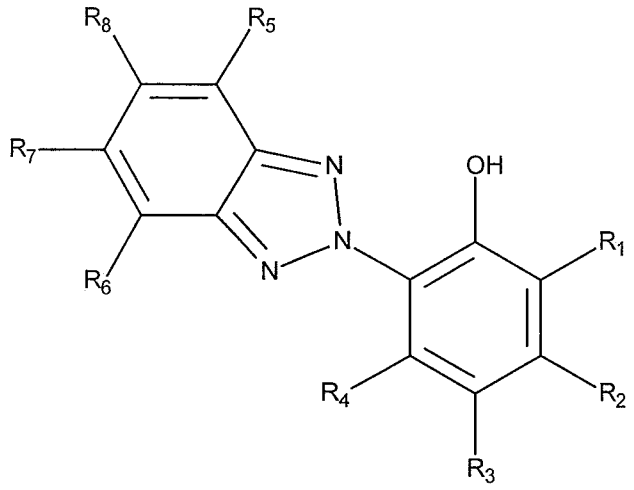



Formula I

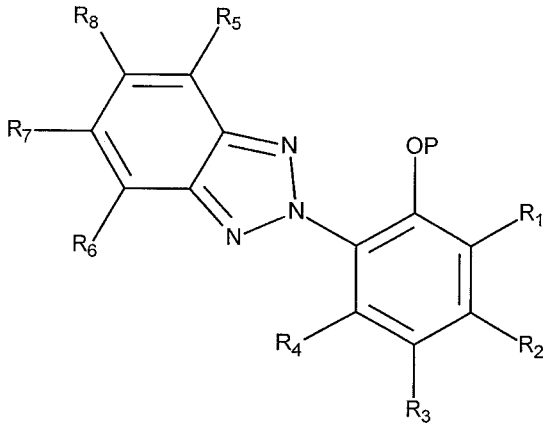
wherein if $R^1$ is an -O-$R^9$, a -N-$R^9R^{10}$, a -B($OR^{18}$)($OR^{19}$) group, or a -$SiR^{20}_3$ group wherein $R^9$ is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, and $R^{10}$ is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, or $R^9$ and $R^{10}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{18}$ and $R^{19}$ is independently a hydrogen atom, an alkyl group, an aryl group, or $R^{18}$ and $R^{19}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{20}$ group is an alkyl group; and

each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom; and

$R^3$ is an alkyl group with 8 carbon atoms.

In some embodiments, the compositions comprise the structure of Formula II:

In another aspect, there is provided a composition comprising a protected substituted benzotriazole phenol comprising the general structure Formula III or Formula IV:



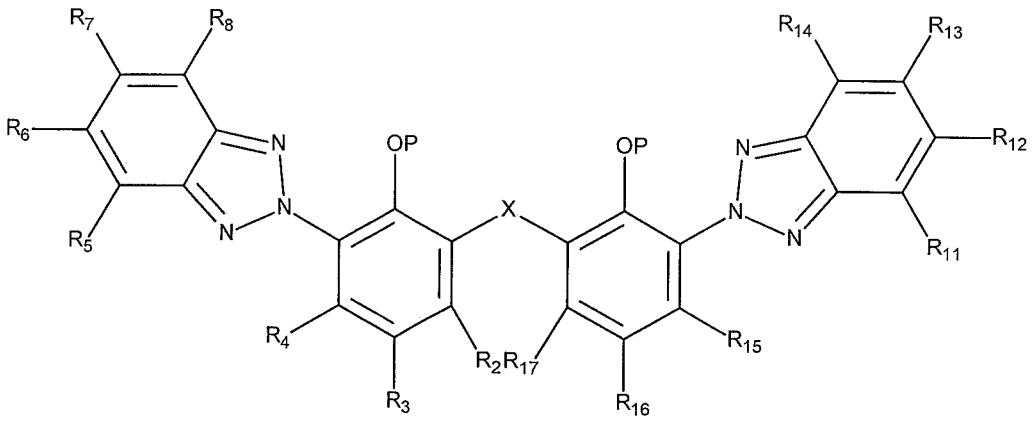

Formula III

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

wherein if $R^1$ is an -O-$R^9$, a -N-$R^9R^{10}$, a -B($OR^{18}$)($OR^{19}$) group, or a –$SiR^{20}_3$ group wherein $R^9$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, and $R^{10}$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, or $R^9$ and $R^{10}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{18}$ and $R^{19}$ is independently a hydrogen atom, an alkyl group, an aryl group, or $R^{18}$ and $R^{19}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{20}$ group is an alkyl group; and

