$, -$NHC(O)OR^{15}$, -$NHC(O)NR^{16}R^{17}$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$, then R^2 is selected from the group consisting of hydrogen and methyl.

Alternatively, R^1 and R^2 together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O. Preferably, R^1 and R^2 together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring. More preferably, R^1 and R^2 together with the carbon atom to which they are attached form a cyclopropyl ring.

In another embodiment R^1 is methyl and R^2 is hydrogen.

In another embodiment R^1 is methyl and R^2 is methyl.

In a preferred embodiment R^1 and R^2 are hydrogen

Q is $(CR^{1a}R^{2b})_m$.

m is 0, 1, 2 or 3. Preferably, m is 0,1 or 2. More preferably, m is 1 or 2. Most preferably, m is 0.

Each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, -OH, -OR^7, -OR^{15a}, -NH_2, -NHR^7, -NHR^{15a}, -$N(R^6)CHO$, -$NR^{7b}R^{7c}$ and –$S(O)_rR^{15}$.

Preferably, each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6fluoroalkyl, -OH, $-NH_2$ and $-NHR^7$. More preferably, each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, C_1-C_6alkyl, –OH and $–NH_2$. Even more preferably, each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, methyl, –OH and $–NH_2$. Even more preferably still, each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen and methyl. Most preferably R^{1a} and R^{2b} are hydrogen.

In another embodiment each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen and C_1-C_6alkyl.

Alternatively, each R^{1a} and R^{2b} together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O. Preferably, each R^{1a} and R^{2b} together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring. More preferably, each R^{1a} and R^{2b} together with the carbon atom to which they are attached form a cyclopropyl ring.

Preferably, R^3 is selected from the group consisting of E, hydrogen, C_1-C_6alkyl and C_1-C_6alkoxy. More preferably, R^3 is selected from the group consisting of E, hydrogen and C_1-C_6alkyl. Even more preferably, R^3 is selected from the group consisting of E, hydrogen and methyl. Most preferably, R^3 is E or hydrogen.

Preferably R^4 is selected from the group consisting of E, hydrogen, C_1-C_6alkyl, C_1-C_6fluoroalkyl, C_1-C_6fluoroalkoxy, C_1-C_6alkoxy, C_3-C_6cycloalkyl and $–NR^6R^7$. More preferably, R^4 is selected from the group consisting of E, hydrogen, C_1-C_6alkyl and C_1-C_6alkoxy. Even more preferably, R^4 is selected from the group consisting of E, hydrogen and C_1-C_6alkyl. Even more preferably still, R^4 is selected from the group consisting of E, hydrogen and methyl. Most preferably, R^4 is E or hydrogen.

Each R^6 is independently selected from hydrogen and C_1-C_6alkyl. Preferably, each R^6 is independently selected from hydrogen and methyl.

Each R^7 is independently selected from the group consisting of C_1-C_6alkyl, $-S(O)_2R^{15}$, $-C(O)R^{15}$, $-C(O)OR^{15}$ and $–C(O)NR^{16}R^{17}$. Preferably, each R^7 is independently selected from the group consisting of C_1-C_6alkyl, $-C(O)R^{15}$ and $–C(O)NR^{16}R^{17}$. More preferably, each R^7 is C_1-C_6alkyl. Most preferably, each R^7 is methyl.

Each R^{7a} is independently selected from the group consisting of $-S(O)_2R^{15}$, $-C(O)R^{15}$, $-C(O)OR^{15}$ – $C(O)NR^{16}R^{17}$ and $–C(O)NR^6R^{15a}$. Preferably, each R^{7a} is independently $-C(O)R^{15}$ or $–C(O)NR^{16}R^{17}$.

R^{7b} and R^{7c} are independently selected from the group consisting of C_1-C_6alkyl, $-S(O)_2R^{15}$, $-C(O)R^{15}$, $-C(O)OR^{15}$, $–C(O)NR^{16}R^{17}$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{7b} and R^{7c} are independently selected from the group consisting of C_1-C_6alkyl, $-C(O)R^{15}$ and $–C(O)NR^{16}R^{17}$. More preferably, R^{7b} and R^{7c} are C_1-C_6alkyl. Most preferably, R^{7b} and R^{7c} are methyl.

Alternatively, R^{7b} and R^{7c} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S. Preferably, R^{7b} and R^{7c} together with the nitrogen atom to which they are attached

form a 5- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N and O. More preferably, R^{7b} and R^{7c} together with the nitrogen atom to which they are attached form an pyrrolidyl, oxazolidinyl, imidazolidinyl, piperidyl, piperazinyl or morpholinyl group.

A^1, A^2 or A^3 and the number p of any substituents R^8 are chosen so that the ring is aromatic.

When R^8 is E, it is attached to a carbon atom in the ring.

Preferably no more than one of A^1, A^2 or A^3 are O or S.

Preferably, A^1 is C, A^2 and A^3 are N and A^3 is substituted with methyl.

Preferably p is 0, 1 or 2, more preferably 1 or 2, even more preferably 1.

Preferably when R^8 is attached to C, R^8 is independently selected from the group consisting of E, hydrogen and C_1-C_6alkyl, more preferably when R^8 is attached to C then R^8 is E or hydrogen.

Preferably when R^8 is attached to N, R^8 is independently selected from the group consisting of hydrogen and C_1-C_6alkyl, more preferably when R^8 is attached to N then R^8 is hydrogen or methyl most preferably methyl.

In one embodiment A^1 is C substituted with hydrogen, A^2 and A^3 are N and A^3 is substituted with methyl.

Each R^9 is independently selected from the group consisting of halogen, cyano, -OH, -$N(R^6)_2$, C_1-C_4alkyl, C_1-C_4alkoxy, C_1-C_4haloalkyl and C_1-C_4haloalkoxy. Preferably, each R^9 is independently selected from the group consisting of halogen, cyano, -$N(R^6)_2$, C_1-C_4alkyl, C_1-C_4alkoxy, C_1-C_4haloalkyl and C_1-C_4haloalkoxy. More preferably, each R^9 is independently selected from the group consisting of halogen, C_1-C_4alkyl, C_1-C_4alkoxy and C_1-C_4haloalkyl. Even more preferably, each R^9 is independently selected from the group consisting of halogen and C_1-C_4alkyl.

Preferably E is selected from the group consisting of –C(O)OR^{10}, -C(O)NHS$(O)_2R^{12}$, -P(O)$(R^{13})(OR^{10})$ and -S$(O)_2(OR^{10})$, more preferably –C(O)OR^{10}, -C(O)NHS$(O)_2R^{12}$ and -P(O)$(R^{13})(OR^{10})$, even more prefeably –C(O)OR^{10} and -C(O)NHS$(O)_2R^{12}$, most preferably –C(O)OR^{10}.

X is selected from the group consisting of C_3-C_6cycloalkyl, phenyl, a 5- or 6- membered heteroaryl, which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and a 4- to 6- membered heterocyclyl, which comprises 1, 2 or 3 heteroatoms individually selected from N, O and S, and wherein said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties are optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties.

Preferably, X is selected from the group consisting of phenyl and a 4- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O, and wherein said phenyl or heterocyclyl moieties are optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said phenyl or heterocyclyl moieties.

More preferably, X is a 4- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O, and wherein said heterocyclyl moieties is optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said heterocyclyl moiety.

In one embodiment, X is a 5-membered heterocyclyl, which comprises 1 heteroatom, wherein said heteroatom is N, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said heterocyclyl moiety. Preferably, X is a 5-membered heterocyclyl, which comprises 1 heteroatom, wherein said heteroatom is N, and wherein the aforementioned CR^1R^2 and Q moieties are attached adjacent to the N atom and the Z moiety is attached to the N atom.

In another embodiment, X is phenyl optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said phenyl moiety. Preferably, X is phenyl and the aforementioned CR^1R^2 and Q moieties are attached in a postion *para* to the Z moiety.

n is 0 or 1. Preferably, n is 0.

Preferably, Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, C_1-C_6alkoxyC_1-C_6alkyl, -C(O)OR^{10}, -C(O)NHOR^{11}, -OC(O)NHOR^{11}, -NR^6C(O)NHOR^{11}, -C(O)NHS(O)$_2R^{12}$, -OC(O)NHS(O)$_2R^{12}$, -NR^6C(O)NHS(O)$_2R^{12}$, -S(O)$_2$OR^{10}, -OS(O)$_2$OR^{10}, -NR^6S(O)$_2$OR^{10}, -NR^6S(O)OR^{10}, -NHS(O)$_2R^{14}$, -S(O)OR^{10}, -OS(O)OR^{10}, -S(O)$_2$NHC(O)R^{18}, -S(O)$_2$NHS(O)$_2R^{12}$, -OS(O)$_2$NHS(O)$_2R^{12}$, -OS(O)$_2$NHC(O)R^{18}, -NR^6S(O)$_2$NHC(O)R^{18}, –N(OH)C(O)R^{15}, –ONHC(O)R^{15}, -NR^6S(O)$_2$NHS(O)$_2R^{12}$, -P(O)(R^{13})(OR^{10}), -P(O)H(OR^{10}), -OP(O)(R^{13})(OR^{10}) and -NR^6P(O)(R^{13})(OR^{10}).

More preferably, Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, –C(O)OR^{10}, -C(O)NHOR^{11}, -C(O)NHS(O)$_2R^{12}$, -S(O)$_2$OR^{10}, -OS(O)$_2$OR^{10}, -NR^6S(O)$_2$OR^{10}, -NHS(O)$_2R^{14}$, -S(O)OR^{10} and -P(O)(R^{13})(OR^{10}).

Even more preferably Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, -C(O)OR^{10}, -C(O)NHS(O)$_2R^{12}$, -S(O)$_2$OR^{10}, and -P(O)(R^{13})(OR^{10}).

Even more preferably still Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl and C_1-C_6hydroxyalkyl.

Most preferably Z is hydrogen or C_1-C_6alkyl , especially hydrogen or methyl.

R^{10} is selected from the group consisting of hydrogen, C_1-C_6alkyl, phenyl and benzyl, and wherein said phenyl or benzyl are optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{10} is selected from the group consisting of hydrogen, C_1-C_6alkyl, phenyl and benzyl. More preferably, R^{10} is selected from the group consisting of hydrogen and C_1-C_6alkyl. Most preferably, R^{10} is hydrogen.

R^{11} is selected from the group consisting of hydrogen, C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{11} is selected from the group consisting of hydrogen, C_1-C_6alkyl and phenyl. More preferably, R^{11} is

selected from the group consisting of hydrogen and C_1-C_6alkyl. Even more preferably, R^{11} is C_1-C_6alkyl. Most preferably, R^{11} is methyl.

R^{12} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -OH, -$N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{12} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -OH, -$N(R^6)_2$ and phenyl. More preferably, R^{12} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6haloalkyl and -$N(R^6)_2$. Even more preferably, R^{12} is selected from the group consisting of methyl, -$N(Me)_2$ and trifluoromethyl. Most preferably, R^{12} is methyl.

R^{13} is selected from the group consisting of -OH, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, -O-propargyl, –O-allyl and phenyl. Preferably R^{13} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, -O-propargyl or –O-allyl. More preferably, R^{13} is selected from the group consisting of –OH and C_1-C_6alkoxy. Even more preferably, R^{13} is selected from the group consisting of methyl, ethyl, propyl, isopropyl, isobutyl, -O propargyl and –O-allyl.

R^{14} is C_1-C_6haloalkyl. Preferably, R^{14} is trifluoromethyl.

R^{15} is selected from the group consisting of C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{15} is selected from the group consisting of C_1-C_6alkyl and phenyl. More preferably, R^{15} is C_1-C_6alkyl. Most preferably R^{15} is methyl.

R^{15a} is phenyl, wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{15a} is phenyl optionally substituted by 1 R^9 substituent. More preferably, R^{15a} is phenyl.

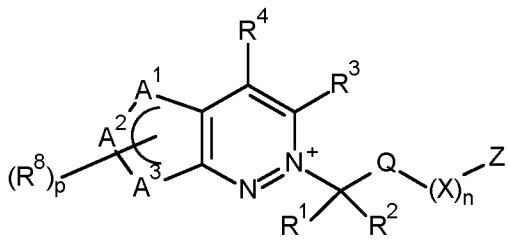
R^{16} and R^{17} are independently selected from the group consisting of hydrogen and C_1-C_6alkyl. Preferably, R^{16} and R^{17} are independently selected from the group consisting of hydrogen and methyl.

Alternatively, R^{16} and R^{17} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S. Preferably, R^{16} and R^{17} together with the nitrogen atom to which they are attached form a 5- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N and O. More preferably, R^{16} and R^{17} together with the nitrogen atom to which they are attached form an pyrrolidyl, oxazolidinyl, imidazolidinyl, piperidyl, piperazinyl or morpholinyl group.

R^{18} is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -$N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different. Preferably, R^{18} is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -$N(R^6)_2$ and phenyl. More preferably, R^{18} is selected from the group consisting of hydrogen, C_1-C_6alkyl and C_1-C_6haloalkyl. Further more preferably, R^{18} is selected from the group consisting of C_1-C_6alkyl and C_1-C_6haloalkyl. Most preferably, R^{18} is methyl or trifluoromethyl.

r is 0, 1 or 2. Preferably, r is 0 or 2.

There is also provided a process for the preparation of compounds of formula (I):

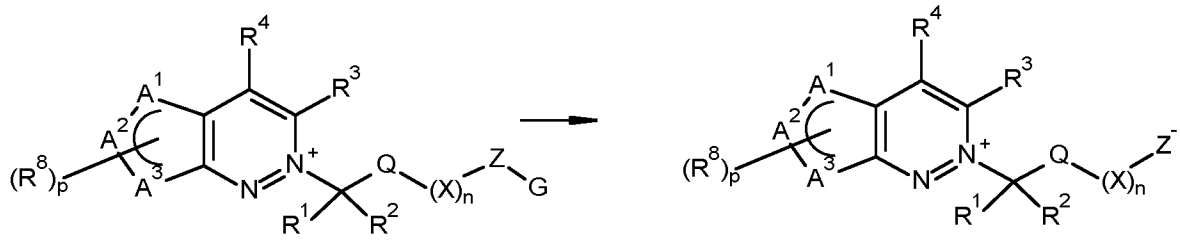


(I)

Wherein Q, Z, X, n, p, R^1, R^2, R^3, R^4, R^8, A^1 , A^2 and A^3 are as defined herein.

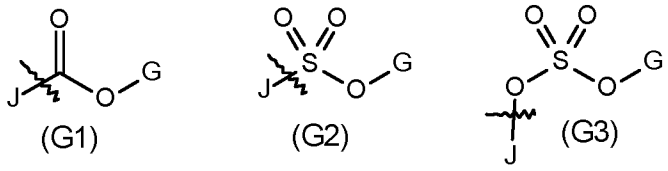
It should be understood that compounds of formula (I) may exist/be manufactured in 'procidal form', wherein they comprise a group 'G'. Such compounds are referred to herein as compounds of formula (I-IV).

G is a group which may be removed in a plant by any appropriate mechanism including, but not limited to, metabolism and chemical degradation to give a compound of formula (I-I), (I-II) or (I-III) wherein Z contains an acidic proton, for example see the scheme below:

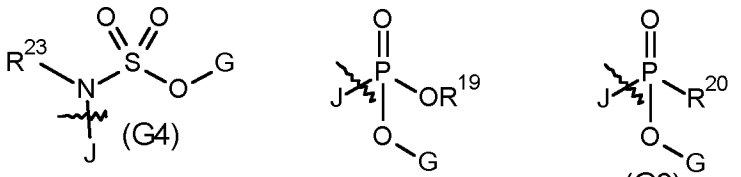


(I-IV) (I-I)

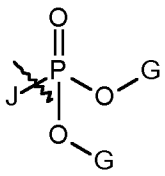
Whilst such G groups may be considered as 'procidal', and thus yield active herbicidal compounds once removed, compounds comprising such groups may also exhibit herbicidal activity in their own right. In such cases in a compound of formula (I-IV), Z-G may include but is not limited to, any one of (G1) to (G7) below and J indicates the point of attachment to the remaining part of a compound of formula (I):



(G1) (G2) (G3)



(G4) (G5) (G6)



(G7)

In embodiments where Z-G is (G1) to (G7), G, R^{19}, R^{20}, R^{21}, R^{22} and R^{23} are defined as follows:

G is C_1-C_6alkyl, C_2-C_6alkenyl, C_2-C_6alkynyl, -$C(R^{21}R^{22})OC(O)R^{19}$, phenyl or phenyl-$C_1$-$C_4$alkyl-, wherein said phenyl moiety is optionally substituted by 1 to 5 substituents independently selected from halo, cyano, nitro, C_1-C_6alkyl, C_1-C_6haloalkyl or C_1-C_6alkoxy.

R^{19} is C_1-C_6alkyl or phenyl,

R^{20} is hydroxy, C_1-C_6alkyl, C_1-C_6alkoxy or phenyl,

R^{21} is hydrogen or methyl,

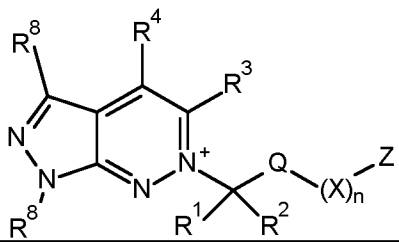
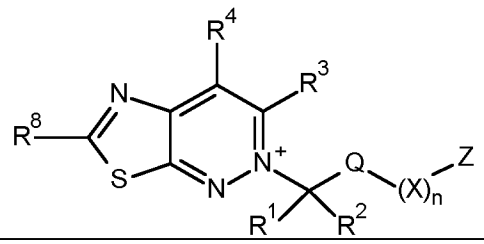
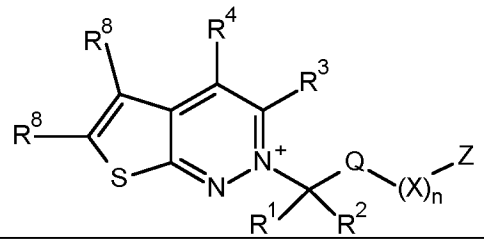
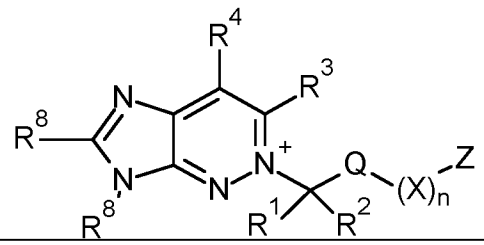
R^{22} is hydrogen or methyl,

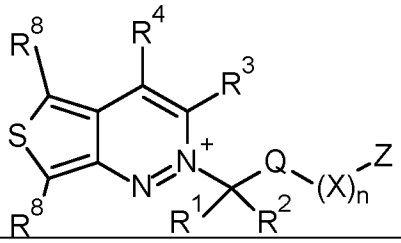
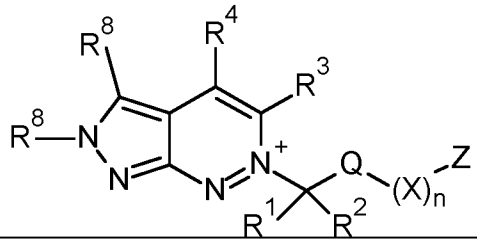
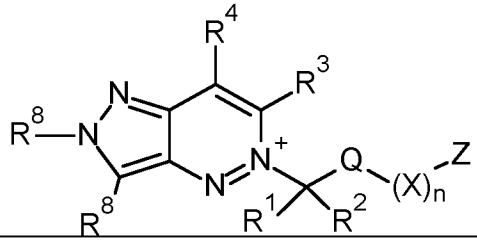
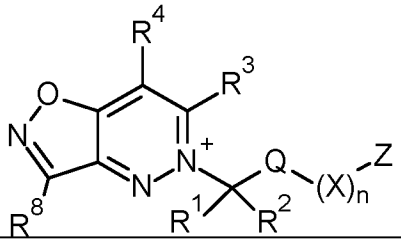
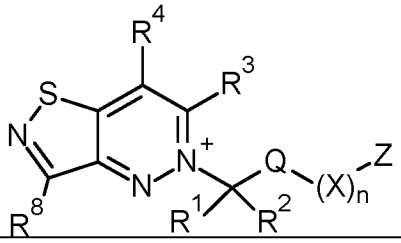
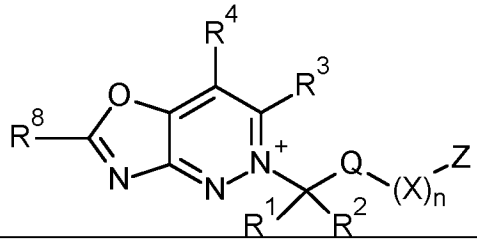
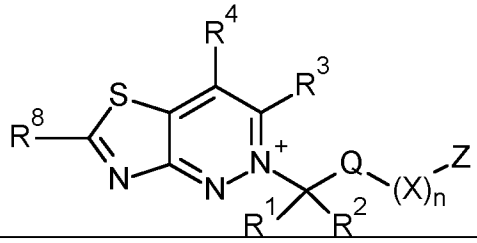
R^{23} is hydrogen or C_1-C_6alkyl.

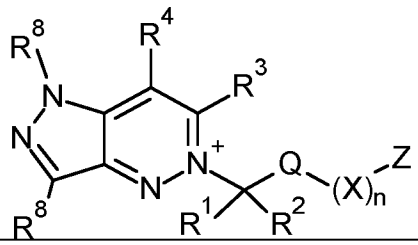
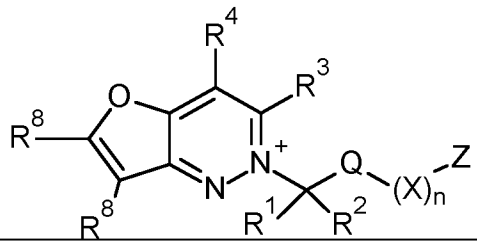
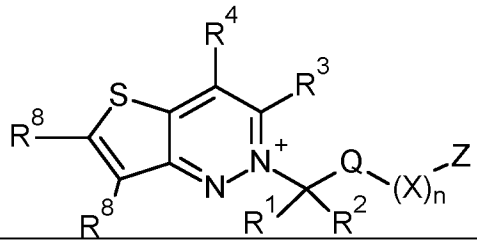
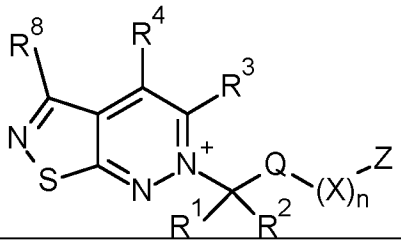
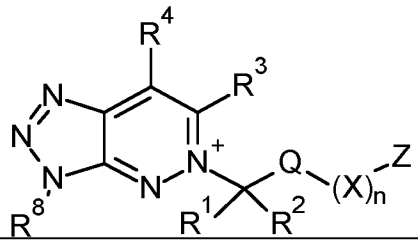
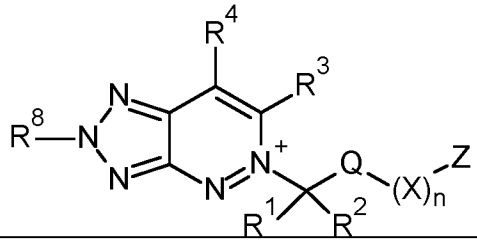
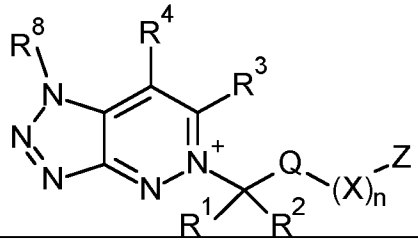
Representative ring structures for compounds of formula (I) are given in table D.

