What is claimed is:

1. A method of synthesizing a mono-substituted cyclopentadiene, the method comprising:

mixing a metal hydroxide, a halide, a cyclopentadiene monomer, an alkaline earth oxide, and a homogeneous catalyst in a solvent; and

allowing a selective catalytic carbon-carbon coupling reaction to form the mono-substituted cyclopentadiene,

wherein approximately 20 - 400% excess amount of the cyclopentadiene monomer is used relative to the amount of the halide.

2. The method of claim1, further comprising:

contacting the mono-substituted cyclopentadiene with a metal compound; and

converting the mono-substituted cyclopentadiene to a metal cyclopentadienyl complex.

3. The method of claim 2, further comprising:

maintaining a temperature within a range of from -15°C to 70ºC under atmospheric pressure.

4. The method of claim 2, further comprising:

optionally purifying the mono-substituted cyclopentadiene.

~~5. The method of any one of claims 1 to 4, wherein approximately 20 - 400% excess amount of the cyclopentadiene monomer is used relative to the amount of the halide.~~

~~6.~~5. The method of any one of claims 1 to 4, wherein approximately 40 - 80% excess amount of the cyclopentadiene monomer is used relative to the amount of the halide.

~~7.~~6. The method of any one of claims 1 to 4, wherein the metal hydroxide is MOH, wherein M is Group I alkali metal.

~~8.~~7. The method of any one of claims 1 to 4, wherein the halide is an silyl-, amino-, alkyl- or hydrocarbonyl halide or fluoroalkyl halide has the formula R(Hal) or R(F)(Hal), wherein Hal is selected from Cl, Br, I; R is selected from

a. a C_1-C_8 linear or branched, saturated or unsaturated hydrocarbyl group;

b. a C_1-C_8 linear or branched, saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine;

c. a silyl group [SiR'_3] with R' being selected from H, a C_1-C_4 saturated or unsaturated hydrocarbyl group;

d. a silyl group [SiR'_3] with each R' being selected from H, F, a C_1-C_4 saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine atom; and

e. an amino group [$–NR^1R^2$] with each R^1 and R^2 being independently selected from H or a C_1-C_6 linear or branched, saturated or unsaturated hydrocarbyl group.

~~9.~~8. The method of any one of claims 1 to 4, wherein the alkaline earth oxide is MO, wherein M is Group II alkaline earth metal.

~~10.~~9. The method of any one of claims 1 to 4, wherein the catalyst is a tertiary phosphonium salt.

~~11.~~10. The method of any one of claims 1 to 4, wherein the catalyst is tetrabutylphosphonium chloride, Bu_4PCl (CAS No: 2304-30-5).

~~12.~~11. The method of claim 2, wherein the metal compound is a Group I, Group II and Group III main group metal compound or a transition metal compound.

~~13.~~12. The method of claim 2, wherein the metal compound is an alkyl metal compound alkyl-M, where M is Group I, Group II and Group III main group metal or a transition metal.

~~14.~~13. The method of claim ~~13~~12, wherein the alkyl metal compound is selected from MeLi or BuLi.

~~15.~~14. The method of claim 2, wherein the metal compound is a metal hydride MH, wherein M is a Group I, Group II or Group III main group metal or a transition metal.

~~16.~~15. The method of claim ~~15~~14, wherein the metal hydride MH, wherein M is selected from K, Na, Sr, Ba, Ga, In, Y or Yb.

~~17.~~16. The method of any one of claims 1 to 4, wherein the solvent is a furan solvent such as THF, Me-THF.

~~18.~~17. The method of any one of claims 1 to 4, wherein the mono-substituted cyclopentadiene is 1-fluorobutyl-cyclopentadiene (C_5H_5-1-F-C_4H_{10}, C_5H_5-1-F-Bu),

2-pentyl-cyclopentadiene (C_5H_5-2-C_5H_{11}, C_5H_5-2-Pent),
2-butyl-cyclopentadiene (C_5H_5-2-C_4H_9, C_5H_5-2-Bu), or
1,1,1-trifluoropropyl-cyclopentadiene (C_5H_5-1,1,1-3F-C_4H_6, C_5H_5-3F-Bu).