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

or



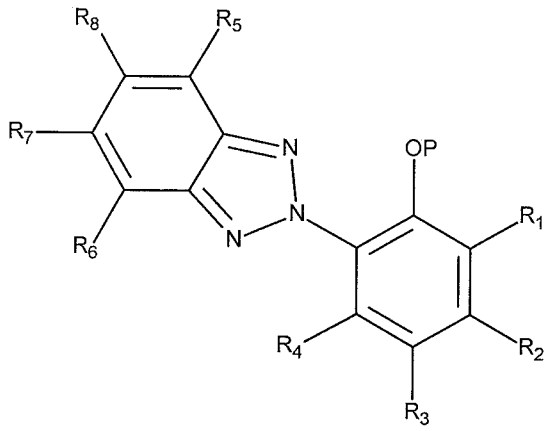

Formula IV

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

and wherein X is an -O-, -$NR^{10}$-, -S(O)-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group,

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, $R^{16}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

Also disclosed herein are methods of preparing substituted benzotriazole phenols comprising providing a protected phenolic compound of Formula III:




Formula III

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

$R^1$ is a leaving group selected from a halogen atom, a triflate group, a tosylate group, or a sulfonate group; and

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

providing a compound with the general formula $R^{21}$-Z-X-H wherein $R^{21}$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

Z is an alkyl or aryl group, or a single bond;

X is an -O-, -$NR^{10}$-, -S(O)-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group;

providing a palladium-based catalyst comprising at least one palladium-phosphine complex;

providing at least one base;

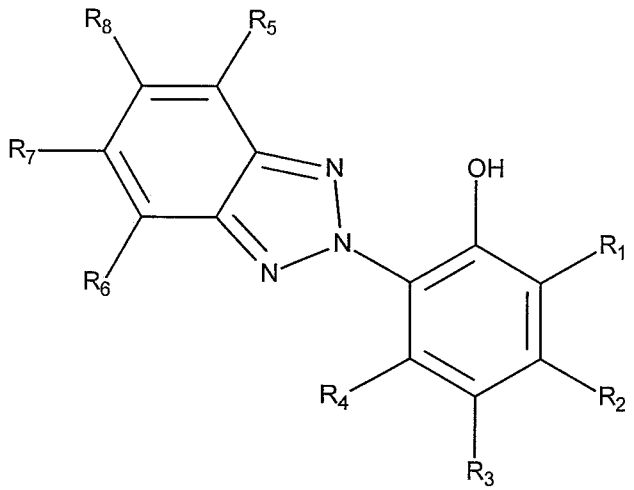
providing at least one solvent;

mixing the protected phenolic compound of Formula III, the compound with the general formula $R^{21}$-Z-X-H, the palladium-based catalyst, the at least one base, and the at least one solvent to form a reaction mixture; and

heating the reaction mixture to a temperature of at least 100°C to effect a coupling reaction.

What is claimed is:

1. A composition comprising a substituted benzotriazole phenol with the structure of Formula I:




Formula I

wherein if $R^1$ is an -O-$R^9$, a -N-$R^9R^{10}$, a -B($OR^{18}$)($OR^{19}$) group, or a -$SiR^{20}_3$ group wherein $R^9$ is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, and $R^{10}$ is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, or $R^9$ and $R^{10}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{18}$ and $R^{19}$ is independently a hydrogen atom, an alkyl group, an aryl group, or $R^{18}$ and $R^{19}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{20}$ group is an alkyl group; and

each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom; and

$R^3$ is an alkyl group with 8 carbon atoms.