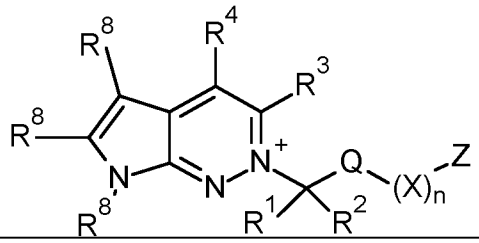
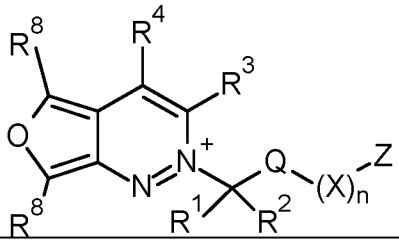
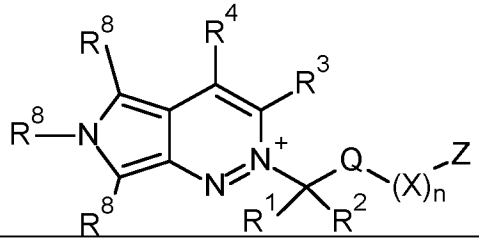
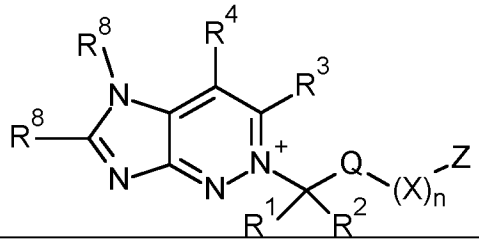
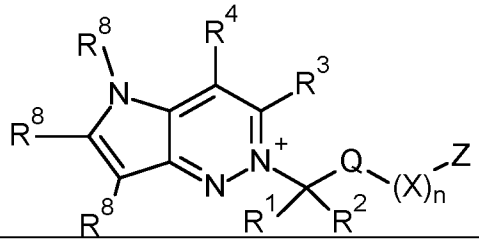
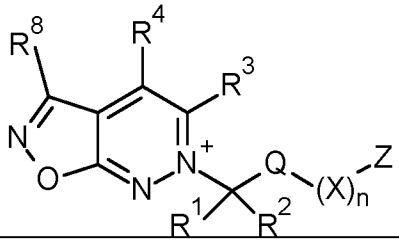
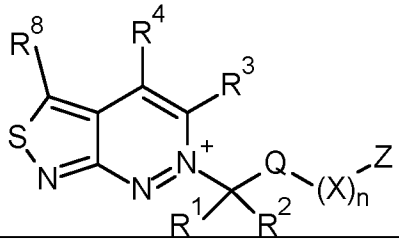
Of the ring structures in Table D, those of 1 to 32 are preferred, 1 to 28 are more preferred, 1 to 14 are even more preferred and most preferred is 1.

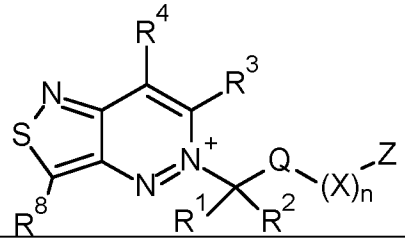
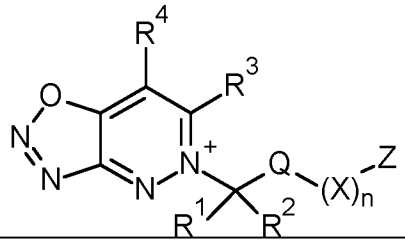
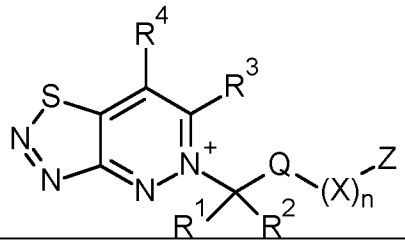
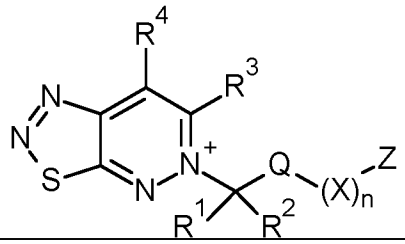
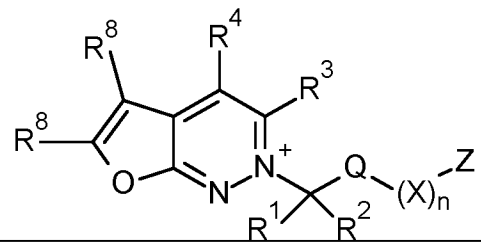
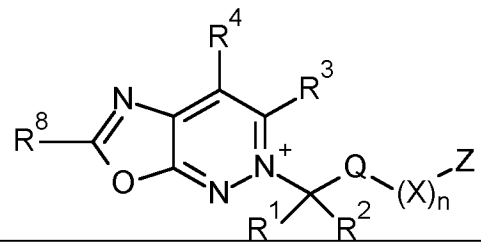
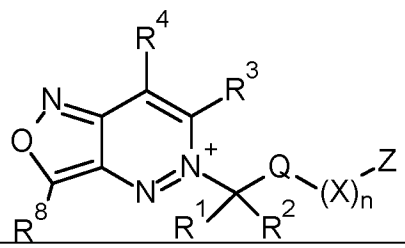
Table D

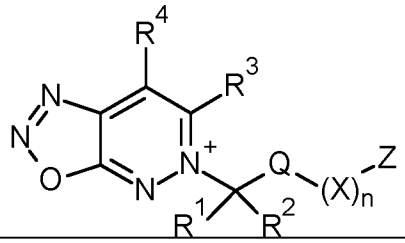
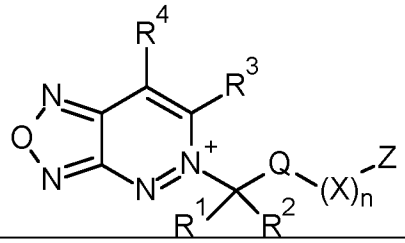
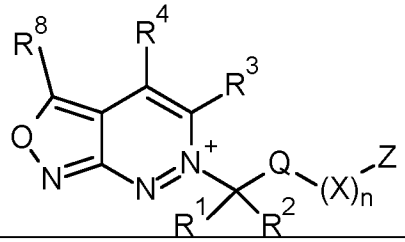
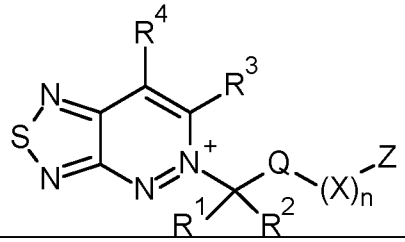
Compound number	Structure
D1	
D2	
D3	
D4	

Compound number	Structure
D5	
D6	
D7	
D8	
D9	
D10	
D11	

Compound number	Structure
D12	
D13	
D14	
D15	
D16	
D17	
D18	

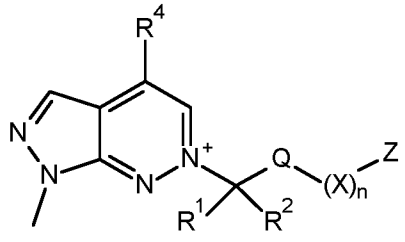
Compound number	Structure
D19	
D20	
D21	
D22	
D23	
D24	
D25	

Compound number	Structure
D26	
D27	
D28	
D29	
D30	
D31	
D32	

Compound number	Structure
D33	
D34	
D35	
D36	

The compounds in Tables 1 to 29 below illustrate the compounds of the invention. The skilled person would understand that the compounds of formula (I) may exist as an agronomically acceptable salt, a zwitterion or an agronomically acceptable salt of a zwitterion as described hereinbefore.

Table 1:
This table discloses 48 specific compounds of the formula (T-1):



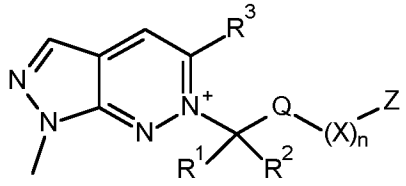
(T-1)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

Compound number	R^4	Z	m	Q
1.001	-P(O)(OH)(OMe)	-H	0	-
1.002	-P(O)(OH)(OMe)	-H	1	$-CH_2$
1.003	-P(O)(OH)(OMe)	-OH	1	$-CH_2$
1.004	-P(O)(OH)(OEt)	-H	0	-

Compound number	R^4	Z	m	Q
1.005	-P(O)(OH)(OEt)	-H	1	$-CH_2$
1.006	-P(O)(OH)(OEt)	-OH	1	$-CH_2$
1.007	-P(O)(OH)(OPr)	-H	0	-
1.008	-P(O)(OH)(OPr)	-H	1	$-CH_2$
1.009	-P(O)(OH)(OPr)	-OH	1	$-CH_2$
1.010	-P(O)(OH)(OiPr)	-H	0	-
1.011	-P(O)(OH)(OiPr)	-H	1	$-CH_2$
1.012	-P(O)(OH)(OiPr)	-OH	1	$-CH_2$
1.013	-P(O)(OH)(OBu)	-H	0	-
1.014	-P(O)(OH)(OBu)	-H	1	$-CH_2$
1.015	-P(O)(OH)(OBu)	-OH	1	$-CH_2$
1.016	-P(O)(OH)(Oallyl)	-H	0	-
1.017	-P(O)(OH)(Oallyl)	-H	1	$-CH_2$
1.018	-P(O)(OH)(Oallyl)	-OH	1	$-CH_2$
1.019	-P(O)(OH)(Opropargyl)	-H	0	-
1.020	-P(O)(OH)(Opropargyl)	-H	1	$-CH_2$
1.021	-P(O)(OH)(Opropargyl)	-OH	1	$-CH_2$
1.022	-P(O)(OH)(OCH_2CF_3)	-H	0	-
1.023	-P(O)(OH)(OCH_2CF_3)	-H	1	$-CH_2$
1.024	-P(O)(OH)(OCH_2CF_3)	-OH	1	$-CH_2$
1.025	-P(O)(OH)(Me)	-H	0	-
1.026	-P(O)(OH)(Me)	-H	1	$-CH_2$
1.027	-P(O)(OH)(Me)	-OH	1	$-CH_2$
1.028	-P(O)(OH)(Et)	-H	0	-
1.029	-P(O)(OH)(Et)	-H	1	$-CH_2$
1.030	-P(O)(OH)(Et)	-OH	1	$-CH_2$
1.031	-P(O)(OH)(Pr)	-H	0	-
1.032	-P(O)(OH)(Pr)	-H	1	$-CH_2$
1.033	-P(O)(OH)(Pr)	-OH	1	$-CH_2$
1.034	-P(O)(OH)(iPr)	-H	0	-
1.035	-P(O)(OH)(iPr)	-H	1	$-CH_2$
1.036	-P(O)(OH)(iPr)	-OH	1	$-CH_2$
1.037	-P(O)(OH)(Bu)	-H	0	-
1.038	-P(O)(OH)(Bu)	-H	1	$-CH_2$
1.039	-P(O)(OH)(Bu)	-OH	1	$-CH_2$
1.040	$-C(O)NHSO_2Me$	-H	0	-
1.041	$-C(O)NHSO_2Me$	-H	1	$-CH_2$
1.042	$-C(O)NHSO_2Me$	-OH	1	$-CH_2$
1.043	$-C(O)NHSO_2Et$	-H	0	-
1.044	$-C(O)NHSO_2Et$	-H	1	$-CH_2$
1.045	$-C(O)NHSO_2Et$	-OH	1	$-CH_2$
1.046	-C(O)OH	-H	0	-
1.047	-C(O)OH	-H	1	$-CH_2$
1.048	-C(O)OH	-OH	1	$-CH_2$

Table 2:
This table discloses 48 specific compounds of the formula (T-2):

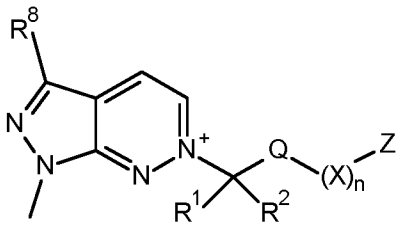


(T-2)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

Compound number	R^3	Z	m	Q
1.001	-P(O)(OH)(OMe)	-H	0	-
1.002	-P(O)(OH)(OMe)	-H	1	$-CH_2$
1.003	-P(O)(OH)(OMe)	-OH	1	$-CH_2$
1.004	-P(O)(OH)(OEt)	-H	0	-
1.005	-P(O)(OH)(OEt)	-H	1	$-CH_2$
1.006	-P(O)(OH)(OEt)	-OH	1	$-CH_2$
1.007	-P(O)(OH)(OPr)	-H	0	-
1.008	-P(O)(OH)(OPr)	-H	1	$-CH_2$
1.009	-P(O)(OH)(OPr)	-OH	1	$-CH_2$
1.010	-P(O)(OH)(OiPr)	-H	0	-
1.011	-P(O)(OH)(OiPr)	-H	1	$-CH_2$
1.012	-P(O)(OH)(OiPr)	-OH	1	$-CH_2$
1.013	-P(O)(OH)(OBu)	-H	0	-
1.014	-P(O)(OH)(OBu)	-H	1	$-CH_2$
1.015	-P(O)(OH)(OBu)	-OH	1	$-CH_2$
1.016	-P(O)(OH)(Oallyl)	-H	0	-
1.017	-P(O)(OH)(Oallyl)	-H	1	$-CH_2$
1.018	-P(O)(OH)(Oallyl)	-OH	1	$-CH_2$
1.019	-P(O)(OH)(Opropargyl)	-H	0	-
1.020	-P(O)(OH)(Opropargyl)	-H	1	$-CH_2$
1.021	-P(O)(OH)(Opropargyl)	-OH	1	$-CH_2$
1.022	-P(O)(OH)(OCH_2CF_3)	-H	0	-
1.023	-P(O)(OH)(OCH_2CF_3)	-H	1	$-CH_2$
1.024	-P(O)(OH)(OCH_2CF_3)	-OH	1	$-CH_2$
1.025	-P(O)(OH)(Me)	-H	0	-
1.026	-P(O)(OH)(Me)	-H	1	$-CH_2$
1.027	-P(O)(OH)(Me)	-OH	1	$-CH_2$
1.028	-P(O)(OH)(Et)	-H	0	-
1.029	-P(O)(OH)(Et)	-H	1	$-CH_2$
1.030	-P(O)(OH)(Et)	-OH	1	$-CH_2$
1.031	-P(O)(OH)(Pr)	-H	0	-
1.032	-P(O)(OH)(Pr)	-H	1	$-CH_2$
1.033	-P(O)(OH)(Pr)	-OH	1	$-CH_2$
1.034	-P(O)(OH)(iPr)	-H	0	-
1.035	-P(O)(OH)(iPr)	-H	1	$-CH_2$
1.036	-P(O)(OH)(iPr)	-OH	1	$-CH_2$
1.037	-P(O)(OH)(Bu)	-H	0	-
1.038	-P(O)(OH)(Bu)	-H	1	$-CH_2$
1.039	-P(O)(OH)(Bu)	-OH	1	$-CH_2$
1.040	-C(O)$NHSO_2$Me	-H	0	-
1.041	-C(O)$NHSO_2$Me	-H	1	$-CH_2$
1.042	-C(O)$NHSO_2$Me	-OH	1	$-CH_2$
1.043	-C(O)$NHSO_2$Et	-H	0	-
1.044	-C(O)$NHSO_2$Et	-H	1	$-CH_2$
1.045	-C(O)$NHSO_2$Et	-OH	1	$-CH_2$
1.046	-C(O)OH	-H	0	-
1.047	-C(O)OH	-H	1	$-CH_2$
1.048	-C(O)OH	-OH	1	$-CH_2$

Table 3:
This table discloses 48 specific compounds of the formula (T-3):



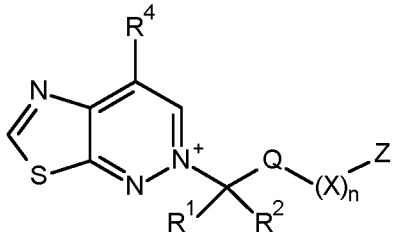
(T-3)

Wherein m, Q, R^8 and Z are as defined in Table 3, R^1, R^2, R^3 and R^4 are hydrogen and n is 0.

Compound number	R^8	Z	m	Q
1.001	-P(O)(OH)(OMe)	-H	0	-
1.002	-P(O)(OH)(OMe)	-H	1	$-CH_2$
1.003	-P(O)(OH)(OMe)	-OH	1	$-CH_2$
1.004	-P(O)(OH)(OEt)	-H	0	-
1.005	-P(O)(OH)(OEt)	-H	1	$-CH_2$
1.006	-P(O)(OH)(OEt)	-OH	1	$-CH_2$
1.007	-P(O)(OH)(OPr)	-H	0	-
1.008	-P(O)(OH)(OPr)	-H	1	$-CH_2$
1.009	-P(O)(OH)(OPr)	-OH	1	$-CH_2$
1.010	-P(O)(OH)(OiPr)	-H	0	-
1.011	-P(O)(OH)(OiPr)	-H	1	$-CH_2$
1.012	-P(O)(OH)(OiPr)	-OH	1	$-CH_2$
1.013	-P(O)(OH)(OBu)	-H	0	-
1.014	-P(O)(OH)(OBu)	-H	1	$-CH_2$
1.015	-P(O)(OH)(OBu)	-OH	1	$-CH_2$
1.016	-P(O)(OH)(Oallyl)	-H	0	-
1.017	-P(O)(OH)(Oallyl)	-H	1	$-CH_2$
1.018	-P(O)(OH)(Oallyl)	-OH	1	$-CH_2$
1.019	-P(O)(OH)(Opropargyl)	-H	0	-
1.020	-P(O)(OH)(Opropargyl)	-H	1	$-CH_2$
1.021	-P(O)(OH)(Opropargyl)	-OH	1	$-CH_2$
1.022	-P(O)(OH)(OCH_2CF_3)	-H	0	-
1.023	-P(O)(OH)(OCH_2CF_3)	-H	1	$-CH_2$
1.024	-P(O)(OH)(OCH_2CF_3)	-OH	1	$-CH_2$
1.025	-P(O)(OH)(Me)	-H	0	-
1.026	-P(O)(OH)(Me)	-H	1	$-CH_2$
1.027	-P(O)(OH)(Me)	-OH	1	$-CH_2$
1.028	-P(O)(OH)(Et)	-H	0	-
1.029	-P(O)(OH)(Et)	-H	1	$-CH_2$
1.030	-P(O)(OH)(Et)	-OH	1	$-CH_2$
1.031	-P(O)(OH)(Pr)	-H	0	-
1.032	-P(O)(OH)(Pr)	-H	1	$-CH_2$
1.033	-P(O)(OH)(Pr)	-OH	1	$-CH_2$
1.034	-P(O)(OH)(iPr)	-H	0	-
1.035	-P(O)(OH)(iPr)	-H	1	$-CH_2$
1.036	-P(O)(OH)(iPr)	-OH	1	$-CH_2$
1.037	-P(O)(OH)(Bu)	-H	0	-
1.038	-P(O)(OH)(Bu)	-H	1	$-CH_2$
1.039	-P(O)(OH)(Bu)	-OH	1	$-CH_2$
1.040	$-C(O)NHSO_2Me$	-H	0	-
1.041	$-C(O)NHSO_2Me$	-H	1	$-CH_2$
1.042	$-C(O)NHSO_2Me$	-OH	1	$-CH_2$
1.043	$-C(O)NHSO_2Et$	-H	0	-

Compound number	R^8	Z	m	Q
1.044	$-C(O)NHSO_2Et$	-H	1	$-CH_2$
1.045	$-C(O)NHSO_2Et$	-OH	1	$-CH_2$
1.046	-C(O)OH	-H	0	-
1.047	-C(O)OH	-H	1	$-CH_2$
1.048	-C(O)OH	-OH	1	$-CH_2$

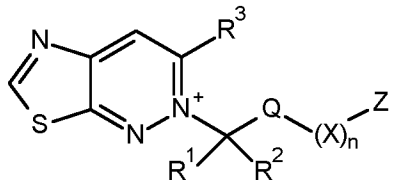
Table 4:
This table discloses 48 specific compounds of the formula (T-4):



(T-4)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

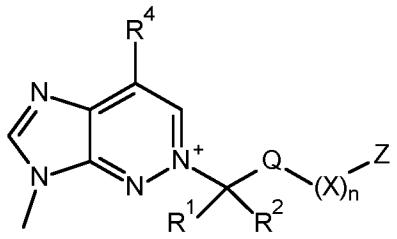
Table 5:
This table discloses 48 specific compounds of the formula (T-5):



(T-5)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

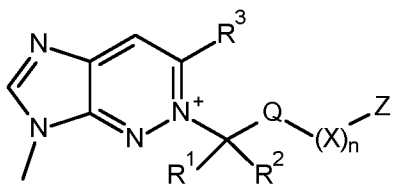
Table 6:
This table discloses 48 specific compounds of the formula (T-6):



(T-6)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

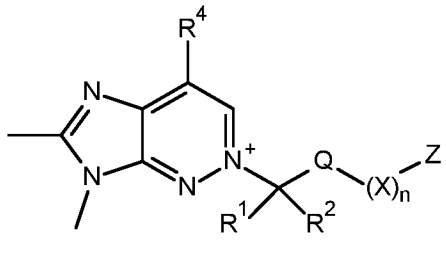
Table 7:
This table discloses 48 specific compounds of the formula (T-7):



(T-7)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

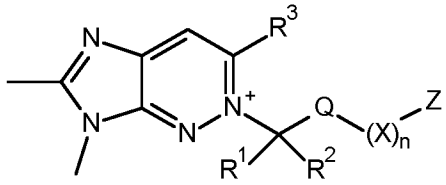
Table 8:
This table discloses 48 specific compounds of the formula (T-8):



(T-8)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

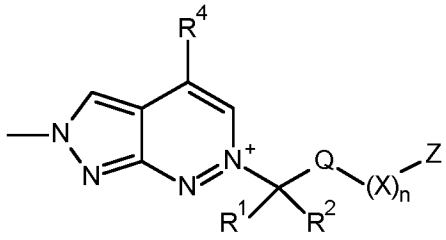
Table 9:
This table discloses 48 specific compounds of the formula (T-9):



(T-9)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

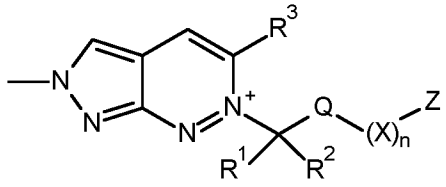
Table 10:
This table discloses 48 specific compounds of the formula (T-10):



(T-10)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

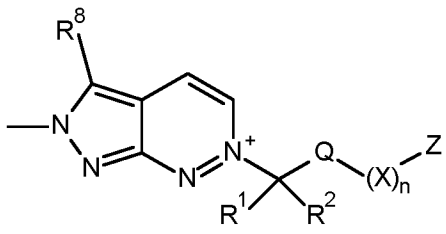
Table 11:
This table discloses 48 specific compounds of the formula (T-11):



(T-11)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

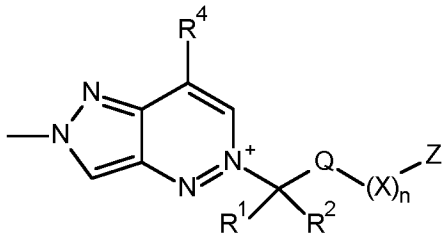
Table 12:
This table discloses 48 specific compounds of the formula (T-12):



(T-12)

Wherein m, Q, R^8 and Z are as defined in Table 3, R^1, R^2, R^3 and R^4 are hydrogen and n is 0.

