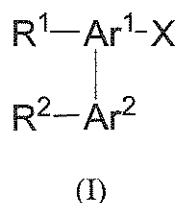


CLAIMS

1. A compound having a structure corresponding to formula (I),



or a salt thereof,

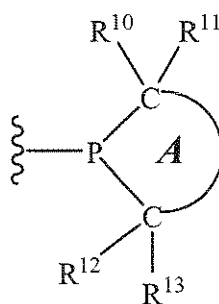
wherein

Ar¹ and Ar² are each independently aryl or heteroaryl, and wherein Ar¹ and Ar² are each independently optionally substituted with one or more R¹ and R², respectively;

R¹ and R² are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino; heteroarylamino; alkylamino; dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; L¹—C(O)—OR^{1'}, L¹—P(O)—(OR^{1'})₂, or L¹—S(O)₂—OR^{1'}, wherein L¹ is a bond or alkylene, and R^{1'} is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; L²—O—C(O)—R^{2'}, wherein L² is a bond or alkylene, and R^{2'} is alkyl or hydroxyalkyl; L³—C(O)—NR^{3'}R^{4'}, wherein L³ is a bond or alkylene, and R^{3'} and R^{4'} are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; L⁴—NR^{5'}—C(O)—R^{6'}, wherein L⁴ is a bond or alkylene, R^{5'} is hydrogen or alkyl, and R^{6'} is alkyl or hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate;

alkylthio; thioalkyl; and a ring containing an alkylene or $-O-(CH_2)_m-O-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a 6-membered cyclic phosphine of formula (Ia):



(Ia)

wherein ring A includes three carbon ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia);

wherein the ring atoms of ring A are each independently optionally substituted with one or more substituents selected from the group consisting of alkenyl; alkoxy; alkoxyalkyl; alkyl; alkylamino; alkylthio; alkynyl; aminoalkyl; N -alkylaminoalkyl; N,N -dialkylaminoalkyl; N,N,N -trialkylammoniumalkyl; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; dialkylamino; halo; haloalkyl; fluoroalkyl; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxy; hydroxyalkyl; oxo; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms; phenyl

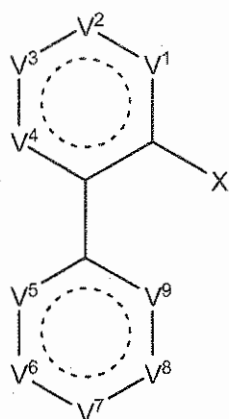
optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl or hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; and $L^7-NR^{8'}-S(O)_2-R^{9'}$, wherein L^7 is a bond or alkylene, $R^{8'}$ is hydrogen or alkyl, and $R^{9'}$ is alkyl or hydroxyalkyl;

as to R^{10} , R^{11} , R^{12} , and R^{13} ,

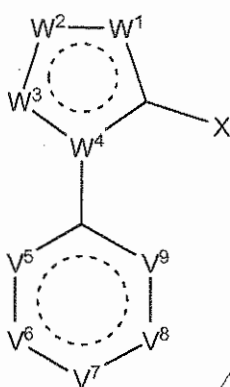
- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring; or
- iii. one or more of R^{10} , R^{11} , R^{12} and R^{13} form a ring together with a ring substituent of ring A; or
- iv. R^{10} , R^{11} , R^{12} , and R^{13} do not form a ring, wherein R^{10} , R^{11} , R^{12} , and R^{13} are each independently selected from the group consisting of alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of

hydrogen, alkyl, and hydroxyalkyl ; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl.

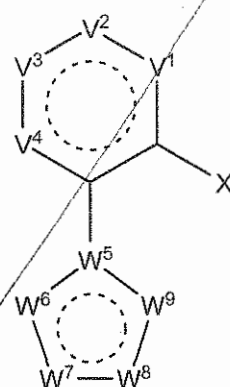
2. The compound according to claim 1, said compound having a structure corresponding to a structure of a formula selected from the group consisting of formulae (I-1) - (I-42), or a salt thereof:



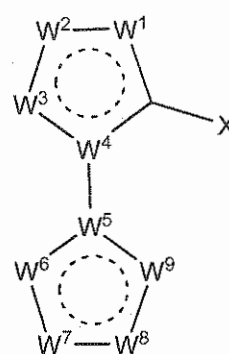
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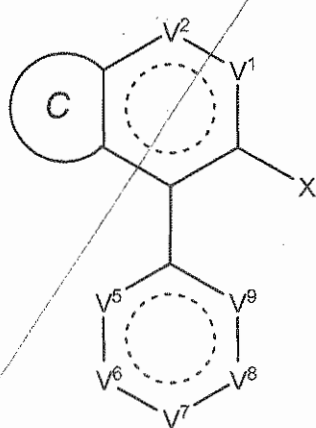
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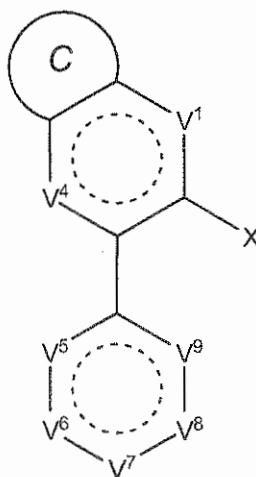
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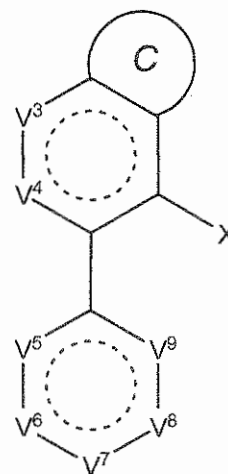
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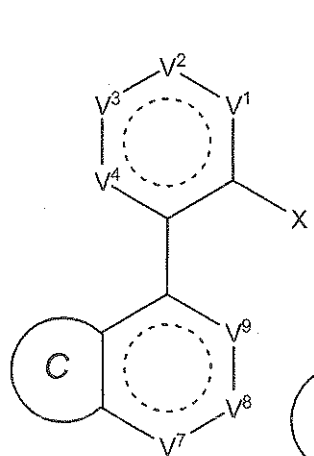
(I-5)



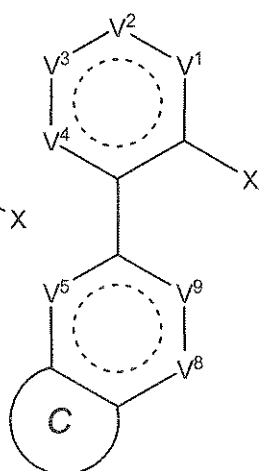
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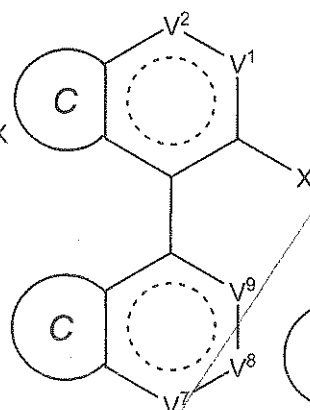
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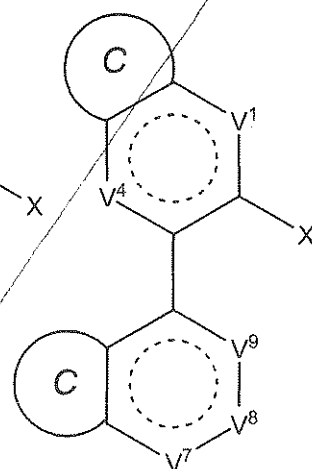
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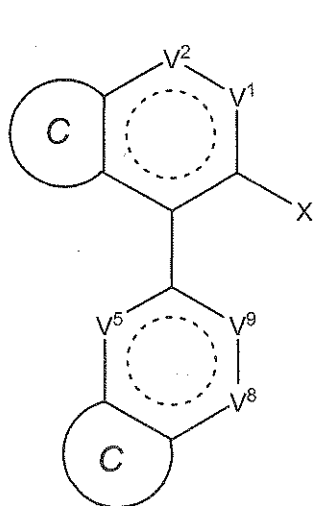
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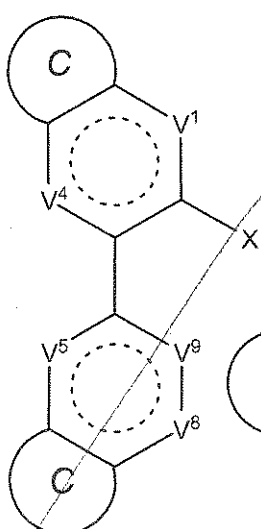
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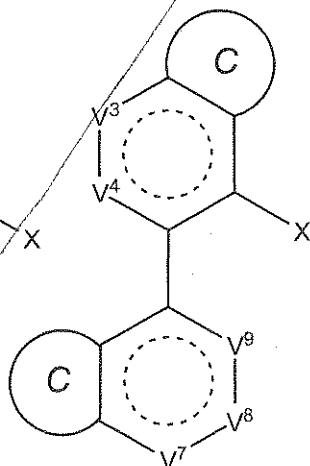
(I-11)



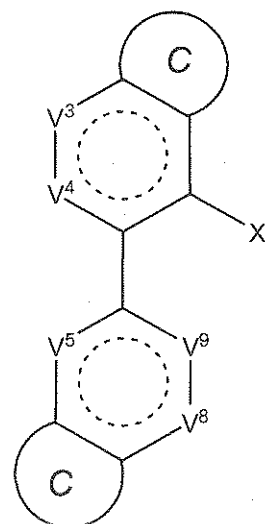
(I-12)



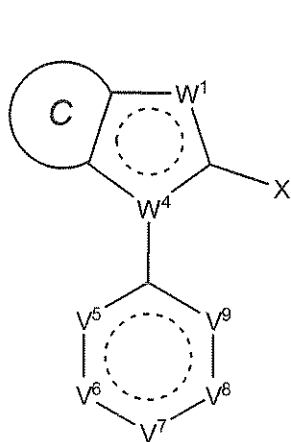
(I-13)



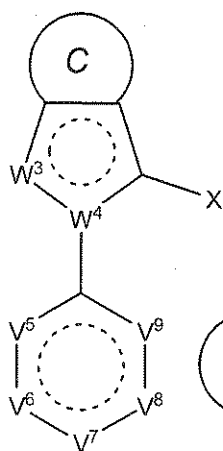
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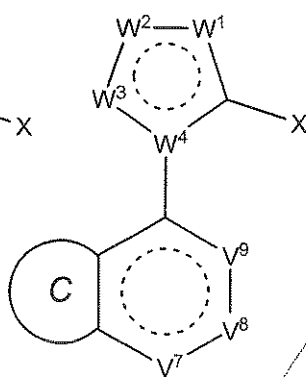
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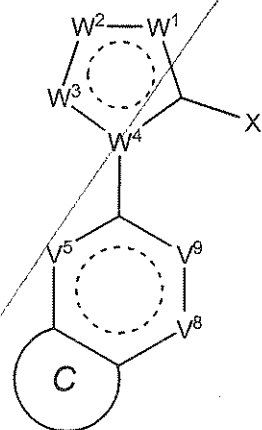
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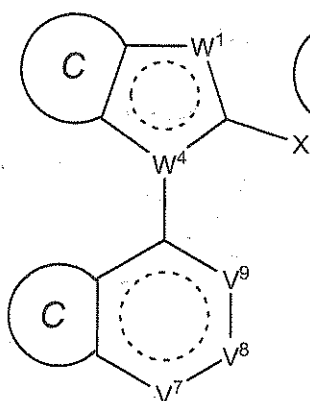
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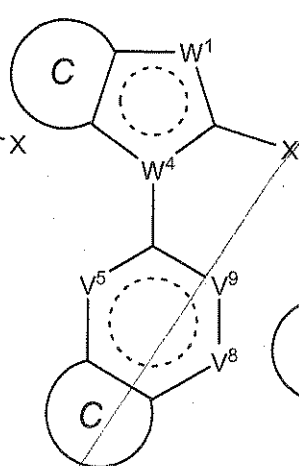
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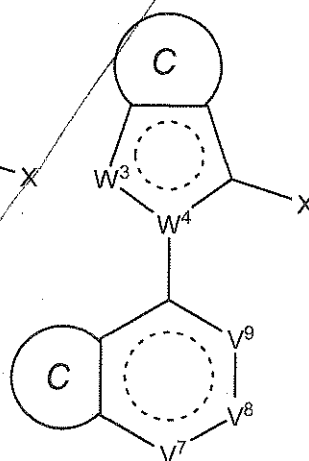
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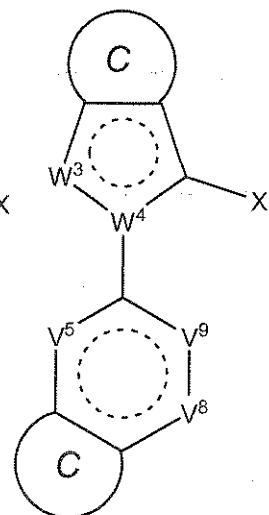
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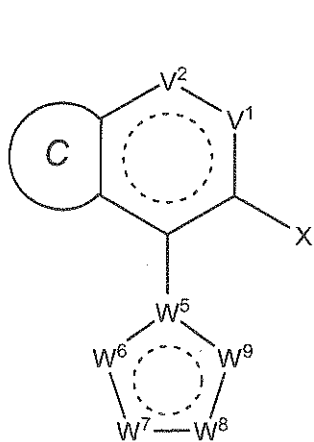
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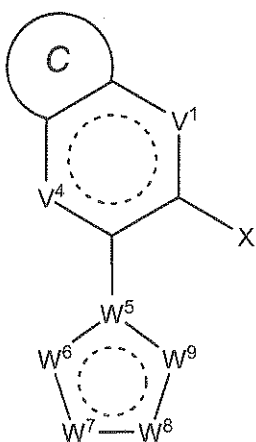
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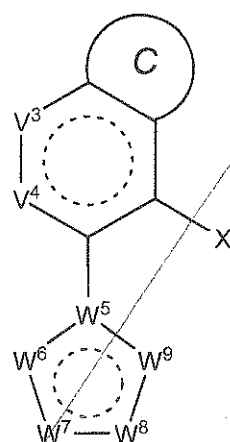
(I-23)



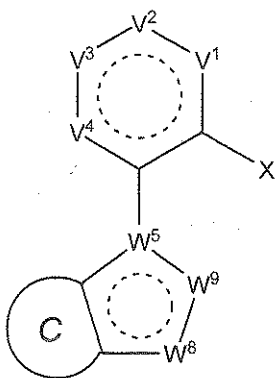
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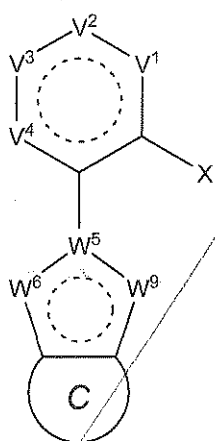
(I-25)



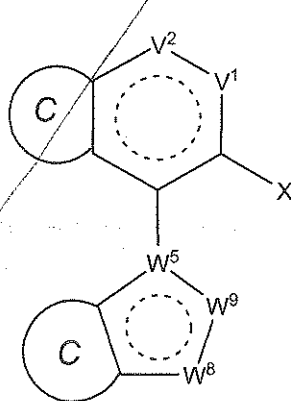
(I-26)



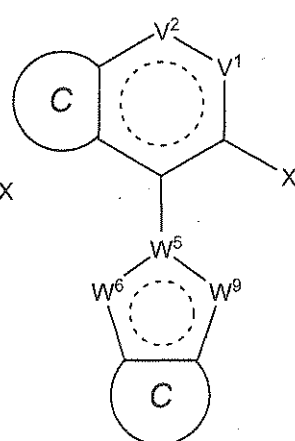
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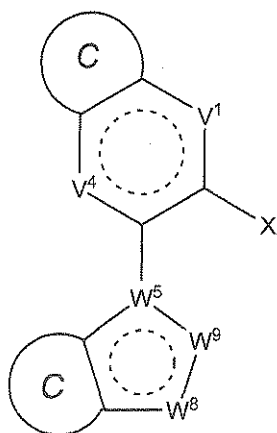
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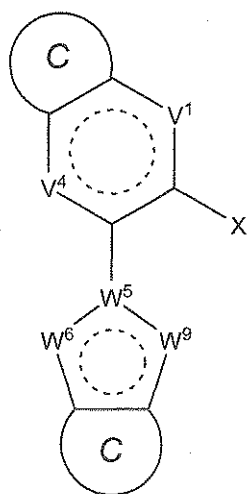
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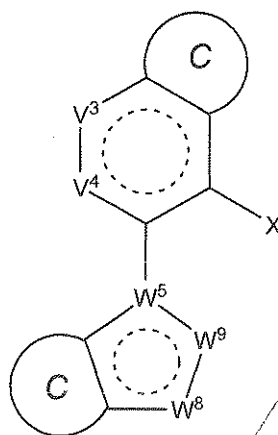
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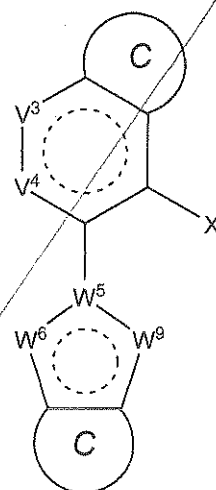
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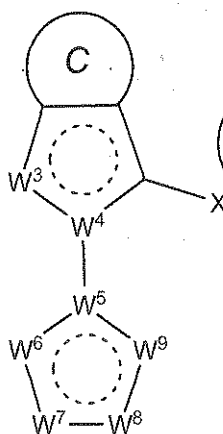
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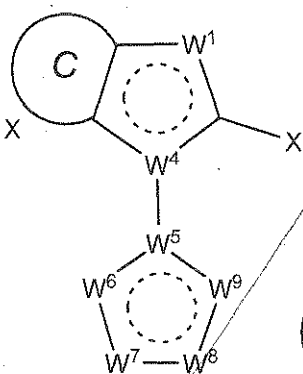
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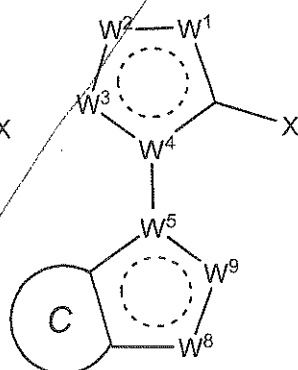
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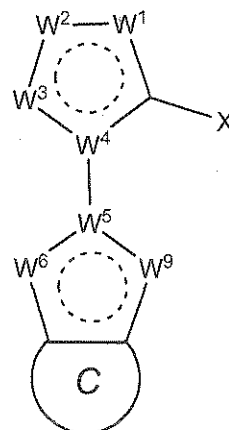
(I-35)



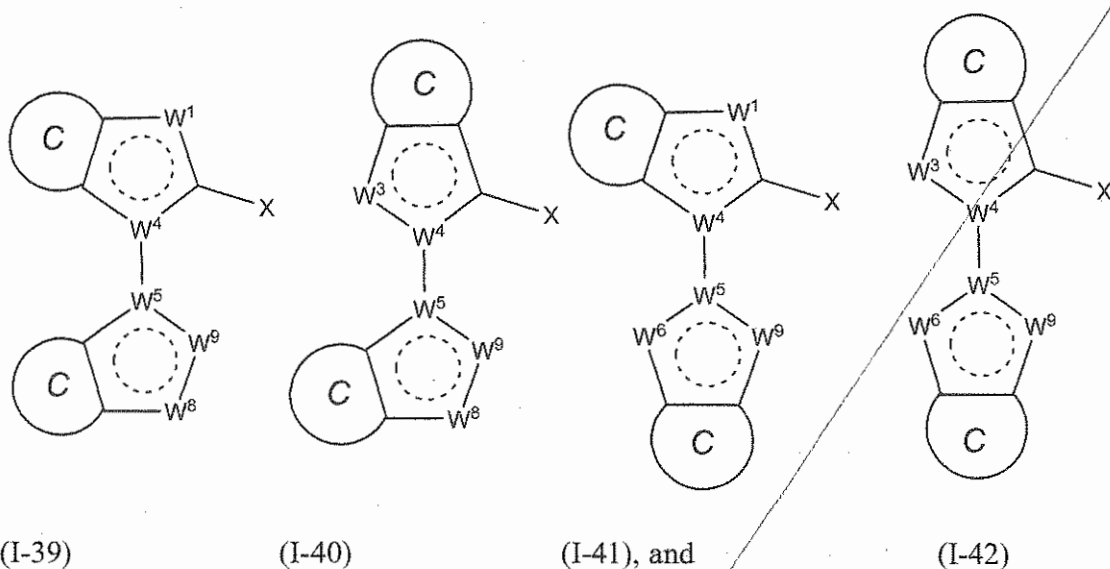
(I-36)



(I-37)



(I-38)



wherein

X is a 6-membered cyclic phosphine of formula (Ia) or a phosphine of formula (Ib);

V^1 , V^2 , V^3 , and V^4 are each independently CR^1 or N;

V^5 , V^6 , V^7 , V^8 and V^9 are each independently CR^2 or N;

W^1 , W^2 , and W^3 are each independently selected from the group consisting of CR^1 , NR^1 , N and O;

W^4 is C or N;

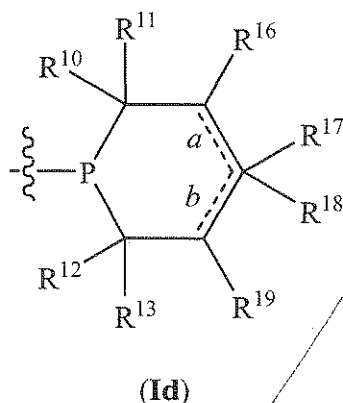
W^5 is C or N;

W^6 , W^7 , W^8 and W^9 are each independently selected from the group consisting of CR^2 , NR^2 , N and O; and

ring C, at each occurrence, is a fused-aryl or fused-heteroaryl and is optionally substituted with R^1 and R^2 .

