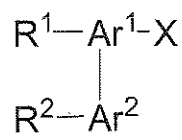


R¹⁴ and R¹⁵ together with the carbon atom to which they are attached form a spirocyclic ring; or

one or more of R¹⁴ and R¹⁵ form a ring together with a ring atom or ring substituent of ring **B**, wherein

if any of substituents R¹⁴ and R¹⁵ do not form a ring, said substituents 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; C₅₋₆ 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; alkoxyalkyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; thioalkyl; L¹³-C(O)-OR^{14'}, L¹³-P(O)-(OR^{14'})₂, or L¹³-S(O)₂-OR^{14'} wherein L¹³ is a bond or alkylene, and R^{14'} is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; L¹⁵-O-C(O)-R^{16'} wherein L¹⁵ is alkylene, and R^{16'} is alkyl or hydroxyalkyl; L¹⁷-C(O)-NR^{18'}R^{19'}, wherein L¹⁷ 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 L²⁰-NR^{21'}-C(O)-R^{22'}, wherein L²⁰ is alkylene, R^{21'} is hydrogen or alkyl, and R^{22'} is alkyl or hydroxyalkyl.

[007a] In one aspect, there is provided a compound having a structure corresponding to formula (I),



(I)

or a salt thereof,

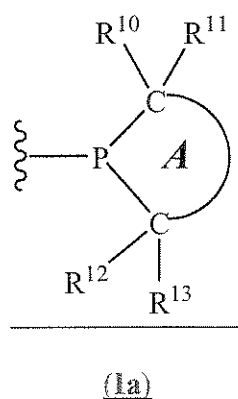
wherein

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; $L^1-C(O)-OR^1$, $L^1-P(O)-(OR^1)_2$, 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 6-membered cyclic phosphine of formula (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;

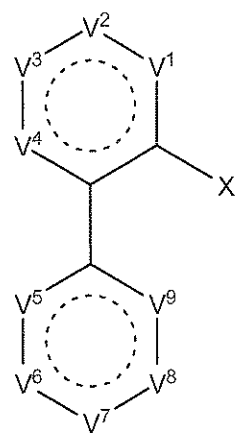
alkoxyalkyl; alkyl; alkylamino; alkylthio; alkynyl; aminoalkyl; *N*-alkylaminoalkyl; *N,N*-dialkylaminoalkyl; *N,N,N*-trialkylammoniumalkyl; arylalkyl optionally substituted with alkyl, alkenyl, alkynyl, alkoxy, cyano, halo, haloalkyl or haloalkoxy; cycloalkyl optionally substituted with alkyl, alkenyl, 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.

[007b] In one aspect, there is provided a compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

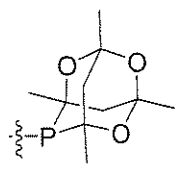
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

V⁵ and V⁹ are CR², wherein R² is independently, at each occurrence, hydrogen or alkyl;

V⁶ and V⁸ are CR², wherein R², at each occurrence, is hydrogen;

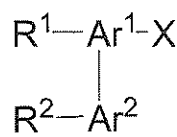
V⁷ is CR², wherein R² is hydrogen or alkyl; and

X is a phosphine of formula 1-37.



1-37

[007c] In one aspect, there is provided a compound having a structure corresponding to formula (I).



(I)

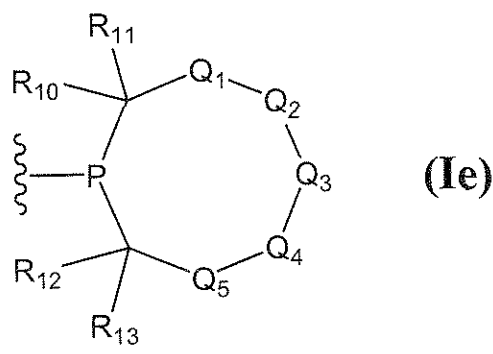
wherein

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; $L^1-C(O)-OR^{1'}$, $L^1-P(O)-(OR^{1'})_2$, 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 Q¹, Q², Q³, Q⁴, or Q⁵ 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 R¹⁰, R¹¹, R¹², and R¹³,

i. R¹⁰ or R¹¹ together with R¹² or R¹³ form a ring; or

ii. R¹⁰ and R¹¹ together with the carbon atom to which they are attached form a spirocyclic ring and/or R¹² and R¹³ together with the carbon atom to which they are attached form a spirocyclic ring; or