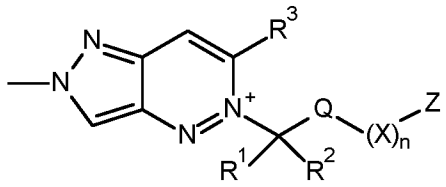
Table 13:
This table discloses 48 specific compounds of the formula (T-13):



(T-13)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

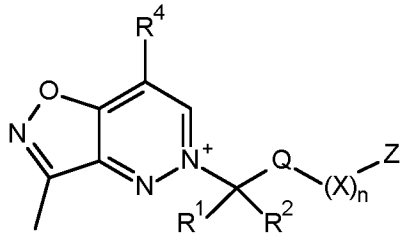
Table 14:
This table discloses 48 specific compounds of the formula (T-14):



(T-14)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

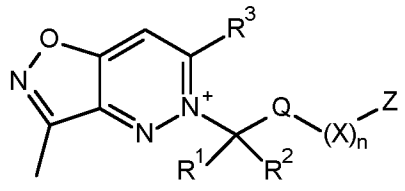
Table 15:
This table discloses 48 specific compounds of the formula (T-15):



(T-15)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

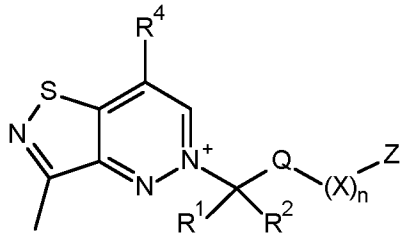
Table 16:
This table discloses 48 specific compounds of the formula (T-16):



(T-16)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

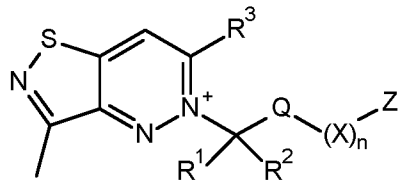
Table 17:
This table discloses 48 specific compounds of the formula (T-17):



(T-17)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

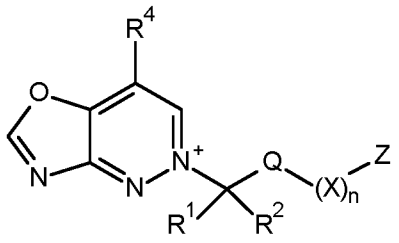
Table 18:
This table discloses 48 specific compounds of the formula (T-18):



(T-18)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

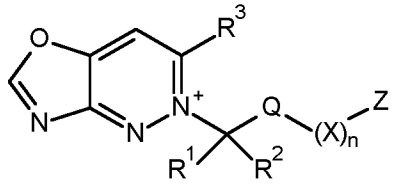
Table 19:
This table discloses 48 specific compounds of the formula (T-19):



(T-20)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

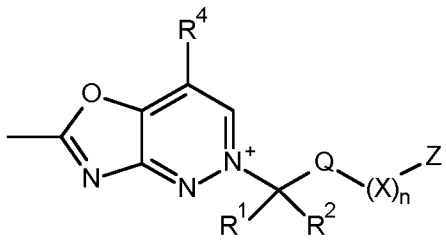
Table 21:
This table discloses 48 specific compounds of the formula (T-21):



(T-21)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

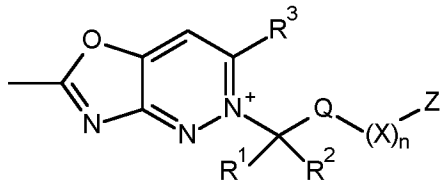
Table 22:
This table discloses 48 specific compounds of the formula (T-22):



(T-22)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

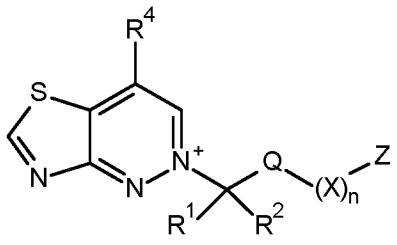
Table 23:
This table discloses 48 specific compounds of the formula (T-23):



(T-23)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

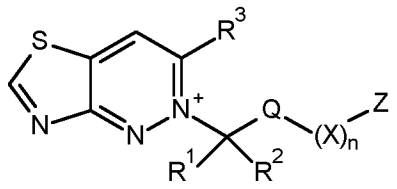
Table 24:
This table discloses 48 specific compounds of the formula (T-24):



(T-24)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

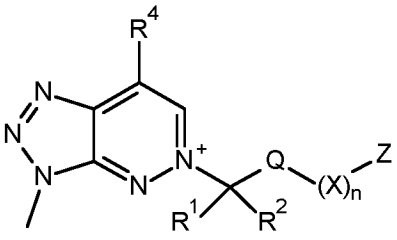
Table 25:
This table discloses 48 specific compounds of the formula (T-25):



(T-25)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

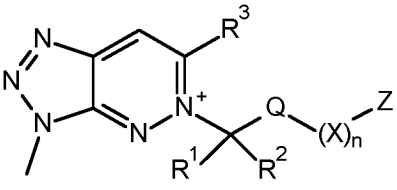
Table 26:
This table discloses 48 specific compounds of the formula (T-26):



(T-26)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

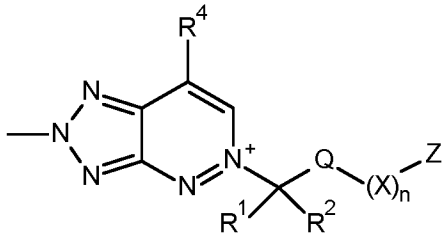
Table 27:
This table discloses 48 specific compounds of the formula (T-27):



(T-27)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

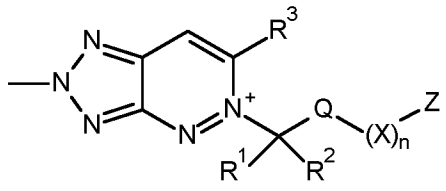
Table 28:
This table discloses 48 specific compounds of the formula (T-28):



(T-28)

Wherein m, Q, R^4, and Z are as defined in Table 1, R^1, R^2 and R^3 are hydrogen and n is 0.

Table 29:
This table discloses 48 specific compounds of the formula (T-29):



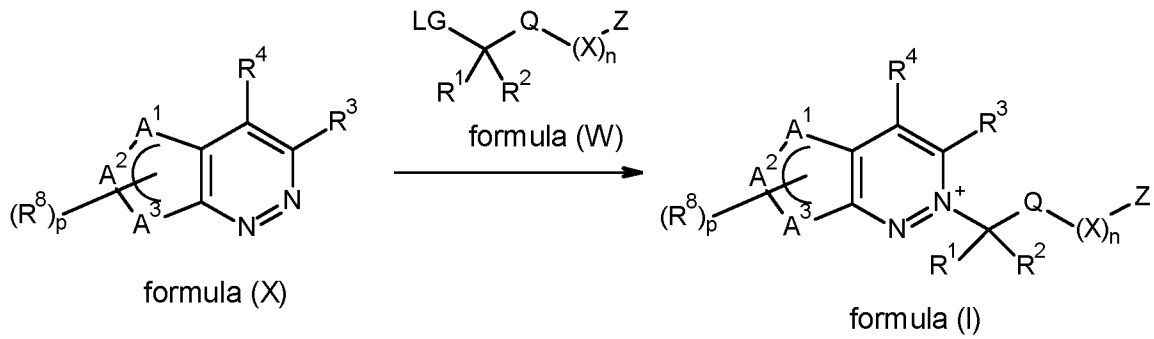
(T-29)

Wherein m, Q, R^3, and Z are as defined in Table 2, R^1, R^2 and R^4 are hydrogen and n is 0.

The compounds of formula (I) may be prepared by the alkylation of compounds of formula (X), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as defined for compounds of formula (I), with a suitable alkylating agent of formula (W), wherein n, R^1, R^2, Q, X and Z are as defined for compounds of formula (I) and LG is a suitable leaving group, for example, halide or pseudohalide such as triflate, mesylate or tosylate, in a suitable solvent at a suitable temperature, as described in reaction scheme 1. Example conditions include stirring a compound of formula (X) with an alkylating agent of formula (W) in a solvent, or mixture of solvents, such as acetone, dichloromethane, dichloroethane, *N,N*-dimethylformamide, acetonitrile, 1,4-dioxane, water, acetic acid or trifluroacetic acid at a temperature between -78ºC and 150ºC. An alkylating agent of formula (W) may include, but is not limited to, methyl iodide, methyl chloride, methyl bromide, methyl triflate, dimethyl sulfate, ethyl iodide, ethyl chloride, ethyl bromide, ethyl triflate, diethyl sulfate, propyl iodide, propyl chloride, propyl bromide, propyl triflate, dipropyl sulfate, butyl iodide, butyl chloride, butyl bromide, butyl triflate, dibutyl sulfate, iodoethanol, chloroethanol, bromoethanol, bromoacetic acid, methyl bromoacetate, 3-bromopropionoic acid, methyl 3-bromopropionate, 2-bromo-*N*-methoxyacetamide, sodium 2-bromoethanesulphonate, 2,2-dimethylpropyl 2-(trifluoromethylsulfonyloxy)ethanesulfonate, 2-bromo-*N*-methanesulfonylacetamide, 3-bromo-*N*-methanesulfonylpropanamide, dimethoxyphosphorylmethyl trifluoromethanesulfonate, dimethyl 3-bromopropylphosphonate, 3-chloro-2,2-dimethyl-propanoic acid and diethyl 2-bromoethylphosphonate. Such alkylating agents and related compounds are either known in the literature or may be prepared by known literature methods. Compounds of formula (I) which may be described as esters of *N*-alkyl acids, which include, but are not limited to, esters of carboxylic acids, phosphonic acids, phosphinic acids, sulfonic acids and sulfinic acids, may be subsequently partially or fully hydrolysed by treament with a

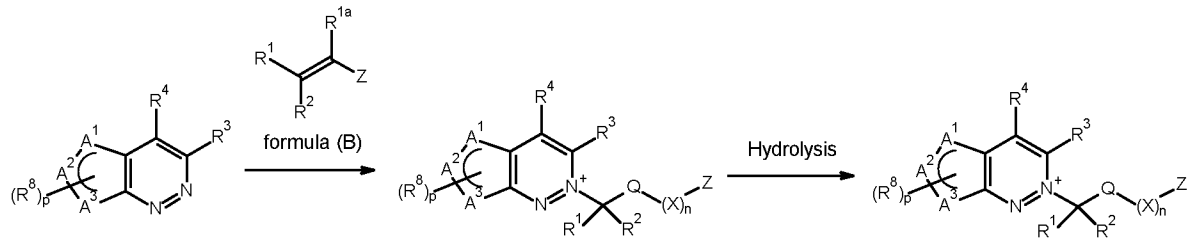
suitable reagent, for example, aqueous hydrochloric acid or trimethylsilyl bromide, in a suitable solvent at a suitable temperature between 0ºC and 100ºC.

Reaction scheme 1



Additionally, compounds of formula (I) may be prepared by reacting compounds of formula (X), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as defined for compounds of formula (I), with a suitably activated electrophilic alkene of formula (B), wherein R^1, R^2 and R^{1a} are as defined for compounds of formula (I) and Z is SO_3R^{11}, $P(O)(R^{13})(OR^{10})$ or $C(O)OR^{10}$, in a suitable solvent at a suitable temperature. Compounds of formula (B) are known in the literature, or may be prepared by known methods. Example reagents include, but are not limited to, acrylic acid, methacrylic acid, crotonic acid, 3,3-dimethylacrylic acid, methyl acrylate, ethene sulfonic acid, isopropyl ethylenesulfonate, 2,2-dimethylpropyl ethenesulfonate and dimethyl vinylphosphonate. The direct products of these reactions, which may be described as esters of N-alkyl acids, which include, but are not limited to, esters of carboxylic acids, phosphonic acids, phosphinic acids, sulfonic acids and sulfinic acids, may be subsequently partially or fully hydrolysed by treament with a suitable reagent in a suitable solvent at a suitable temperature, as described in reaction scheme 2.

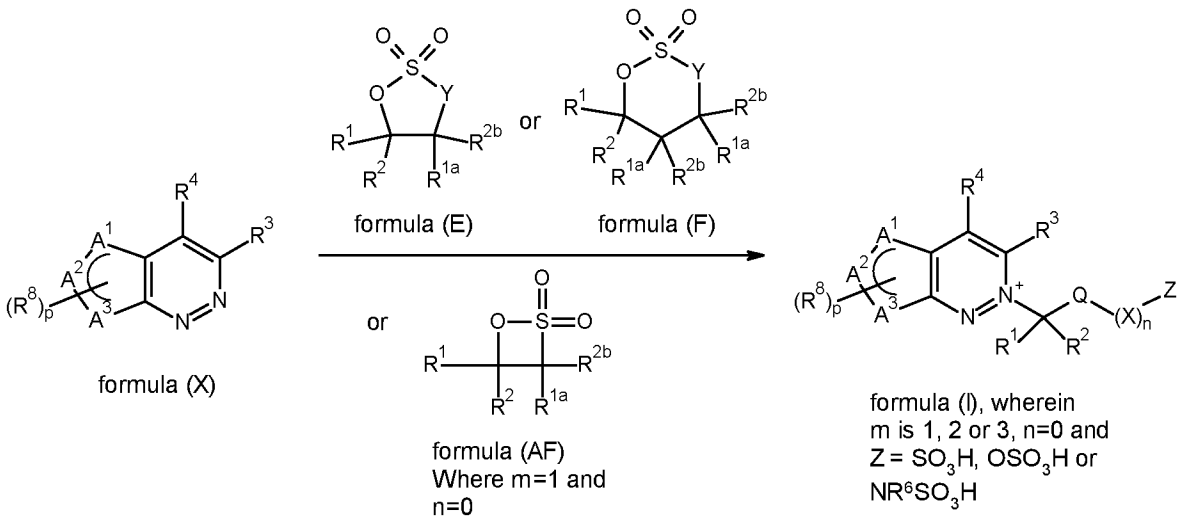
Reaction scheme 2



In a related reaction compounds of formula (I), wherein Q is $C(R^{1a}R^{2b})$, m is 1, 2 or 3, n=0 and Z is SO_3H, OSO_3H or NR^6SO_3H, may be prepared by the reaction of compounds of formula (X), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as defined for compounds of formula (I), with a cyclic alkylating agent of formula (E), (F) or (AF), wherein Y is $C(R^{1a}R^{2b})$, O or NR^6 and R^1, R^2, R^{1a} and R^{2b} are as defined for compounds of formula (I), in a suitable solvent at a suitable temperature, as described in reaction scheme 3. Suitable solvents and suitable temperatures are as previously described. An alkylating agent of formula (E) or (F) may include, but is not limited to, 1,3-propanesultone, 1,4-butanesultone, ethylenesulfate, 1,3-

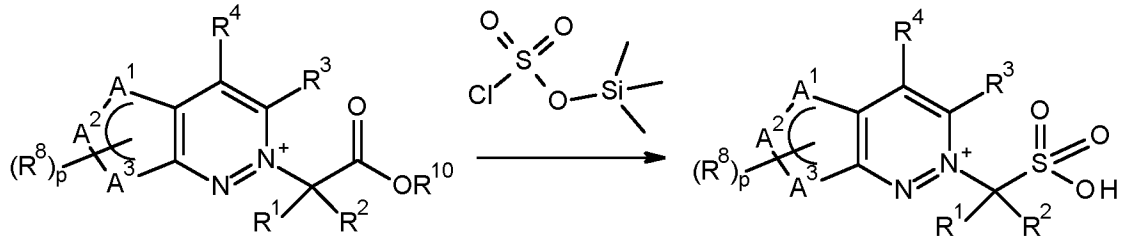
propylene sulfate and 1,2,3-oxathiazolidine 2,2-dioxide. Such alkylating agents and related compounds are either known in the literature or may be prepared by known literature methods.

Reaction scheme 3



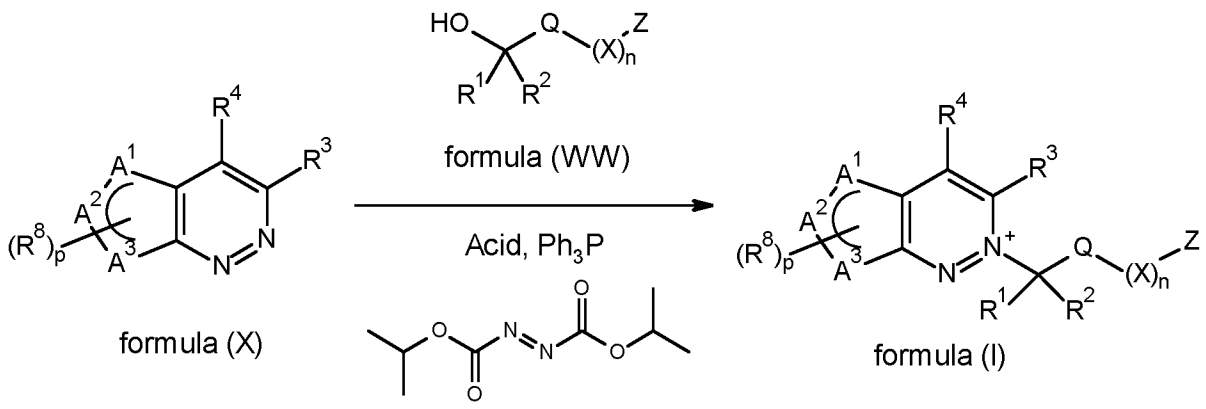
A compound of formula (I), wherein m is 0, n is 0 and Z is SO_3H, may be prepared from a compound of formula (I), wherein m is 0, n is 0 and Z is $C(O)OR^{10}$, by treatment with trimethylsilylchlorosulfonate in a suitable solvent at a suitable temperature, as described in reaction scheme 4. Preferred conditions include heating the carboxylate precursor in neat trimethylsilylchlorosulfonate at a temperature between 25ºC and 150ºC.

Reaction scheme 4



Furthermore, compounds of formula (I) may be prepared by reacting compounds of formula (X), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as previously defined, with a suitable alcohol of formula (WW), wherein R^1, R^2, Q, X, n and Z are as defined for compounds of formula (I), under Mitsunobu-type conditions such as those reported by Petit et al, Tet. Lett. 2008, 49 (22), 3663. Suitable phosphines include triphenylphosphine, suitable azodicarboxylates include diisopropylazodicarboxylate and suitable acids include fluoroboric acid, triflic acid and bis(trifluoromethylsulfonyl)amine, as described in reaction scheme 5. Such alcohols are either known in the literature or may be prepared by known literature methods.

Reaction scheme 5

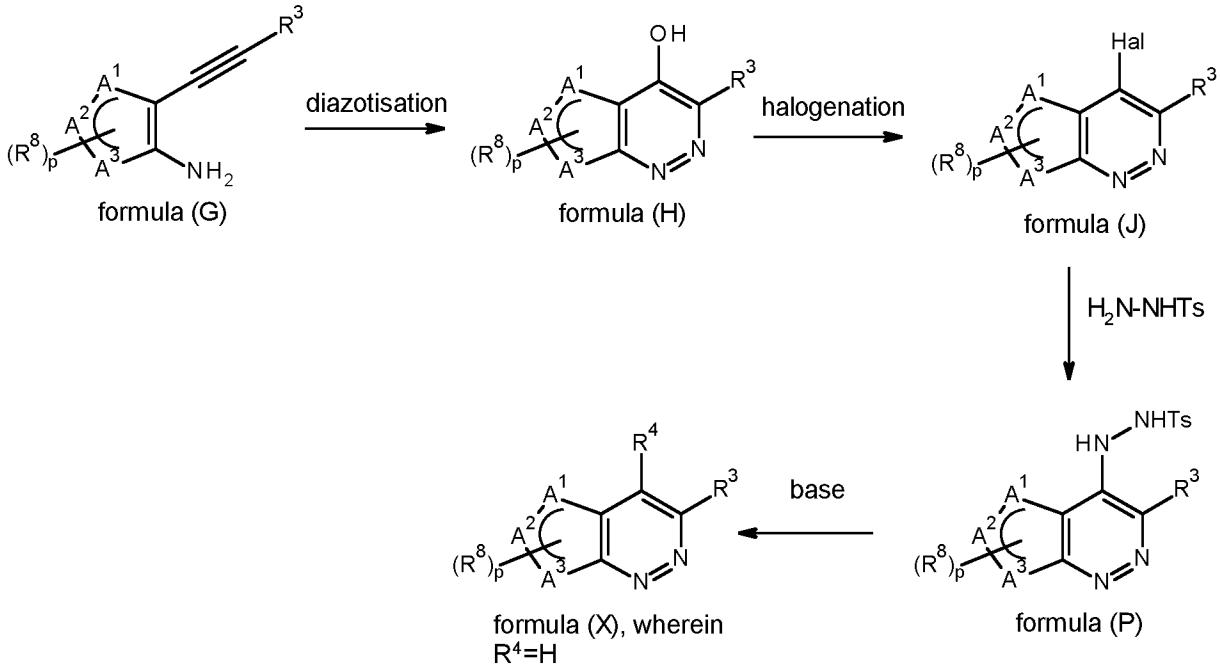


Compounds of formula (X) are known in the literature, or may be prepared by known methods. See for example Lund, H.; Gruhn, S. Acta Chem. Scand. 1966, 20(10), 2637, Wells, F. V.; Castle, R. N.; Cook, P. D. J. Het. Chem. 1976, 13(5), 1009, Liu et al CN 103664996, Altmann et al WO 2014002058, Babu et al WO 2011031554, Ball, C. J.; Gilmore, J.; Willis, M. C. Angew. Chem. Int. Ed. 2012, 51(23), 5718, Behalo, M. S.; Issac, Y. A. Olaj, Szappan, Kozmetika 2012, 61(1-2), 41, Blaquiere et al WO 2015025025, Cacciari, B.; Spalluto, G.; Ferretti, V. Journal of Heterocyclic Chemistry 2003, 40(6), 1065, Deghati, P. Y. F.; Wanner, M. J.; Koomen, G. Tetrahedron Letters 1998, 39(25), 4561, Dornow, A.; Abele, W. Chemische Berichte 1964, 97(12), 3349, Druey, J. Angewandte Chemie 1958, 70, 5, El-Dean, A. M. K.; Gaber, A. E. M.; El-Gaby, M. S. A.; Eyada, H. A.; Al-Kamali, A. S. N. Phosphorus, Sulfur and Silicon and the Related Elements 2004, 179(2), 321, Findlay et al WO 2017136871, Galatsis et al WO 2015092592, Gerhardt, G. A.; Castle, R. N. J. Het. Chem. 1964, 1(5), 247, Harcken, C.; Ward, Y.; Thomson, D.; Riether, D. Synlett 2005, (20), 3121, Jones, G.; Rafferty, P., Tetrahedron 1979, 35(17), 2027, Kuraishi, T.; Castle, R. N. J. Het. Chem. 1964, 1(1), 42, Kuraishi, Tsukasa; Castle, Raymond N. J. Het. Chem. 1966, 3(2), 218, Moody, C. J.; Rees, C. W.; Tsoi, S. C. J. Chem. Soc., Chem. Commun., 1981, (11), 550, Munoz-Mingarro, D.; Lozach, O.; Meijer, L. J. Med. Chem. 2005, 48(22), 6843, Murakami, H.; Castle, R. N. J. Het. Chem. 1967, 4(4), 555, Patel, N. R.; Rich, W. M.; Castle, R. N. J. Het. Chem. 1968, 5(1), 13, Poole, A. J.; Rose, F. L. Chem. Commun., 1969, (6), 281, Ramanaiah, K. C. V.; Stevens, E. D.; Trudell, M. L.; Pagoria, P. F. Journal of Heterocyclic Chemistry 2000, 37(6), 1597, Rose, F. L.; Poole, A. J. J. Chem. Soc. C 1971, (7), 1285, Sako, M. Science of Synthesis (2004), 16, 1109, Schmidt, P.; Eichenberger, K.; Wilhelm, M. Angewandte Chemie 1961, 73, 15, Tan et al WO 2017133667, Tan, X.; Shen, H.; Wu, J.; Liu, Y.; Li, D.; Wang, L.; Neidhart, W.; Shi, T.; Wu, G. J. Med. Chem. 2017, 60(10), 4458 and Yanai, M.; Takeda, S.; Mitsuoka, T. Chemical & Pharmaceutical Bulletin 1977, 25(7), 1708.