3. The compound according to claim 1, wherein X is the 6-membered cyclic phosphine of formula (Ia) and wherein X is attached to an atom of Ar^1 adjacent to the atom bonded to Ar^2 .

4. The compound according to claim 1 or claim 2, wherein X is a phosphine of formula (Id), or a salt thereof:



wherein

one or more of R^{16} , R^{17} , R^{18} , and R^{19} optionally form a ring with R^{10} , R^{11} , R^{12} , or R^{13} ; or

R^{17} together with R^{18} optionally form a carbonyl; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms, optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or

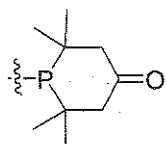
R^{16} and R^{19} are each independently selected from the group consisting of hydrogen, halo, alkyl, haloalkyl, fluoroalkyl, alkenyl, and alkoxy; or

R^{17} and R^{18} are each independently selected from the group consisting of hydrogen; halo; fluoro; alkyl; alkenyl; alkynyl; haloalkyl; fluoroalkyl; alkyloxy; *N*-alkylamino; *N,N*-dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy, phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1

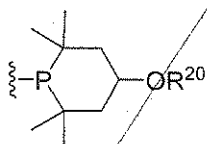
is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, and $R^{5'}$ is hydrogen or alkyl, $R^{6'}$ is alkyl or hydroxyalkyl; and alkylthio; and

at least one of bonds a and b in formula (Id) is a single bond and one of bonds a or b is optionally a double bond.

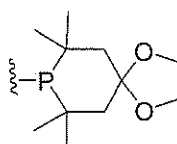
5. The compound according to claim 4, wherein R^{16} and R^{19} are hydrogen.
6. The compound according to claim 4; wherein R^{17} and R^{18} together with the carbon atom to which they are attached form a 3-, 4-, 5-, 6-, or 7-membered spirocyclic ring containing 0, 1, or 2 ring heteroatoms.
7. The compound according to claim 4, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of:



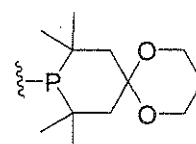
1-1



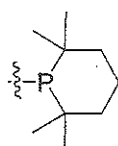
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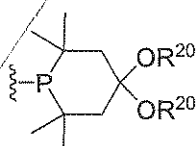
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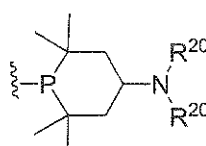
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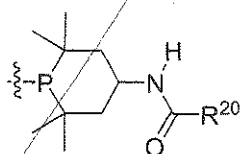
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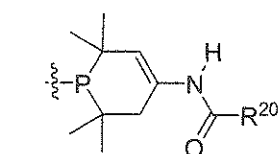
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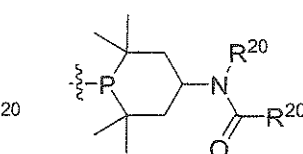
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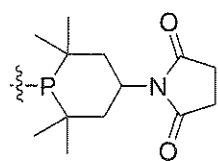
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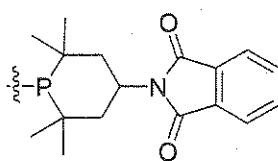
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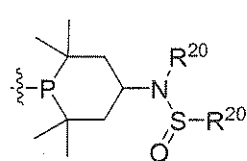
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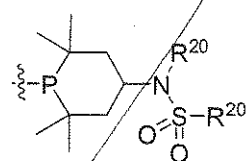
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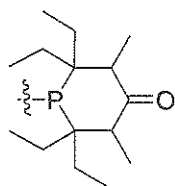
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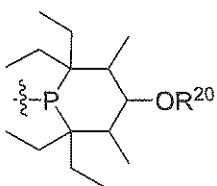
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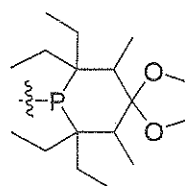
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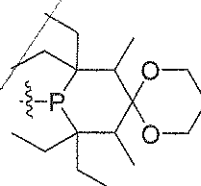
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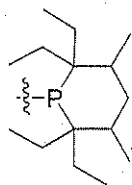
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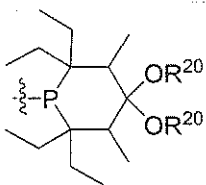
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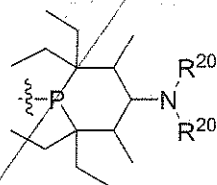
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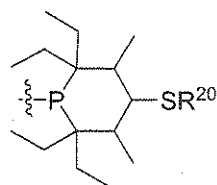
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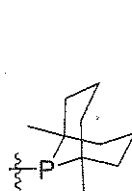
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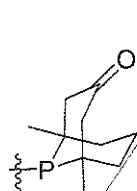
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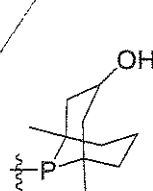
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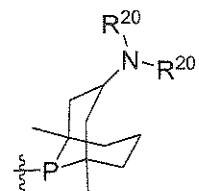
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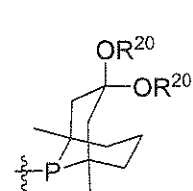
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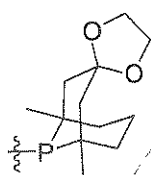
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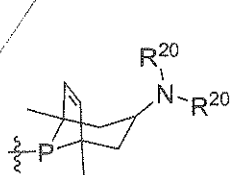
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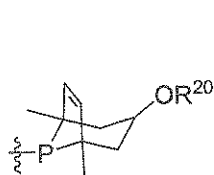
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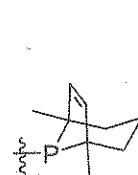
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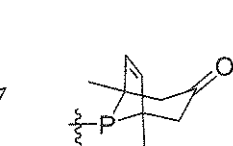
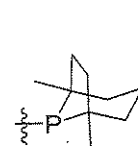
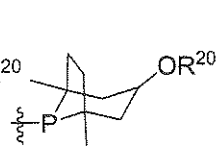
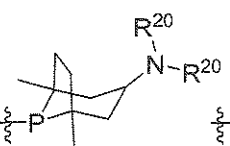
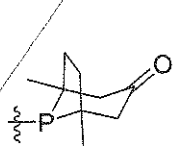
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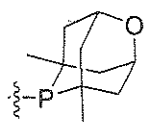
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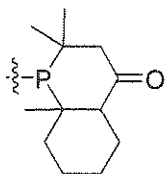
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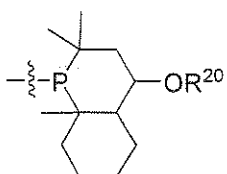
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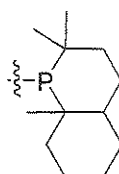
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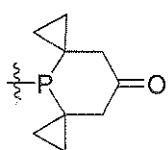


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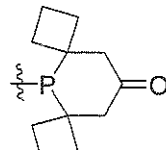


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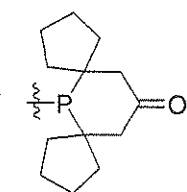
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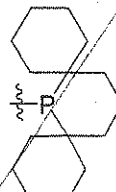
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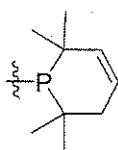
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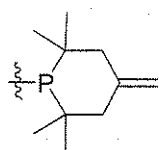
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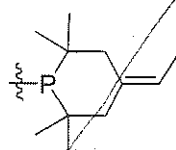
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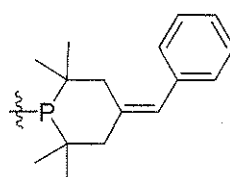
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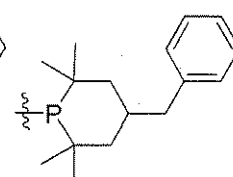
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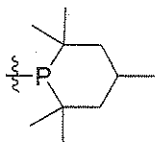
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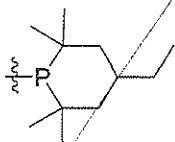
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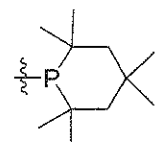
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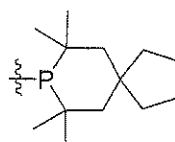
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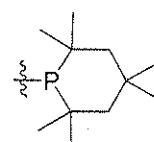
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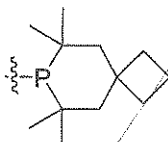
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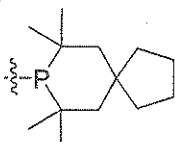
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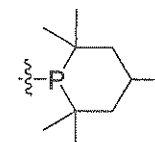
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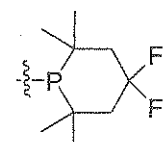
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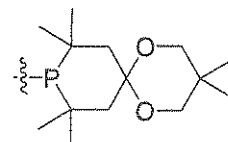
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1-59



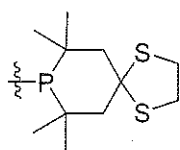
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1-61

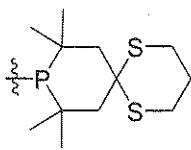
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1-63

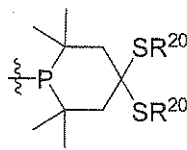
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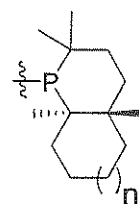
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1-66



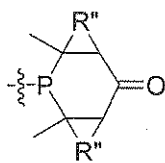
1-67



1-68



1-69, and



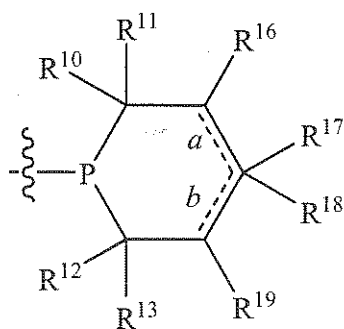
1-70

or a salt thereof, wherein R'' is selected from the group consisting of oxygen, NR²⁰, and C(R²⁰)₂;

R²⁰ is hydrogen, alkyl, aryl, heteroaryl, arylalkyl or heteroarylalkyl, wherein the aryl, heteroaryl, aryl of arylalkyl and heteroaryl of heteroarylalkyl are optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; and

n is 0, 1, or 2.

8. The compound of claim 1, wherein Ar¹ and Ar² are each aryl.
9. The compound of claim 1, wherein Ar¹ is substituted with two R¹ and Ar² is substituted with three R².
10. The compound of claim 1, wherein R¹ is alkyloxy and wherein R² is alkyl.
11. The compound of claim 1, wherein R² is isopropyl.
12. The compound of claim 1, wherein X is a phosphine of formula (Id):



(Id)

wherein each of R¹⁰, R¹¹, R¹², R¹³ is alkyl;

R¹⁷ and R¹⁸ are each independently selected from the group consisting of hydrogen, or R¹⁷ together with R¹⁸ optionally form a carbonyl or a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms;

each of R¹⁶ and R¹⁹ is hydrogen; and

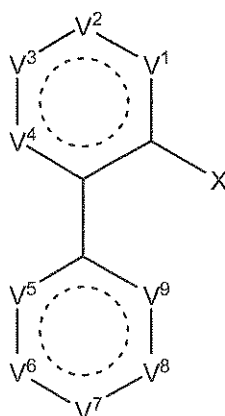
each of bonds a and b is a single bond.

13. The compound of claim 12, wherein R¹⁷ together with R¹⁸ form a 5-membered spiro ring containing two heteroatoms.

14. The compound of claim 13, wherein the two heteroatoms are each oxygen.

15. The compound of claim 1, wherein R¹⁰, R¹¹, R¹², and R¹³ are each methyl.

16. The compound of claim 2, said compound having the structure corresponding to formula (I-1)



(I-1)

wherein

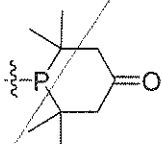
V^1 and V^4 are each CR^1 , wherein R^1 at each occurrence is alkoxy;

V^2 and V^3 are each CR^1 , wherein R^1 at each occurrence is hydrogen;

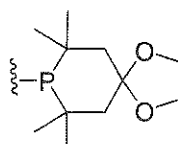
V^5 , V^7 and V^9 are each CR^2 , wherein R^2 at each occurrence is alkyl;

V^6 and V^8 are each CR^2 , wherein R^2 at each occurrence is hydrogen; and

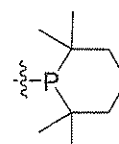
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3

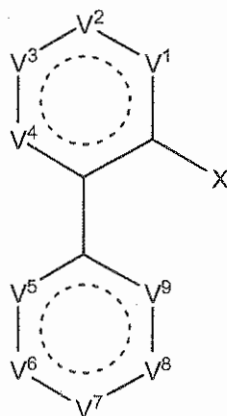


1-5

17. The compound of claim 2, said compound having a structure corresponding to any of formulae (I-1) - (I-42), wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae (Ia) and (Ib).

18. The compound of claim 17, said compound having a structure corresponding to

formula (I-1),



(I-1)

or a salt thereof,

wherein

V^1 and V^4 are CR^1 , wherein R^1 is independently, at each occurrence, hydrogen or alkoxy;

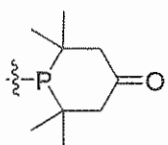
V^2 and V^3 are CR^1 , wherein R^1 is independently, at each occurrence, hydrogen or alkoxy;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, selected from the group consisting of hydrogen, alkoxy, alkyl, and dialkylamino;

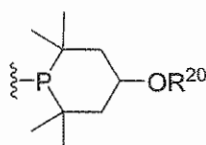
V^6 and V^8 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkoxy;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

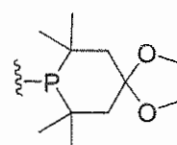
X is selected from the group consisting of phosphines of formulae 1-1, 1-2, 1-3, 1-4, 1-5, and 1-64.



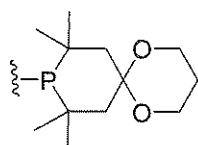
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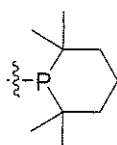
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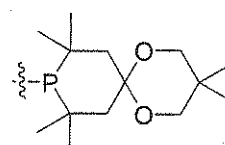
1-3



1-4



1-5



1-64

19. The compound of claim 18, wherein the compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinane;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinan-4-ol;

7,7,9,9-tetramethyl-8-(2',4',6'-triisopropylbiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane;

8,8,10,10-tetramethyl-9-(2',4',6'-triisopropylbiphenyl-2-yl)-1,5-dioxo-9-phosphaspiro[5.5]undecane;

3,3,8,8,10,10-hexamethyl-9-(2',4',6'-triisopropylbiphenyl-2-yl)-1,5-dioxo-9-phosphaspiro[5.5]undecane;

1-(2'-(dimethylamino)-6'-methoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-bis(dimethylamino)biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-diisopropoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2'-(dimethylamino)biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(3,6-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(3,6-dimethoxy-2',4',6'-trimethylbiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)phosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-4,5-dimethoxybiphenyl-2-yl)phosphinan-4-one;

1-(3',5'-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(4'-*tert*-butylbiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

6-methoxy-*N,N*-dimethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2-amine;

*N*²,*N*²,*N*⁶,*N*⁶-tetramethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2,6-diamine;

8-(2',6'-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(2',6'-diisopropoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

N,N-dimethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2-amine;

8-(biphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(3,6-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(3,6-dimethoxy-2',4',6'-trimethylbiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane;

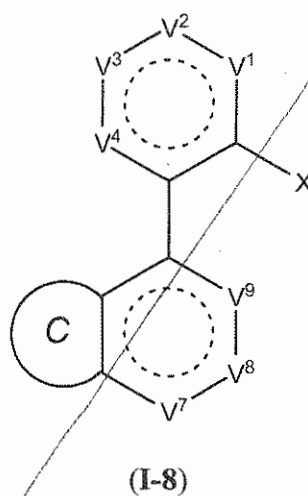
7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-4,5-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(3',5'-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(4'-*tert*-butylbiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;
and

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)phosphinane.

20. The compound of claim 17, said compound having a structure corresponding to formula (I-8),



or a salt thereof,

wherein

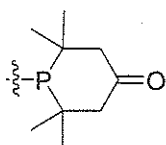
V^1 and V^2 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^7 and V^8 are each CR^2 , wherein R^2 is, at each occurrence, hydrogen;

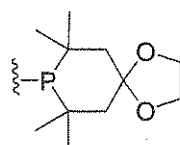
V^9 is CR^2 , wherein R^2 is hydrogen;

ring C at each occurrence is an unsubstituted fused-phenyl; and

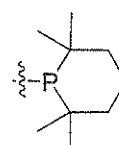
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



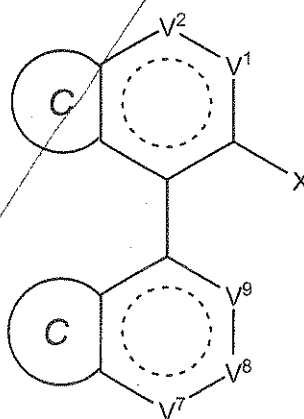
1-5

21. The compound of claim 20, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2-(naphthalen-1-yl)phenyl)phosphinan-4-one; and

7,7,9,9-tetramethyl-8-(4-methyl-2-(naphthalen-1-yl)phenyl)-1,4-dioxo-8-phosphaspiro[4.5]decane.

22. The compound of claim 17, said compound having a structure corresponding to formula (I-10),



(I-10)

or a salt thereof,

wherein

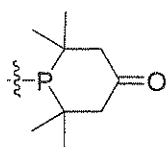
V^1 and V^2 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^7 and V^8 are each CR^2 , wherein R^2 is, at each occurrence, hydrogen;

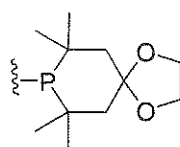
V^9 is CR^2 , wherein R^2 is hydrogen or alkoxy;

ring C at each occurrence is an unsubstituted fused-phenyl; and

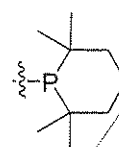
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3, and 1-5.



1-1



1-3



1-5

23. The compound of claim 22, wherein said compound is selected from the group consisting of:

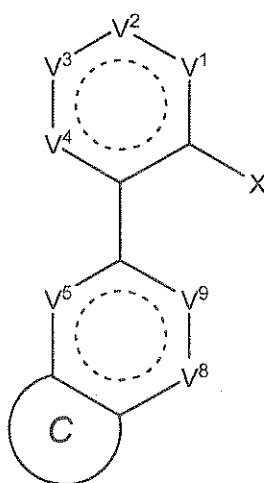
1-(1,1'-binaphthyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2'-methoxy-1,1'-binaphthyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

8-(1,1'-binaphthyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane; and

8-(2'-methoxy-1,1'-binaphthyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane.

24. The compound of claim 17, said compound having a structure corresponding to formula (I-9),



(I-9)

or a salt thereof,

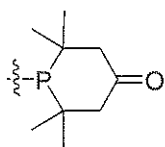
wherein

V^1 , V^2 , V^3 , and V^4 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

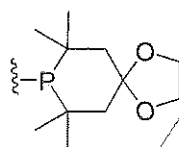
V^5 , V^8 and V^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen;

ring *C* is an unsubstituted fused-phenyl; and

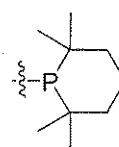
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3, and 1-5.



1-1



1-3



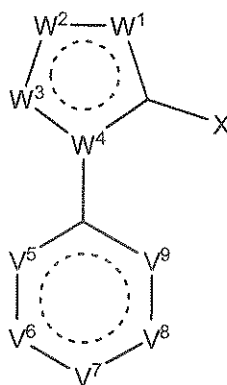
1-5

25. The compound of claim 24, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2-(naphthalen-2-yl)phenyl)phosphinan-4-one; and

7,7,9,9-tetramethyl-8-(2-(naphthalen-2-yl)phenyl)-1,4-dioxo-8-phosphaspiro[4.5]decane.

26. The compound of claim 17, said compound having a structure corresponding to formula (I-2),



(I-2)

or a salt thereof,

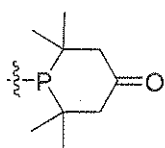
wherein

W^1 and W^2 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

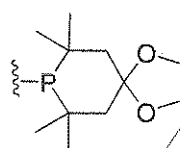
W^3 and W^4 are each N;

V^5 , V^6 , V^7 , V^8 , and V^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen; and

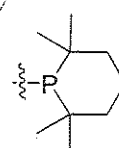
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



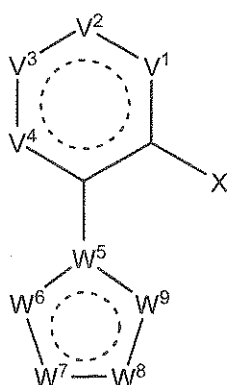
1-5

27. The compound of claim 26, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(1-phenyl-1*H*-pyrazol-5-yl)phosphinan-4-one; and

1-phenyl-5-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)-1*H*-pyrazole.