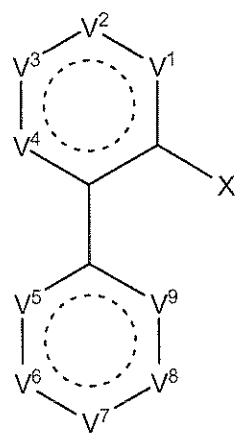
iii. one or more of R¹⁰, R¹¹, R¹² and R¹³ form a ring together with a ring substituent of ring A; or

iv. R¹⁰, R¹¹, R¹², and R¹³ do not form a ring, wherein R¹⁰, R¹¹, R¹² and R¹³ 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; L¹³-C(O)-OR^{14'}, L¹³-P(O)-(OR^{14'})₂, or L¹³-S(O)₂-OR^{14'}, wherein L¹³ is a bond or alkylene, and R^{14'} is selected from the group consisting of hydrogen, alkyl and hydroxyalkyl; L¹⁵-O-C(O)-R^{16'}, wherein L¹⁵ is alkylene and R^{16'} is alkyl or hydroxyalkyl; L¹⁷-C(O)-NR^{18'}R^{19'}, wherein L¹⁷ 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 L²⁰-NR^{21'}-C(O)-R^{22'}, wherein L²⁰ is alkylene, R^{21'} is hydrogen or alkyl, and R^{22'} is alkyl or hydroxyalkyl; and

R²¹-R⁴⁰ 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} .

[007d] In one aspect, there is provided a compound having a structure corresponding to formula (I-1),



(I-1)

or a salt thereof,

wherein

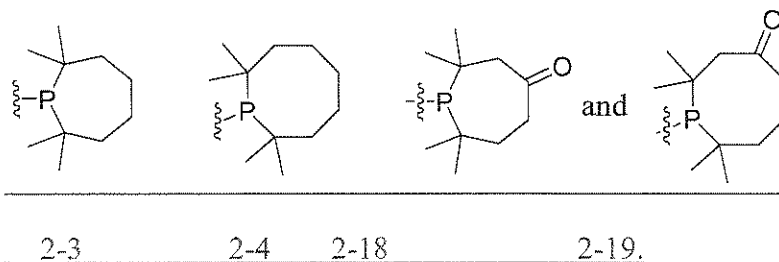
V^1 , V^2 , V^3 and V^4 are each CR^1 , wherein R^1 is, at each occurrence, hydrogen;

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

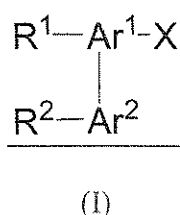
V^6 and V^8 are CR^2 , wherein R^2 , at each occurrence, is hydrogen;

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

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



[007e] In one aspect, there is provided a compound having a structure corresponding to formula (I),



or a salt thereof,

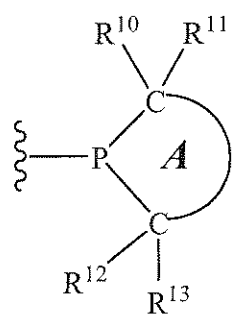
wherein

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 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.

[007f] In one aspect, there is provided a catalyst composition comprising a transition metal catalyst precursor and a compound as defined above.

[007g] In one aspect, there is provided a catalyst composition comprising a palladium catalyst precursor and a compound as defined above.

[007h] In one aspect, there is provided 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.

[007i] In one aspect, there is provided a heterogeneous catalyst composition comprising a compound as defined above covalently bonded to a solid catalyst support.

[007j] In one aspect, there is provided 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 as defined above.

[007k] In one aspect, there is provided a method of performing a bond-forming reaction comprising catalyzing said reaction with a compound as defined above, 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.

[007l] In one aspect, there is provided a method of forming a bond in a chemical reaction comprising catalyzing said reaction with a compound as defined above, 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.

[007m] In one aspect, there is provided a method of preparing phosphacycles as defined above 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.

[008] The disclosure is directed to catalyst compositions comprising a ligand of formula (I) and one or more transition metal compounds.

[009] The disclosure is directed to catalyst compositions comprising a ligand of formula (I) covalently bonded to a solid catalyst support.

[010] The disclosure is directed to methods of performing a bond-forming reaction comprising catalyzing said reaction with a ligand of formula (I), 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.

[011] The disclosure is directed to methods of forming a bond in a chemical reaction comprising catalyzing said reaction with a ligand of formula (I), 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.