In one approach a compound of formula (X), wherein R^3, R^4, R^8 and p are as defined for compounds of formula (I) and R^4 is hydrogen, may be prepared by a sequence starting with the diazotisation of an optionally substituted 2-alkynylaniline of formula (G) wherein R^3, R^8 and p are as defined for compounds of formula (I), with either an inorganic nitrite or alkyl nitrite in the presence of acid in a suitable solvent at a suitable temperature (for example Von Richter, V. Chem. Ber., 1883, 677-683) to afford the derived 4-hydroxy cinnoline of formula (H) wherein R^3, R^8 and p are as defined for compounds of formula (I) or

4-haloxy cinnoline of formula (J) wherein R^3, R^8 and p are as defined for compounds of formula (I). For similar chemistry see Alagramam, K. N.; Gopal, S. R.; Geng, R.; Chen, D. H-C.; Nemet, I.; Lee, R.; Tian, G.; Miyagi, M.; Malagu, K. F.; Lock, C. J.; Esmieu, W. R. K.; Owens, A. P.; Lindsay, N. A.; Ouwehand, K.; Albertus, F.; Fischer, D. F.; Burli, R. W.; MacLeod, A. M.; Harte, W. E.; Palczewski, K.; Imanishi, Y. Nature Chemical Biology, 2016, 12(6), 444. A compound of formula (H) may be converted to a compound of formula (J), wherein halogen is chlorine or bromine, by treatment with known halogenating agents, such as phosphoryl halide, in a suitable solvent at a suitable temperature (for example Ruchelman, A. L. et al Bioorg. Med. Chem., 2004, 12(4), 795-806). A compound of formula (J), wherein halogen is chlorine or bromine, may be reduced to a compound of formula (X), wherein R^4 is hydrogen, by a variety of methods including treatment with tosyl hydrazine to prepare a compound of formula (P) wherein R^3, R^8 and p are as defined for compounds of formula (I) followed by base, such as aqueous sodium carbonate, in a suitable solvent at a suitable temperature (for example Osborn, A. R.; Schofield, K. J. Chem. Soc., 1956, 4207-13). This sequence of reactions is as described in reaction scheme 7. Compounds of formula (G) are known in the literature or may be prepared by known methods (for example Bernier et al WO 2016102435, Schieweck et al WO 2005040162, Tretyakov, E. V.; Knight, D. W.; Vasilevsky, S. F. J. Chem. Soc., Perkin Trans. 1, 1999, 24, 3713, Belov, A. I.; Terekhova, M. I.; Petrov, E. S.; Vasilevskii, S. F.; Shvartsberg, M. S. Izvestiya Akademi Nauk, Seriya Khimicheskaya, 1992, (3), 507, Vasilevskii, S. F.; Anisimova, T. V.; Shvartsberg, M. S. Izvestiya Akademii Nauk SSSR, Seriya Khimicheskaya, 1983, (3), 688 and Moody, D. L. et al Bioorg. Med. Chem. Lett., 2007, 17(8), 2380-2384).

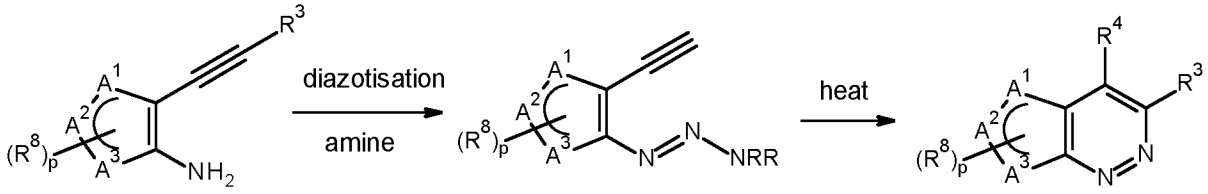
Reaction scheme 7



In a related reaction compounds of formula (X), wherein both R^3 and R^4 are hydrogen, may be prepared by the thermal rearrangement of compounds of formula (K) under neutral conditions. Triazenes of formula (K) may be prepared by the diazotization of 2-ethynylanilines of formula (G), wherein R^3 is hydrogen, followed by trapping with an amine, such as diethylamine (for example, Kehoe, J. M. et al

Org. Lett., 2000, 2(7), 969-972). These triazenes may be heated in an appropriate solvent at an appropriate temperature, such as dichlorobenzene at 200ºC, to achieve the desired cyclisation (for example, Kimball, D. B. et al J. Org. Chem., 2002, 67(18), 6395-6405), as described in reaction scheme 8.

Reaction scheme 8



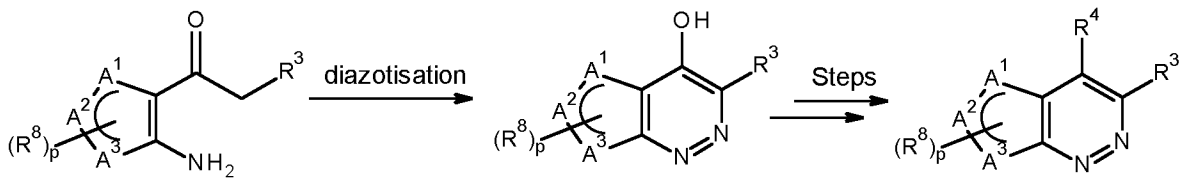
formula (G), wherein R^3=H

formula (K), wherein R = H or C_{1-6}alkyl

formula (X), wherein R^3=H, R^4=H

In another approach a compound of formula (X), wherein R^4 is hydrogen, may be prepared by a sequence starting with the diazotisation of an optionally substituted 2-aminoarylketone of formula (L), wherein R^3, R^8, A^1, A^2, A^3 and p are as defined for compounds of formula (I), with either an inorganic nitrite or alkyl nitrite in the presence of acid in a suitable solvent at a suitable temperature (for similar chemistry see Burli et al WO 2014066836, Babu et al WO 2012106448, Borsche, W.; Herbert, A. Liebigs Ann. Chem., 1941, 546, 293, and Koelsch, C. F. J. Org. Chem., 1943, 8, 295) to afford a compound of formula (H), as described in reaction scheme 9. A compound of formula (H) may be further derivatised as described previously. Compounds of formula (L) are known in the literature or may be prepared by known methods (for example, Stevens, M. A.; Giner-Sorolla, A.; Smith, H. W.; Brown, G. B. J. Org. Chem. 1962, 27, 567, Kiehneet al DE 1945964, Lam, F. L.; Parham, J. C. J. Am. Chem. Soc. 1975, 97(10), 2839, Stepanova, S. V.; L'vova, S. D.; Belikov, A. B.; Gunar, V. I. Zhurnal Organicheskoi Khimii 1977, 13(4), 889, Albert, A.; Lin, C. J. J. Chem. Soc., Perkin Trans. 1, 1977, (16), 1819, Grell et al DE 2722416, Kulikov, A. S.; Makhova, N. N.; Godovikova, T. I.; Golova, S. P.; Khmel'nitskii, L. I. Izvestiya Akademii Nauk, Seriya Khimicheskaya 1994, (4), 679, Cernuchova, P.; Vo-Thanh, G.; Milata, V.; Loupy, A.; Jantova, S.; Theiszova, M. Tetrahedron, 2005, 61(22), 5379, Eller, G. A.; Holzer, W. Molecules 2006, 11(5), 371 and Jana, S. et al Org. Biomol. Chem., 2015, 13(31), 8411-8415).

Reaction scheme 9



formula (L)

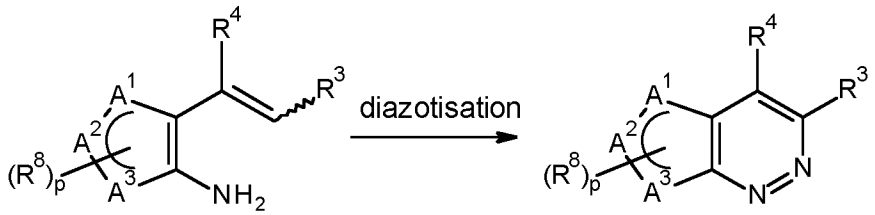
formula (H)

formula (X), wherein R^4=H

In a further approach a compound of formula (X) may be prepared by the diazotisation of a 2-aminostyrene of formula (Q), wherein R^3, R^8, A^1, A^2, A^3 and p are as defined for compounds of formula (I), with either an inorganic nitrite or alkyl nitrite in the presence of acid in a suitable solvent at a suitable temperature (for related chemistry see Widman, O. Chem. Ber., 1884, 17, 722 and Stoermer, R.; Fincke, H. Chem. Ber., 1909, 42, 3115), as described in reaction scheme 10. Compounds of

formula (Q) are known in the literature or may be prepared by known methods (for example, Tiebes et al WO 2016102420, Wagner, F. F.; Bishop, J. A.; Gale, J. P.; Shi, .; Walk, M.; Ketterman, J.; Patnaik, D.; Barker, D.; Walpita, D.; Campbell, A. J.; Nguyen, S.; Lewis, M.; Ross, L.; Weiwer, M.; An, W. F.; Germain, A. R.; Nag, P. P.; Metkar, S.; Kaya, T.; Dandapani, S.; Olson, D. E.; Barbe, A-L.; Lazzaro, F.; Sacher, J. R.; Cheah, J. H.; Fei, D.; Perez, J.; Munoz, B.; Palmer, M.; Stegmaier, K.; Schreiber, S. L.; Scolnick, E.; Zhang, Y-L.; Haggarty, S. J.; Holson, E. B.; Pan, J. Q. Chemical Biology 2016, 11(7), 1952, Holladay et al WO 2017019804, Wang et al CN 108264520 and Kobayashi, K. et al Heterocycles, 2008, 75(1), 95-105).

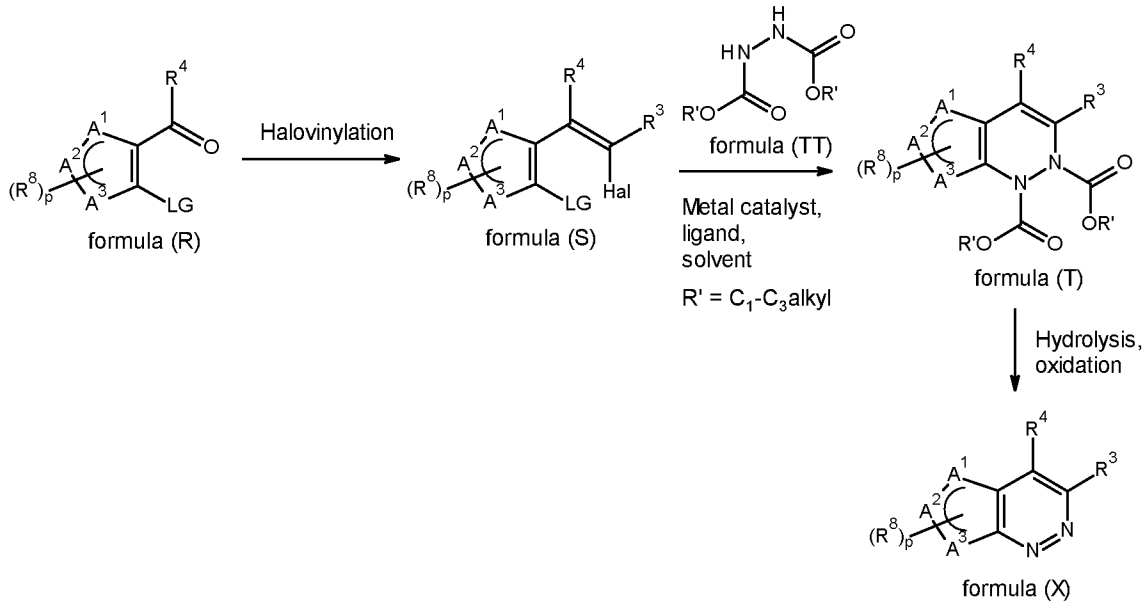
Reaction scheme 10



formula (Q) formula (X)

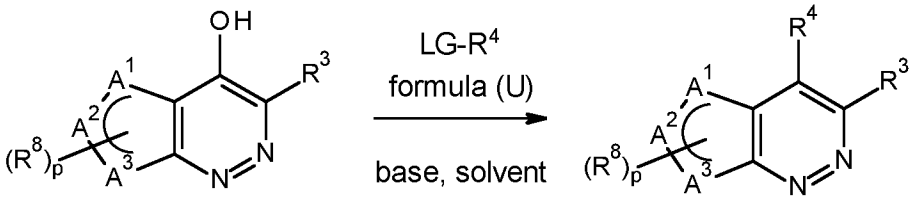
In an alternative approach a compound of formula (X) may be prepared, as described in reaction scheme 11, by a sequence starting with the conversion of a compound of formula (R) to a halo-alkene of formula (S), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as defined for a compound of formula (I), LG is a halide or pseudohalide such as triflate, mesylate or tosylate and Hal is either chlorine, bromine or iodine. Such a transformation is carried out by a suitable reagent in a suitable solvent at a suitable temperature, for example treating a compound of formula (R) with a halomethyltriphenylphosphonium salt in the presence of a base such as potassium *tert*-butoxide in a solvent such as tetrahydrofuran. A compound of formula (S) may then be coupled with a compound of formula (TT), wherein R‘ is C_1-C_3 alkyl, in the presence of a suitable transition metal catalyst, suitable ligand, suitable base and in a suitable solvent. Example conditions include treating a compound of formula (S) with diethyl hydrazine-1,2-dicarboxylate, copper iodide, 1,2-ethanediamine and potassium carbonate in 1,4-dioxane. A compound of formula (T) may then be converted to a compound of formula (X) by treatment with aqueous sodium hydroxide followed by aerial oxidation. See, for example, Ball, C. J.; Gilmore, J.; Willis, M. C. Angew. Chem. Int. Ed., 2012, 51(23), 5718.

Reaction scheme 11



Compounds of formula (H), wherein R^3, R^8, A^1, A^2, A^3 and p are as previously defined, may be further derivatised by alkylation or acylation with a range of carbon electrophiles of formula (U), wherein R^4 is C_1-C_6alkyl, C_1-C_6alkylcarbonyl, C_3-C_6cycloalkyl, C_1-C_6haloalkyl, C_3-C_6alkenyl, C_3-C_6alkynyl, C_1-C_6alkoxycarbonyl, C_1-C_6alkylaminocarbonyl or di-C_1-C_6alkylaminocarbonyl and wherein LG is a halide or pseudohalide such as triflate, mesylate or tosylate, or by reaction with suitably activated electrophilic alkene, in the presence of an appropriate base, in an appropriate solvent at an appropriate temperature (for example, see WO2011/159854), as described in reaction scheme 12.

Reaction scheme 12

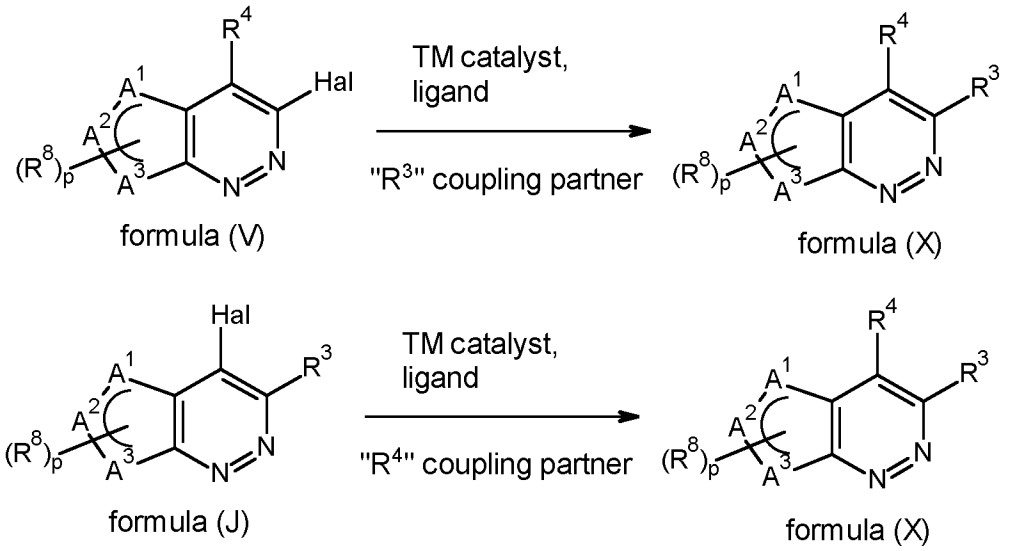


formula (A), wherein
R^4= OR^7 (R^7 is not H),
C_3-C_6cycloalkoxy,
C_1-C_6haloalkoxy,
C_3-C_6alkenyloxy,
C_3-C_6alkynyloxy.

A compound of formula (V) and a compound of formula (J), wherein R^3, R^4, R^8, A^1, A^2, A^3 and p are as defined for a compound of formula (I) and Hal is a halogen or pseudo-halogen such as mesylate, tosylate or triflate, may both be derivatised by a range of transition-metal catalyzed cross couplings, including but not limited to, Suzuki (for example Heiter, H. J. et al J. Heterocyclic. Chem., 2013, 50(1), 141-144), Negishi (for example see WO2015/086523), Stille (for example Bui, C. T.; Flynn, B. L. Mol. Divers., 2011, 15(1), 83-89) Sonogashira (for example Heiter, H. J. et al J. Heterocyclic. Chem., 2013, 50(1),

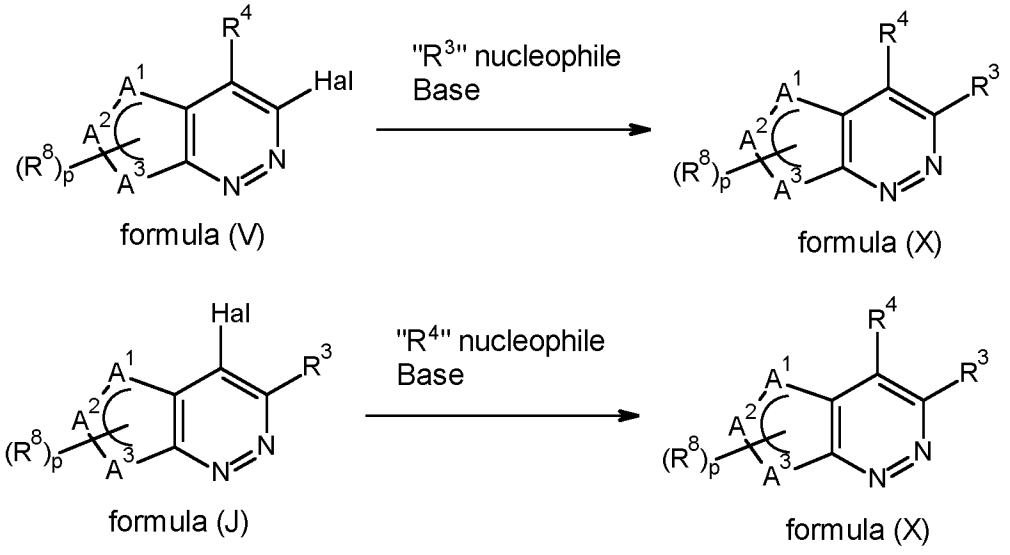
141-144) and Heck (for example Ames, D. E.; Bull, D. Tetrahedron, 1982, 38, 383), as described in reaction scheme 13. The coupling partners may be selected with reference to the specific cross coupling reaction and target product. Transition metal catalysts, ligands, bases, solvents and temperatures may be selected with reference to the desired coupling and are known in the literature. Cross-coupling reactions using pseudo halides, including but not limited to, triflates, mesylates and tosylates, may also be achieved under related conditions.

Reaction scheme 13



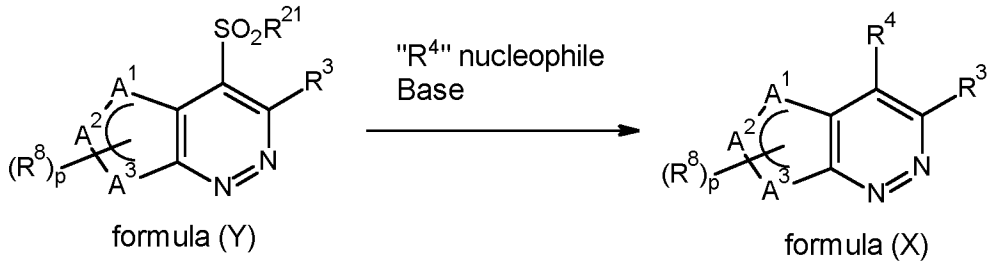
A compound of formula (V) and a compound of formula (J), as previously described, may both be further derivatised by substitution with various nucleophiles to afford a compound of formula (X), as described in reaction scheme 14. Suitable nucleophiles include, but are not limited to, optionally substituted alcohols, amines, thiols and sulfinates. Such a substitution is preferably achieved at the C4 position, and these reactions are known in the literature.

Reaction scheme 14



Analogous reactions may also be carried out using compounds of formula (Y), wherein R^3, R^8, A^1, A^2, A^3 and p are as defined for a compound of formula (I), which feature alternative alkyl or aryl sulfinate leaving groups $S(O)_2R^{21}$, wherein R^{21} may include, but is not limited to, methyl, phenyl or tolyl (for example, Gardner, G.; Steffens, J. J.; Grayson, B. T.; Kleier, D. A. J. Agric. Food. Chem., 1992, 318-321, and Miyashita, A.; Suzuki, Y.; Iwamoto, K.; Oishi, E.; Higashino, T. Heterocycles, 1998, 49, 405), as described in reaction scheme 15. Compounds of formula (Y) are either known in the literature or can be prepared by known methods (for example, Kleier, D. A. J. Agric. Food. Chem., 1992, 318-321, Barlin, G. B.; Brown, W. V. J. Chem. Soc (C), 1969, 921-923 and Klatt, T. et al Org. Lett. 2014, 16, 1232−1235).

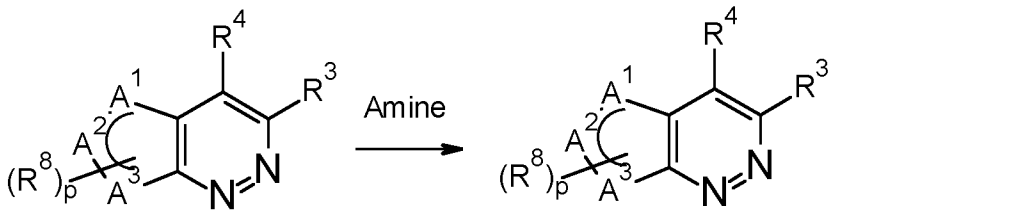
Reaction scheme 15



formula (Y) formula (X)

A compound of formula (X), wherein one of R^3, R^4 or R^8 is selected from $-C(O)R^{24}$, $-C(O)NHOR^{11}$, $-C(O)NHCN$, $-C(O)NR^6R^{25}$, $-C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, $-C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and $-C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$ may be prepared by reacting an amine with a compound of formula (X), wherein one of R^3, R^4 or R^8 is a carboxylic acid, in the presence of a suitable coupling agent in a suitable solvent or mixture of solvents, at a suitable temperature between -78ºC and 200ºC, and optionally in the presence of a suitable base, as described in reaction scheme 16. Suitable coupling reagents include, but are not limited to, a carbodiimide, for example dicyclohexylcarbodiimide or 1-ethyl-3-[3-dimethylaminopropyl]carbodiimide hydrochloride, a phosphonic anhydride, for example 2,4,6-tripropyl-1,3,5,2,4,6-trioxatriphosphorinane-2,4,6-trioxide, or a phosphonium salt, for example benzotriazol-1-yloxy(tripyrrolidin-1-yl)phosphonium hexafluorophosphate. Suitable solvents include, but are not limited to, dichloromethane, *N,N*-dimethylformamide, THF or toluene, and suitable bases include, but are not limited to, triethylamine, pyridine and *N,N*-diisopropylethylamine.