28. The compound of claim 17, said compound having a structure corresponding to formula (I-3),



(I-3)

or a salt thereof,

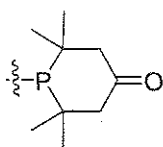
wherein

V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

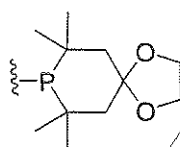
W^6 , W^7 , W^8 and W^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen;

W^5 is N; and

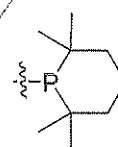
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



1-5

29. The compound of claim 28, wherein said compound is selected from the group consisting of:

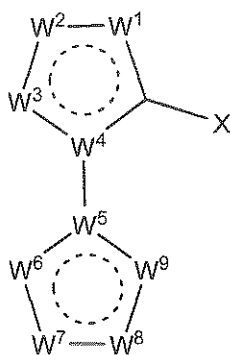
1-(2-(1*H*-pyrrol-1-yl)phenyl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)phenyl)-1*H*-pyrrole;

and

1-(2-(2,2,6,6-tetramethylphosphinan-1-yl)phenyl)-1*H*-pyrrole.

30. The compound of claim 17, said compound having a structure corresponding to formula (I-4),



(I-4)

or a salt thereof, wherein

W^1 and W^2 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

W^3 and W^4 are each N;

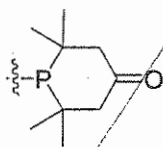
W^5 is C;

W^6 and W^9 are each CR^2 , wherein R^2 , at each occurrence, is substituted or unsubstituted phenyl;

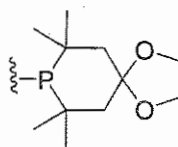
W^7 is N;

W^8 is NR^2 , wherein R^2 , at each occurrence, is phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; and

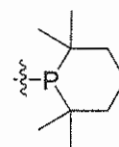
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



1-5

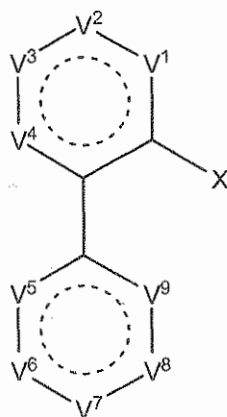
31. The compound of claim 30, wherein said compound is selected from the group consisting of:

2,2,6,6-Tetramethyl-1-(1',3',5'-triphenyl-1'H-1,4'-bipyrazol-5-yl)phosphinan-4-one;

1'1',3',5'-Triphenyl-5-(7,7,9,9-tetramethyl-1,4-dioxaspiro[4.5]decan-8-yl)-1'H-1,4'-bipyrazole; and

1',3',5'-Triphenyl-5-(2,2,6,6-tetramethylphosphinan-1-yl)-1'H-1,4'-bipyrazole.

32. A compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

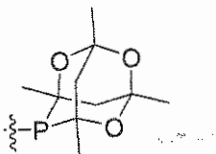
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkyl;

V^6 and V^8 are CR^2 , wherein R^2 , at each occurrence, is hydrogen;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

X is a phosphine of formula 1-37.



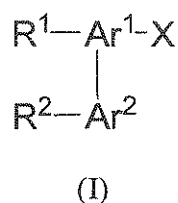
1-37

33. The compound of claim 32, wherein the compound is selected from the group consisting of:

1,3,5,7-tetramethyl-8-(2',4',6'-triisopropylbiphenyl-2-yl)-2,4,6-trioxa-8-phosphatricyclo[3.3.1.1^{3,7}]decane; and

8-(biphenyl-2-yl)-1,3,5,7-tetramethyl-2,4,6-trioxa-8-phosphatricyclo[3.3.1.1^{3,7}]decane.

34. A compound having a structure corresponding to formula (I),



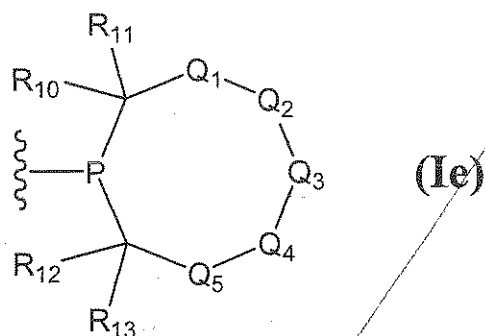
wherein

Ar^1 and Ar^2 are each independently aryl or heteroaryl, and wherein Ar^1 and Ar^2 are each independently optionally substituted with one or more R^1 and R^2 , respectively;

R^1 and R^2 are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino; heteroarylamino; alkylamino; dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $\text{L}^1-\text{C}(\text{O})-\text{OR}^{1'}$, $\text{L}^1-\text{P}(\text{O})-(\text{OR}^{1'})_2$, or $\text{L}^1-\text{S}(\text{O})_2-\text{OR}^{1'}$, wherein L^1 is a bond or alkylene, and $\text{R}^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $\text{L}^2-\text{O}-\text{C}(\text{O})-\text{R}^{2'}$, wherein L^2 is a bond or alkylene, and $\text{R}^{2'}$ is alkyl or hydroxyalkyl; $\text{L}^3-\text{C}(\text{O})-\text{NR}^{3'}\text{R}^{4'}$, wherein L^3 is a bond or alkylene, and $\text{R}^{3'}$ and $\text{R}^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $\text{L}^4-\text{NR}^{5'}-\text{C}(\text{O})-\text{R}^{6'}$, wherein L^4 is a bond or alkylene, $\text{R}^{5'}$ is hydrogen or alkyl, and $\text{R}^{6'}$ is alkyl or

hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate; alkylthio; thioalkyl; and a ring containing an alkylene or $-\text{O}-(\text{CH}_2)_m-\text{O}-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a phosphine of formula (Ie), or a salt thereof,



wherein

Q^1 is selected from the group consisting of a bond; $-\text{O}-$, $-\text{S}-$, $-\text{N}(\text{R}^{21})-$, $=\text{C}(\text{R}^{22})-$, and $-\text{C}(\text{R}^{23})(\text{R}^{24})-$;

Q^2 is selected from the group consisting of a bond, $-\text{O}-$, $-\text{S}-$, $-\text{N}(\text{R}^{25})-$, $=\text{C}(\text{R}^{26})-$, and $-\text{C}(\text{R}^{27})(\text{R}^{28})-$;

Q^3 is selected from the group consisting of a bond, $-\text{O}-$, $-\text{S}-$, $-\text{N}(\text{R}^{29})-$, $=\text{C}(\text{R}^{30})-$, and $-\text{C}(\text{R}^{32})(\text{R}^{30})-$;

Q^4 is selected from the group consisting of a bond, $-\text{O}-$, $-\text{S}-$, $-\text{N}(\text{R}^{33})-$, $=\text{C}(\text{R}^{34})-$, and $-\text{C}(\text{R}^{35})(\text{R}^{36})-$;

Q^5 is selected from the group consisting of a bond, $-\text{O}-$, $-\text{S}-$, $-\text{N}(\text{R}^{37})-$, $=\text{C}(\text{R}^{38})-$, and $-\text{C}(\text{R}^{39})(\text{R}^{40})-$; and at least one of Q^1 , Q^2 , Q^3 , Q^4 , and Q^5 is not a bond; or

two of Q^1 , Q^2 , Q^3 , Q^4 , or Q^5 together form a carbonyl; an exocyclic double bond optionally substituted with alkyl, alkenyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or a 3-8-membered spiro ring containing zero, one, or two hetero ring atoms, optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy;

as to R^{10} , R^{11} , R^{12} , and R^{13} ,

- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring; or
- iii. one or more of R^{10} , R^{11} , R^{12} and R^{13} form a ring together with a ring substituent of ring A; or
- iv. R^{10} , R^{11} , R^{12} , and R^{13} do not form a ring, wherein R^{10} , R^{11} , R^{12} and R^{13} are each independently selected from the group consisting of alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl; and

$R^{21}-R^{40}$ are, at each occurrence, independently selected from the group consisting of hydrogen, halo, fluoro, alkyl, haloalkyl, fluoroalkyl, alkenyl, alkynyl, alkyloxy, *N*-alkylamino, *N,N*-dialkylamino, *N,N,N*-trialkylammoniumalkyl; substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted heteroaryl, substituted or unsubstituted phenyl; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$ where $R^{1'}$ is hydrogen, alkyl or hydroxyalkyl and L^1 is a bond or alkylene; $L^2-O-C(O)-R^{2'}$ where $R^{2'}$ is alkyl or hydroxyalkyl and L^2 is a bond or alkylene; $L^3-C(O)-NR^3R^4$ where R^3 and R^4 are independently selected from H, alkyl, and hydroxyalkyl and wherein L^3 is

a bond or alkylene; $L^4-NR^{5'}-C(O)-R^{6'}$ wherein $R^{5'}$ is selected from H and alkyl, $R^{6'}$ is selected from alkyl and hydroxyalkyl, and L^4 is a bond or alkylene; and alkylthio; or additionally one or more of $R^{21}-R^{40}$ form a ring with another of R^{10} , R^{11} , R^{12} , R^{13} , and $R^{21}-R^{40}$.

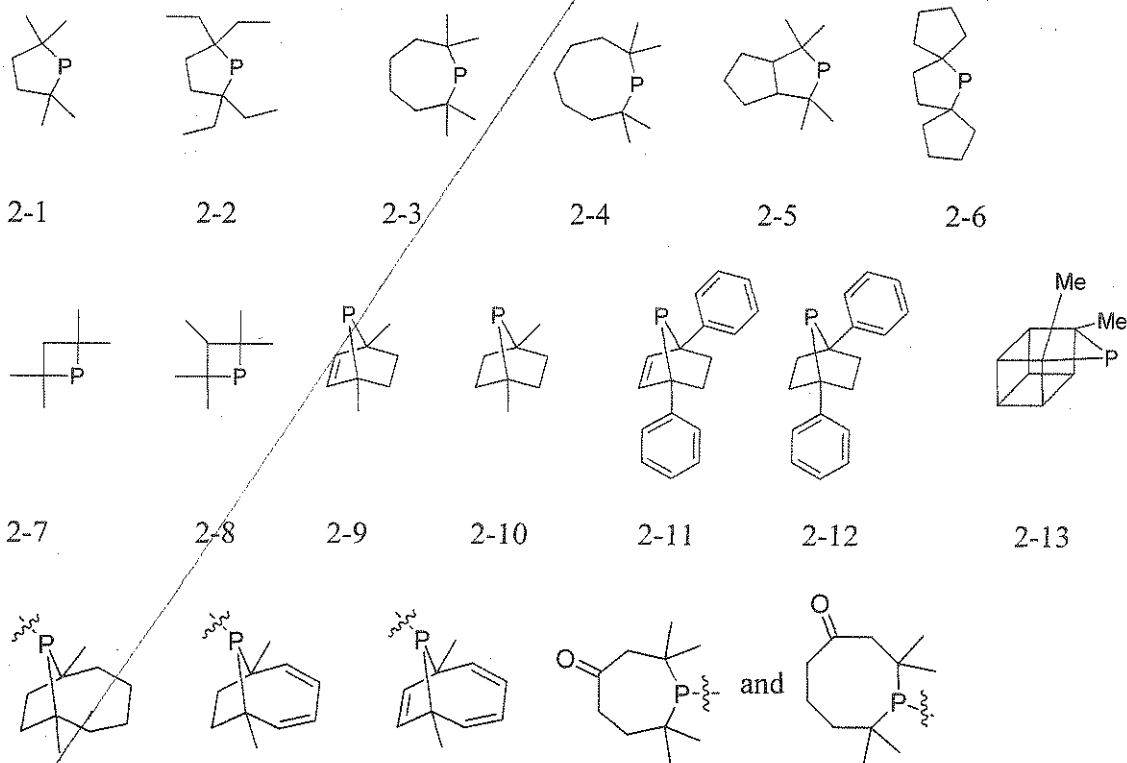
35. The compound according to claim 34, wherein X comprises a 4-membered ring.

36. The compound according to claim 34, wherein X comprises a 5-membered ring.

37. The compound according to claim 34, wherein X comprises a 7-membered ring or an 8-membered ring.

38. The compound according to claim 34, wherein R^{10} , R^{11} , R^{12} , and R^{13} are selected from the group consisting of alkyl, phenyl, and heteroaryl, or wherein R^{10} or R^{11} together with R^{12} or R^{13} form a ring.

39. The compound according to claim 34, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of



2-14

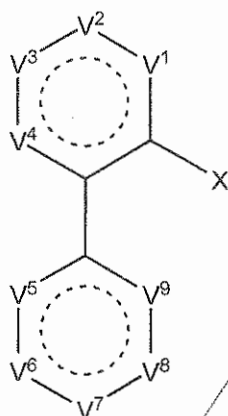
2-15

2-16

2-18; and

2-19

40. The compound of claim 34, said compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

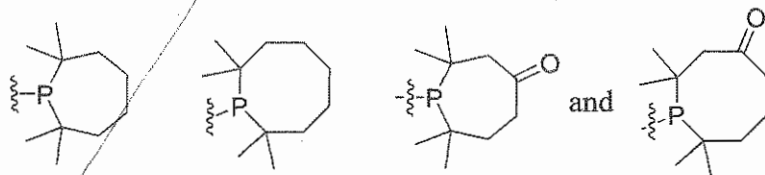
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkyl;

V^6 and V^8 are CR^2 , wherein R^2 , at each occurrence, is hydrogen;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 2-3, 2-4, 2-18, and 2-19



2-3

2-4

2-18

2-19.

41. The compound of claim 40, wherein the compound is selected from the group consisting of:

1-(biphenyl-2-yl)-2,2,7,7-tetramethylphosphhepan-4-one;

1-(biphenyl-2-yl)-2,2,7,7-tetramethylphosphhepane;

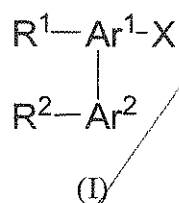
2,2,7,7-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphhepan-4-one;

2,2,7,7-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphhepane;

2,2,8,8-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphocan-4-one; and

2,2,8,8-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphocane.

42. A compound having a structure corresponding to formula (I),



or a salt thereof,

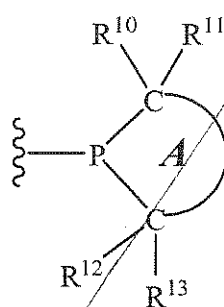
wherein

Ar^1 and Ar^2 are each independently aryl or heteroaryl, and wherein Ar^1 and Ar^2 are each independently optionally substituted with one or more R^1 and R^2 , respectively;

R^1 and R^2 are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino; heteroarylamino; alkylamino; dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $\text{L}^1-\text{C}(\text{O})-\text{OR}^{1'}$, $\text{L}^1-\text{P}(\text{O})-(\text{OR}^{1'})_2$, or $\text{L}^1-\text{S}(\text{O})_2-\text{OR}^{1'}$, wherein L^1 is a bond or alkylene, and $\text{R}^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $\text{L}^2-\text{O}-\text{C}(\text{O})-\text{R}^{2'}$, wherein L^2 is a bond or alkylene, and $\text{R}^{2'}$ is

alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate; alkylthio; thioalkyl; and a ring containing an alkylene or $-O-(CH_2)_m-O-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a phosphine of formula (Ia):



(Ia)

wherein ring *A* includes 0 to 9 ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia), wherein said ring atoms are each independently selected from the group consisting of carbon, oxygen, nitrogen, phosphorus and sulfur; and

wherein the ring atoms of ring *A* are each independently optionally substituted with one or more substituents selected from the group consisting of alkenyl; alkoxy; alkoxyalkyl; alkyl; alkylamino; alkylthio; alkynyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; dialkylamino; halo; haloalkyl; fluoroalkyl; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxy; hydroxyalkyl; oxo; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy;

$L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl or hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; and $L^7-NR^{8'}-S(O)_2-R^{9'}$, wherein L^7 is a bond or alkylene, $R^{8'}$ is hydrogen or alkyl, and $R^{9'}$ is alkyl or hydroxyalkyl; and

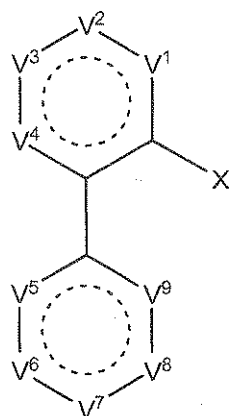
as to R^{10} , R^{11} , R^{12} , and R^{13} ,

- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring;

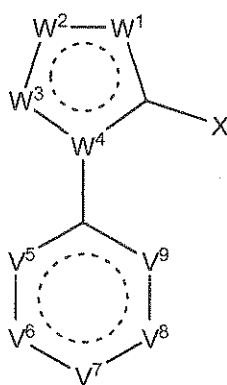
wherein, any of substituents R^{10} , R^{11} , R^{12} , and R^{13} that do not form the ring set forth in (i) or (ii) are each independently selected from the group consisting of hydrogen; alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl.

43. The compound according to claim 42, said compound having a structure

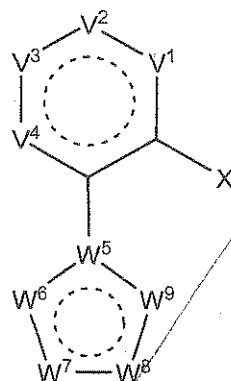
corresponding to a structure of a formula selected from the group consisting of formulae (I-1) - (I-42), or a salt thereof:



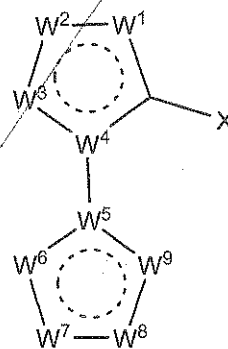
(I-1)



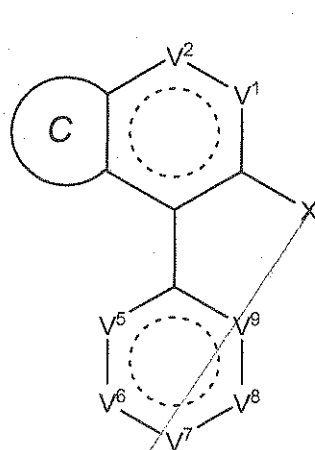
(I-2)



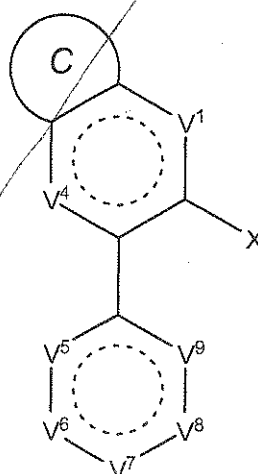
(I-3)



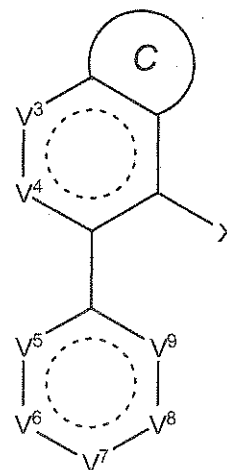
(I-4)



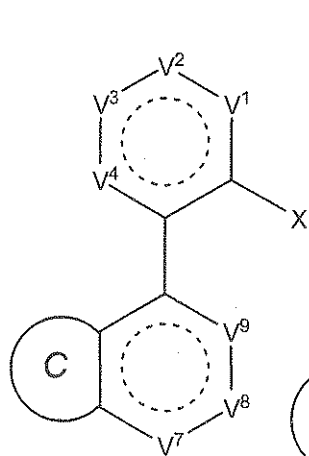
(I-5)



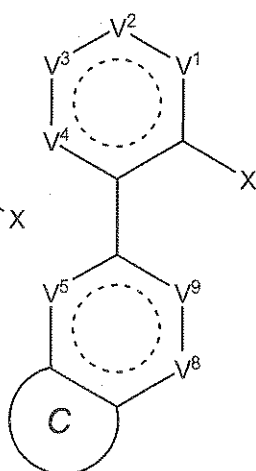
(I-6)



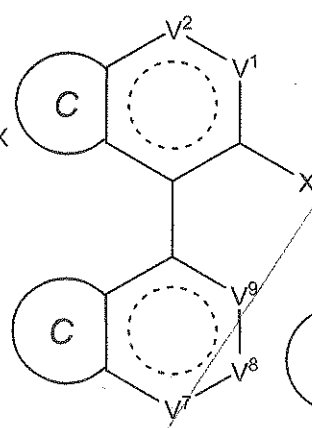
(I-7)



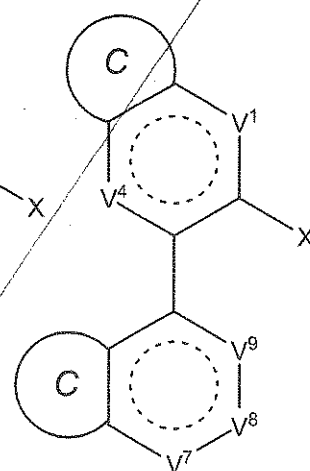
(I-8)



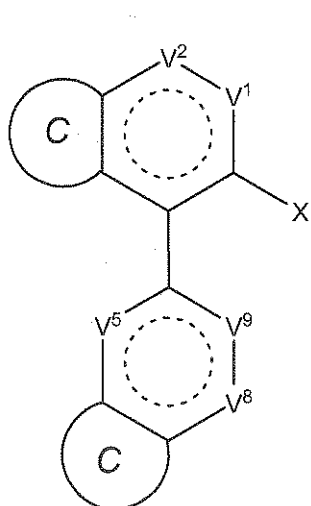
(I-9)



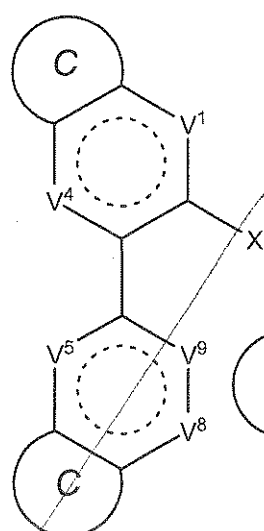
(I-10)