2. The composition of claim 1, wherein $R^1$ is an -O-$R^9$ group wherein $R^9$ is:

an alkyl group with 1-20 carbon atoms; or

an aryl group; and

$R^3$ is an alkyl group with 8 carbon atoms.

3. The composition of claim 2, wherein $R^9$ is:

an alkyl group with 1-6 carbon atoms; or

an aryl group comprising a substituted phenyl group.

4. The composition of claim 1, wherein $R^1$ is a -N-$R^9R^{10}$ group:

wherein $R^9$ is a hydrogen atom; an alkyl group with 1-20 carbon atoms; or an aryl group;

$R^{10}$ is a hydrogen atom or an alkyl group with 1-6 carbon atoms; and

$R^3$ is an alkyl group with 8 carbon atoms.

5. The composition of claim 4, wherein $R^9$ is:

an alkyl group with 1-6 carbon atoms; or

an aryl group comprising a 3-alkyl substituted phenyl group, wherein the alkyl substituted group has 1-6 carbon atoms;

$R^{10}$ is a hydrogen atom.

6. The composition of claim 2, wherein $R^1$ is an -O-$R^9$ group wherein $R^9$ is an alkyl group with 4 carbon atoms; and

$R^3$ is an alkyl group with 8 carbon atoms.

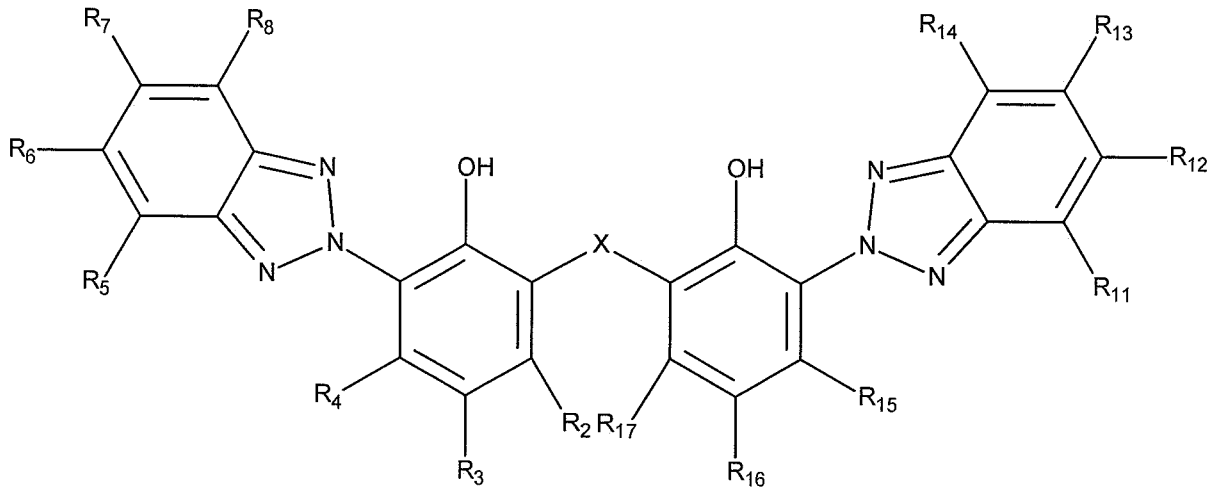
7. The composition of claim 2, wherein $R^1$ is an -O-$R^9$ group wherein $R^9$ is an aryl group selected from a 3-methyl phenyl group, or a 4-methyl phenyl group; and
$R^3$ is an alkyl group with 8 carbon atoms.

8. The composition of claim 4, wherein $R^1$ is an -N-$R^9R^{10}$ group wherein $R^9$ is an alkyl group with 1 carbon atom, or an alkyl group with 6 carbon atoms;
$R^{10}$ is a hydrogen atom; and
$R^3$ is an alkyl group with 8 carbon atoms.

9. The composition of claim 4, wherein $R^1$ is an -N-$R^9R^{10}$ group wherein $R^9$ is an aryl group being an alkyl substituted phenyl group, wherein the alkyl substituted group has 1-20 carbon atoms;
$R^{10}$ is selected from a hydrogen atom; and
$R^3$ is an alkyl group with 8 carbon atoms.