Reaction scheme 16

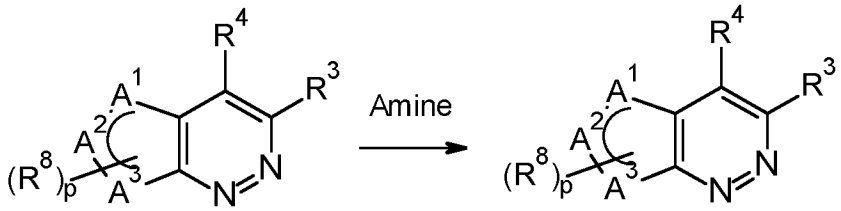


formula (X) wherein one of R^3, R^4 or R^8 is CO_2H

formula (X), wherein one of R^3, R^4 or R^8 is $-C(O)R^{24}$, $-C(O)NHOR^{11}$, $-C(O)NHCN$, $-C(O)NR^6R^{25}$, $-C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, $-C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and $-C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$

Alternatively, a compound of formula (X), wherein one of R^3, R^4 or R^8 is selected from $-C(O)R^{24}$, $-C(O)NHOR^{11}$, $-C(O)NHCN$, $-C(O)NR^6R^{25}$ $-C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, $-C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and $-C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$ may be prepared from a compound of formula (X) by classical amide bond forming reactions which are very well known in the literature, as described in reaction scheme 17. Examples include, but are not limited to, reacting an amine with an acid halide of formula (X), wherein T is halogen and R^3, R^4 and R^5 are as previously defined, in a suitable solvent or mixture of solvents, optionally in the presence of a suitable base at a suitable temperature between -78ºC and 200ºC. In an alternative approach a compound of formula (X) may be prepared by reacting an amine with an ester or activated ester of formula (X), wherein T is, for example, $-OC_1$-C_6alkyl, pentafluorophenol, *p*-nitrophenol, 2,4,6-trichlorophenol, $-OC(O)R^{\cdots}$ or $-OS(O)_2R^{\cdots}$, and $R^{\cdots}$ is, for example, C_1-C_6alkyl, C_1-C_6haloalkyl or optionally substituted phenyl. Such reactions are performed in a suitable solvent or mixture of solvents and optionally in the presence of a suitable base at a suitable temperature between -78ºC and 200ºC. Suitable bases include, but are not limited to, triethylamine, pyridine, *N,N*-diisopropylethylamine, an alkali metal carbonate, such as sodium carbonate, potassium carbonate or cesium carbonate, or an alkali metal alkoxide, such as sodium methoxide. Suitable solvents include, but are not limited to, dichloromethane, *N,N*-dimethylformamide, THF or toluene. Acid halides or activated esters of formula (X) are either known in the literature or may be prepared by known literature methods or may be commercially available.

Reaction scheme 17



formula (X) wherein one of R^3, R^4 or R^8 is CO(T)

formula (X), wherein one of R^3, R^4 or R^8 is $-C(O)R^{24}$, $-C(O)NHOR^{11}$, $-C(O)NHCN$, $-C(O)NR^6R^{25}$, $-C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, $-C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and $-C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$

The compounds according to the invention can be used as herbicidal agents in unmodified form, but they are generally formulated into compositions in various ways using formulation adjuvants, such as carriers, solvents and surface-active substances. The formulations can be in various physical forms, e.g. in the form of dusting powders, gels, wettable powders, water-dispersible granules, water-dispersible tablets, effervescent pellets, emulsifiable concentrates, microemulsifiable concentrates, oil-in-water emulsions, oil-flowables, aqueous dispersions, oily dispersions, suspo-emulsions, capsule suspensions, emulsifiable granules, soluble liquids, water-soluble concentrates (with water or a water-miscible organic solvent as carrier), impregnated polymer films or in other forms known e.g. from the Manual on Development and Use of FAO and WHO Specifications for Pesticides, United Nations, First Edition, Second Revision (2010). For water-soluble compounds, soluble liquids, water-soluble concentrates or water soluble granules are preferred. Such formulations can either be used directly or diluted prior to use. The dilutions can be made, for example, with water, liquid fertilisers, micronutrients, biological organisms, oil or solvents.

The formulations can be prepared e.g. by mixing the active ingredient with the formulation adjuvants in order to obtain compositions in the form of finely divided solids, granules, solutions, dispersions or emulsions. The active ingredients can also be formulated with other adjuvants, such as finely divided solids, mineral oils, oils of vegetable or animal origin, modified oils of vegetable or animal origin, organic solvents, water, surface-active substances or combinations thereof.

The active ingredients can also be contained in very fine microcapsules. Microcapsules contain the active ingredients in a porous carrier. This enables the active ingredients to be released into the environment in controlled amounts (e.g. slow-release). Microcapsules usually have a diameter of from 0.1 to 500 microns. They contain active ingredients in an amount of about from 25 to 95 % by weight of the capsule weight. The active ingredients can be in the form of a monolithic solid, in the form of fine particles in solid or liquid dispersion or in the form of a suitable solution. The encapsulating membranes can comprise, for example, natural or synthetic rubbers, cellulose, styrene/butadiene copolymers, polyacrylonitrile, polyacrylate, polyesters, polyamides, polyureas, polyurethane or chemically modified polymers and starch xanthates or other polymers that are known to the person skilled in the art. Alternatively, very fine microcapsules can be formed in which the active ingredient is contained in the

form of finely divided particles in a solid matrix of base substance, but the microcapsules are not themselves encapsulated.

The formulation adjuvants that are suitable for the preparation of the compositions according to the invention are known *per se*. As liquid carriers there may be used: water, toluene, xylene, petroleum ether, vegetable oils, acetone, methyl ethyl ketone, cyclohexanone, acid anhydrides, acetonitrile, acetophenone, amyl acetate, 2-butanone, butylene carbonate, chlorobenzene, cyclohexane, cyclohexanol, alkyl esters of acetic acid, diacetone alcohol, 1,2-dichloropropane, diethanolamine, p-diethylbenzene, diethylene glycol, diethylene glycol abietate, diethylene glycol butyl ether, diethylene glycol ethyl ether, diethylene glycol methyl ether, *N,N*-dimethylformamide, dimethyl sulfoxide, 1,4-dioxane, dipropylene glycol, dipropylene glycol methyl ether, dipropylene glycol dibenzoate, diproxitol, alkylpyrrolidone, ethyl acetate, 2-ethylhexanol, ethylene carbonate, 1,1,1-trichloroethane, 2-heptanone, alpha-pinene, d-limonene, ethyl lactate, ethylene glycol, ethylene glycol butyl ether, ethylene glycol methyl ether, gamma-butyrolactone, glycerol, glycerol acetate, glycerol diacetate, glycerol triacetate, hexadecane, hexylene glycol, isoamyl acetate, isobornyl acetate, isooctane, isophorone, isopropylbenzene, isopropyl myristate, lactic acid, laurylamine, mesityl oxide, methoxypropanol, methyl isoamyl ketone, methyl isobutyl ketone, methyl laurate, methyl octanoate, methyl oleate, methylene chloride, m-xylene, *n*-hexane, *n*-octylamine, octadecanoic acid, octylamine acetate, oleic acid, oleylamine, o-xylene, phenol, polyethylene glycol, propionic acid, propyl lactate, propylene carbonate, propylene glycol, propylene glycol methyl ether, p-xylene, toluene, triethyl phosphate, triethylene glycol, xylenesulfonic acid, paraffin, mineral oil, trichloroethylene, perchloroethylene, ethyl acetate, amyl acetate, butyl acetate, propylene glycol methyl ether, diethylene glycol methyl ether, methanol, ethanol, isopropanol, and alcohols of higher molecular weight, such as amyl alcohol, tetrahydrofurfuryl alcohol, hexanol, octanol, ethylene glycol, propylene glycol, glycerol, *N*-methyl-2-pyrrolidone and the like.

Suitable solid carriers are, for example, talc, titanium dioxide, pyrophyllite clay, silica, attapulgite clay, kieselguhr, limestone, calcium carbonate, bentonite, calcium montmorillonite, cottonseed husks, wheat flour, soybean flour, pumice, wood flour, ground walnut shells, lignin and similar substances.

A large number of surface-active substances can advantageously be used in both solid and liquid formulations, especially in those formulations which can be diluted with a carrier prior to use. Surface-active substances may be anionic, cationic, non-ionic or polymeric and they can be used as emulsifiers, wetting agents or suspending agents or for other purposes. Typical surface-active substances include, for example, salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; salts of alkylarylsulfonates, such as calcium dodecylbenzenesulfonate; alkylphenol/alkylene oxide addition products, such as nonylphenol ethoxylate; alcohol/alkylene oxide addition products, such as tridecylalcohol ethoxylate; soaps, such as sodium stearate; salts of alkylnaphthalenesulfonates, such as sodium dibutylnaphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl)sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryltrimethylammonium chloride, polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; and salts of mono- and di-alkylphosphate esters; and also further substances described e.g. in McCutcheon's Detergents and Emulsifiers Annual, MC Publishing Corp., Ridgewood New Jersey (1981).

Further adjuvants that can be used in pesticidal formulations include crystallisation inhibitors, viscosity modifiers, suspending agents, dyes, anti-oxidants, foaming agents, light absorbers, mixing auxiliaries, antifoams, complexing agents, neutralising or pH-modifying substances and buffers, corrosion inhibitors, fragrances, wetting agents, take-up enhancers, micronutrients, plasticisers, glidants, lubricants, dispersants, thickeners, antifreezes, microbicides, and liquid and solid fertilisers.

The compositions according to the invention can include an additive comprising an oil of vegetable or animal origin, a mineral oil, alkyl esters of such oils or mixtures of such oils and oil derivatives. The amount of oil additive in the composition according to the invention is generally from 0.01 to 10 %, based on the mixture to be applied. For example, the oil additive can be added to a spray tank in the desired concentration after a spray mixture has been prepared. Preferred oil additives comprise mineral oils or an oil of vegetable origin, for example rapeseed oil, olive oil or sunflower oil, emulsified vegetable oil, alkyl esters of oils of vegetable origin, for example the methyl derivatives, or an oil of animal origin, such as fish oil or beef tallow. Preferred oil additives comprise alkyl esters of C_8-C_{22} fatty acids, especially the methyl derivatives of C_{12}-C_{18} fatty acids, for example the methyl esters of lauric acid, palmitic acid and oleic acid (methyl laurate, methyl palmitate and methyl oleate, respectively). Many oil derivatives are known from the Compendium of Herbicide Adjuvants, 10th Edition, Southern Illinois University, 2010.

The herbicidal compositions generally comprise from 0.1 to 99 % by weight, especially from 0.1 to 95 % by weight, compounds of formula (I) and from 1 to 99.9 % by weight of a formulation adjuvant which preferably includes from 0 to 25 % by weight of a surface-active substance. The inventive compositions generally comprise from 0.1 to 99 % by weight, especially from 0.1 to 95 % by weight, of compounds of the present invention and from 1 to 99.9 % by weight of a formulation adjuvant which preferably includes from 0 to 25 % by weight of a surface-active substance. Whereas commercial products may preferably be formulated as concentrates, the end user will normally employ dilute formulations.

The rates of application vary within wide limits and depend on the nature of the soil, the method of application, the crop plant, the pest to be controlled, the prevailing climatic conditions, and other factors governed by the method of application, the time of application and the target crop. As a general guideline compounds may be applied at a rate of from 1 to 2000 l/ha, especially from 10 to 1000 l/ha.

Preferred formulations can have the following compositions (weight %):

<u>Emulsifiable concentrates</u>:

active ingredient:	1 to 95 %, preferably 60 to 90 %
surface-active agent:	1 to 30 %, preferably 5 to 20 %
liquid carrier:	1 to 80 %, preferably 1 to 35 %

<u>Dusts</u>:

active ingredient:	0.1 to 10 %, preferably 0.1 to 5 %
solid carrier:	99.9 to 90 %, preferably 99.9 to 99 %

<u>Suspension concentrates</u>:

active ingredient:	5 to 75 %, preferably 10 to 50 %

water: 94 to 24 %, preferably 88 to 30 %

surface-active agent: 1 to 40 %, preferably 2 to 30 %

Wettable powders:

active ingredient: 0.5 to 90 %, preferably 1 to 80 %

surface-active agent: 0.5 to 20 %, preferably 1 to 15 %

solid carrier: 5 to 95 %, preferably 15 to 90 %

Granules:

active ingredient: 0.1 to 30 %, preferably 0.1 to 15 %

solid carrier: 99.5 to 70 %, preferably 97 to 85 %

The composition of the present may further comprise at least one additional pesticide. For example, the compounds according to the invention can also be used in combination with other herbicides or plant growth regulators. In a preferred embodiment the additional pesticide is a herbicide and/or herbicide safener.

Thus, compounds of formula (I) can be used in combination with one or more other herbicides to provide various herbicidal mixtures. Specific examples of such mixtures include (wherein "I" represents a compound of formula (I)):- I + acetochlor; I + acifluorfen (including acifluorfen-sodium); I + aclonifen; I + alachlor; I + alloxydim; I + ametryn; I + amicarbazone; I + amidosulfuron; I + aminocyclopyrachlor ; I + aminopyralid; I + amitrole; I + asulam; I + atrazine; I + bensulfuron (including bensulfuron-methyl); I + bentazone; I + bicyclopyrone; I + bilanafos; I + bifenox; I + bispyribac-sodium; I + bixlozone; I + bromacil; I + bromoxynil; I + butachlor; I + butafenacil; I + cafenstrole; I + carfentrazone (including carfentrazone-ethyl); cloransulam (including cloransulam-methyl); I + chlorimuron (including chlorimuron-ethyl); I + chlorotoluron; I + cinosulfuron; I + chlorsulfuron; I + cinmethylin; I + clacyfos; I + clethodim; I + clodinafop (including clodinafop-propargyl); I + clomazone; I + clopyralid; I + cyclopyranil; I + cyclopyrimorate; I + cyclosulfamuron; I + cyhalofop (including cyhalofop-butyl); I + 2,4-D (including the choline salt and 2-ethylhexyl ester thereof); I + 2,4-DB; I + daimuron; I + desmedipham; I + dicamba (including the aluminum, aminopropyl, bis-aminopropylmethyl, choline, dichloroprop, diglycolamine, dimethylamine, dimethylammonium, potassium and sodium salts thereof); I + diclofop-methyl; I + diclosulam; I + diflufenican; I + difenzoquat; I + diflufenican; I + diflufenzopyr; I + dimethachlor; I + dimethenamid-P; I + diquat dibromide; I + diuron; I + esprocarb; I + ethalfluralin; I + ethofumesate; I + fenoxaprop (including fenoxaprop-P-ethyl); I + fenoxasulfone; I + fenquinotrione; I + fentrazamide; I + flazasulfuron; I + florasulam; I + florpyrauxifen; I + fluazifop (including fluazifop-P-butyl); I + flucarbazone (including flucarbazone-sodium);; I + flufenacet; I + flumetralin; I + flumetsulam; I + flumioxazin; I + flupyrsulfuron (including flupyrsulfuron-methyl-sodium);; I + fluroxypyr (including fluroxypyr-meptyl);; I + fluthiacet-methyl; I + fomesafen; I + foramsulfuron; I + glufosinate (including the ammonium salt thereof); I + glyphosate (including the diammonium, isopropylammonium and potassium salts thereof); I + halauxifen (including halauxifen-methyl); I + halosulfuron-methyl; I + haloxyfop (including haloxyfop-methyl); I + hexazinone; I + hydantocidin; I + imazamox; I + imazapic; I + imazapyr; I + imazaquin; I + imazethapyr; I + indaziflam; I + iodosulfuron (including iodosulfuron-methyl-sodium); I + iofensulfuron; I +

iofensulfuron-sodium; I + ioxynil; I + ipfencarbazone; I + isoproturon; I + isoxaben; I + isoxaflutole; I + lactofen; I + lancotrione; I + linuron; I + MCPA; I + MCPB; I + mecoprop-P; I + mefenacet; I + mesosulfuron; I + mesosulfuron-methyl; I + mesotrione; I + metamitron; I + metazachlor; I + methiozolin; I + metobromuron; I + metolachlor; I + metosulam; I + metoxuron; I + metribuzin; I + metsulfuron; I + molinate; I + napropamide; I + nicosulfuron; I + norflurazon; I + orthosulfamuron; I + oxadiargyl; I + oxadiazon; I + oxasulfuron; I + oxyfluorfen; I + paraquat dichloride; I + pendimethalin; I + penoxsulam; I + phenmedipham; I + picloram; I + picolinafen; I + pinoxaden; I + pretilachlor; I + primisulfuron-methyl; I + prodiamine; I + prometryn; I + propachlor; I + propanil; I + propaquizafop; I + propham; I + propyrisulfuron, I + propyzamide; I + prosulfocarb; I + prosulfuron; I + pyraclonil; I + pyraflufen (including pyraflufen-ethyl): I + pyrasulfotole; I + pyrazolynate, I + pyrazosulfuron-ethyl; I + pyribenzoxim; I + pyridate; I + pyriftalid; I + pyrimisulfan, I + pyrithiobac-sodium; I + pyroxasulfone; I + pyroxsulam ; I + quinclorac; I + quinmerac; I + quizalofop (including quizalofop-P-ethyl and quizalofop-P-tefuryl),; I + rimsulfuron; I + saflufenacil; I + sethoxydim; I + simazine; I + *S*-metolachlor; I + sulcotrione; I + sulfentrazone; I + sulfosulfuron; I + tebuthiuron; I + tefuryltrione; I + tembotrione; I + terbuthylazine; I + terbutryn; I + thiencarbazone; I + thifensulfuron; I + tiafenacil; I + tolpyralate; I + topramezone; I + tralkoxydim; I + triafamone; I + triallate; I + triasulfuron; I + tribenuron (including tribenuron-methyl); I + triclopyr; I + trifloxysulfuron (including trifloxysulfuron-sodium); I + trifludimoxazin; I + trifluralin; I + triflusulfuron; I + tritosulfuron; I + 4-hydroxy-1-methoxy-5-methyl-3-[4-(trifluoromethyl)-2-pyridyl]imidazolidin-2-one; I + 4-hydroxy-1,5-dimethyl-3-[4-(trifluoromethyl)-2-pyridyl]imidazolidin-2-one; I + 5-ethoxy-4-hydroxy-1-methyl-3-[4-(trifluoromethyl)-2-pyridyl]imidazolidin-2-one; I + 4-hydroxy-1-methyl-3-[4-(trifluoromethyl)-2-pyridyl]imidazolidin-2-one; I + 4-hydroxy-1,5-dimethyl-3-[1-methyl-5-(trifluoromethyl)pyrazol-3-yl]imidazolidin-2-one; I + (4R)1-(5-tert-butylisoxazol-3-yl)-4-ethoxy-5-hydroxy-3-methyl-imidazolidin-2-one; I + 3-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]bicyclo[3.2.1]octane-2,4-dione; I + 2-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-5-methyl-cyclohexane-1,3-dione; I + 2-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]cyclohexane-1,3-dione; I + 2-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-5,5-dimethyl-cyclohexane-1,3-dione; I + 6-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-2,2,4,4-tetramethyl-cyclohexane-1,3,5-trione; I + 2-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-5-ethyl-cyclohexane-1,3-dione; I + 2-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-4,4,6,6-tetramethyl-cyclohexane-1,3-dione; I + 2-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]-5-methyl-cyclohexane-1,3-dione; I + 3-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]bicyclo[3.2.1]octane-2,4-dione; I + 2-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]-5,5-dimethyl-cyclohexane-1,3-dione; I + 6-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]-2,2,4,4-tetramethyl-cyclohexane-1,3,5-trione; I + 2-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]cyclohexane-1,3-dione; I + 4-[2-(3,4-dimethoxyphenyl)-6-methyl-3-oxo-pyridazine-4-carbonyl]-2,2,6,6-tetramethyl-tetrahydropyran-3,5-dione and I + 4-[6-cyclopropyl-2-(3,4-dimethoxyphenyl)-3-oxo-pyridazine-4-carbonyl]-2,2,6,6-tetramethyl-tetrahydropyran-3,5-dione.

The mixing partners of the compound of formula (I) may also be in the form of esters or salts, as mentioned e.g. in The Pesticide Manual, Fourteenth Edition, British Crop Protection Council, 2006.

The compound of formula (I) can also be used in mixtures with other agrochemicals such as fungicides, nematicides or insecticides, examples of which are given in The Pesticide Manual.

The mixing ratio of the compound of formula (I) to the mixing partner is preferably from 1: 100 to 1000:1.

The mixtures can advantageously be used in the above-mentioned formulations (in which case "active ingredient" relates to the respective mixture of compound of formula (I) with the mixing partner).

Compounds of formula (I) of the present invention may also be combined with herbicide safeners. Preferred combinations (wherein "I" represents a compound of formula (I)) include:- I + benoxacor, I + cloquintocet (including cloquintocet-mexyl); I + cyprosulfamide; I + dichlormid; I + fenchlorazole (including fenchlorazole-ethyl); I + fenclorim; I + fluxofenim; I+ furilazole I + isoxadifen (including isoxadifen-ethyl); I + mefenpyr (including mefenpyr-diethyl); I + metcamifen; I + N-(2-methoxybenzoyl)-4-[(methylaminocarbonyl)amino] benzenesulfonamide and I + oxabetrinil.

Particularly preferred are mixtures of a compound of formula (I) with cyprosulfamide, isoxadifen (including isoxadifen-ethyl), cloquintocet (including cloquintocet-mexyl) and/or N-(2-methoxybenzoyl)-4-[(methyl-aminocarbonyl)amino]benzenesulfonamide.

The safeners of the compound of formula (I) may also be in the form of esters or salts, as mentioned e.g. in The Pesticide Manual, 14th Edition (BCPC), 2006. The reference to cloquintocet-mexyl also applies to a lithium, sodium, potassium, calcium, magnesium, aluminium, iron, ammonium, quaternary ammonium, sulfonium or phosphonium salt thereof as disclosed in WO 02/34048, and the reference to fenchlorazole-ethyl also applies to fenchlorazole, etc.

Preferably the mixing ratio of compound of formula (I) to safener is from 100:1 to 1:10, especially from 20:1 to 1:1.

The mixtures can advantageously be used in the above-mentioned formulations (in which case "active ingredient" relates to the respective mixture of compound of formula (I) with the safener).

The compounds of formula (I) of this invention are useful as herbicides. The present invention therefore further comprises a method for controlling unwanted plants comprising applying to the said plants or a locus comprising them, an effective amount of a compound of the invention or a herbicidal composition containing said compound. 'Controlling' means killing, reducing or retarding growth or preventing or reducing germination. Generally the plants to be controlled are unwanted plants (weeds). 'Locus' means the area in which the plants are growing or will grow.

The rates of application of compounds of formula (I) may vary within wide limits and depend on the nature of the soil, the method of application (pre-emergence; post-emergence; application to the seed furrow; no tillage application etc.), the crop plant, the weed(s) to be controlled, the prevailing climatic conditions, and other factors governed by the method of application, the time of application and the target crop. The compounds of formula (I) according to the invention are generally applied at a rate of from 10 to 2000 g/ha, especially from 50 to 1000 g/ha.

The application is generally made by spraying the composition, typically by tractor mounted sprayer for large areas, but other methods such as dusting (for powders), drip or drench can also be used.

Useful plants in which the composition according to the invention can be used include crops such as cereals, for example barley and wheat, cotton, oilseed rape, sunflower, maize, rice, soybeans, sugar beet, sugar cane and turf.

Crop plants can also include trees, such as fruit trees, palm trees, coconut trees or other nuts. Also included are vines such as grapes, fruit bushes, fruit plants and vegetables.

Crops are to be understood as also including those crops which have been rendered tolerant to herbicides or classes of herbicides (e.g. ALS-, GS-, EPSPS-, PPO-, ACCase- and HPPD-inhibitors) by conventional methods of breeding or by genetic engineering. An example of a crop that has been rendered tolerant to imidazolinones, e.g. imazamox, by conventional methods of breeding is Clearfield® summer rape (canola). Examples of crops that have been rendered tolerant to herbicides by genetic engineering methods include e.g. glyphosate- and glufosinate-resistant maize varieties commercially available under the trade names RoundupReady® and LibertyLink®.