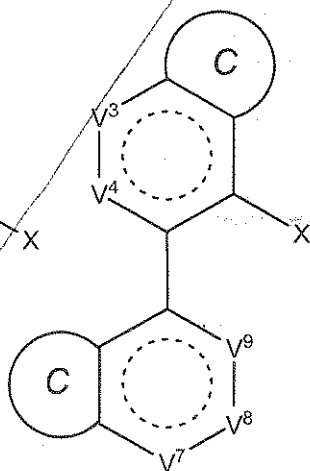
(I-11)



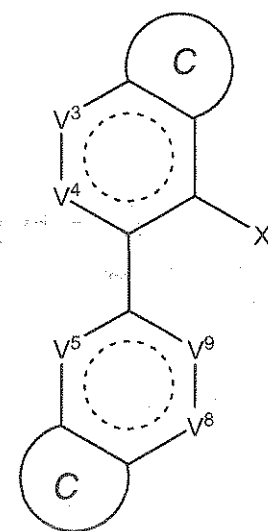
(I-12)



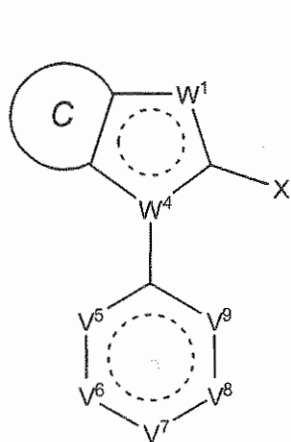
(I-13)



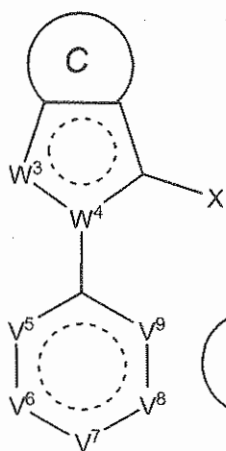
(I-14)



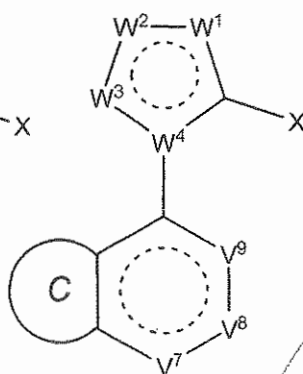
(I-15)



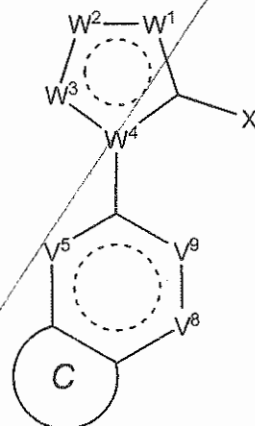
(I-16)



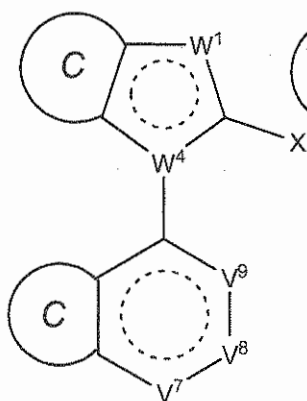
(I-17)



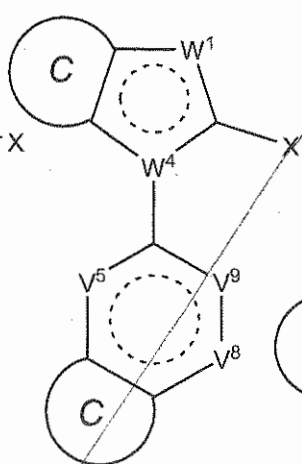
(I-18)



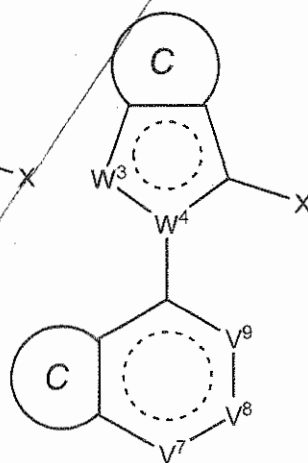
(I-19)



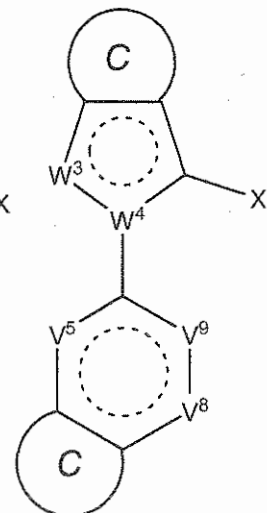
(I-20)



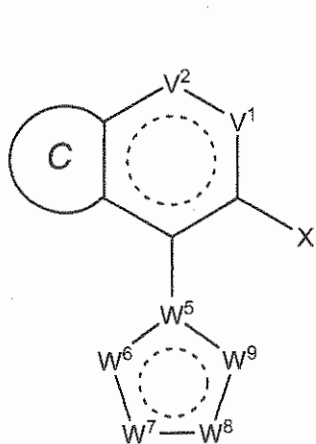
(I-21)



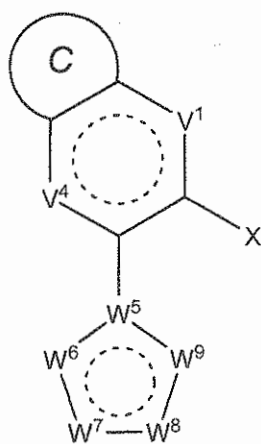
(I-22)



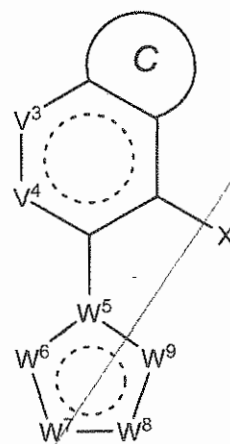
(I-23)



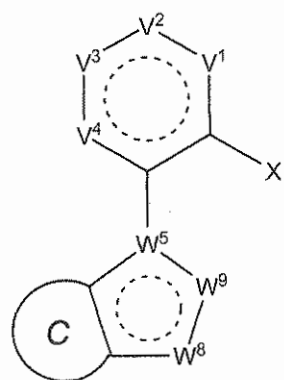
(I-24)



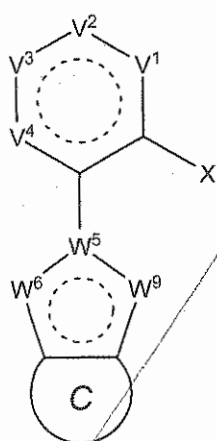
(I-25)



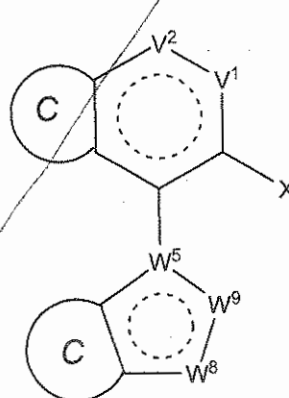
(I-26)



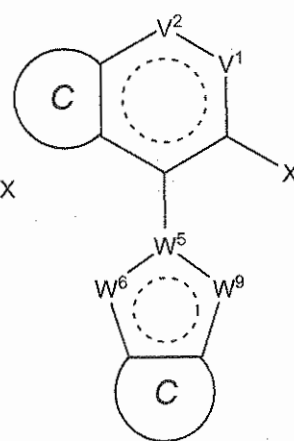
(I-27)



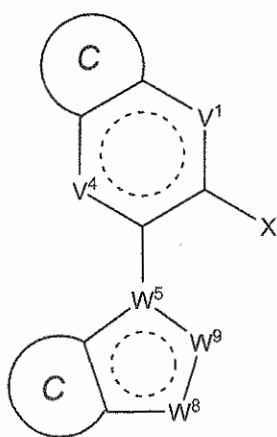
(I-28)



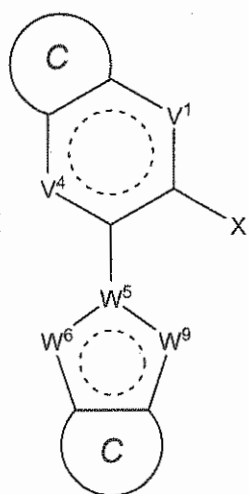
(I-29)



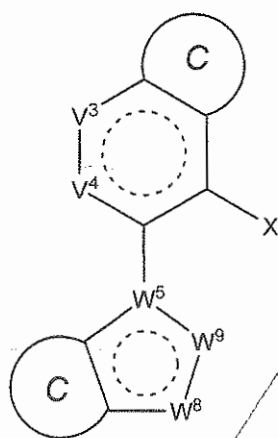
(I-30)



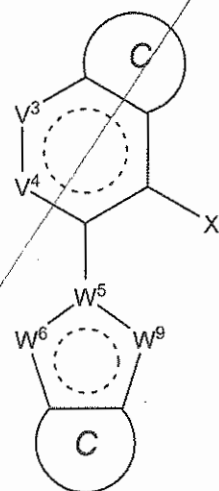
(I-31)



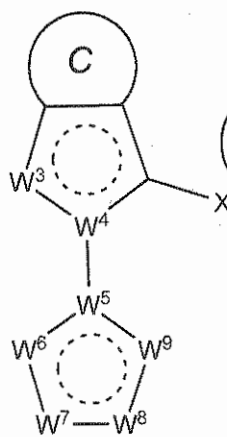
(I-32)



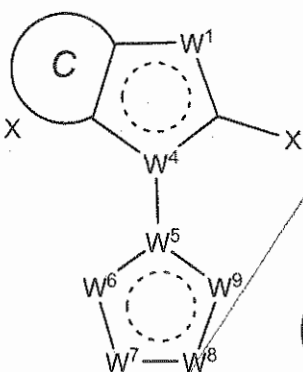
(I-33)



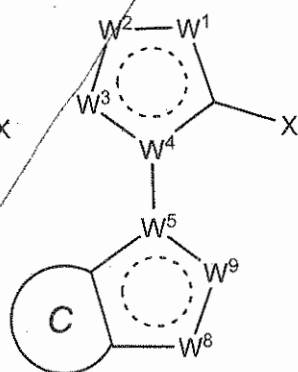
(I-34)



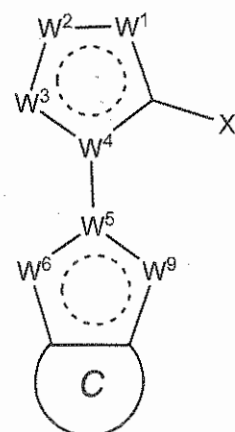
(I-35)



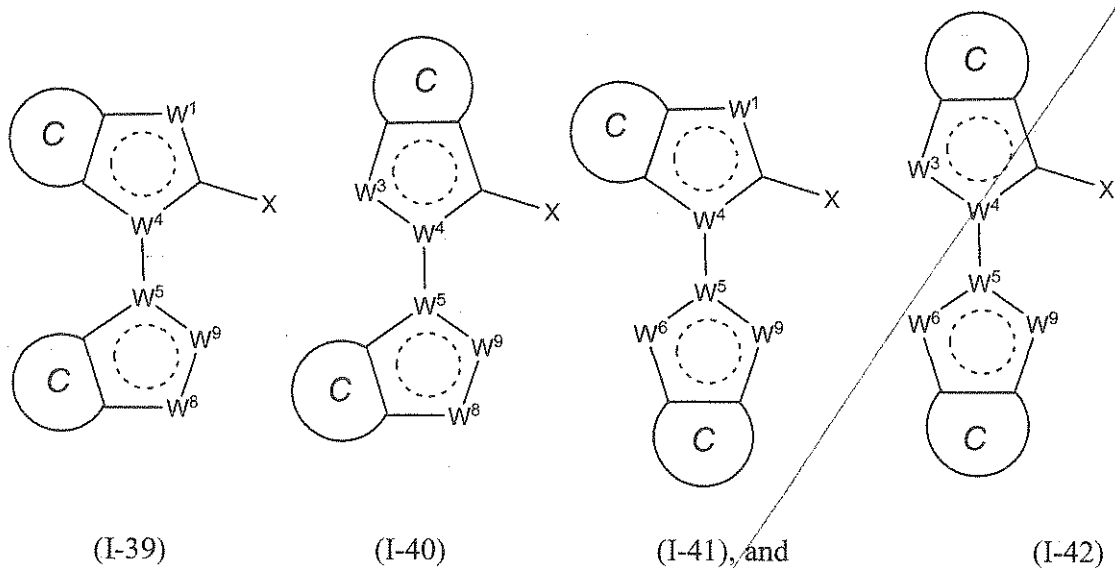
(I-36)



(I-37)



(I-38)



wherein

V^1 , V^2 , V^3 , and V^4 are each independently CR^1 or N;

V^5 , V^6 , V^7 , V^8 and V^9 are each independently CR^2 or N;

W^1 , W^2 , and W^3 are each independently selected from the group consisting of CR^1 , NR^1 , N and O;

W^4 is C or N;

W^5 is C or N;

W^6 , W^7 , W^8 and W^9 are each independently selected from the group consisting of CR^2 , NR^2 , N and O; and

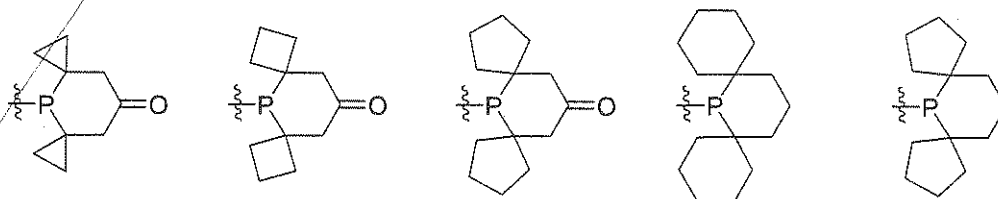
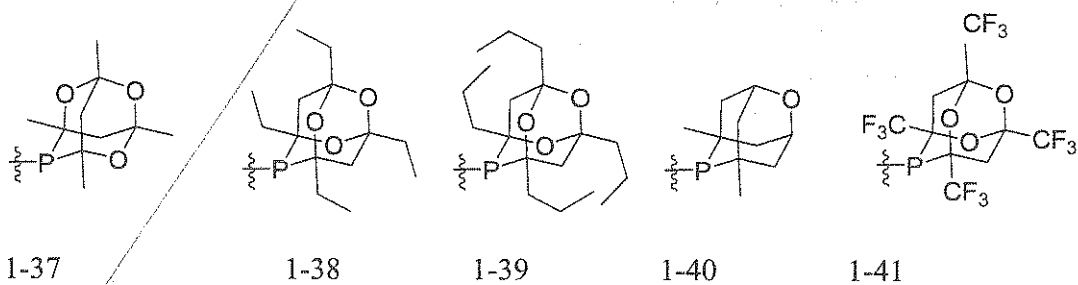
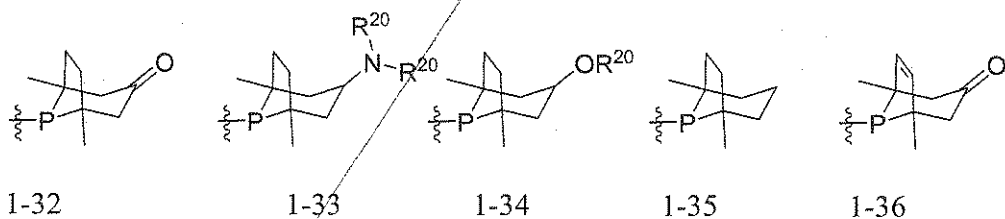
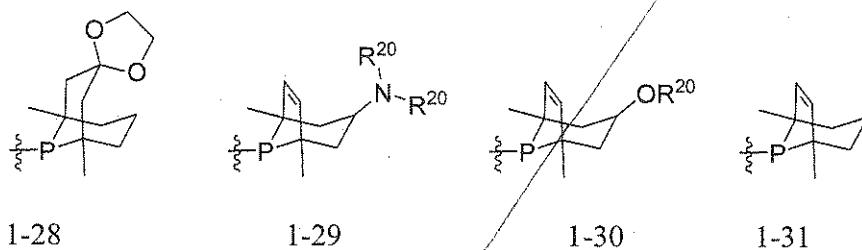
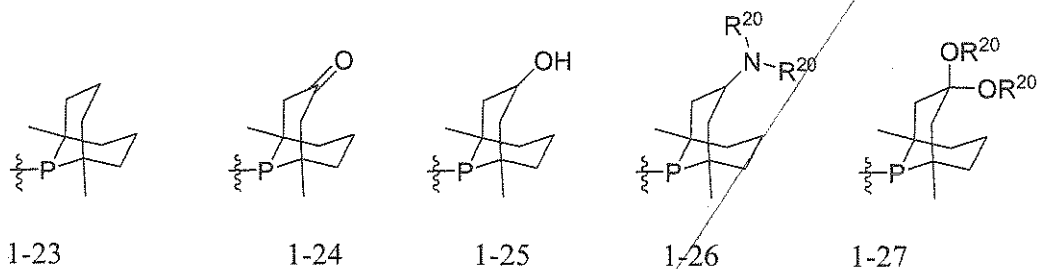
ring C, at each occurrence, is a fused-aryl or fused-heteroaryl and is optionally substituted with R^1 and R^2 .

44. The compound according to any one of claims 42-43, wherein ring A is a 4-, 5-, 6-, 7-, or 8-membered ring, and wherein each of the ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia) are carbon.

45. The compound according to claim 42, wherein ring A of formula (Ia) is bicyclic.

46. The compound according to claim 42, wherein ring A of formula (Ia) is tricyclic.

47. The compound according to claim 42, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of:



1-45

1-46

1-47

1-48, and

1-49

or a salt thereof, wherein R^{20} is hydrogen, alkyl, aryl, heteroaryl, arylalkyl or heteroarylalkyl, wherein the aryl, heteroaryl, aryl of arylalkyl and heteroaryl of heteroarylalkyl are optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy.

48. 7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane.

49. A catalyst composition comprising a transition metal catalyst precursor and a compound according to any one of claims 1-48.

50. The catalyst composition according to claim 49, wherein the transition metal catalyst precursor is selected from the group consisting of palladium, rhodium, ruthenium, platinum, gold, cobalt, iridium, copper and nickel.

51. The catalyst composition according to claim 50, wherein the transition metal catalyst precursor contains palladium.

52. A catalyst composition comprising a palladium catalyst precursor and a compound according to claim 7.

53. A catalyst composition comprising a palladium catalyst precursor and 7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane.

54. A heterogeneous catalyst composition comprising a compound according to any one of claims 1-48 covalently bonded to a solid catalyst support.

55. A method for synthesizing a secondary organic sulfonamide, comprising reacting an aryl nonaflate with a primary sulfonamide in the presence of a palladium catalyst precursor and at least one compound selected from the compounds of any one of claims 1-48.

56. A method of performing a bond-forming reaction comprising catalyzing said reaction with a compound of any one of claims 1-48, wherein the bond-forming reaction is selected from the group consisting of carbon-nitrogen, carbon-oxygen, carbon-carbon, carbon-

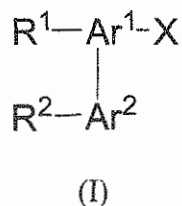
sulfur, carbon-phosphorus, carbon-boron, carbon-fluorine and carbon-hydrogen.

57. A method of forming a bond in a chemical reaction comprising catalyzing said reaction with a compound of any one of claims 1-48, wherein the bond is selected from the group consisting of a carbon-nitrogen bond, a carbon-oxygen bond, a carbon-carbon bond, a carbon-sulfur bond, a carbon-phosphorus bond, a carbon-boron bond, a carbon-fluorine bond and a carbon-hydrogen bond.

58. A method of preparing phosphacycles of any one of claims 1-48 comprising:
metalation of a biaryl halide to form a biaryl lithium species;
reacting a chlorophosphate with said biaryl lithium species to form a biaryl phosphonate;
reduction of second product to form primary phosphine; and
reacting primary phosphine with a divinylketone.