10. The composition of claim 9, wherein the alkyl substituted phenyl group is a 4-hexyl phenyl group.

11. The composition of claim 1, comprising the structure of Formula II:




Formula II

wherein X is an -O-, -$NR^{10}$-, -S(O)-, -$S(O)_2$-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group,

each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, $R^{16}$, and $R^{17}$, independently is selected from a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom; and

$R^3$ is an alkyl group with 8 carbon atoms.

12. The composition of claim 11, wherein X is an -$NR^{10}$- linking group where $R^{10}$ is a hydrogen atom, or an alkyl group comprising 1-3 carbon atoms;

$R^3$ is an alkyl group with 8 carbon atoms; and $R^{16}$ is an alkyl group with 1-20 carbon atoms.

13. The composition of claim 11, wherein X is an -O- linking group;

$R^3$ is an alkyl group with 8 carbon atoms; and $R^{16}$ is an alkyl group with 1-20 carbon atoms.

14. The composition of claim 11, wherein X is an -$NR^{10}$- linking group where $R^{10}$ is a hydrogen atom;

$R^3$ is an alkyl group with 8 carbon atoms; and $R^{16}$ is an alkyl group with 1-20 carbon atoms;

each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

15. The composition of claim 11, wherein X is an -$NR^{10}$- linking group where $R^{10}$ is a methyl group;

$R^3$ is an alkyl group with 8 carbon atoms; and $R^{16}$ is an alkyl group with 1-20 carbon atoms;

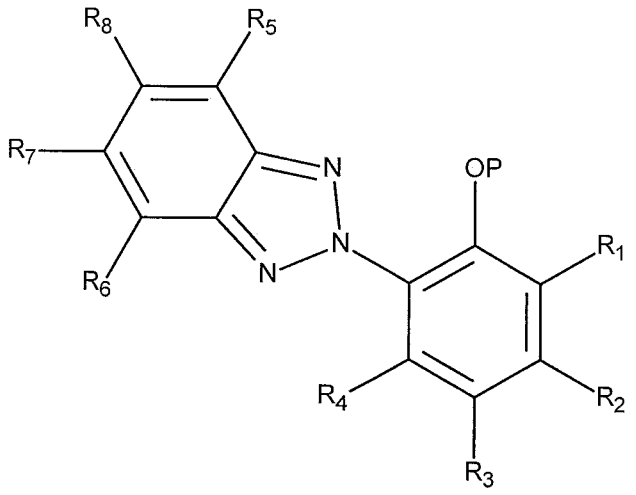
each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

16. The composition of claim 11, wherein X is an -O- linking group;

$R^3$ is an alkyl group with 8 carbon atoms; and $R^{16}$ is an alkyl group with 1-20 carbon atoms;

each $R^2$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

17. A composition comprising a protected substituted benzotriazole phenol comprising the general structure Formula III or Formula IV:



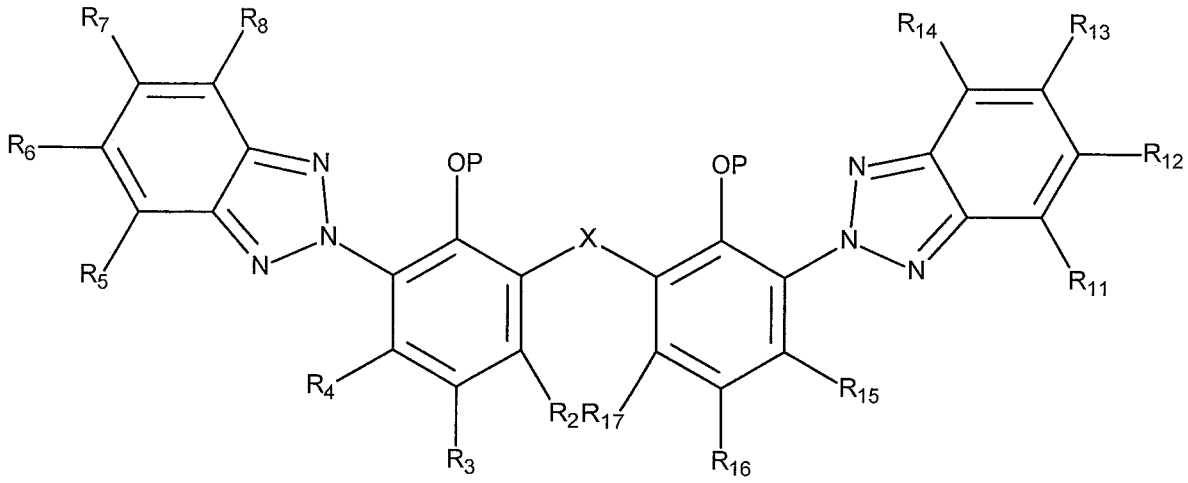

Formula III

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

wherein if $R^1$ is an -O-$R^9$, a -N-$R^9R^{10}$, a -B($OR^{18}$)($OR^{19}$) group, or a –$SiR^{20}_3$ group wherein $R^9$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, and $R^{10}$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a heteroatom-containing group comprising one or more oxygen, nitrogen, sulfur, or phosphorous atoms, or $R^9$ and $R^{10}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{18}$ and $R^{19}$ is independently a hydrogen atom, an alkyl group, an aryl group, or $R^{18}$ and $R^{19}$ together with the atoms connecting form a heterocyclic ring structure, each $R^{20}$ group is an alkyl group; and

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

or




Formula IV

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

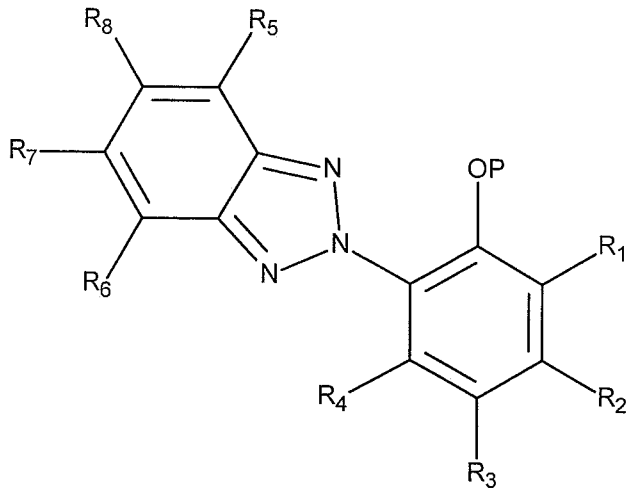
and wherein X is an -O-, -$NR^{10}$-, -S(O)-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group,

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, $R^{16}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

18. The composition of claim 17, wherein P comprises a methyl group, a -$CH_2OCH_3$ group, or a -Si((i-Pr)$_3$ group, where i-Pr is an iso-propyl group.

19. A method of preparing a substituted benzotriazole phenol comprising:

providing a protected phenolic compound of Formula III:




Formula III

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

$R^1$ is a leaving group selected from a halogen atom, a triflate group, a tosylate group, or a sulfonate group; and

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

providing a compound with the general formula $R^{21}$-Z-X-H

wherein $R^{21}$ is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom;

Z is an alkyl or aryl group, or a single bond;

X is an -O-, -$NR^{10}$-, -S(O)-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group;

providing a palladium-based catalyst comprising at least one palladium-phosphine complex;

providing at least one base;

providing at least one solvent;

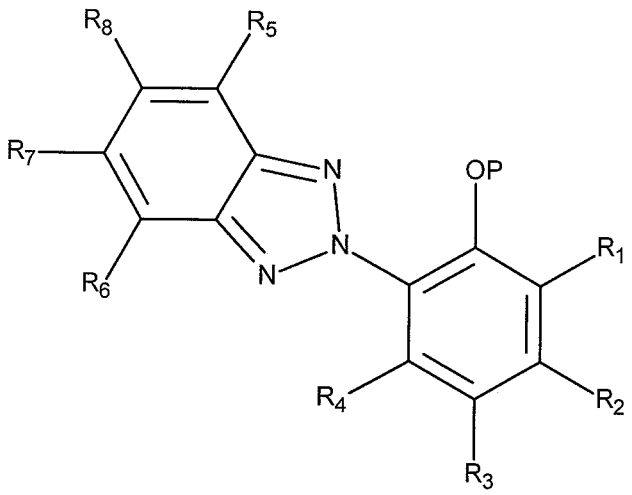
mixing the protected phenolic compound of Formula III, the compound with the

general formula $R^{21}$-Z-X-H, the palladium-based catalyst, the at least one base, and the at least one solvent to form a reaction mixture; and

heating the reaction mixture to a temperature of at least 100°C to effect a coupling reaction.