Crops are also to be understood as being those which have been rendered resistant to harmful insects by genetic engineering methods, for example Bt maize (resistant to European corn borer), Bt cotton (resistant to cotton boll weevil) and also Bt potatoes (resistant to Colorado beetle). Examples of Bt maize are the Bt 176 maize hybrids of NK® (Syngenta Seeds). The Bt toxin is a protein that is formed naturally by *Bacillus thuringiensis* soil bacteria. Examples of toxins, or transgenic plants able to synthesise such toxins, are described in EP-A-451 878, EP-A-374 753, WO 93/07278, WO 95/34656, WO 03/052073 and EP-A-427 529. Examples of transgenic plants comprising one or more genes that code for an insecticidal resistance and express one or more toxins are KnockOut® (maize), Yield Gard® (maize), NuCOTIN33B® (cotton), Bollgard® (cotton), NewLeaf® (potatoes), NatureGard® and Protexcta®. Plant crops or seed material thereof can be both resistant to herbicides and, at the same time, resistant to insect feeding ("stacked" transgenic events). For example, seed can have the ability to express an insecticidal Cry3 protein while at the same time being tolerant to glyphosate.

Crops are also to be understood to include those which are obtained by conventional methods of breeding or genetic engineering and contain so-called output traits (e.g. improved storage stability, higher nutritional value and improved flavour).

Other useful plants include turf grass for example in golf-courses, lawns, parks and roadsides, or grown commercially for sod, and ornamental plants such as flowers or bushes.

Compounds of formula (I) and compositions of the invention can typically be used to control a wide variety of monocotyledonous and dicotyledonous weed species. Examples of monocotyledonous species that can typically be controlled include *Alopecurus myosuroides, Avena fatua, Brachiaria plantaginea, Bromus tectorum, Cyperus esculentus, Digitaria sanguinalis, Echinochloa crus-galli, Lolium perenne, Lolium multiflorum, Panicum miliaceum, Poa annua, Setaria viridis, Setaria faberi and Sorghum bicolor.* Examples of dicotyledonous species that can be controlled include *Abutilon theophrasti, Amaranthus retroflexus, Bidens pilosa, Chenopodium album, Euphorbia heterophylla, Galium aparine, Ipomoea hederacea, Kochia scoparia, Polygonum convolvulus, Sida spinosa, Sinapis arvensis, Solanum nigrum, Stellaria media, Veronica persica and Xanthium strumarium.*

The compounds of formula (I) are also useful for pre-harvest desiccation in crops, for example, but not limited to, potatoes, soybean, sunflowers and cotton. Pre-harvest desiccation is used to desiccate crop foliage without significant damage to the crop itself to aid harvesting.

Compounds/compositions of the invention are particularly useful in non-selective burn-down applications, and as such may also be used to control volunteer or escape crop plants.

Various aspects and embodiments of the present invention will now be illustrated in more detail by way of example. It will be appreciated that modification of detail may be made without departing from the scope of the invention.

EXAMPLES

The Examples which follow serve to illustrate, but do not limit, the invention.

Formulation Examples

Wettable powders	**a)**	**b)**	**c)**
active ingredients	25 %	50 %	75 %
sodium lignosulfonate	5 %	5 %	-
sodium lauryl sulfate	3 %	-	5 %
sodium diisobutylnaphthalenesulfonate	-	6 %	10 %
phenol polyethylene glycol ether (7-8 mol of ethylene oxide)	-	2 %	-
highly dispersed silicic acid	5 %	10 %	10 %
Kaolin	62 %	27 %	-

The combination is thoroughly mixed with the adjuvants and the mixture is thoroughly ground in a suitable mill, affording wettable powders that can be diluted with water to give suspensions of the desired concentration.

Emulsifiable concentrate	
active ingredients	10 %
octylphenol polyethylene glycol ether (4-5 mol of ethylene oxide)	3 %
calcium dodecylbenzenesulfonate	3 %
castor oil polyglycol ether (35 mol of ethylene oxide)	4 %
Cyclohexanone	30 %
xylene mixture	50 %

Emulsions of any required dilution, which can be used in plant protection, can be obtained from this concentrate by dilution with water.

Dusts	**a)**	**b)**	**c)**
Active ingredients	5 %	6 %	4 %
Talcum	95 %	-	-
Kaolin	-	94 %	-
mineral filler	-	-	96 %

Ready-for-use dusts are obtained by mixing the combination with the carrier and grinding the mixture in a suitable mill.

Extruded granules	
Active ingredients	15 %
sodium lignosulfonate	2 %
carboxymethylcellulose	1 %
Kaolin	82 %

The combination is mixed and ground with the adjuvants, and the mixture is moistened with water. The mixture is extruded and then dried in a stream of air.

Coated granules	
Active ingredients	8 %
polyethylene glycol (mol. wt. 200)	3 %
Kaolin	89 %

The finely ground combination is uniformly applied, in a mixer, to the kaolin moistened with polyethylene glycol. Non-dusty coated granules are obtained in this manner.

Suspension concentrate

active ingredients	40 %
propylene glycol	10 %
nonylphenol polyethylene glycol ether (15 mol of ethylene oxide)	6 %
Sodium lignosulfonate	10 %
carboxymethylcellulose	1 %
silicone oil (in the form of a 75 % emulsion in water)	1 %
Water	32 %

The finely ground combination is intimately mixed with the adjuvants, giving a suspension concentrate from which suspensions of any desired dilution can be obtained by dilution with water.

Slow Release Capsule Suspension

28 parts of the combination are mixed with 2 parts of an aromatic solvent and 7 parts of toluene diisocyanate/polymethylene-polyphenylisocyanate-mixture (8:1). This mixture is emulsified in a mixture of 1.2 parts of polyvinylalcohol, 0.05 parts of a defoamer and 51.6 parts of water until the desired particle size is achieved. To this emulsion a mixture of 2.8 parts 1,6-diaminohexane in 5.3 parts of water is added. The mixture is agitated until the polymerization reaction is completed.

The obtained capsule suspension is stabilized by adding 0.25 parts of a thickener and 3 parts of a dispersing agent. The capsule suspension formulation contains 28% of the active ingredients. The medium capsule diameter is 8-15 microns.

The resulting formulation is applied to seeds as an aqueous suspension in an apparatus suitable for that purpose.

List of Abbreviations:

Boc	= *tert*-butyloxycarbonyl
br	= broad
$CDCl_3$	= chloroform-d
CD_3OD	= methanol-d
°C	= degrees Celsius
D_2O	= water-d
DCM	= dichloromethane
d	= doublet
dd	= double doublet
dt	= double triplet
DMSO	= dimethylsulfoxide
EtOAc	= ethyl acetate
h	= hour(s)
HCl	= hydrochloric acid
HPLC	= high-performance liquid chromatography (description of the apparatus and the methods used for HPLC are given below)
m	= multiplet
M	= molar
min	= minutes
MHz	= mega hertz
mL	= millilitre
mp	= melting point
ppm	= parts per million
q	= quartet
quin	= quintet
rt	= room temperature
s	= singlet
t	= triplet

THF = tetrahydrofuran

LC/MS = Liquid Chromatography Mass Spectrometry

Preparative Reverse Phase HPLC Method:

Compounds purified by mass directed preparative HPLC using ES+/ES- on a Waters FractionLynx Autopurification system comprising a 2767 injector/collector with a 2545 gradient pump, two 515 isocratic pumps, SFO, 2998 photodiode array (Wavelength range (nm): 210 to 400), 2424 ELSD and QDa mass spectrometer. A Waters Atlantis T3 5micron 19x10mm guard column was used with a Waters Atlantis T3 OBD, 5micron 30x100mm prep column.

Ionisation method: Electrospray positive and negative: Cone (V) 20.00, Source Temperature (°C) 120, Cone Gas Flow (L/Hr.) 50

Mass range (Da): positive 100 to 800, negative 115 to 800.

The preparative HPLC was conducted using an 11.4 minute run time (not using at column dilution, bypassed with the column selector), according to the following gradient table:

Time (mins)	Solvent A (%)	Solvent B (%)	Flow (ml / min)
0.00	100	0	35
2.00	100	0	35
2.01	100	0	35
7.0	90	10	35
7.3	0	100	35
9.2	0	100	35
9.8	99	1	35
11.35	99	1	35
11.40	99	1	35

515 pump 0ml/min Acetonitrile (ACD)

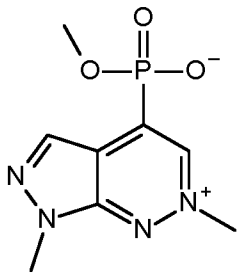
515 pump 1ml/min 90% Methanol/10% Water (make up pump)

Solvent A: Water with 0.05% Trifluoroacetic Acid

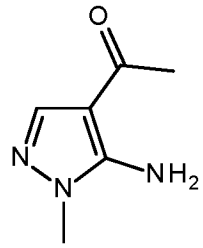
Solvent B: Acetonitrile with 0.05% Trifluoroacetic Acid

PREPARATION EXAMPLES

Example 1: Preparation of (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)-methoxy-phosphinate A1



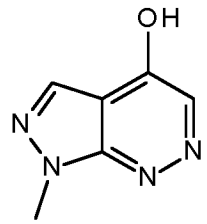
Step 1: Preparation of 1-(5-amino-1-methyl-pyrazol-4-yl)ethanone



To a stirred suspension of 5-amino-1-methyl-1H-pyrazole-4-carbonitrile (5 g) in tetrahydrofuran (50 mL) was added methylmagnesium chloride solution (55 mL, 3M solution in tetrahydrofuran) dropwise at room temperature under a nitrogen atmosphere. The reaction mixture was stirred at this temperature for 3 hours then subsequently hydrolysed with 6M aqueous hydrochloric acid (250 mL). After stirring for a further 1 hour the reaction mixture was basified with 6M aqueous sodium hydroxide solution (250 mL) and the crude product was extracted with 10% methanol in dichloromethane (3 × 500 mL). The combined organic phases were dried with sodium sulfate and concentrated. The crude product was purified by silica gel chromatography eluting with 2% methanol in dichloromethane to afford 1-(5-amino-1-methyl-pyrazol-4-yl)ethanone as an off-white solid which was used directly in the next step.

^{1}H NMR (400 MHz, DMSO-d_6) 7.65 (s, 1H), 6.63 (br s, 2H), 3.51 (s, 3H) 2.20 (s, 3H)

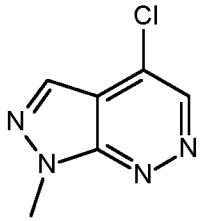
Step 2: Preparation of 1-methylpyrazolo[3,4-c]pyridazin-4-ol



To a suspension of 1-(5-amino-1-methyl-pyrazol-4-yl)ethanone (5.50 g) in concentrated aqueous hydrochloric acid (153 mL) and water (23 mL) was added a solution of sodium nitrite (5.46 g,) in water (14 mL) dropwise at -5°C. The reaction mixture was heated at 65°C for 45 minutes then cooled to room temperature. Concentration afforded the crude product 1-methylpyrazolo[3,4-c]pyridazin-4-ol as a brown solid which was used directly in the next step.

^{1}H NMR (400 MHz, DMSO-d_6) 8.10 (s, 1H) 7.72 (s, 1H) 3.98 (s, 3H) (OH proton missing)

Step 3: Preparation of 4-chloro-1-methyl-pyrazolo[3,4-c]pyridazine

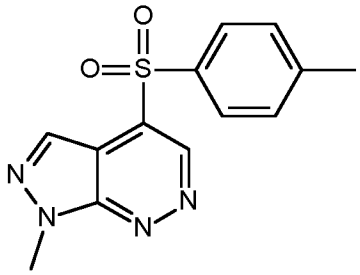


To a solution of 1-methylpyrazolo[3,4-c]pyridazin-4-ol 3 (3.50 g) in dichloromethane (35 mL) at 0°C was added thionyl chloride (35 mL) dropwise, followed by N,N-dimethylformamide (3.5 mL), under a nitrogen atmosphere. The reaction mixture was stirred at room temperature for 3 hours then quenched into ice cold saturated aqueous sodium bicarbonate (50 mL) and extracted with dichloromethane (3 × 100 mL).

The combined organic phases were washed with brine (250 mL), dried over sodium sulfate and concentrated. The crude product was purified by silica gel chromatography eluting with 1.5% methanol in dichloromethane to afford 4-chloro-1-methyl-pyrazolo[3,4-c]pyridazine as an off-white solid which was used directly in the next step.

^{1}H NMR (400 MHz, $CDCl_3$) 9.09 (s, 1H) 8.19 (s, 1H) 4.38 (s, 3H)

Step 4: Preparation of 1-methyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine



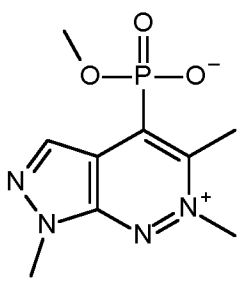
To a solution of 4-chloro-1-methyl-pyrazolo[3,4-c]pyridazine (1.3 g) in dimethylformamide (30 mL) was added sodium p-toluenesulfinate (3 g) at room temperature. The reaction mixture was stirred for a further 16 hours then quenched into water (20 mL). The resulting solid was filtered, washed with water (10 mL) and dried under vacuum to afford 1-methyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine as an off-white solid which was used directly in the next step.

Step 5: Preparation of (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)-methoxy-phosphinate A1

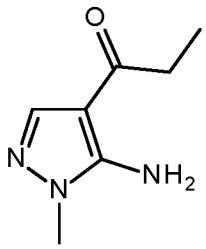
To a stirred solution of sodium hydride (0.104 g) in tetrahydrofuran (18 mL) at 0°C, under a nitrogen atmosphere, was added dimethyl phosphite (0.292 g) dropwise. The reaction mixture was warmed to room temperature and stirred for a further 1 hour. The reaction mixture was cooled to 0°C and 1-methyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine (0.5 g) was added in one portion. After stirring for 2 hours the reaction mixture was quenched with water (20 mL) and extracted with ethyl acetate (3 × 20 mL). The combined organic phases were washed with brine, dried over magnesium sulfate and concentrated to afford crude 4-dimethoxyphosphoryl-1-methyl-pyrazolo[3,4-c]pyridazine. This material was subsequently dissolved in methanol (3 mL) and heated at 70°C for 24 hours. After cooling to room temperature the reaction was concentrated and purified by preparative reverse phase HPLC to afford (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)-methoxy-phosphinate as a yellow solid.

^{1}H NMR (400MHz, D_2O) 9.33 (d, 1H), 8.75 (s, 1H), 4.77 (s, 3H), 4.28 (s, 3H), 3.53 (d, 3H)

Example 2: Preparation of methoxy-(1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)phosphinate A2



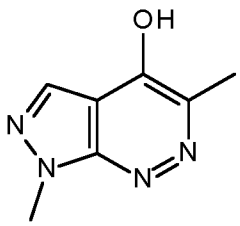
Step 1: Preparation of 1-(5-amino-1-methyl-pyrazol-4-yl)propan-1-one



To a solution of 5-amino-1-methyl-pyrazole-4-carbonitrile (5 g) in tetrahydrofuran (100 mL), under a nitrogen atmosphere, was added ethyl magnesium chloride (102 mL, 1M in tetrahydrofuran) at room temperature. After stirring at room temperature for 16 hours the reaction mixture was cooled to 10°C and quenched with 6M aqueous hydrochloric acid (200 mL), then stirred for 1 hour. The mixture was basified with 6M aqueous sodium hydroxide and extracted with 10% methanol in dichloromethane (3 x 200 mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1-(5-amino-1-methyl-pyrazol-4-yl)propan-1-one as yellow solid.

^{1}H NMR (400 MHz, DMSO-d_6) 7.66 (s, 1H) 6.63 (brs, 2H) 3.51 (s, 3H) 2.58 (q, 2H) 1.05 (t, 3H)

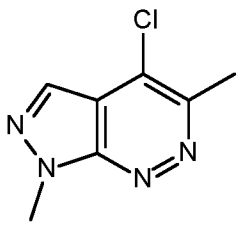
Step 2: Preparation of 1,5-dimethylpyrazolo[3,4-c]pyridazin-4-ol



To a solution of 1-(5-amino-1-methyl-pyrazol-4-yl)propan-1-one (0.2 g) in water (1.6 mL) was added concentrated hydrochloric acid (5.4 mL) at room temperature and the reaction mixture was stirred for 10 minutes. After cooling to -12°C a solution of sodium nitrite (1.8 g) in water (3 mL) was added and stirring was continued at -12°C for 15 minutes. After warming to room temperature, the mixture was heated at 65°C for 30 minutes. The reaction mixture was cooled to room temperature, concentrated and triturated using dichloromethane to afford 1,5-dimethylpyrazolo[3,4-c]pyridazin-4-ol as yellow solid.

^{1}H NMR (400 MHz, DMSO-d_6) 8.04 (s, 1H) 3.96 (s, 3H) 2.24 (s, 3H) (OH proton missing)

Step 3: Preparation of 4-chloro-1,5-dimethyl-pyrazolo[3,4-c]pyridazine

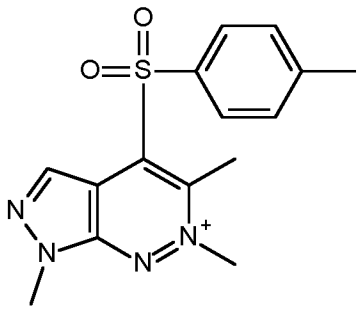


To a solution of 1,5-dimethylpyrazolo[3,4-c]pyridazin-4-ol (0.2 g) and 2-methylpyridine (0.02 g) in chlorobenzene (2 mL), under a nitrogen atmosphere, was added phosphorus oxychloride (0.17 mL) dropwise at room temperature. The reaction mixture was heated at 120°C for 1 hour, cooled to room temperature, poured into ice cold water and extracted with dichloromethane (3 x 50 mL). The combined

organic phases were concentrated and purified by silica gel chromatography eluting with 30% ethyl acetate in cyclohexane to give 4-chloro-1,5-dimethyl-pyrazolo[3,4-c]pyridazine.

LCMS : 183 $(M+H)^+$

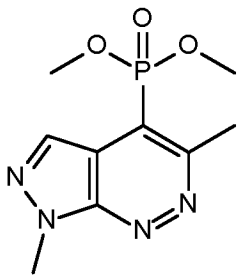
Step 4: Preparation of 1,5-dimethyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine



To a solution of 4-chloro-1,5-dimethyl-pyrazolo[3,4-c]pyridazine (0.1 g) in acetonitrile (1.2 mL) was added sodium p-toluenesulfinate (0.17g, 0.60 mmol) at 0°C, under a nitrogen atmosphere. The reaction mixture was stirred for 1 hour at 0°C, allowed to warm to room temperature and then heated at 100°C for 48 hours. The reaction mixture was quenched in water and extracted with ethyl acetate (3 x 100mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1,5-dimethyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine.

LCMS : 303 $(M+H)^+$

Step 5: Preparation of 1,5-dimethyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine



To a solution of dimethyl phosphite (0.1 mL,) in acetonitile (9 mL) was added cesium carbonate (0.48g) and 1,5-dimethyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine (0.3 g) at room temperature. After stirring for 16 hours the reaction mixture was concentrated. To the residue was added water (100 mL) and the mixture was extracted with ethyl acetate (3 x 50 mL). The combined organic phases were dried over sodium sulfate and concentrated to afford 1,5-dimethyl-4-(p-tolylsulfonyl)pyrazolo[3,4-c]pyridazine(0.18g) as yellow oil.

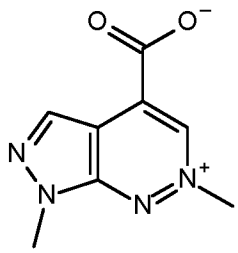
LCMS : 257 $(M+H)^+$

Step 6: Preparation of methoxy-(1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)phosphinate A2

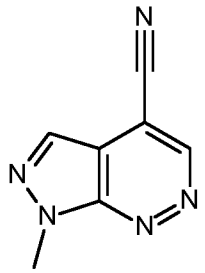
To a solution of 4-dimethoxyphosphoryl-1,5-dimethyl-pyrazolo[3,4-c]pyridazine (0.18 g) in acetone (3.6 mL) was added methyl iodide (0.026 mL) at room temperature and the reaction mixture was stirred at room temperature for 16 hours. The resulting solid was filtered, washed with *tert*-butyl methyl ether and dried under vacuum to give methoxy-(1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-yl)phosphinate.

^{1}H NMR (400 MHz, DMSO-d_6) 8.92 (s, 1H) 4.65 (s, 3H) 4.20 (s, 3H) 3.29 (s,3H) 3.18 (s, 3H)

Example 3: Preparation of 1, 6-dimethylpyrazolo [3, 4-c] pyridazin-6-ium-4-carboxylate A3



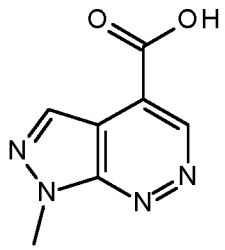
Step 1: Preparation of 1-methylpyrazolo[3,4-c]pyridazine-4-carbonitrile



To a solution of 4-chloro-1-methyl-pyrazolo[3,4-c]pyridazine (1.7 g) in *N,N*-dimethylformamide (17 mL) was added tetrakis(triphenylphosphine)palladium (2.3 g) and zinc cyanide (3.6 g), under nitrogen atmosphere, at room temperature. The mixture was heated at 120°C for 16 hours then quenched with ice cold water and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were washed with brine, dried over sodium sulfate and concentrated to give 1-methylpyrazolo[3,4-c]pyridazine-4-carbonitrile as a brown solid which was used without further purification.

LCMS : 159 $(M+H)^+$

Step 2: Preparation of 1-methylpyrazolo[3,4-c]pyridazine-4-carboxylic acid



To a solution of 1-methylpyrazolo[3,4-c]pyridazine-4-carbonitrile (1 g) in water (1 mL) was added concentrated sulfuric acid (1 mL) followed by heating at 80°C for 16 hours. The reaction mixture was quenched in ice cold water, basified with saturated aqeuous sodium carbonate and extracted with dichloromethane (3 x 100 mL). The aqueous layer was acidified using 2M aqueous hydrochloric acid and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were concentrated to give 1-methylpyrazolo[3,4-c]pyridazine-4-carboxylic acid as brown solid.

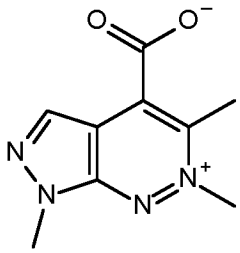
^{1}H NMR (400 MHz, CD_3OD) 9.46 (s 1H) 8.54 (s, 1H) 4.37 (s, 3H) (one CO_2H proton missing)

Step 3: Preparation of 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carboxylate A3

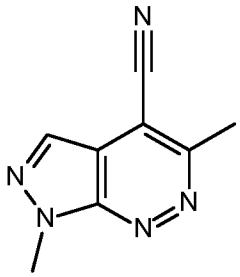
To a solution of 1-methylpyrazolo[3,4-c]pyridazine-4-carboxylic acid (0.08 g) in acetone (4 mL) was added methyl iodide (0.14 mL) and reaction mixture was stirred for 48 hours at room temperature. The resulting solid was filtered off and washed with acetone to afford 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carboxylate.

^{1}H NMR (400 MHz, DMSO-d_6) 9.86 (s, 1H) 9.05 (s, 1H) 4.82 (s, 3H) 4.30 (s, 3H)

Example 4: Preparation of 1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carboxylate A4



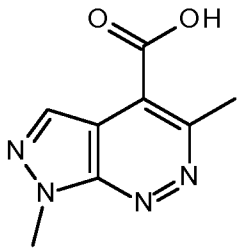
Step 1: Preparation of 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carbonitrile



To a solution of 4-chloro-1,5-dimethyl-pyrazolo[3,4-c]pyridazine (0.3 g) in *N,N*-dimethyl formamide (3 mL) was added tetrakis(triphenylphosphine)palladium (0.38 g) and zinc cyanide (0.59 g), under a nitrogen atmosphere. After heating at 120°C for 2 hours the reaction mixture was quenched with ice cold water and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were washed with brine, dried over sodium sulfate and concentrated. The crude product was purified by silica gel chromatography eluting with 30% ethyl acetate in hexane to give 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carbonitrile as yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) 8.20 (s, 1H) 4.43 (s, 3H) 3.12 (s, 3H)

Step 2: Preparation of 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carboxylic acid



To a mixture of 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carbonitrile (0.05 g) in water (0.5 mL) was added concentrated sulfuric acid (0.5 mL) and the mixture was heated at 80°C for 16 hours. The reaction mixture was quenched with ice cold water, basified using sodium carbonate solution and extracted with

dichloromethane (3 x 100 mL). The aqueous phase was acidifed using 2M aqueous hydrochloric acid and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were concentrated to give 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carboxylic acid as brown solid.