CLAIMS

1. A compound having a structure corresponding to formula (I),



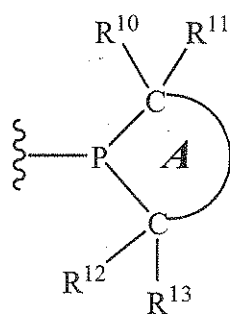
or a salt thereof,

wherein

Ar^1 and Ar^2 are each independently aryl or heteroaryl, and wherein Ar^1 and Ar^2 are each independently optionally substituted with one or more R^1 and R^2 , respectively;

R^1 and R^2 are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino; heteroarylamino; alkylamino; dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $\text{L}^1-\text{C}(\text{O})-\text{OR}^{1'}$, $\text{L}^1-\text{P}(\text{O})-(\text{OR}^{1'})_2$, or $\text{L}^1-\text{S}(\text{O})_2-\text{OR}^{1'}$, wherein L^1 is a bond or alkylene, and $\text{R}^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $\text{L}^2-\text{O}-\text{C}(\text{O})-\text{R}^{2'}$, wherein L^2 is a bond or alkylene, and $\text{R}^{2'}$ is alkyl or hydroxyalkyl; $\text{L}^3-\text{C}(\text{O})-\text{NR}^{3'}\text{R}^{4'}$, wherein L^3 is a bond or alkylene, and $\text{R}^{3'}$ and $\text{R}^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $\text{L}^4-\text{NR}^{5'}-\text{C}(\text{O})-\text{R}^{6'}$, wherein L^4 is a bond or alkylene, $\text{R}^{5'}$ is hydrogen or alkyl, and $\text{R}^{6'}$ is alkyl or hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate; alkylthio; thioalkyl; and a ring containing an alkylene or $-\text{O}-(\text{CH}_2)_m-\text{O}-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a 6-membered cyclic phosphine of formula (Ia):



(Ia)

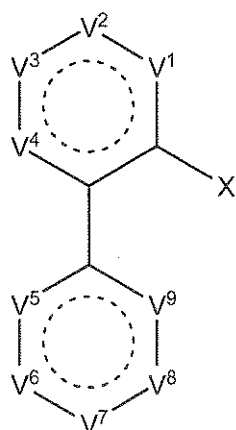
wherein ring *A* includes three carbon ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia);

wherein the ring atoms of ring *A* are each independently optionally substituted with one or more substituents selected from the group consisting of alkenyl; alkoxy; alkoxyalkyl; alkyl; alkylamino; alkylthio; alkynyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; dialkylamino; halo; haloalkyl; fluoroalkyl; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxy; hydroxyalkyl; oxo; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl or hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; and $L^7-NR^{8'}-S(O)_2-R^{9'}$, wherein L^7 is a bond or alkylene, $R^{8'}$ is hydrogen or alkyl, and $R^{9'}$ is alkyl or hydroxyalkyl;

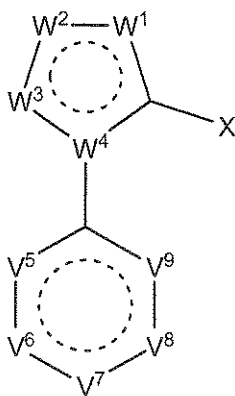
as to R^{10} , R^{11} , R^{12} , and R^{13} ,

- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring; or
- iii. one or more of R^{10} , R^{11} , R^{12} and R^{13} form a ring together with a ring substituent of ring A; or
- iv. R^{10} , R^{11} , R^{12} , and R^{13} do not form a ring, wherein R^{10} , R^{11} , R^{12} , and R^{13} are each independently selected from the group consisting of alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl.

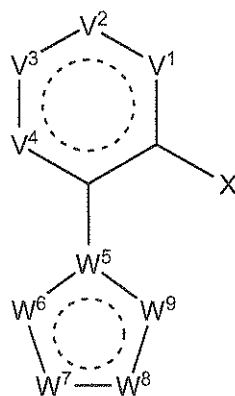
2. The compound according to claim 1, said compound having a structure corresponding to a structure of a formula selected from the group consisting of formulae (I-1) - (I-42), or a salt thereof:



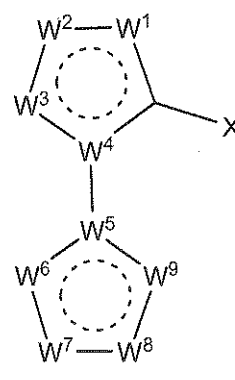
(I-1)



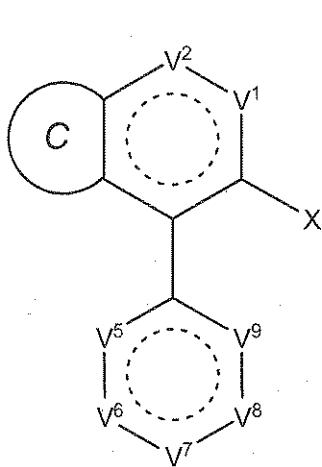
(I-2)



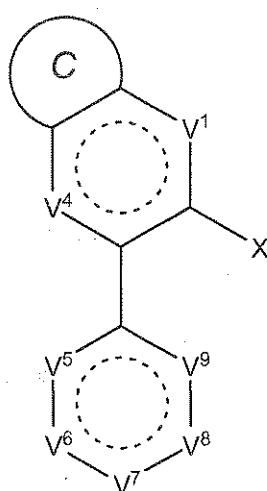
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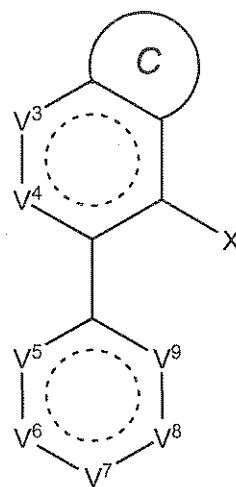
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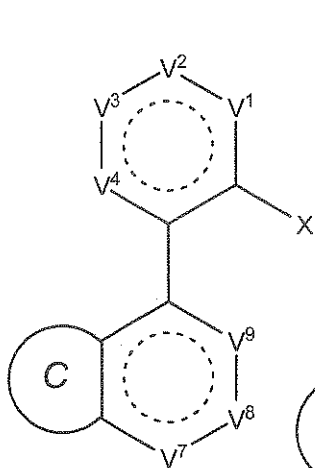
(I-5)



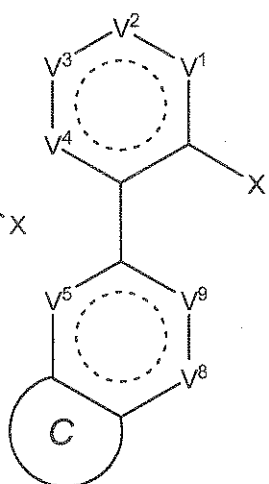
(I-6)



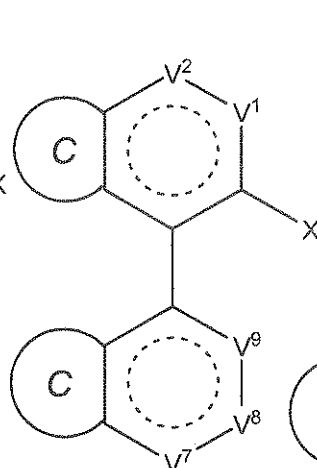
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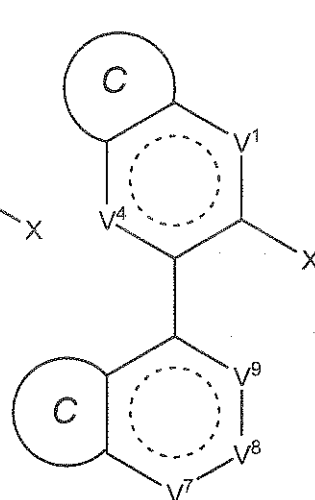
(I-8)



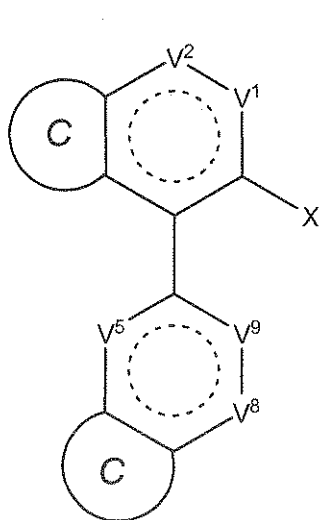
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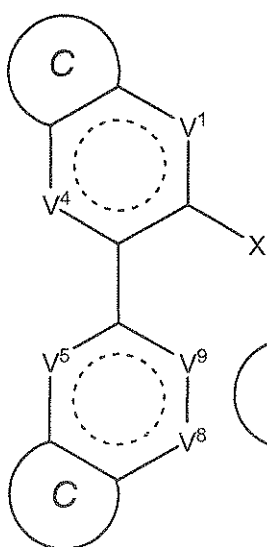
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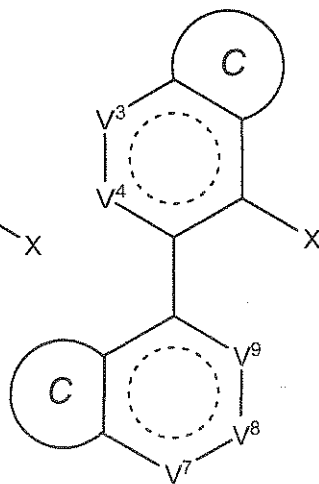
(I-11)



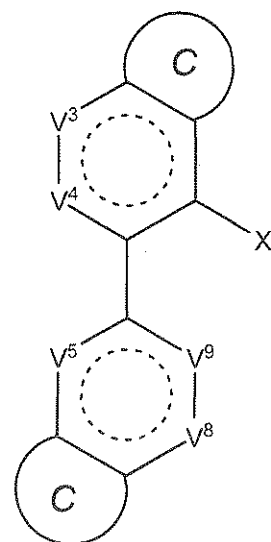
(I-12)



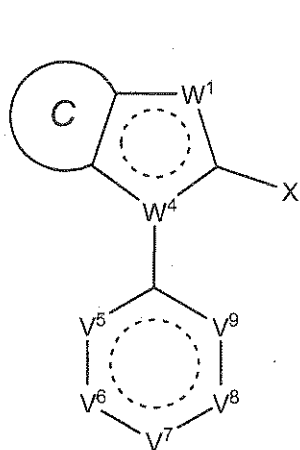
(I-13)



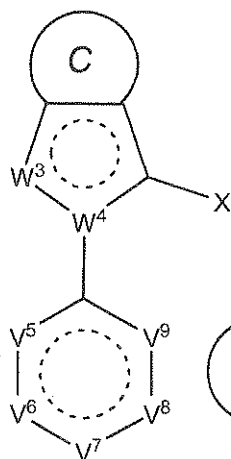
(I-14)



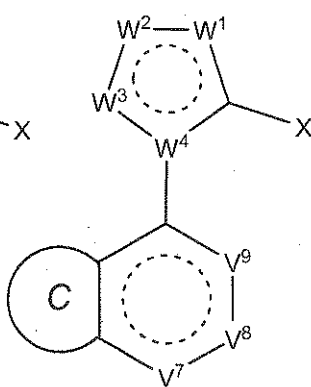
(I-15)



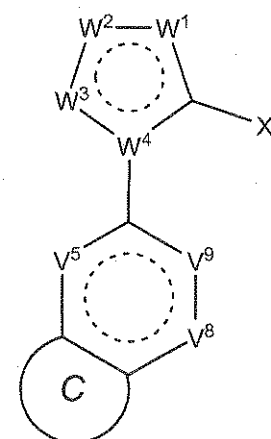
(I-16)



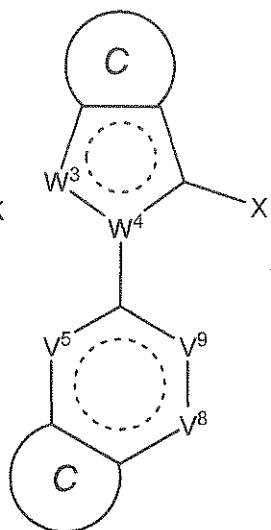
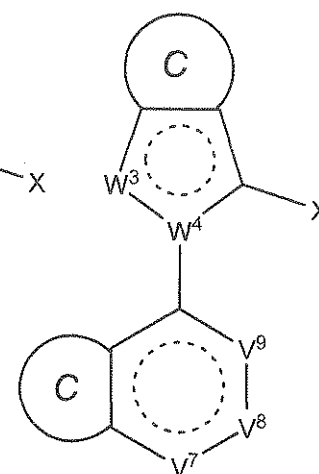
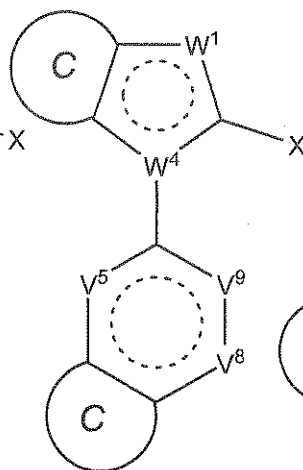
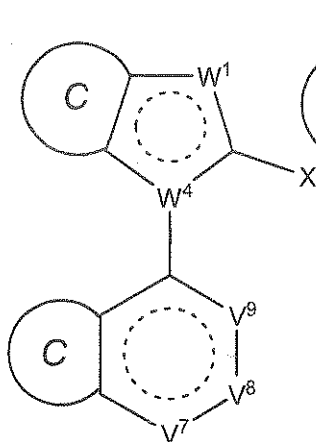
(I-17)



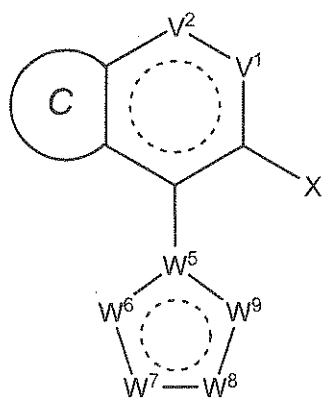
(I-18)



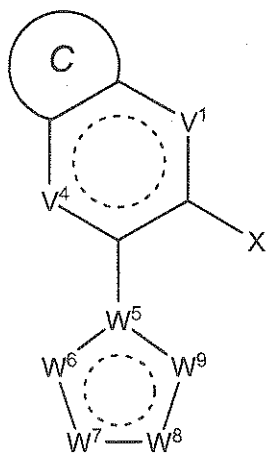
(I-19)



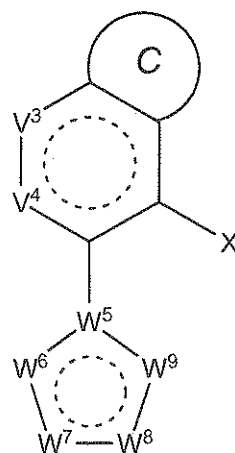
(I-20)



(I-21)



(I-22)

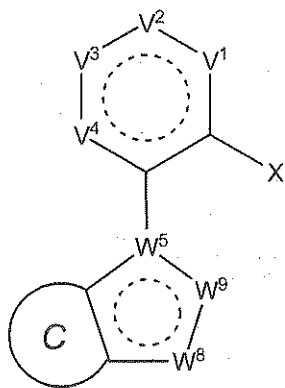


(I-23)

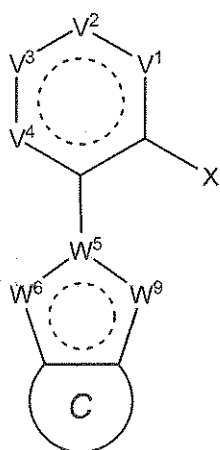
(I-24)

(I-25)

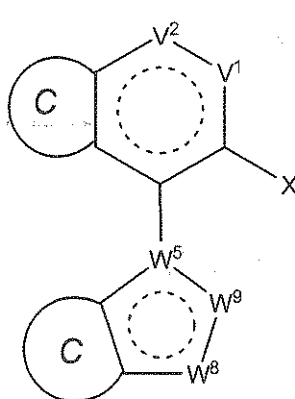
(I-26)



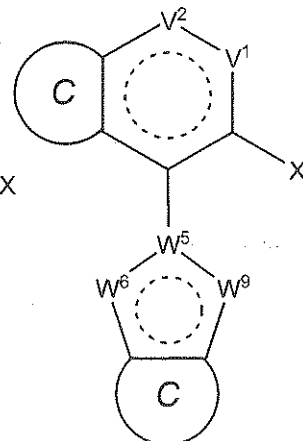
(I-27)



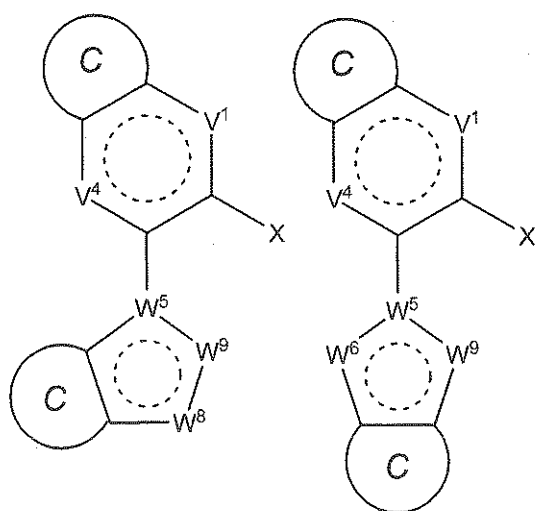
(I-28)



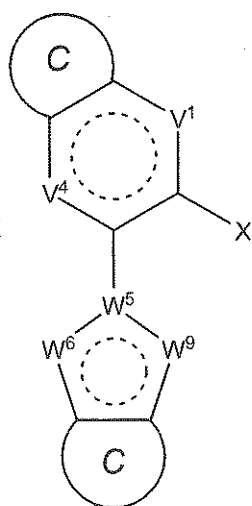
(I-29)



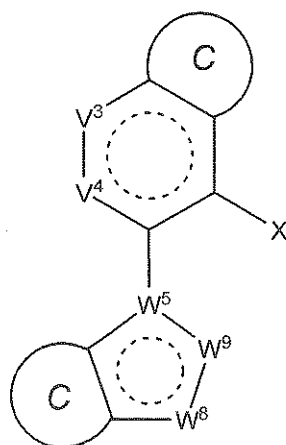
(I-30)



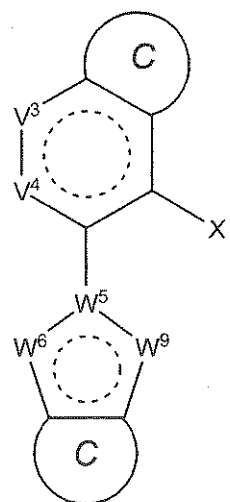
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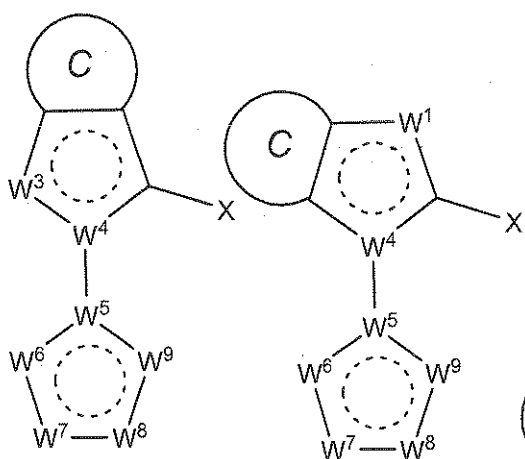
(I-32)



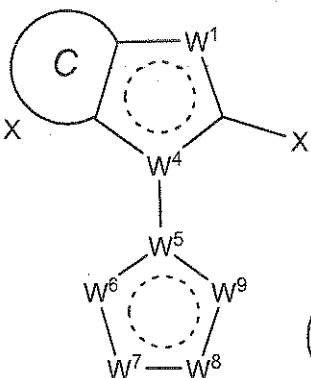
(I-33)



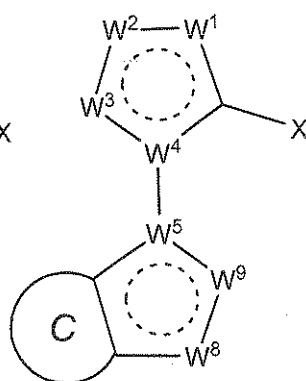
(I-34)



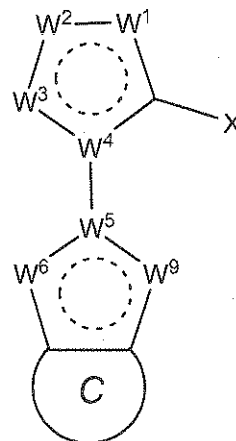
(I-35)



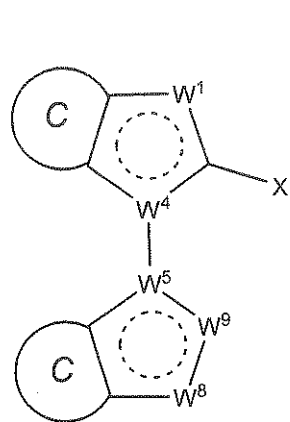
(I-36)



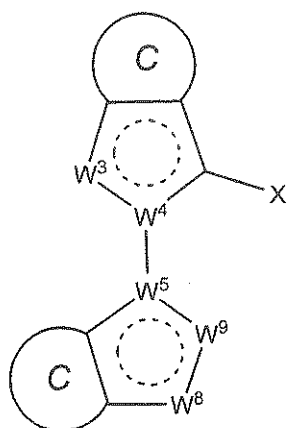
(I-37)



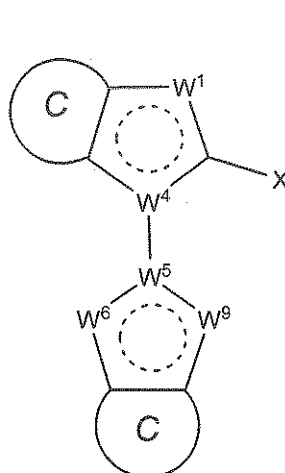
(I-38)



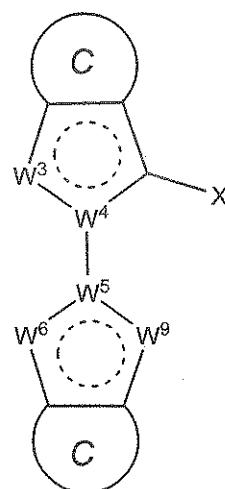
(I-39)



(I-40)



(I-41), and



(I-42)

wherein

V^1 , V^2 , V^3 , and V^4 are each independently CR^1 or N;

V^5 , V^6 , V^7 , V^8 and V^9 are each independently CR^2 or N;

W^1 , W^2 , and W^3 are each independently selected from the group consisting of CR^1 , NR^1 , N and O;

W^4 is C or N;

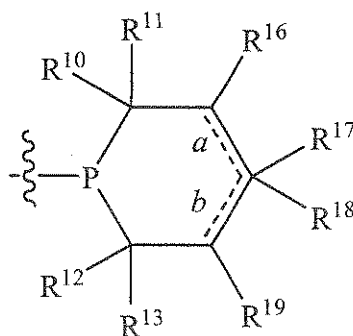
W^5 is C or N;

W^6 , W^7 , W^8 and W^9 are each independently selected from the group consisting of CR^2 , NR^2 , N and O; and

ring C, at each occurrence, is a fused-aryl or fused-heteroaryl and is optionally substituted with R^1 and R^2 .