20. The method of claim 19, wherein the compound with the general formula $R^{21}$-Z-X-H is a compound where X is -O-, or -, -$NR^{10}$-, where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group, and the $R^{21}$-Z- group is an alkyl group, or a substituted aromatic group.

21. The method of claim 19, wherein the compound with the general formula $R^{21}$-Z-X-H comprises a compound of Formula IIIa:




Formula IIIa

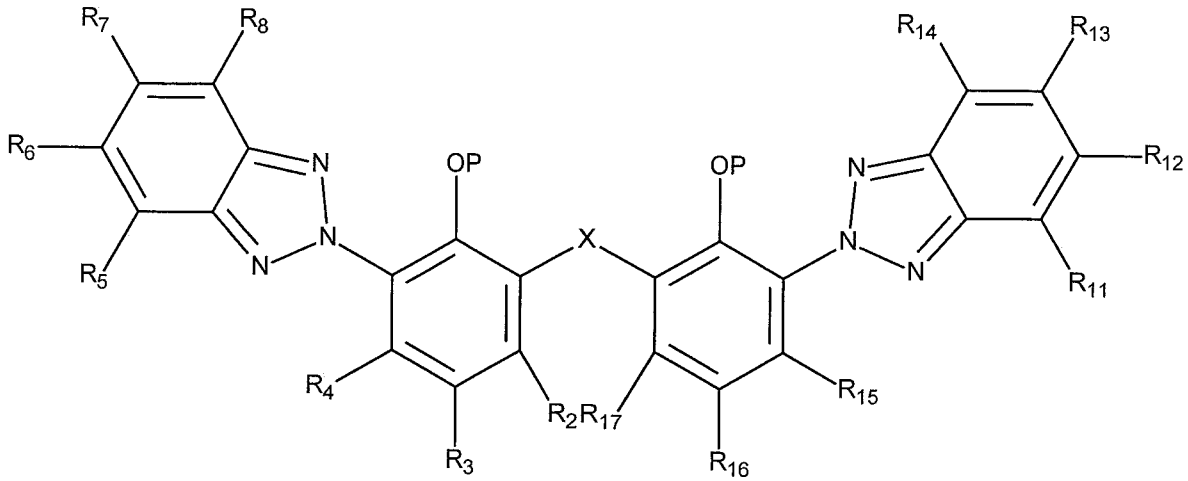
wherein $R^1$ is the group -XH, where X is an -O-, -$NR^{10}$-, -S(O)-, or -S- linking group where $R^{10}$ is a hydrogen atom, an alkyl group, or an aryl group;

the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group; and

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, and $R^8$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

22. The method of claim 21, wherein $R^1$ is an -OH group.

23. The method of claim 19, wherein the compound with the general formula $R^{21}$-Z-XH comprises $NH_3$, and the coupling reaction comprises a second coupling reaction to form a compound of Formula IV:




Formula IV

wherein the group P is a protective group comprising an alkyl, a substituted alkyl, or a silyl group;

and wherein X is an -$NR^{10}$- linking group where $R^{10}$ is a hydrogen atom,

each $R^2$, $R^3$, $R^4$, $R^5$, $R^6$, $R^7$, $R^8$, $R^{11}$, $R^{12}$, $R^{13}$, $R^{14}$, $R^{15}$, $R^{16}$, and $R^{17}$, independently is a hydrogen atom, an alkyl group, an alkenyl group, an aryl group, or a halogen atom.

24. The method of claim 19, further comprising replacing the protective group P with a hydrogen atom.