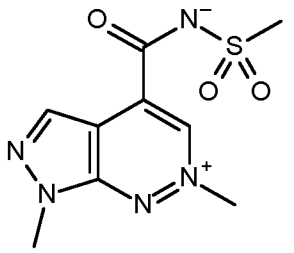
LCMS : 193 $(M+H)^+$

Step 2: Preparation of 1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carboxylate A4

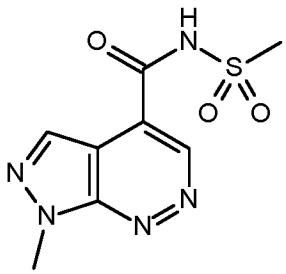
To a solution of 1,5-dimethylpyrazolo[3,4-c]pyridazine-4-carboxylic acid (0.045 g,) in 1,4-dioxane (0.4 mL) was added dimethyl sulfate (0.025 mL) followed by stirring for 48 hours at room temperature. The resulting solid was filtered off and washed with acetone to give 1,5,6-trimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carboxylate.

^{1}H NMR (400 MHz, DMSO-d_6) 8.71 (s, 1H) 4.64 (s, 3H) 4.23 (s, 3H) 3.01 (s, 3H)

Example 5: Preparation of (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carbonyl)-methylsulfonyl-azanide A5



Step 1: Preparation of 1-methyl-N-methylsulfonyl-pyrazolo[3,4-c]pyridazine-4-carboxamide



To a solution of 1-methylpyrazolo[3,4-c]pyridazine-4-carboxylic acid (0.2 g) in dichloromethane (2 mL) was added *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (0.29 g), 4-dimethylaminopyridine (0.175 g) and methane sulfonamide (0.128 g). After stirring at room temperature for 16 hours the reaction mixture was concentrated and the residue dissolved 2M aqueous hydrochloric acid and extracted with 20% methanol in dichloromethane (3 x 100 mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1-methyl-N-methylsulfonyl-pyrazolo[3,4-c]pyridazine-4-carboxamide as yellow solid.

^{1}H NMR (400 MHz, DMSO-d_6) 9.61 (s, 1H) 8.57 (s, 1H) 4.34 (s, 3H) 3.46 (s, 3H) (one NH proton missing)

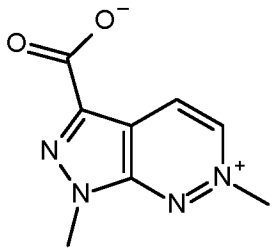
Step 2: Preparation of (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carbonyl)-methylsulfonyl-azanide A5

To a solution of 1-methyl-*N*-methylsulfonyl-pyrazolo[3,4-c]pyridazine-4-carboxamide (0.15 g) in acetone (2.9 mL) was added methyl iodide (0.18 mL) and the mixture was stirred at room temperature for 16

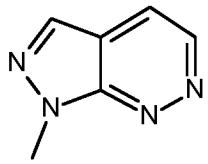
hours. The resulting solid was filtered off, washed with acetone and dried under vacuum to give (1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-4-carbonyl)-methylsulfonyl-azanide as a yellow solid.

^{1}H NMR (400 MHz, D_2O) 9.85 (s, 1H) 9.05 (s, 1H) 4.81 (s, 3H) 4.42 (s, 3H) 3.02 (s, 3H)

Example 6: Preparation of 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-3-carboxylate A6



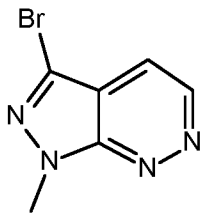
Step 1: Preparation of 1-methylpyrazolo[3,4-c]pyridazine



To a solution of 4-chloro-1-methyl-pyrazolo[3,4-c]pyridazine (2 g) in methanol (40 mL) was added triethylamine (4.96 mL) and 10% palladium on carbon (0.6 g). The suspension was stirred at room temperature under a hydrogen atmosphere for 2 hours. The reaction mixture was filtered through diatomaceous earth and washed with methanol (50 mL) then concentrated. The residue was purified by silica gel chromatography eluting with 3% methanol in dichloromethane to afford 1-methylpyrazolo[3,4-c]pyridazine as an off-white solid which was used directly in the next step.

^{1}H NMR (400 MHz, $CDCl_3$) 9.60 (d, 1H) 9.20 (d, 1H) 8.90 (s, 1H) 4.30 (s, 3H)

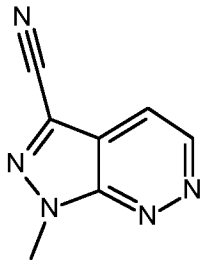
Step 2: Preparation of 3-bromo-1-methyl-pyrazolo[3,4-c]pyridazine



To a solution of 1-methylpyrazolo[3,4-c]pyridazine (0.3 g) in glacial acetic acid (0.6 mL) was added *N*-bromosuccinimide (0.24 g) and the mixture was heated at 120°C for 16 hours. After quenching with water the reaction mixture was basified with aqueous sodium bicarbonate and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were dried over sodium sulphate, concentrated and purified by silica gel chromatography eluting with 30% ethyl acetate in cyclohexane to give 3-bromo-1-methyl-pyrazolo[3,4-c]pyridazine as yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) 9.21 (d, 1H) 7.78 (d, 1H) 4.40 (s, 3H)

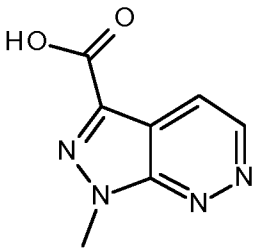
Step 3: Preparation of 1-methylpyrazolo[3,4-c]pyridazine-3-carbonitrile



To a solution of 3-bromo-1-methyl-pyrazolo[3,4-c]pyridazine (0.026 g) in *N,N*-dimethyl formamide (2.6 mL) was added tetrakis(triphenylphosphine)palladium (0.28 g) and zinc cyanide (0.43 g), under a nitrogen atmosphere. After heating at 120°C for 16 hours the reaction was cooled to room temperature, quenched with ice cold water and extracted with ethyl acetate (3 x 50 mL). The combined organic phases were concentrated and purified by silica gel chromatography to give 1-methylpyrazolo[3,4-c]pyridazine-3-carbonitrile.

LCMS : 160 $(M+H)^+$

Step 4: Preparation of 1-methylpyrazolo [3,4-c]pyridazine-3-carboxylic acid



To a solution of 1-methylpyrazolo[3,4-c]pyridazine-3-carbonitrile (0.03 g) in water (0.3 mL) was added concentrated sulfuric acid (0.3 mL) and the mixture was heated at 90°C for 16 hours. After cooling to room temperature the reaction mixture was quenched with ice cold water, basified with aqueous sodium bicarbonate solution and washed with dichloromethane (3 x 100 mL). The aqueous phase was acidified with 2M aqueous hydrochloric acid and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were concentrated to give 1-methylpyrazolo [3,4-c]pyridazine-3-carboxylic acid as white solid .

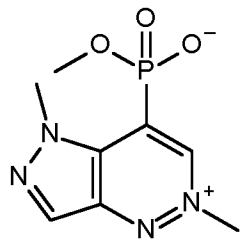
LCMS : 179 $(M+H)^+$

Step 5: Preparation of 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-3-carboxylate A6

To a solution of 1-methylpyrazolo[3,4-c]pyridazine-3-carboxylic acid (0.08g, 0.44 mmol) in acetone (2.2 mL) was added methyl iodide (0.140 mL, 2.24 mmol) followed by stirring at room temperature for 16 hours. The resulting solid was filtered, washed with *tert*-butyl methyl ether then dried under vaccum to give 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-3-carboxylate.

^{1}H NMR (400 MHz, DMSO- d_6) 9.74 (d, 1H) 9.28 (d, 1H) 4.85 (s, 3H) 4.37 (s, 3H)

Example 7: Preparation of (1,5-dimethylpyrazolo[4,3-c]pyridazin-5-ium-7-yl)-methoxy-phosphinate A7

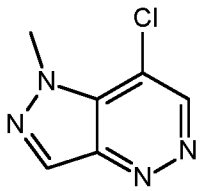


Step 1: Preparation of 1-methylpyrazolo[4,3-c]pyridazin-7-ol

To a solution of *tert*-butyl *N*-(5-acetyl-1-methyl-pyrazol-4-yl)carbamate (2.80 g) in water (20 mL) was added concentrated hydrochloric acid (75 mL) at room temperature. The reaction mixture was stirred for 10 minutes then cooled to -12°C and a solution of sodium nitrite (1.6 g) in water (22 mL) was added and stirred at -12°C for a further 15 minutes. The mixture was warmed to room temperature and heated at 65°C for 30 minutes. The reaction mixture was cooled, concentrated and the residue was dissolved in methanol (20 mL). The methanol was filtered, concentrated and the residue was triturated with dichloromethane to afford 1-methylpyrazolo[4,3-c]pyridazin-7-ol as yellow solid.

LCMS : 151 $(M+H)^+$

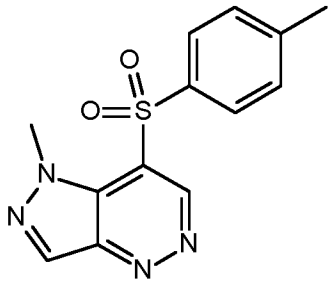
Step 2: Prepration of 7-chloro-1-methyl-pyrazolo[4,3-c]pyridazine



To a solution of 1-methylpyrazolo[4,3-c]pyridazin-7-ol (2 g) and 2-methylpyridine (0.025 g) in chlorobenzene (10 mL) was added phosphorus oxychloride (1.38 mL) at 0°C followed by stirring at room temperature for 16 hours, under a nitrogen atmosphere. The reaction mixture was poured into ice cold water and extracted with ethyl acetate (3 x 50mL). The combined organic phases were concentrated to give 7-chloro-1-methyl-pyrazolo[4,3-c]pyridazine as white solid.

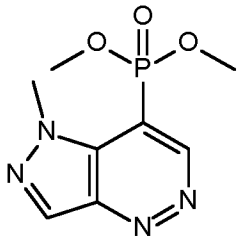
LCMS : 169 $(M+H)^+$

Step 3: Preparation of of 1-methyl-7-(p-tolylsulfonyl)pyrazolo[4,3-c]pyridazine



To a cooled solution of 7-chloro-1-methyl-pyrazolo[4,3-c]pyridazine (0.26 g) in acetonitrile (3 mL) at 0°C was added sodium p-toluenesulfinate (0.302 g) in one portion. The reaction mixture was stirred at this temperature for 1 hour then heated to 100°C for a further 16 hours. The reaction mixture was quenched with water and extracted with ethyl acetate (3 x 50 mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1-methyl-7-(p-tolylsulfonyl)pyrazolo[4,3-c]pyridazine.
LCMS : 289 $(M+H)^+$

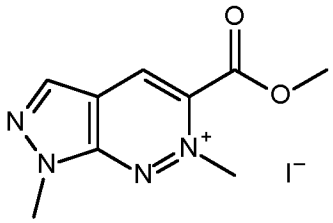
Step 4: Preparation of 1-methyl-7-(p-tolylsulfonyl)pyrazolo[4,3-c]pyridazine



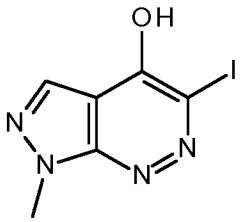
To a solution of dimethyl phosphite (0.017 mL) in acetonitile (14 mL) was added cesium carbonate (0.08 g) and 1-methyl-7-(p-tolylsulfonyl)pyrazolo[4,3-c]pyridazine (0.486 g). After stirring at room temperature for 16 hours the reaction mixture was concentrated. To the residue was added water (100 mL) and extracted with ethyl acetate (3 x 50 mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1-methyl-7-(p-tolylsulfonyl)pyrazolo[4,3-c]pyridazine as a yellow solid.
LCMS : 242 $(M+H)^+$

Step 5: Preparation of (1,5-dimethylpyrazolo[4,3-c]pyridazin-5-ium-7-yl)-methoxy-phosphinate A7
To a solution of 7-dimethoxyphosphoryl-1-methyl-pyrazolo[4,3-c]pyridazine (0.03g, 0.12 mmol) in acetone (2.6 mL) was added methyl iodide (0.129 mL, 2.6mmol) and the reaction mixture was stirred at room temperature for 16 hours. The resulting solid was filtered, washed with *tert*-butyl methyl ether then dried under vacuum to give (1,5-dimethylpyrazolo[4,3-c]pyridazin-5-ium-7-yl)-methoxy-phosphinate.
^{1}H NMR (400 MHz, DMSO-d_6) 9.40 (s 1H) 9.28 (d, 1H) 4.70 (s, 3H) 4.58 (s, 3H) 3.38 (d, 3H)

Example 8: Preparation of methyl 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-5-carboxylate iodide A8



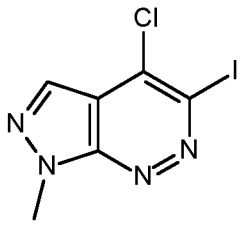
Step 1: Preparation of 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-ol



To a cooled solution of 1-methylpyrazolo[3,4-c]pyridazin-4-ol (8 g) in ethanol (80 mL) and water (40 mL) at 0°C was added *N*-iodosuccinimide (23.9 g). The reaction mixture was heated at 120°C for 48 hours, cooled to room temperature then quenched with water. The crude product was extracted with 10% methanol in dichloromethane and the organic phase was dried over sodium sulfate and concentrated to give 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-ol.

^{1}H NMR (400 MHz, DMSO-d_6) 14.35 (br s, 1H) 8.05 (s, 1H) 3.92 (s, 3H)

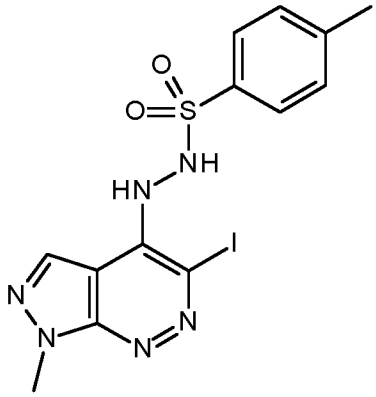
Step 2: Preparation of 4-chloro-5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine



To a solution 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-ol (5.5 g) in chlorobenzene (60 mL) was added 2-methylpyridine (0.37 g) at room temperature, under a nitrogen atmosphere. To this reaction mixture was added phosphorus oxychloride (2.8 mL) dropwise, followed by heating at 120°C for 2 hours. After cooling to room temperature the reaction mixture was quenched with ice cold water and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were washed with water (3 x 200 mL), concentrated and purifed by silica gel chromatography eluting with a 3:7 ethyl acetate and hexane to afford 4-chloro-5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine.

^{1}H NMR (400 MHz, $CDCl_3$) 8.11 (s, 1H) 4.35 (s, 3H)

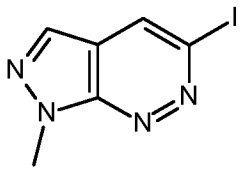
Step 3: Preparation of *N'*-(5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-yl)-4-methyl-benzenesulfonohydrazide



To a solution of 4-chloro-5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine (2.5 g) in 1,2-dichloroethane (50 mL) was added 4-methylbenzenesulfonohydrazide (1.7 g) at room temperature. The reaction mixture was heated at 70°C for 14 hours. After cooling to room temperature the resulting solid was filtered off, washed with dichloromethane (30 mL) to afford *N'*-(5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-yl)-4-methyl-benzenesulfonohydrazide.

LCMS : 445 $(M+H)^+$

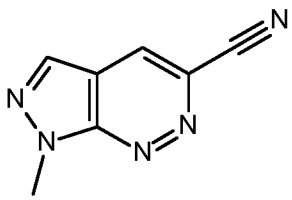
Step 4 : Preparation of 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine



To a mixture of water (2 mL) *N'*-(5-iodo-1-methyl-pyrazolo[3,4-c]pyridazin-4-yl)-4-methyl-benzenesulfonohydrazide (0.2 g) was added a solution of sodium carbonate (0.14 g) in water (50 mL) dropwise at room temperature. The reaction mixture was heated at 100°C for 16 hours, cooled and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were concentrated to give 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine as red gum.

LCMS : 261 $(M+H)^+$

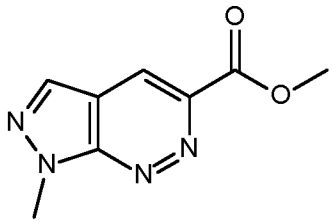
Step 5 : Preparation of 1-methylpyrazolo[3,4-c]pyridazine-5-carbonitrile



To a solution of 5-iodo-1-methyl-pyrazolo[3,4-c]pyridazine (0.6 g) in *N,N*-dimethyl formamide (0.6 mL) was added tetrakis(triphenylphosphine)palladium (0.5 g) and zinc cyanide (0.82 g) at room temperature, under a nitrogen atmosphere. After heating at 120°C for 2 hours the reaction mixture was quenched with ice cold water and extracted with ethyl acetate (3 x 100 mL). The combined organic phases were dried over sodium sulfate and concentrated to give 1-methylpyrazolo[3,4-c]pyridazine-5-carbonitrile.

LCMS : 160 $(M+H)^+$

Step 6: Preparation of methyl 1-methylpyrazolo[3,4-c]pyridazine-5-carboxylate



To a solution of 1-methylpyrazolo[3,4-c]pyridazine-5-carbonitrile (0.05 g) in methanol (0.5 mL) was added chlorotrimethylsilane (0.2 g) at room temperature and the reaction mixture was heated at 65°C for 12 hours. After cooling to room temperature, the reaction mixture was concentrated and purified by silica gel chromatography eluting with a 1:1 ratio of cyclohexane and ethyl acetate to afford methyl 1-methylpyrazolo[3,4-c]pyridazine-5-carboxylate.

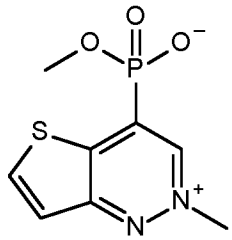
LCMS : 193 $(M+H)^+$

Step 7: Preparation of methyl 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-5-carboxylate iodide A8

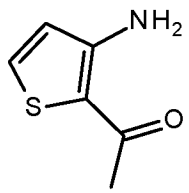
To a mixture of methyl 1-methylpyrazolo[3,4-c]pyridazine-5-carboxylate (0.02 g) in acetone (0.5 mL) was added methyl iodide (0.03 mL) and the mixture was heated at 45°C for 48 hours. The reaction mixture was concentrated and the residue was triturated with cold acetone to afford methyl 1,6-dimethylpyrazolo[3,4-c]pyridazin-6-ium-5-carboxylate iodide as brown solid.

^{1}H NMR (400 MHz, $CDCl_3$) 9.46 (s, 1H) 8.18 (s, 1H) 5.01 (s, 3H) 4.34 (s, 3H) 4.08 (s, 3H)

Example 9: Preparation of methoxy-(2-methylthieno[3,2-c]pyridazin-2-ium-4-yl)phosphinate A9



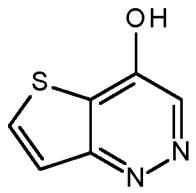
Step 1: Preparation of 1-(3-amino-2-thienyl)ethanone



To a solution of 1-sulfanylpropan-2-one (20 g) in methanol (100 mL) was added a solution of sodium methoxide (23.9 g) in methanol (200 mL) dropwise over 15 minutes at 0°C. After stirring at this temperature for a further 20 minutes the reaction mixture was allowed to warm to room temperature then stirred for 16 hours. The reaction mixture was concentrated and the crude product was partitioned between water (400 mL) and methyl tert-butyl ether (400 mL). The organic phase was washed with brine (300 mL), dried over anhydrous sodium sulfate and concentrated. The crude was purified by silica

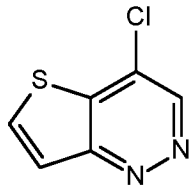
gel chromatography eluting with 15% ethyl acetate in hexanes to afford 1-(3-amino-2-thienyl)ethanone as a dark brown oil which was used directly in the next step.

Step 2: Preparation of thieno[3,2-c]pyridazin-4-ol



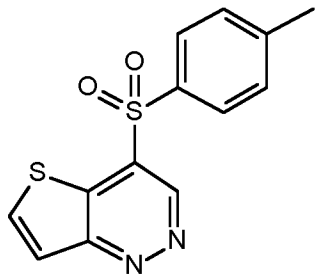
To a solution of 1-(3-amino-2-thienyl)ethanone (10 g) in acetic acid (8 mL) was added a mixture of concentrated aqueous hydrochloric acid (13 mL) and water (28 mL) over 15 minutes at 0°C. To this was added an ice-cold solution of sodium nitrite (5.86 g) in water (19 mL). After stirring at 0°C for an additional 1 hour 15 minutes, urea (0.47 g) was added portionwise over 10 minutes, followed by stirring for an additional 1 hour. To this mixture at 0°C was added a solution of sodium acetate in water (200 mL), followed dichloromethane (100 mL). After stirring for a further 16 hours at room temperature the reaction mixture was separated and the aqueous phase was extracted with dichloromethane (100 mL). The organic phase was filtered and concentrated to afford thieno[3,2-c]pyridazin-4-ol as a dark brown solid which was used directly in the next step.

Step 3: Preparation of 4-chlorothieno[3,2-c]pyridazine



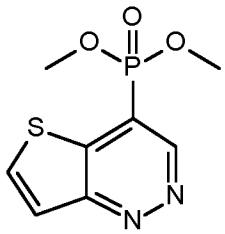
To a stirred solution of thieno[3,2-c]pyridazin-4-ol (5 g) in chlorobenzene (125 mL) was added phosphoryl trichloride (4.60 mL) dropwise at room temperature over 10 minutes. To this was added 2-methyl pyridine (0.91 g). The reaction mixture was heated at 140°C for 1 hour. After cooling to room temperature, the reaction mixture was poured into ice water and basified with aqueous sodium carbonate solution (500 mL). The resulting mixture was extracted with dichloromethane (2 × 150 mL) and the combined organic phases were dried over sodium sulfate, concentrated and purified by silica gel chromatography eluting with 20% ethyl acetate in hexanes to afford 4-chlorothieno[3,2-c]pyridazine as a light brown solid which was used directly in the next step.

Step 4: Preparation of 4-(p-tolylsulfonyl)thieno[3,2-c]pyridazine



To a solution of 4-chlorothieno[3,2-c]pyridazine (2.2 g) in *N,N*-dimethylformamide (40 mL) was added sodium p-toluenesulfinate (4.18 g) portionwise at room temperature. The reaction mixture was stirred for a further 16 hours then quenched into ice water (200 mL). The resulting solid was filtered off and dried under vacuum to afford 4-(p-tolylsulfonyl)thieno[3,2-c]pyridazine as a light brown solid which was used directly in the next step.

Step 5: Preparation of 4-dimethoxyphosphorylthieno[3,2-c]pyridazine



To a suspension of sodium hydride (0.103 g) in tetrahydrofuran (17 mL), under a nitrogen atmosphere, at 0°C was added dimethyl phosphite (0.29 g) dropwise, followed by warming to room temperature and stirring for an additional hour. The reaction mixture was then cooled to 0°C and 4-(p-tolylsulfonyl)thieno[3,2-c]pyridazine (0.5 g) was added in one portion. After warming to room temperature the reaction mixture was stirred for an additional 4 hours. To this was added water (20 mL) and the crude product was extracted with ethyl acetate (3 × 20 mL). The combined organic phases were washed with brine, dried over magnesium sulfate and concentrated to afford crude 4-dimethoxyphosphorylthieno[3,2-c]pyridazine which was used directly in the next step.