3. The compound according to claim 1, wherein X is attached to an atom of Ar^1 adjacent to the atom bonded to Ar^2 .

4. The compound according to claim 1 or claim 2, wherein X is a phosphine of formula (Id), or a salt thereof:



(Id)

wherein

one or more of R^{16} , R^{17} , R^{18} , and R^{19} optionally form a ring with R^{10} , R^{11} , R^{12} , or R^{13} ; or

R^{17} together with R^{18} optionally form a carbonyl; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms,

optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or

R^{16} and R^{19} are each independently selected from the group consisting of hydrogen, halo, alkyl, haloalkyl, fluoroalkyl, alkenyl, and alkoxy; or

R^{17} and R^{18} are each independently selected from the group consisting of hydrogen; halo; fluoro; alkyl; alkenyl; alkynyl; haloalkyl; fluoroalkyl; alkyloxy; *N*-alkylamino; *N,N*-dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy, phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, and $R^{5'}$ is hydrogen or alkyl, $R^{6'}$ is alkyl or hydroxyalkyl; and alkylthio; and

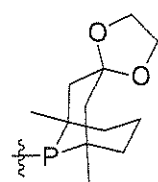
at least one of bonds *a* and *b* in formula (Id) is a single bond and one of bonds *a* or *b* is optionally a double bond.

5. The compound according to claim 4, wherein R^{16} and R^{19} are hydrogen.

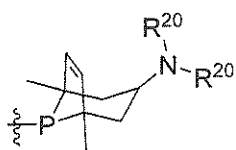
6. The compound according to claim 4, wherein R^{17} and R^{18} together with the carbon atom to which they are attached form a 3-, 4-, 5-, 6-, or 7-membered spirocyclic ring containing 0, 1, or 2 ring heteroatoms.

7. The compound according to claim 4, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of:

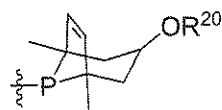
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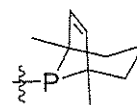
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1-25



1-26

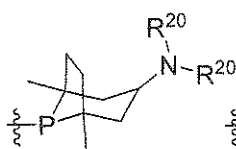


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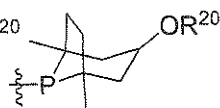
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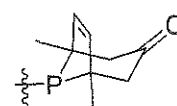
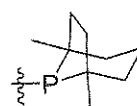
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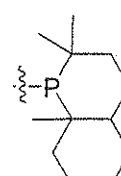
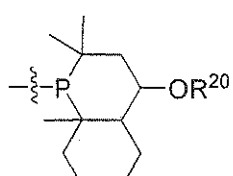
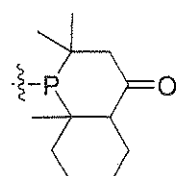
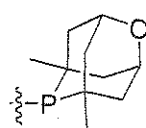
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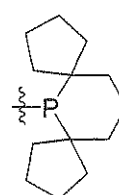
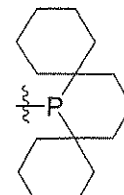
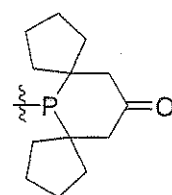
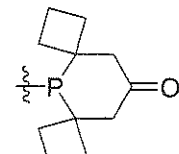
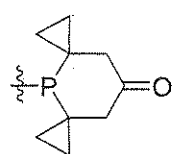


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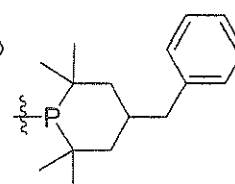
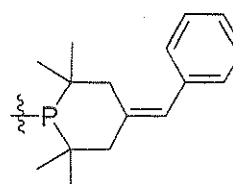
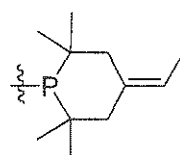
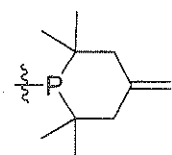
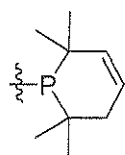
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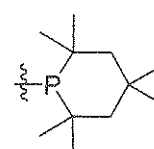
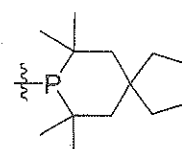
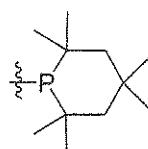
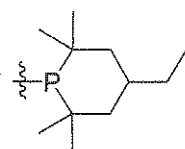
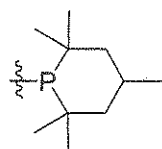
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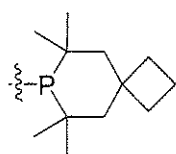
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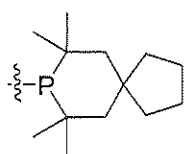
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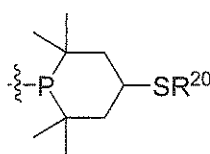
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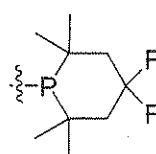
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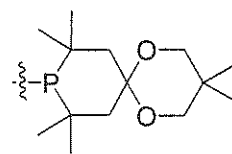
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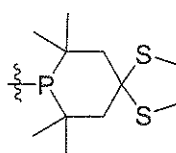
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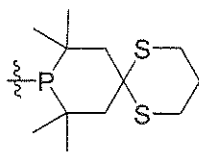
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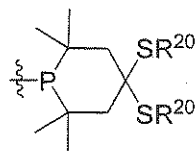
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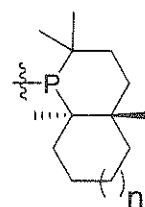
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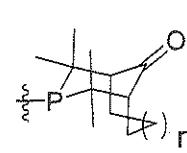
1-66



1-67

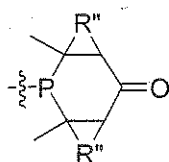


1-68



1-69,

and



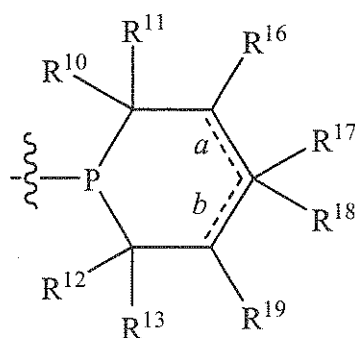
1-70

or a salt thereof, wherein R'' is selected from the group consisting of oxygen, NR²⁰, and C(R²⁰)₂;

R²⁰ is hydrogen, alkyl, aryl, heteroaryl, arylalkyl or heteroarylalkyl, wherein the aryl, heteroaryl, aryl of arylalkyl and heteroaryl of heteroarylalkyl are optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; and

n is 0, 1, or 2.

8. The compound of claim 1, wherein Ar¹ and Ar² are each aryl.
9. The compound of claim 1, wherein Ar¹ is substituted with two R¹ and Ar² is substituted with three R².
10. The compound of claim 1, wherein R¹ is alkyloxy and wherein R² is alkyl.
11. The compound of claim 1, wherein R² is isopropyl.
12. The compound of claim 1, wherein X is a phosphine of formula (Id):



(Id)

wherein each of R¹⁰, R¹¹, R¹², R¹³ is alkyl;

R¹⁷ and R¹⁸ are each independently selected from the group consisting of hydrogen, or R¹⁷ together with R¹⁸ optionally form a carbonyl or a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms;

each of R¹⁶ and R¹⁹ is hydrogen; and

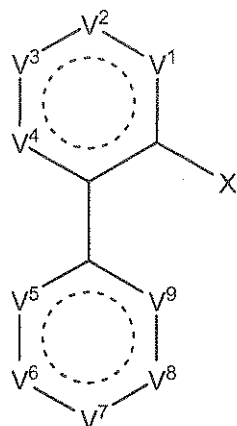
each of bonds a and b is a single bond.

13. The compound of claim 12, wherein R¹⁷ together with R¹⁸ form a 5-membered spiro ring containing two heteroatoms.

14. The compound of claim 13, wherein the two heteroatoms are each oxygen.

15. The compound of claim 1, wherein R¹⁰, R¹¹, R¹², and R¹³ are each methyl.

16. The compound of claim 2, said compound having the structure corresponding to formula (I-1)



(I-1)

wherein

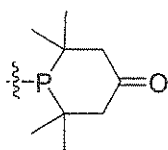
V^1 and V^4 are each CR^1 , wherein R^1 at each occurrence is alkoxy;

V^2 and V^3 are each CR^1 , wherein R^1 at each occurrence is hydrogen;

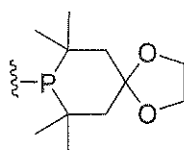
V^5 , V^7 and V^9 are each CR^2 , wherein R^2 at each occurrence is alkyl;

V^6 and V^8 are each CR^2 , wherein R^2 at each occurrence is hydrogen; and

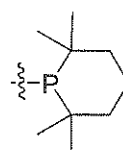
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1

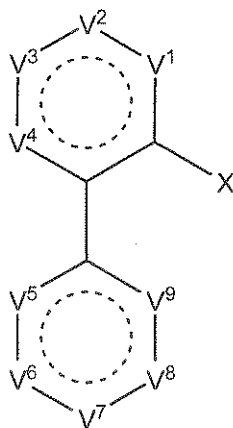


1-3



1-5

17. The compound of claim 2, said compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

V^1 and V^4 are CR^1 , wherein R^1 is independently, at each occurrence, hydrogen or alkoxy;

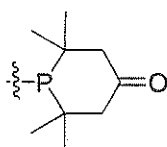
V^2 and V^3 are CR^1 , wherein R^1 is independently, at each occurrence, hydrogen or alkoxy;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, selected from the group consisting of hydrogen, alkoxy, alkyl, and dialkylamino;

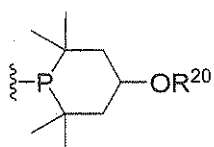
V^6 and V^8 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkoxy;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

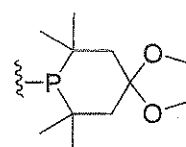
X is selected from the group consisting of phosphines of formulae 1-1, 1-2, 1-3, 1-4, 1-5, and 1-64.



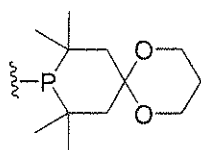
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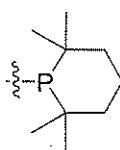
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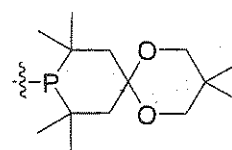
1-3



1-4



1-5



1-64

18. The compound of claim 17, wherein the compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinane;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphinan-4-ol;

7,7,9,9-tetramethyl-8-(2',4',6'-triisopropylbiphenyl-2-yl)-1,4-dioxa-8-phosphaspiro[4.5]decane;

8,8,10,10-tetramethyl-9-(2',4',6'-triisopropylbiphenyl-2-yl)-1,5-dioxa-9-phosphaspiro[5.5]undecane;

3,3,8,8,10,10-hexamethyl-9-(2',4',6'-triisopropylbiphenyl-2-yl)-1,5-dioxa-9-phosphaspiro[5.5]undecane;

1-(2'-(dimethylamino)-6'-methoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-bis(dimethylamino)biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2',6'-diisopropoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2'-(dimethylamino)biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(biphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(3,6-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(3,6-dimethoxy-2',4',6'-trimethylbiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)phosphinan-4-one;

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-4,5-dimethoxybiphenyl-2-yl)phosphinan-4-one;

1-(3',5'-dimethoxybiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(4'-*tert*-butylbiphenyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

6-methoxy-*N,N*-dimethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2-amine;

*N*²,*N*²,*N*⁶,*N*⁶-tetramethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2,6-diamine;

8-(2',6'-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decane;

8-(2',6'-diisopropoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decane;

N,N-dimethyl-2'-(7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decan-8-yl)biphenyl-2-amine;

8-(biphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxa-8-phosphaspiro[4.5]decane;

8-(3,6-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(3,6-dimethoxy-2',4',6'-trimethylbiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane;

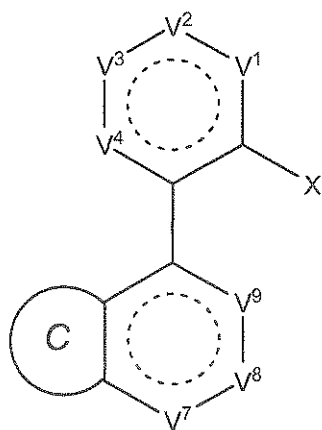
7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-4,5-dimethoxybiphenyl-2-yl)-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(3',5'-dimethoxybiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane;

8-(4'-*tert*-butylbiphenyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane; and

2,2,6,6-tetramethyl-1-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)phosphinane.

19. The compound of claim 2, said compound having a structure corresponding to formula (I-8),



(I-8)

or a salt thereof,

wherein

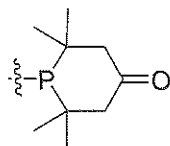
V¹ and V² are each CR¹, wherein R¹ is, at each occurrence, hydrogen;

V^7 and V^8 are each CR^2 , wherein R^2 is, at each occurrence, hydrogen;

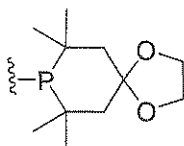
V^9 is CR^2 , wherein R^2 is hydrogen;

ring C at each occurrence is an unsubstituted fused-phenyl; and

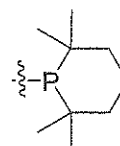
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



1-5

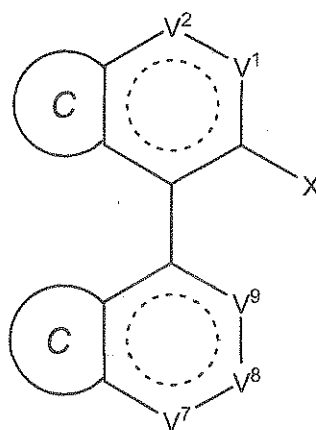
20. The compound of claim 19, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2-(naphthalen-1-yl)phenyl)phosphinan-4-one;

and

7,7,9,9-tetramethyl-8-(4-methyl-2-(naphthalen-1-yl)phenyl)-1,4-dioxaspiro[4.5]decane.

21. The compound of claim 2, said compound having a structure corresponding to formula (I-10),



(I-10)

or a salt thereof,

wherein

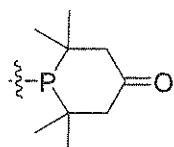
V^1 and V^2 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^7 and V^8 are each CR^2 , wherein R^2 is, at each occurrence, hydrogen;

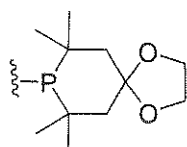
V^9 is CR^2 , wherein R^2 is hydrogen or alkoxy;

ring C at each occurrence is an unsubstituted fused-phenyl; and

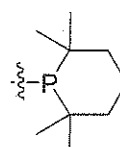
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3, and 1-5.



1-1



1-3



1-5

22. The compound of claim 21, wherein said compound is selected from the group consisting of:

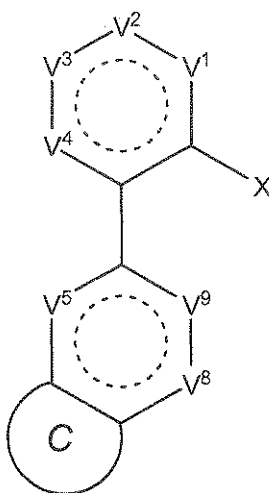
1-(1,1'-binaphthyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2'-methoxy-1,1'-binaphthyl-2-yl)-2,2,6,6-tetramethylphosphinan-4-one;

8-(1,1'-binaphthyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane; and

8-(2'-methoxy-1,1'-binaphthyl-2-yl)-7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decane.

23. The compound of claim 2, said compound having a structure corresponding to formula (I-9),



(I-9)

or a salt thereof,

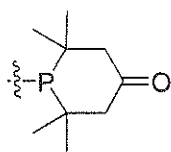
wherein

V^1 , V^2 , V^3 , and V^4 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

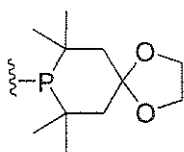
V^5 , V^8 and V^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen;

ring C is an unsubstituted fused-phenyl; and

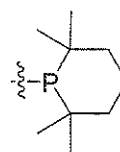
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3, and 1-5.



1-1



1-3



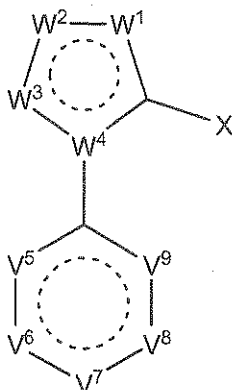
1-5

24. The compound of claim 23, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(2-(naphthalen-2-yl)phenyl)phosphinan-4-one; and

7,7,9,9-tetramethyl-8-(2-(naphthalen-2-yl)phenyl)-1,4-dioxo-8-phosphaspiro[4.5]decane.

25. The compound of claim 2, said compound having a structure corresponding to formula (I-2),



(I-2)

or a salt thereof,

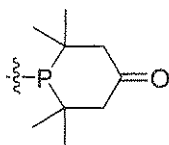
wherein

W^1 and W^2 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

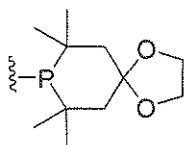
W^3 and W^4 are each N;

V^5 , V^6 , V^7 , V^8 , and V^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen; and

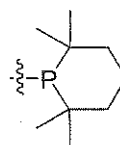
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



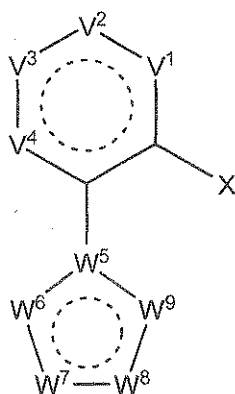
1-5

26. The compound of claim 25, wherein said compound is selected from the group consisting of:

2,2,6,6-tetramethyl-1-(1-phenyl-1*H*-pyrazol-5-yl)phosphinan-4-one; and

1-phenyl-5-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)-1*H*-pyrazole.

27. The compound of claim 2, said compound having a structure corresponding to formula (I-3),



(I-3)

or a salt thereof,

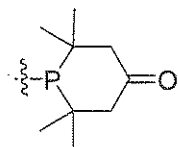
wherein

V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

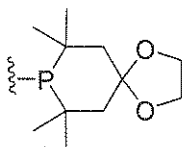
W^6 , W^7 , W^8 and W^9 are each CR^2 , wherein R^2 , at each occurrence, is hydrogen;

W^5 is N; and

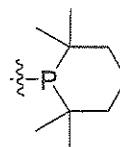
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



1-5

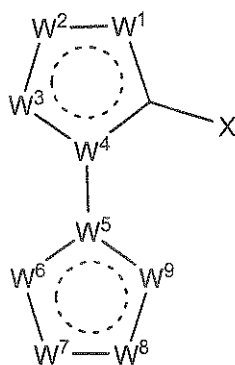
28. The compound of claim 27, wherein said compound is selected from the group consisting of:

1-(2-(1*H*-pyrrol-1-yl)phenyl)-2,2,6,6-tetramethylphosphinan-4-one;

1-(2-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)phenyl)-1*H*-pyrrole; and

1-(2-(2,2,6,6-tetramethylphosphinan-1-yl)phenyl)-1*H*-pyrrole.

29. The compound of claim 2, said compound having a structure corresponding to formula (I-4),



(I-4)

or a salt thereof, wherein

W^1 and W^2 are each CR^1 , wherein R^1 , at each occurrence, is hydrogen;

W^3 and W^4 are each N;

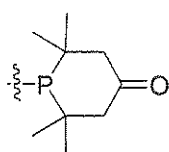
W^5 is C;

W^6 and W^9 are each CR^2 , wherein R^2 , at each occurrence, is substituted or unsubstituted phenyl;

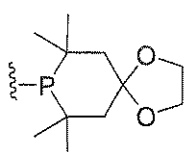
W^7 is N;

W^8 is NR^2 , wherein R^2 , at each occurrence, is phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; and

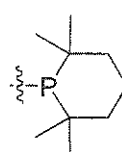
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 1-1, 1-3 and 1-5.



1-1



1-3



1-5

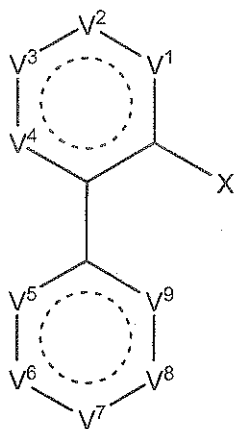
30. The compound of claim 29, wherein said compound is selected from the group consisting of:

2,2,6,6-Tetramethyl-1-(1',3',5'-triphenyl-1'*H*-1,4'-bipyrazol-5-yl)phosphinan-4-one;

1',3',5'-Triphenyl-5-(7,7,9,9-tetramethyl-1,4-dioxo-8-phosphaspiro[4.5]decan-8-yl)-1'*H*-1,4'-bipyrazole; and

1',3',5'-Triphenyl-5-(2,2,6,6-tetramethylphosphinan-1-yl)-1'*H*-1,4'-bipyrazole.

31. A compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

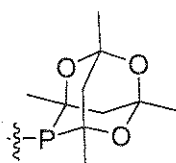
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkyl;

V^6 and V^8 are CR^2 , wherein R^2 , at each occurrence, is hydrogen;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

X is a phosphine of formula 1-37.



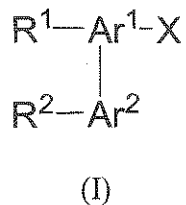
1-37

32. The compound of claim 31, wherein the compound is selected from the group consisting of:

1,3,5,7-tetramethyl-8-(2',4',6'-triisopropylbiphenyl-2-yl)-2,4,6-trioxa-8-phosphatricyclo[3.3.1.1^{3,7}]decane; and

8-(biphenyl-2-yl)-1,3,5,7-tetramethyl-2,4,6-trioxa-8-phosphatricyclo[3.3.1.1^{3,7}]decane.

33. A compound having a structure corresponding to formula (I),

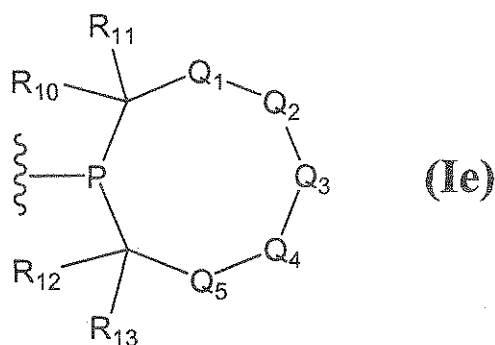


wherein

Ar^1 and Ar^2 are each independently aryl or heteroaryl, and wherein Ar^1 and Ar^2 are each independently optionally substituted with one or more R^1 and R^2 , respectively;

R^1 and R^2 are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino; heteroarylamino; alkylamino; dialkylamino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate; alkylthio; thioalkyl; and a ring containing an alkylene or $-O-(CH_2)_m-O-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a phosphine of formula (Ie), or a salt thereof,



wherein

Q^1 is selected from the group consisting of a bond; $-O-$, $-S-$, $-N(R^{21})-$, $=C(R^{22})-$, and $-C(R^{23})(R^{24})-$;

Q^2 is selected from the group consisting of a bond, $-O-$, $-S-$, $-N(R^{25})-$, $=C(R^{26})-$, and $-C(R^{27})(R^{28})-$;

Q^3 is selected from the group consisting of a bond, $-O-$, $-S-$, $-N(R^{29})-$, $=C(R^{30})-$, and $-C(R^{32})(R^{30})-$;

Q^4 is selected from the group consisting of a bond, $-O-$, $-S-$, $-N(R^{33})-$, $=C(R^{34})-$, and $-C(R^{35})(R^{36})-$;

Q^5 is selected from the group consisting of a bond, $-O-$, $-S-$, $-N(R^{37})-$, $=C(R^{38})-$, and $-C(R^{39})(R^{40})-$; and at least one of Q^1 , Q^2 , Q^3 , Q^4 , and Q^5 is not a bond; or

two of Q^1 , Q^2 , Q^3 , Q^4 , or Q^5 together form a carbonyl; an exocyclic double bond optionally substituted with alkyl, alkenyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; or a 3-8-membered spiro ring containing zero, one, or two hetero ring atoms, optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy;

as to R^{10} , R^{11} , R^{12} , and R^{13} ,

- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring; or
- iii. one or more of R^{10} , R^{11} , R^{12} and R^{13} form a ring together with a ring substituent of ring *A*; or
- iv. R^{10} , R^{11} , R^{12} , and R^{13} do not form a ring, wherein R^{10} , R^{11} , R^{12} and R^{13} are each independently selected from the group consisting of alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or

alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl; and

$R^{21}-R^{40}$ are, at each occurrence, independently selected from the group consisting of hydrogen, halo, fluoro, alkyl, haloalkyl, fluoroalkyl, alkenyl, alkynyl, alkyloxy, *N*-alkylamino, *N,N*-dialkylamino, *N,N,N*-trialkylammoniumalkyl; substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted heteroaryl, substituted or unsubstituted phenyl; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$ where $R^{1'}$ is hydrogen, alkyl or hydroxyalkyl and L^1 is a bond or alkylene; $L^2-O-C(O)-R^{2'}$ where $R^{2'}$ is alkyl or hydroxyalkyl and L^2 is a bond or alkylene; $L^3-C(O)-NR^{3'}R^{4'}$ where $R^{3'}$ and $R^{4'}$ are independently selected from H, alkyl, and hydroxyalkyl and wherein L^3 is a bond or alkylene; $L^4-NR^{5'}-C(O)-R^{6'}$ wherein $R^{5'}$ is selected from H and alkyl, $R^{6'}$ is selected from alkyl and hydroxyalkyl, and L^4 is a bond or alkylene; and alkylthio; or additionally one or more of $R^{21}-R^{40}$ form a ring with another of R^{10} , R^{11} , R^{12} , R^{13} , and $R^{21}-R^{40}$.

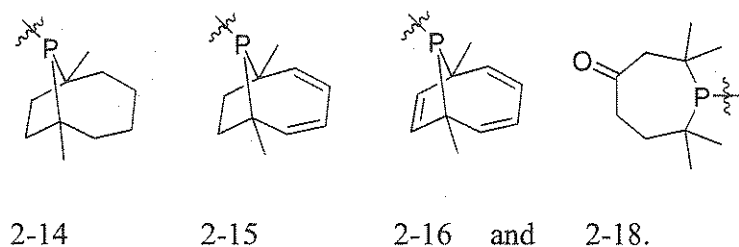
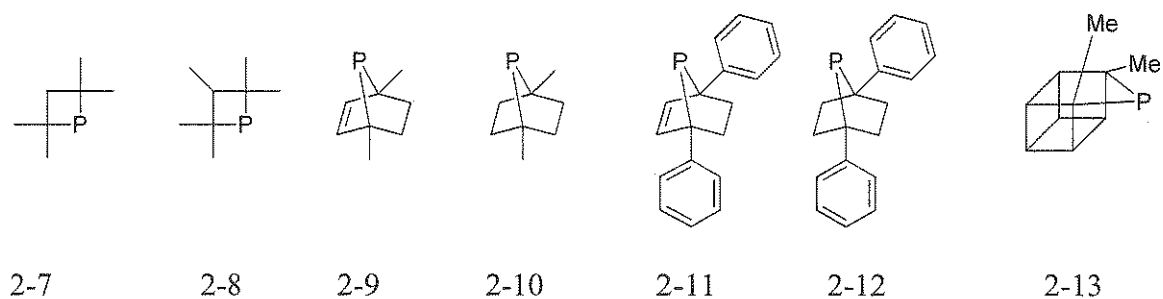
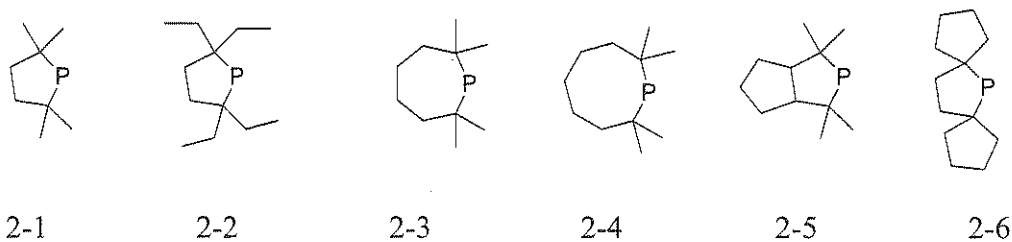
34. The compound according to claim 33, wherein X comprises a 4-membered ring.

35. The compound according to claim 33, wherein X comprises a 5-membered ring.

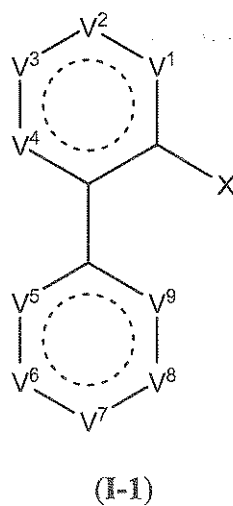
36. The compound according to claim 33, wherein X comprises a 7-membered ring or an 8-membered ring.

37. The compound according to claim 33, wherein R^{10} , R^{11} , R^{12} , and R^{13} are selected from the group consisting of alkyl, phenyl, and heteroaryl, or wherein R^{10} or R^{11} together with R^{12} or R^{13} form a ring.

38. The compound according to claim 33, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of



39. A compound having a structure corresponding to formula (I-1),



or a salt thereof,

wherein

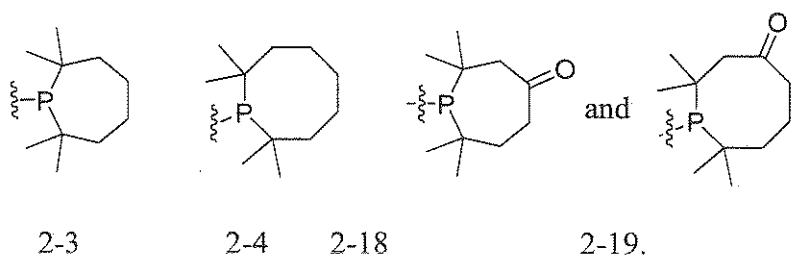
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V^5 and V^9 are CR^2 , wherein R^2 is independently, at each occurrence, hydrogen or alkyl;

V^6 and V^8 are CR^2 , wherein R^2 , at each occurrence, is hydrogen;

V^7 is CR^2 , wherein R^2 is hydrogen or alkyl; and

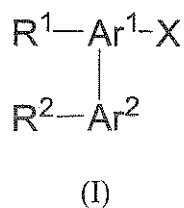
X is a phosphine having a structure corresponding to a formula selected from the group consisting of formulae 2-3, 2-4, 2-18, and 2-19



40. The compound of claim 39, wherein the compound is selected from the group consisting of:

- 1-(biphenyl-2-yl)-2,2,7,7-tetramethylphosphhepan-4-one;
- 1-(biphenyl-2-yl)-2,2,7,7-tetramethylphosphhepane;
- 2,2,7,7-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphhepan-4-one;
- 2,2,7,7-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphhepane;
- 2,2,8,8-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphocan-4-one; and
- 2,2,8,8-tetramethyl-1-(2',4',6'-triisopropylbiphenyl-2-yl)phosphocane.

41. A compound having a structure corresponding to formula (I),



or a salt thereof,

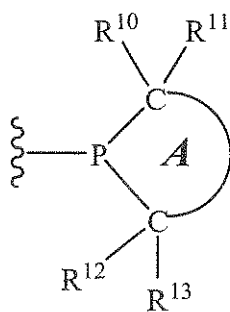
wherein

Ar^1 and Ar^2 are each independently aryl or heteroaryl, and wherein Ar^1 and Ar^2 are each independently optionally substituted with one or more R^1 and R^2 , respectively;

R^1 and R^2 are independently selected at each occurrence from the group consisting of hydrogen; amino; hydroxyl; cyano; halo; alkyl; alkenyl; alkynyl; haloalkyl; haloalkoxy; oxoalkyl; alkoxy; aryloxy; heteroaryloxy; arylamino;

heteroaryl-amino; alkyl-amino; dialkyl-amino; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyloxy optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; 5- or 6-membered heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; hydroxyalkoxy; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; sulfamoyl; *N*-(alkyl)sulfamoyl; *N,N*-(dialkyl)sulfamoyl; sulfonamide; sulfate; alkylthio; thioalkyl; and a ring containing an alkylene or $-O-(CH_2)_m-O-$ formed by the joining together of any two R^1 or any two R^2 or an R^1 and an R^2 , wherein m is 1, 2, 3 or 4;

X is a phosphine of formula (Ia):



(Ia)

wherein ring A includes 0 to 9 ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia), wherein said ring atoms are each independently selected from the group consisting of carbon, oxygen, nitrogen, phosphorus and sulfur; and

wherein the ring atoms of ring A are each independently optionally substituted with one or more substituents selected from the group consisting of alkenyl; alkoxy;

alkoxyalkyl; alkyl; alkylamino; alkylthio; alkynyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; dialkylamino; halo; haloalkyl; fluoroalkyl; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxy; hydroxyalkyl; oxo; an exocyclic double bond optionally substituted with alkyl, alkenyl, alkynyl, aryl, cycloalkyl, heterocyclyl, or heteroaryl; a 3- to 7-membered spiro ring containing zero, one, or two heteroatoms; phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, or $L^1-S(O)_2-OR^{1'}$, wherein L^1 is a bond or alkylene, and $R^{1'}$ is selected from the group consisting of hydrogen, alkyl or hydroxyalkyl; $L^2-O-C(O)-R^{2'}$, wherein L^2 is a bond or alkylene, and $R^{2'}$ is alkyl or hydroxyalkyl; $L^3-C(O)-NR^{3'}R^{4'}$, wherein L^3 is a bond or alkylene, and $R^{3'}$ and $R^{4'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; $L^4-NR^{5'}-C(O)-R^{6'}$, wherein L^4 is a bond or alkylene, $R^{5'}$ is hydrogen or alkyl, and $R^{6'}$ is alkyl or hydroxyalkyl; and $L^7-NR^{8'}-S(O)_2-R^{9'}$, wherein L^7 is a bond or alkylene, $R^{8'}$ is hydrogen or alkyl, and $R^{9'}$ is alkyl or hydroxyalkyl; and

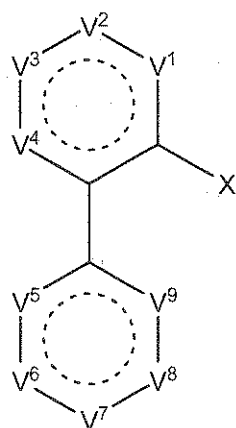
as to R^{10} , R^{11} , R^{12} , and R^{13} ,

- i. R^{10} or R^{11} together with R^{12} or R^{13} form a ring; or
- ii. R^{10} and R^{11} together with the carbon atom to which they are attached form a spirocyclic ring and/or R^{12} and R^{13} together with the carbon atom to which they are attached form a spirocyclic ring;

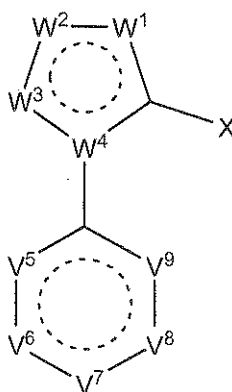
wherein, any of substituents R^{10} , R^{11} , R^{12} , and R^{13} that do not form the ring set forth in (i) or (ii) are each independently selected from the group consisting of hydrogen; alkyl; alkenyl; haloalkyl; alkynyl; oxoalkyl; cycloalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heterocyclyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; heteroaryl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy;

phenyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; hydroxyalkyl; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; $L^{13}-C(O)-OR^{14'}$, $L^{13}-P(O)-(OR^{14'})_2$, or $L^{13}-S(O)_2-OR^{14'}$, wherein L^{13} is a bond or alkylene, and $R^{14'}$ is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; $L^{15}-O-C(O)-R^{16'}$, wherein L^{15} is alkylene and $R^{16'}$ is alkyl or hydroxyalkyl; $L^{17}-C(O)-NR^{18'}R^{19'}$, wherein L^{17} is a bond or alkylene, and $R^{18'}$ and $R^{19'}$ are each independently selected from the group consisting of hydrogen, alkyl, and hydroxyalkyl; and $L^{20}-NR^{21'}-C(O)-R^{22'}$, wherein L^{20} is alkylene, $R^{21'}$ is hydrogen or alkyl, and $R^{22'}$ is alkyl or hydroxyalkyl.

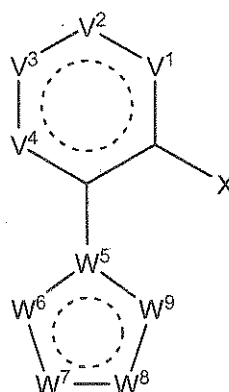
42. The compound according to claim 41, said compound having a structure corresponding to a structure of a formula selected from the group consisting of formulae (I-1) - (I-42), or a salt thereof:



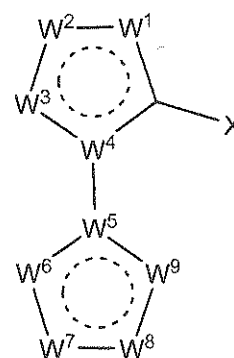
(I-1)



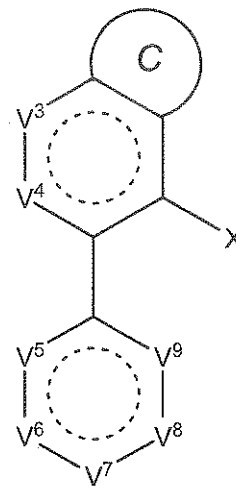
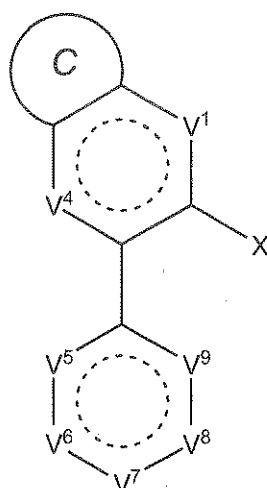
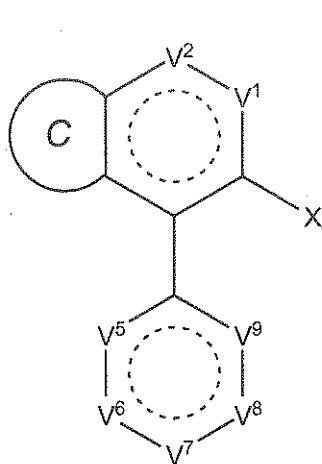
(I-2)



(I-3)



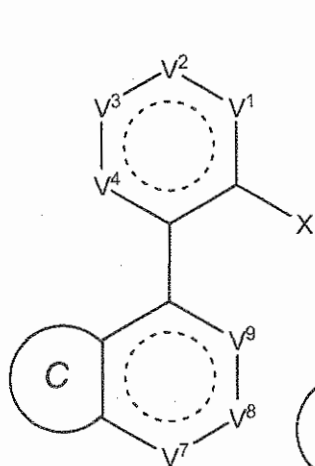
(I-4)



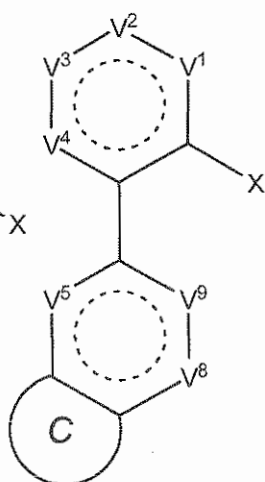
(I-5)

(I-6)

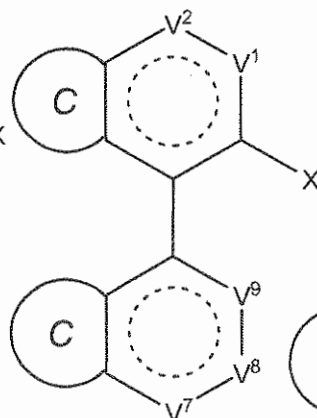
(I-7)



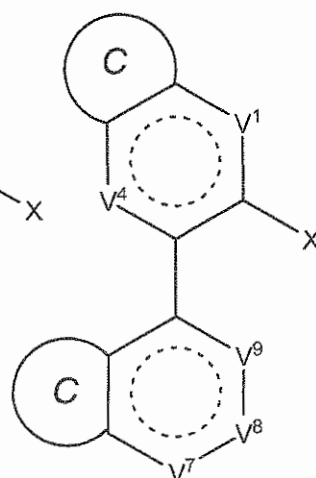
(I-8)



(I-9)

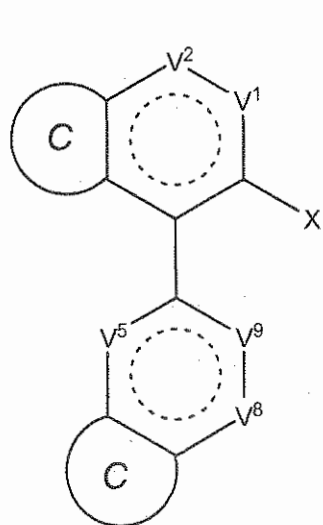


(I-10)

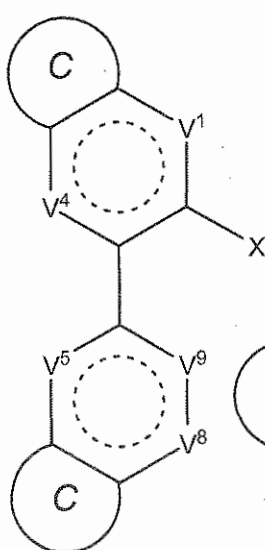


(I-11)

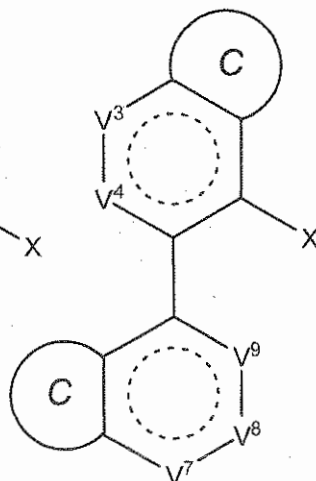
11)



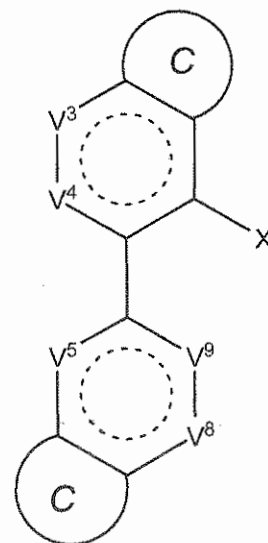
(I-12)