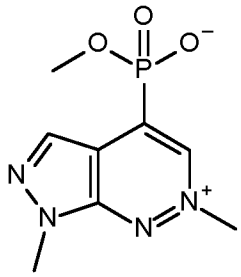
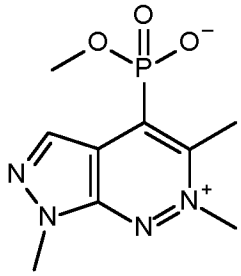
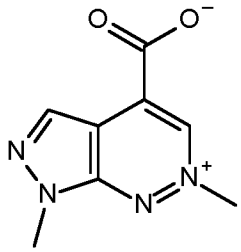
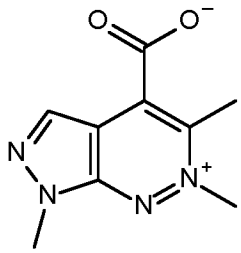
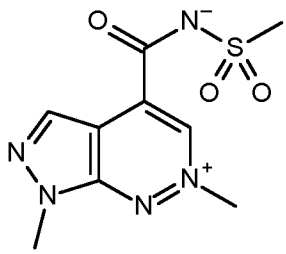
Step 6: Preparation of methoxy-(2-methylthieno[3,2-c]pyridazin-2-ium-4-yl)phosphinate A9

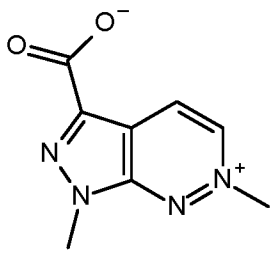
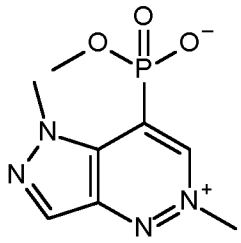
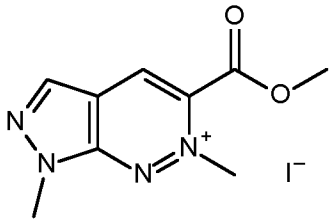
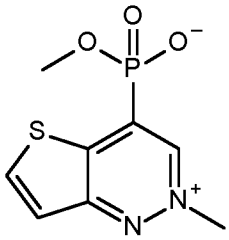
A solution of 4-dimethoxyphosphorylthieno[3,2-c]pyridazine (0.2 g) in methanol (3 mL) was heated at 70°C for 24 hours. After cooling to room temperature the mixture was concentrated and the residue triturated with acetone to afford methoxy-(2-methylthieno[3,2-c]pyridazin-2-ium-4-yl)phosphinate as a dark red solid.

^{1}H NMR (400MHz, CD_3OD) 9.46 (d, 1H), 8.76 (d, 1H), 8.00 (d, 1H), 4.79 (s, 3H), 3.65-3.56 (m, 3H)

Additional compounds in Table A were prepared by analogous procedures, from appropriate starting materials.

Table A physical data for compounds of the invention

Compound Number	Structure	^{1}H NMR
A1		(400MHz, D_2O) 9.33 (d, 1H), 8.75 (s, 1H), 4.77 (s, 3H), 4.28 (s, 3H), 3.53 (d, 3H)
A2		(400MHz, DMSO-d_6) 8.92 (s, 1H) 4.65 (s, 3H) 4.20 (s, 3H) 3.29 (s,3H) 3.18 (s, 3H)
A3		(400MHz, DMSO-d_6) 9.86 (s, 1H) 9.05 (s, 1H) 4.82 (s, 3H) 4.30 (s, 3H)
A4		(400MHz, DMSO-d_6) 8.71 (s, 1H) 4.64 (s, 3H) 4.23 (s, 3H) 3.01 (s, 3H)
A5		(400MHz, D_2O) 9.85 (s, 1H) 9.05 (s, 1H) 4.81 (s, 3H) 4.42 (s, 3H) 3.02 (s, 3H)

Compound Number	Structure	^{1}H NMR
A6		(400MHz, DMSO-d_6) 9.74 (d, 1H) 9.28 (d, 1H) 4.85 (s, 3H) 4.37 (s, 3H)
A7		(400MHz, DMSO-d_6) 9.40 (s, 1H) 9.28 (d, 1H) 4.70 (s, 3H) 4.58 (s, 3H) 3.38 (d, 3H)
A8		(400MHz, $CDCl_3$) 9.46 (s, 1H) 8.18 (s, 1H) 5.01 (s, 3H) 4.34 (s, 3H) 4.08 (s, 3H)
A9		(400MHz, CD_3OD) 9.46 (d, 1H) 8.76 (d, 1H) 8.00 (d, 1H) 4.79 (s, 3H) 3.65-3.56 (m, 3H)

BIOLOGICAL EXAMPLES

Post-emergence efficacy

Method A

Seeds of a variety of test species were sown in standard soil in pots. After cultivation for 14 days (post-emergence) under controlled conditions in a glasshouse (at 24/16 °C, day/night; 14 hours light; 65 % humidity), the plants were sprayed with an aqueous spray solution derived from the dissolution of the technical active ingredient formula (I) in a small amount of acetone and a special solvent and emulsifier mixture referred to as IF50 (11.12% Emulsogen EL360 TM + 44.44% N-methylpyrrolidone + 44.44% Dowanol DPM glycol ether), to create a 50g/l solution which was then diluted to required concentration using a solution of 0.25% or 1% Empicol ESC70 (Sodium lauryl ether sulphate) + 1% ammonium sulphate in water as diluent.

The test plants were then grown in a glasshouse under controlled conditions (at 24/16 °C, day/night; 14 hours light; 65 % humidity) and watered twice daily. After 13 days the test was evaluated (100 = total damage to plant; 0 = no damage to plant).

The results are shown in Table B (below). A value of n/a indicates that this combination of weed and test compound was not tested/assessed.

Test plants:

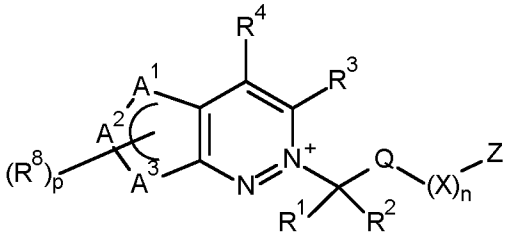
Ipomoea hederacea (IPOHE), *Euphorbia heterophylla* (EPHHL), *Chenopodium album* (CHEAL), *Amaranthus palmeri* (AMAPA), *Lolium perenne* (LOLPE), *Digitaria sanguinalis* (DIGSA), *Eleusine indica* (ELEIN), *Echinochloa crus-galli* (ECHCG), *Setaria faberi* (SETFA)

Table B – Control of weed species by compounds of formula (I) after post-emergence application

Compound Number	Application Rate g/Ha	AMAPA	CHEAL	EPHHL	IPOHE	ELEIN	LOLPE	DIGSA	SETFA	ECHCG
A1	1000	100	100	100	80	100	90	100	100	100
A2	1000	100	100	70	60	70	30	80	50	50
A3	1000	100	90	100	100	80	80	90	100	100
A4	1000	40	70	40	60	60	20	70	10	50
A5	1000	100	100	100	100	90	40	70	60	40
A6	1000	100	100	100	100	60	60	70	70	40
A7	500	100	40	40	40	60	40	100	90	70
A8	500	100	100	90	80	80	80	60	60	50
A9	1000	-	20	90	40	60	10	90	60	70

CLAIMS:

1. A compound of formula (I) or an agronomically acceptable salt or zwitterionic species thereof:



(I)

R^1 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_2-C_6alkenyl, C_2-C_6alkynyl, C_3-C_6cycloalkyl, C_1-C_6haloalkyl, -OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$;

R^2 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl and C_1-C_6haloalkyl;

and wherein when R^1 is selected from the group consisting of –OR^7, -OR^{15a}, -$N(R^6)S(O)_2R^{15}$, -$N(R^6)C(O)R^{15}$, -$N(R^6)C(O)OR^{15}$, –$N(R^6)C(O)NR^{16}R^{17}$, -$N(R^6)CHO$, -$N(R^{7a})_2$ and –$S(O)_rR^{15}$, R^2 is selected from the group consisting of hydrogen and C_1-C_6alkyl; or

R^1 and R^2 together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O;

Q is $(CR^{1a}R^{2b})_m$;

m is 0, 1, 2 or 3;

each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, -OH, -OR^7, -OR^{15a}, -NH_2, -NHR^7, -NHR^{15a}, -$N(R^6)CHO$, -$NR^{7b}R^{7c}$ and –$S(O)_rR^{15}$; or

each R^{1a} and R^{2b} together with the carbon atom to which they are attached form a C_3-C_6cycloalkyl ring or a 3- to 6- membered heterocyclyl, which comprises 1 or 2 heteroatoms individually selected from N and O;

R^3 is selected from the group consisting of hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl and C_1-C_6alkoxy and E;

R^4 is selected from the group consisting of E, hydrogen, nitro, cyano, -NH_2, -NR^6R^7, -OH, -OR^7, -$S(O)_rR^{12}$, -$NR^6S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_1-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, -$C(R^8)$=NOR^8, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents R^9, which may be the same or different;

each R^6 is independently selected from hydrogen and C_1-C_6alkyl;

each R^7 is independently selected from the group consisting of C_1-C_6alkyl, -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$ and –$C(O)NR^{16}R^{17}$;

each R^{7a} is independently selected from the group consisting of -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$ –$C(O)NR^{16}R^{17}$ and –$C(O)NR^6R^{15a}$;

R^{7b} and R^{7c} are independently selected from the group consisting of C_1-C_6alkyl, -$S(O)_2R^{15}$, -$C(O)R^{15}$, -$C(O)OR^{15}$, –$C(O)NR^{16}R^{17}$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different; or

R^{7b} and R^{7c} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S; and

the ring comprising A^1, A^2 and A^3 together with the carbon atoms of the adjacent ring to which A^1 and A^3 are attached is aromatic;

A^1, A^2 and A^3 are independently selected from the group consisting of C, N, O and S;

at least one of A^1, A^2 and A^3 are N, O or S;

when A^1, A^2 and A^3 are C or N, they may each be substituted by R^8 substituents;

p is 0, 1, 2 or 3;

when p is 1 or 2, and R^8 is attached to N then R^8 is independently selected from the group consisting of hydrogen, -OR^7, -$S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_2-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents, which may be the same or different, selected from R^9, or

when p is 1 or 2 and R^8 is attached to C then each R^8 is independently selected from the group consisting of E, hydrogen, halogen, nitro, cyano, -NR^6R^7, -OR^7, -$S(O)_rR^{12}$, -$NR^6S(O)_rR^{12}$, C_1-C_6alkyl, C_1-C_6haloalkyl, C_3-C_6cycloalkyl, C_3-C_6halocycloalkyl, C_3-C_6cycloalkoxy, C_2-C_6alkenyl, C_2-C_6haloalkenyl, C_2-C_6alkynyl, C_1-C_3alkoxyC_1-C_3alkyl-, hydroxyC_1-C_6alkyl-, C_1-C_6alkoxy, C_1-C_6haloalkoxy, C_1-C_3haloalkoxyC_1-C_3alkyl-, C_1-C_6alkoxycarbonyl, C_3-C_6alkenyloxy, C_3-C_6alkynyloxy, C_1-C_6alkylcarbonyl, C_1-C_6alkylaminocarbonyl, di-C_1-C_6alkylaminocarbonyl, -$C(R^6)$=NOR^6, phenyl and heteroaryl, wherein the heteroaryl moiety is a 5- or 6-membered monocyclic aromatic ring which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and wherein any of said phenyl or heteroaryl moieties are optionally substituted by 1, 2 or 3 substituents, which may be the same or different, selected from R^9, or

when p is 3, and R^8 is attached to N then each R^8 is independently selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy;

when p is 3, and R^8 is attached to C then each R^8 is independently selected from the group consisting of E, hydrogen, halogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy and C_1-C_6haloalkoxy;

each R^9 is independently selected from the group consisting of halogen, cyano, -OH, -$N(R^6)_2$, C_1-C_4alkyl, C_1-C_4alkoxy, C_1-C_4haloalkyl and C_1-C_4haloalkoxy;

E is selected from the group consisting of of –$C(O)OR^{10}$, -CHO, -$C(O)R^{24}$, -$C(O)NHOR^{11}$, -C(O)NHCN, -$C(O)NHR^{25}$, -$S(O)_2NHR^{25}$, -$C(O)NR^6(CR^6_2)_qC(O)(OR^{10})$, -$C(O)NR^6(CR^6_2)_qS(O)_2(OR^{10})$ and -$C(O)NR^6(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$(CR^6_2)_qC(O)OR^{10}$, -$(CR^6_2)_qS(O)_2(OR^{10})$, -$(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$OC(O)NHOR^{11}$, -$O(CR^6_2)_qC(O)OR^{10}$, -OC(O)NHCN, -$O(CR^6_2)_qS(O)_2(OR^{10})$, -$O(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$NR^6C(O)NHOR^{11}$, -$NR^6C(O)NHCN$, -$C(O)NHS(O)_2R^{12}$, -$OC(O)NHS(O)_2R^{12}$, -$NR^6C(O)NHS(O)_2R^{12}$, -$S(O)_2OR^{10}$, -$OS(O)_2OR^{10}$, -$NR^6S(O)_2OR^{10}$, -$NR^6S(O)OR^{10}$, -$NHS(O)_2R^{14}$, -$S(O)OR^{10}$, -$S(CR^6_2)_qC(O)OR^{10}$, -$S(CR^6_2)_qS(O)_2(OR^{10})$, -$S(CR^6_2)_qP(O)(R^{13})(OR^{10})$, -$OS(O)OR^{10}$, -$S(O)_2NHCN$, -$S(O)_2NHC(O)R^{18}$, -$S(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHCN$, -$OS(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHC(O)R^{18}$, -$NR^6S(O)_2NHCN$, -$NR^6S(O)_2NHC(O)R^{18}$, –$N(OH)C(O)R^{15}$, –$ONHC(O)R^{15}$, -$NR^6S(O)_2NHS(O)_2R^{12}$, -$P(O)(R^{13})(OR^{10})$, -$P(O)H(OR^{10})$, -$OP(O)(R^{13})(OR^{10})$, -$NR^6P(O)(R^{13})(OR^{10})$ and tetrazole;

q is 1, 2 or 3;

one of R^3, R^4 and R^8 is a group E;

R^8 can only be E if it is attached to C;

X is selected from the group consisting of C_3-C_6cycloalkyl, phenyl, a 5- or 6- membered heteroaryl, which comprises 1, 2, 3 or 4 heteroatoms individually selected from N, O and S, and a 4- to 6- membered heterocyclyl, which comprises 1, 2 or 3 heteroatoms individually selected from N, O and S, and wherein said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties are optionally substituted by 1 or 2 substituents, which may be the same or different, selected from R^9, and wherein the aforementioned CR^1R^2, Q and Z moieties may be attached at any position of said cycloalkyl, phenyl, heteroaryl or heterocyclyl moieties;

n is 0 or 1;

Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, C_1-C_6alkoxyC_1-C_6alkyl, nitro, halo, haloalkoxy, cyano, -NH_2, -OH, -OR^7, -$C(O)R^{15}$, -$C(O)NR^{16}R^{17}$, –$C(O)OR^{10}$, -CHO, -$C(O)NHOR^{11}$, -C(O)NHCN, -$OC(O)NHOR^{11}$, -OC(O)NHCN, -$NR^6C(O)NHOR^{11}$, -$NR^6C(O)NHCN$, -$C(O)NHS(O)_2R^{12}$, -$OC(O)NHS(O)_2R^{12}$, -NHR^7, -$N(R^7)_2$, -$NR^6C(O)NHS(O)_2R^{12}$, -$NR^6S(O)_2R^{15}$, -$S(O)_2OR^{10}$, -$OS(O)_2OR^{10}$, -$NR^6S(O)_2OR^{10}$, -$NR^6S(O)OR^{10}$, -$NHS(O)_2R^{14}$, -$S(O)_rR^{15}$, -$S(O)OR^{10}$, -$S(O)_2NR^{16}R^{17}$ -$OS(O)OR^{10}$, -$S(O)_2NHCN$, -$S(O)_2NHC(O)R^{18}$, -$S(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHCN$, -$OS(O)_2NHS(O)_2R^{12}$, -$OS(O)_2NHC(O)R^{18}$, -$NR^6S(O)_2NHCN$, -$NR^6S(O)_2NHC(O)R^{18}$, –$N(OH)C(O)R^{15}$, –$ONHC(O)R^{15}$, -$NR^6S(O)_2NHS(O)_2R^{12}$, -$P(O)(R^{13})(OR^{10})$, -$P(O)H(OR^{10})$, -$OP(O)(R^{13})(OR^{10})$, -$NR^6P(O)(R^{13})(OR^{10})$, tetrazole;

R^{10} is selected from the group consisting of hydrogen, C_1-C_6alkyl, phenyl and benzyl, and wherein said phenyl or benzyl are optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{11} is selected from the group consisting of hydrogen, C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{12} is selected from the group consisting of C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -OH, -$N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{13} is selected from the group consisting of -OH, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6haloalkoxy, -O-propargyl, –O-allyl and phenyl;

R^{14} is C_1-C_6haloalkyl;

R^{15} is selected from the group consisting of C_1-C_6alkyl and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{15a} is phenyl, wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{16} and R^{17} are independently selected from the group consisting of hydrogen and C_1-C_6alkyl; or

R^{16} and R^{17} together with the nitrogen atom to which they are attached form a 4- to 6-membered heterocyclyl ring which optionally comprises one additional heteroatom individually selected from N, O and S;

R^{18} is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6alkoxy, -$N(R^6)_2$ and phenyl, and wherein said phenyl is optionally substituted by 1, 2 or 3 R^9 substituents, which may be the same or different;

R^{24} is a peptide moiety comprising one, two or three amino acid moieties independently selected from the group consisting of Ala, Cys, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp and Tyr, wherein said peptide moiety is bonded to the rest of the molecule via a nitrogen atom in the amino acid moiety;

R^{25} is selected from the group consisting of 5- or 6- membered heteroaromatic moieties, optionally substituted with one or more groups independently selected from R^2;

R^{25} is selected from the group consisting of 5- or 6- membered heteroaromatic moieties, containing at least two N atoms, optionally substituted with one or more groups independently selected from R^9;

and

r is 0, 1 or 2.

2. The compound according to claim 1, wherein R^1 and R^2 are independently selected from the group consisting of hydrogen and C_1-C_6alkyl.

3. The compound according to claim 1 or claim 2, wherein each R^{1a} and R^{2b} are independently selected from the group consisting of hydrogen, C_1-C_6alkyl, –OH and –NH_2.

4. The compound according to any one of claims 1 to 3, wherein m is 0.

5. The compound according to any one of claims 1 to 4, wherein R^3 and R^4 are independently selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6alkoxy and E.

6. The compound according to any one of claims 1 to 5, wherein R^3 and R^4 are hydrogen, methyl or E.

7. The compound according to any one of claims 1 to 6, wherein A^1 is C, A^2 and A^3 are N and A^3 is substituted with methyl.

8. The compound according to any one of claims 1 to 7, wherein p is 1 or 2.

9. The compound according to claim 8 in which p is 1.

10 The compound according to any one of claims 1 to 9, wherein each R^8 when attached to C is independently selected from the group consisting of E, hydrogen and C_1-C_6alkyl and when attached to N is independently selected from the group consisting of hydrogen and C_1-C_6alkyl.

11. The compound according to any one of claims 1 to 10, wherein Z is selected from the group consisting of hydrogen, C_1-C_6alkyl, C_1-C_6haloalkyl, C_1-C_6hydroxyalkyl, C_1-C_6alkyoxyC_1-C_6alkyl, -C(O)OR^{10}, -C(O)NHS$(O)_2R^{12}$, -S$(O)_2OR^{10}$, and -P(O)$(R^{13})(OR^{10})$.

12. The compound according to claim 11, wherein Z is hydrogen or C_1-C_6alkyl.

13. The compound according to any one of claims 1 to 12, wherein n is 0.

14. An agrochemical composition comprising a herbicidally effective amount of a compound of formula (I) as defined in any one of claims 1 to 13 and an agrochemically-acceptable diluent or carrier.

15. A method of controlling or preventing undesirable plant growth, wherein a herbicidally effective amount of a compound of formula (I) as defined in any one of claims 1 to 13, or a herbicidal composition according to claim 14, is applied to the plants, to parts thereof or to the locus thereof.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052912

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07D487/04 C07D513/04 A01N43/90
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 2019/034757 A1 (SYNGENTA PARTICIPATIONS AG [CH]) 21 February 2019 (2019-02-21) claims 1,16	1-15
A,P	WO 2019/185875 A1 (SYNGENTA PARTICIPATIONS AG [CH]) 3 October 2019 (2019-10-03) claims 1,15	1-15
A	WO 2018/108726 A1 (SYNGENTA PARTICIPATIONS AG [CH]) 21 June 2018 (2018-06-21) page 1, line 2 - line 4; claims 1,21	1-15
A	WO 2016/020286 A1 (SYNGENTA PARTICIPATIONS AG [CH]) 11 February 2016 (2016-02-11) page 1, line 1 - line 5; claim 1	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2020	23/04/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gettins, Marc

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052912

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/067701 A1 (SYNGENTA PARTICIPATIONS AG [CH]; SYNGENTA LTD [GB]) 14 May 2015 (2015-05-14) claim 1 -----	1-15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2020/052912

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1-6, 8-15(all partially)
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Continuation of Box II.2

Claims Nos.: 1-6, 8-15(all partially)

1.1 Present claim 1 relates to an extremely large number of possible compounds (I). This applies in particular to the large number of possible bicyclic rings due to the variation in A1-A3. Support and disclosure in the sense of Article 6 and 5 PCT is to be found however for only a very small proportion of the compounds claimed, see examples 1-8 and A1-A11. Note that Tables 1-39 are not taken to refer to anything more than theoretical examples and are not taken as true support for the scope of (I).

1.2 The non-compliance with the substantive provisions is to such an extent, that the search was performed taking into consideration the non-compliance in determining the extent of the search of claim 1 (PCT Guidelines 9.19 and 9.23).

1.3 The search of claim 1 was restricted to those claimed compounds which appear to be supported and a generalisation of their structural formulae. Table D on pages 18-23 gives various possibilities based upon the bicyclic ring system. Using the definitions of the given in Table D this means that compounds of type D1, D3, D7, D11, D14, D16 and D22 have been searched. Other possibilities have not been searched

1.4 This means that only claim 7 was searched fully and all other claims were partially searched. All of examples 1-8 and A1-A11 were covered by the scope of the search.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/052912

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2019034757 A1	21-02-2019	AR 112682 A1	27-11-2019
		AU 2018316526 A1	13-02-2020
		CA 3071643 A1	21-02-2019
		CO 2020001631 A2	01-04-2020
		TW 201920145 A	01-06-2019
		UY 37849 A	29-03-2019
		WO 2019034757 A1	21-02-2019
WO 2019185875 A1	03-10-2019	TW 202003497 A	16-01-2020
		WO 2019185875 A1	03-10-2019
WO 2018108726 A1	21-06-2018	BR 112019012127 A2	05-11-2019
		CN 110022682 A	16-07-2019
		EP 3554242 A1	23-10-2019
		JP 2020502115 A	23-01-2020
		US 2019308982 A1	10-10-2019
		WO 2018108726 A1	21-06-2018
WO 2016020286 A1	11-02-2016	BR 112017002407 A2	26-06-2018
		CN 106661023 A	10-05-2017
		EP 3177620 A1	14-06-2017
		ES 2701835 T3	26-02-2019
		JP 2017523997 A	24-08-2017
		US 2017215425 A1	03-08-2017
		WO 2016020286 A1	11-02-2016
WO 2015067701 A1	14-05-2015	AR 098358 A1	26-05-2016
		BR 112016010566 A2	02-05-2018
		CA 2927901 A1	14-05-2015
		CN 105764894 A	13-07-2016
		EP 3068777 A1	21-09-2016
		ES 2651470 T3	26-01-2018
		US 2016262395 A1	15-09-2016
		WO 2015067701 A1	14-05-2015