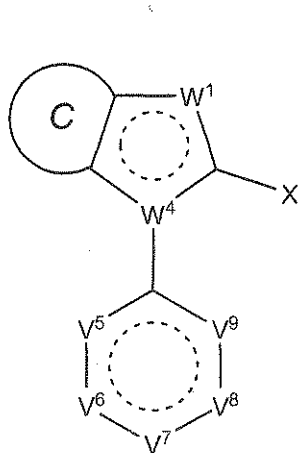
(I-13)



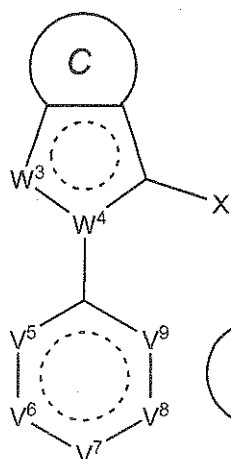
(I-14)



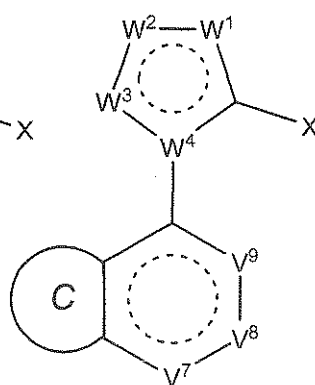
(I-15)



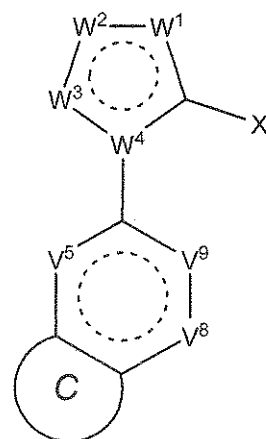
(I-16)



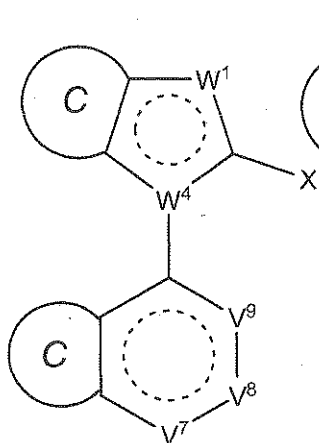
(I-17)



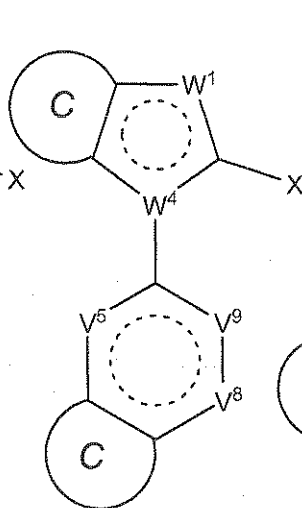
(I-18)



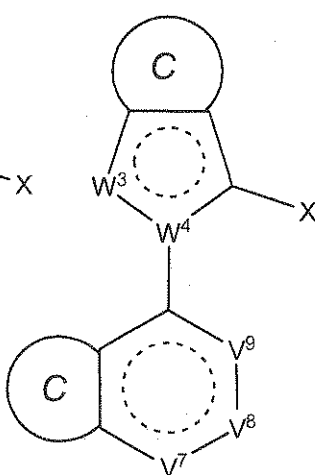
(I-19)



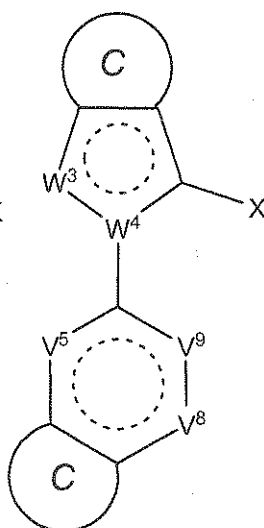
(I-20)



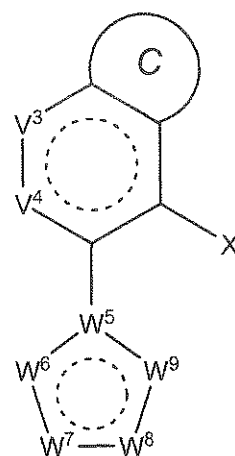
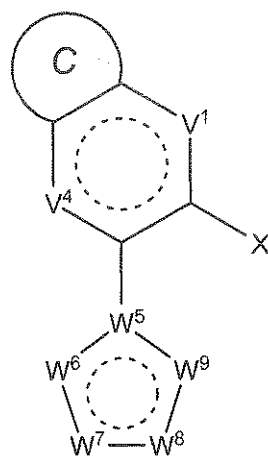
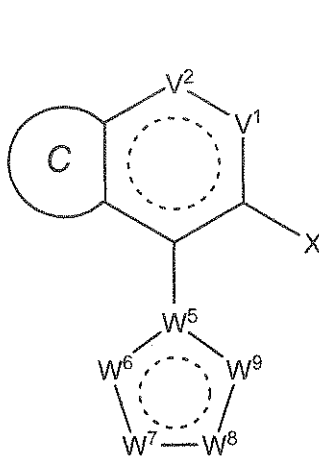
(I-21)



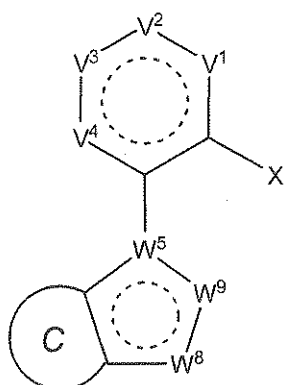
(I-22)



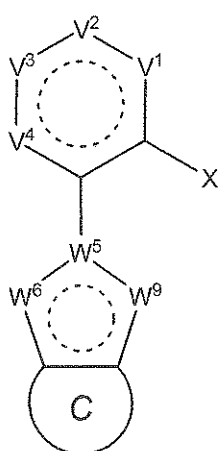
(I-23)



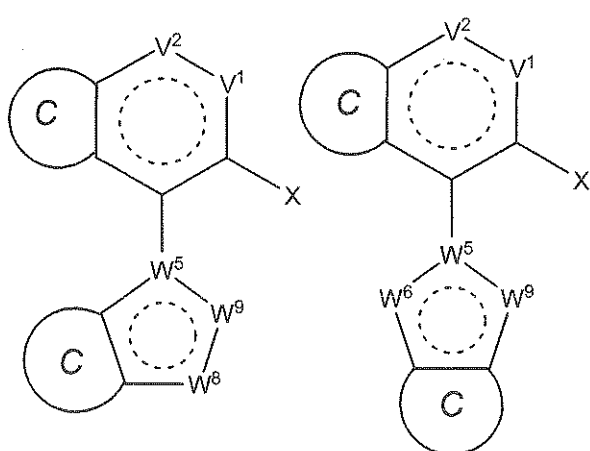
(I-24)



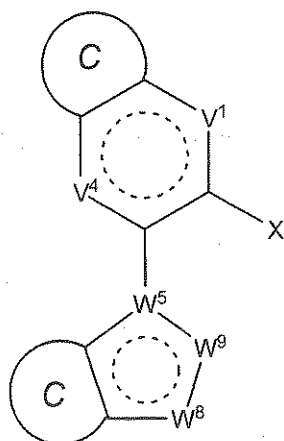
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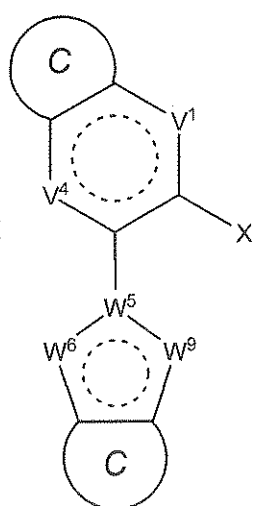
(I-26)



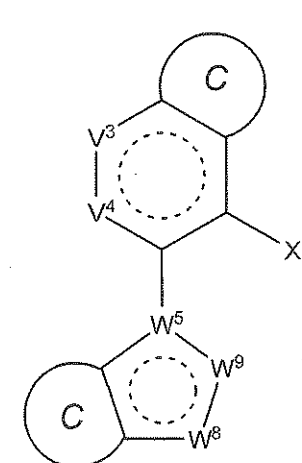
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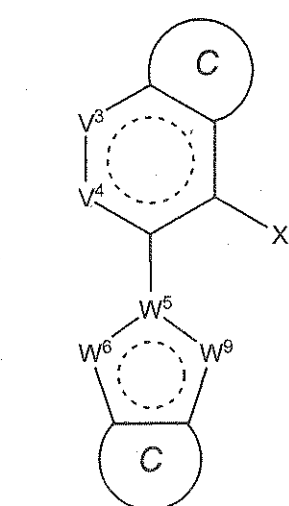
(I-28)



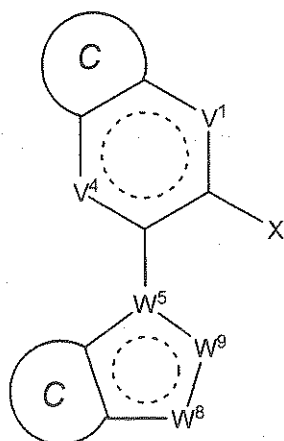
(I-29)



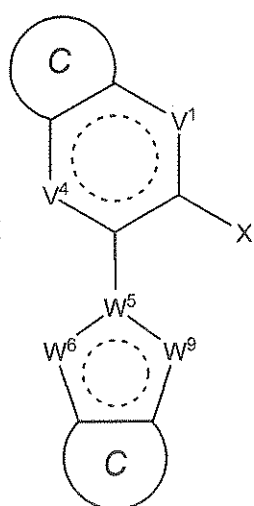
(I-30)



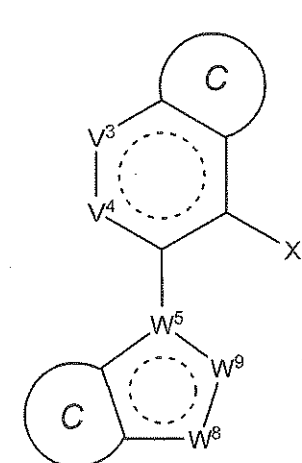
(I-31)



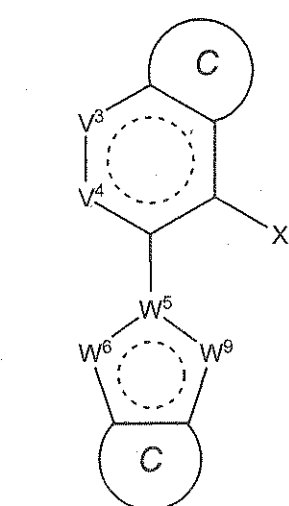
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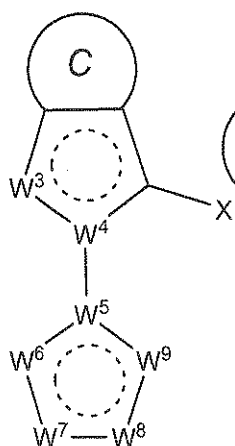


(I-33)

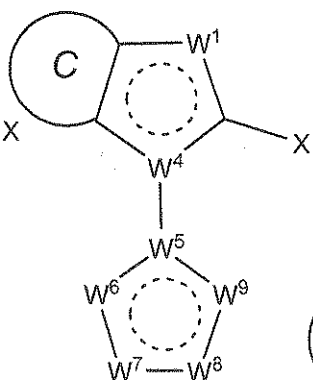


(I-34)

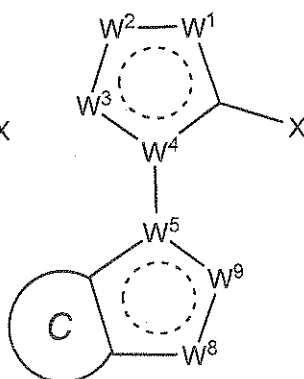




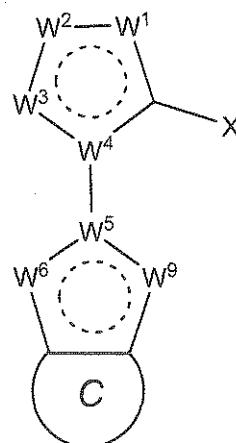
(I-35)



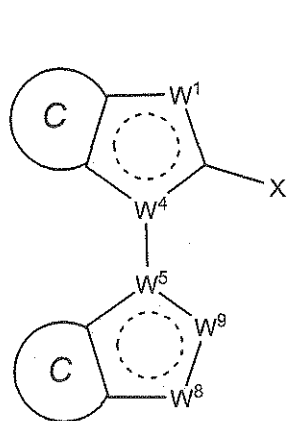
(I-36)



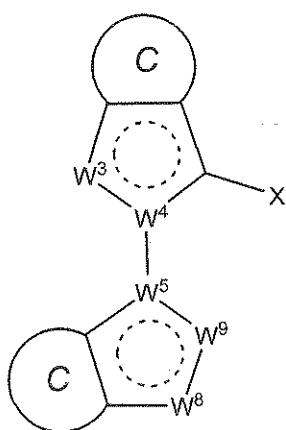
(I-37)



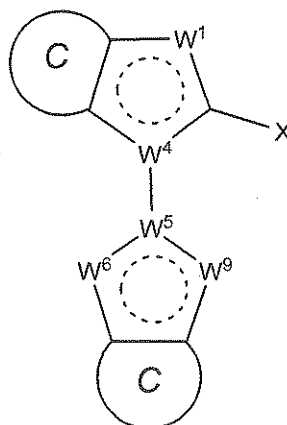
(I-38)



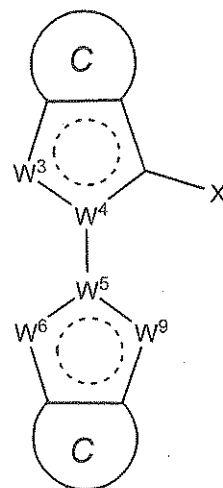
(I-39)



(I-40)



(I-41), and



(I-42)

wherein

V^1 , V^2 , V^3 , and V^4 are each independently CR^1 or N;

V^5 , V^6 , V^7 , V^8 and V^9 are each independently CR^2 or N;

W^1 , W^2 , and W^3 are each independently selected from the group consisting of CR^1 , NR^1 , N and O;

W^4 is C or N;

W^5 is C or N;

W^6 , W^7 , W^8 and W^9 are each independently selected from the group consisting of CR^2 , NR^2 , N and O; and

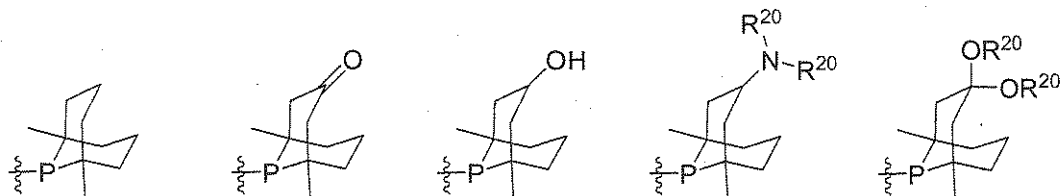
ring C, at each occurrence, is a fused-aryl or fused-heteroaryl and is optionally substituted with R^1 and R^2 .

43. The compound according to any one of claims 41-42, wherein ring A is a 4-, 5-, 6-, 7-, or 8-membered ring, and wherein each of the ring atoms in addition to the phosphorus and 2 carbon ring atoms of formula (Ia) are carbon.

44. The compound according to claim 41, wherein ring A of formula (Ia) is bicyclic.

45. The compound according to claim 41, wherein ring A of formula (Ia) is tricyclic.

46. The compound according to claim 41, wherein X is a phosphine having a structure corresponding to a formula selected from the group consisting of:



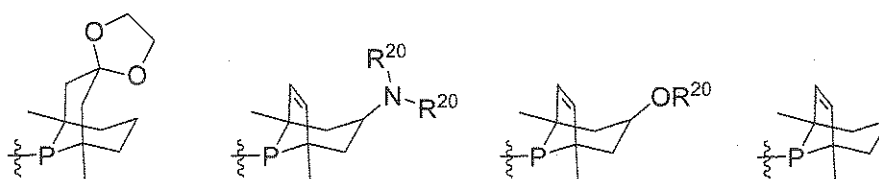
1-23

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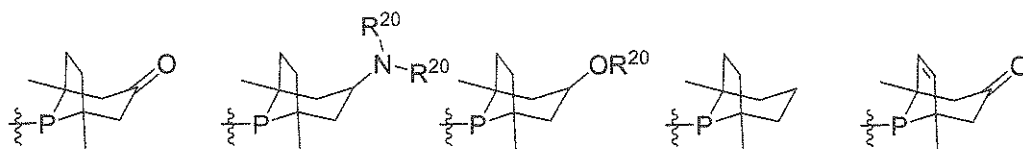


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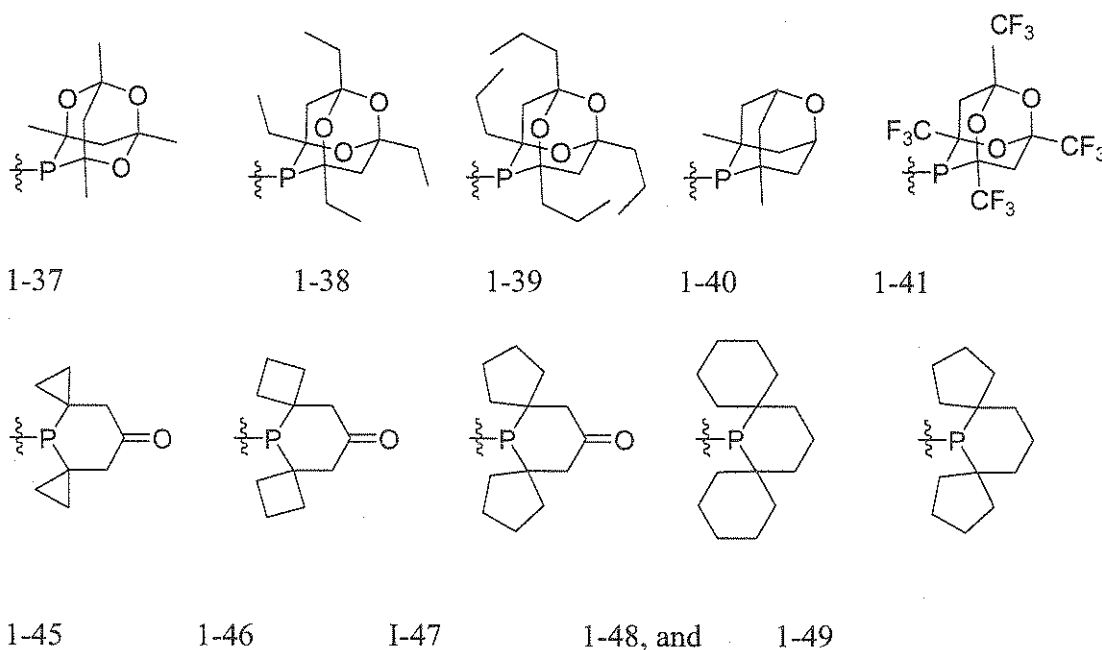
1-32

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1-34

1-35

1-36



or a salt thereof, wherein R^{20} is hydrogen, alkyl, aryl, heteroaryl, arylalkyl or heteroarylalkyl, wherein the aryl, heteroaryl, aryl of arylalkyl and heteroaryl of heteroarylalkyl are optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy.

47. 7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxaspiro[4.5]decane.

48. A catalyst composition comprising a transition metal catalyst precursor and a compound according to any one of claims 1-47.

49. The catalyst composition according to claim 48, wherein the transition metal catalyst precursor is selected from the group consisting of palladium, rhodium, ruthenium, platinum, gold, cobalt, iridium, copper and nickel.

50. The catalyst composition according to claim 49, wherein the transition metal catalyst precursor contains palladium.

51. A catalyst composition comprising a palladium catalyst precursor and a compound according to claim 7.

52. A catalyst composition comprising a palladium catalyst precursor and 7,7,9,9-tetramethyl-8-(2',4',6'-triisopropyl-3,6-dimethoxybiphenyl-2-yl)-1,4-dioxaspiro[4.5]decane.

53. A heterogeneous catalyst composition comprising a compound according to any one of claims 1-47 covalently bonded to a solid catalyst support.

54. A method for synthesizing a secondary organic sulfonamide, comprising reacting an aryl nonaflate with a primary sulfonamide in the presence of a palladium catalyst precursor and at least one compound selected from the compounds of any one of claims 1-47.

55. A method of performing a bond-forming reaction comprising catalyzing said reaction with a compound of any one of claims 1-47, wherein the bond-forming reaction is selected from the group consisting of carbon-nitrogen, carbon-oxygen, carbon-carbon, carbon-sulfur, carbon-phosphorus, carbon-boron, carbon-fluorine and carbon-hydrogen.

56. A method of forming a bond in a chemical reaction comprising catalyzing said reaction with a compound of any one of claims 1-47, wherein the bond is selected from the group consisting of a carbon-nitrogen bond, a carbon-oxygen bond, a carbon-carbon bond, a carbon-sulfur bond, a carbon-phosphorus bond, a carbon-boron bond, a carbon-fluorine bond and a carbon-hydrogen bond.

57. A method of preparing phosphacycles of any one of claims 1-47 comprising:

metalation of a biaryl halide to form a biaryl lithium species;

reacting a chlorophosphate with said biaryl lithium species to form a biaryl phosphonate;

reduction of second product to form primary phosphine; and

reacting primary phosphine with a divinylketone.