~~19.~~18. The method of any one of claims 1 to 4, wherein the mono-substituted cyclopentadiene is 1-fluorobutyl-cyclopentadiene (C_5H_5-1-F-C_4H_{10}, C_5H_5-1-F-Bu).

~~20.~~19. The method of claim 2, wherein the metal cyclopentadienyl precursor is Li(C_5H_4-2-C_5H_{11}) (Li(Cp-2-Pent), CAS No: 2413046-23-6), K(C_5H_4-2-C_5H_{11}) (K(Cp-2-Pent)), Na(C_5H_4-2-C_5H_{11}) (Na(Cp-2-Pent)), K(C_5H_4-1-F-C_4H_{10}) (K(Cp-1-F-Bu)), K(C_5H_4-1,1,1-3F-C_4H_6) (K(Cp-1,1,1-3F-Bu)), Li(C_5H_4-2-C_4H_9) (Li(Cp-2-Bu)), or In(C_5H_4-2-C_5H_{11}) (In(Cp-2-Pent), CAS No.: 2364634-67-1).

~~21.~~20. The method of claim 2, wherein the metal cyclopentadienyl precursor is Li(C_5H_4-2-C_5H_{11}) (Li(Cp-2-Pent), CAS No: 2413046-23-6).

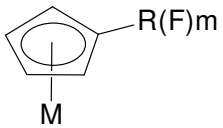
~~22.~~21. The method of claim 2, wherein the metal cyclopentadienyl precursor is K(C_5H_4-2-C_5H_{11}) (K(Cp-2-Pent)).

~~23.~~22. The method of claim 2, wherein the metal cyclopentadienyl precursor is K(C_5H_4-1-F-C_4H_{10}) (K(Cp-1-F-Bu)).

~~24.~~23. The method of claim 2, wherein the metal cyclopentadienyl precursor is Na(C_5H_4-2-C_5H_{11}) (Na(Cp-2-Pent)).

~~25.~~24. The method of claim 2, wherein the metal cyclopentadienyl precursor is In(C_5H_4-2-C_5H_{11}) (In(Cp-2-Pent), CAS No.: 2364634-67-1).

~~26.~~25. A metal cyclopentadienyl complex having the following formula:



$M(C_5H_4(R(F)_m))$ { }

wherein m ≥ 0; M is a main group, alkali or transition metal; C_5H_4 represents a cyclopentadienyl (Cp) ring where two hydrogens are substituted by M and $R(F)_m$, respectively; $R(F)_m$ is connected to any one of the carbon atoms of the Cp and selected from

i) a C_1-C_8 linear or branched, saturated or unsaturated hydrocarbyl group;

ii) a C_1-C_8 linear or branched, saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine;

iii) a silyl group [SiR'_3] with each R' being selected from H, a C_1-C_4 saturated or unsaturated hydrocarbyl group;

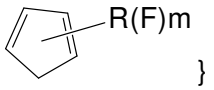
iv) a silyl group [SiR'_3] with R' being independently selected from H, F, a C_1-C_4 saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine atom; and

v) an amino group [$–NR^1R^2$] with R^1 and R^2 each being selected from H or C_1-C_6 linear or branched, saturated or unsaturated hydrocarbyl group.

~~27.~~26. The metal cyclopentadienyl complex of claim ~~26~~25, wherein R is selected from n-Pr, i-Pr, n-Bu, i-Bu, 2-Bu, n-Pent, i-Pent, 2-Pent, n-Hex, i-Hex, 2-Hex, n-Hept, i-Hept, 2-Hept, $–CF_3$, –1,1,1-trifluoropropane (–1,1,1-PrF_3), –1,1,1-trifluorobutane (–1,1,1-BuF_3), or –1-fluorobutane (–1,1,1-BuF).

~~28.~~27. The metal cyclopentadienyl complex of claim ~~26~~25, wherein M is selected from K, Na, Sr, Ba, Ga, In, Y or Yb.

~~29.~~28. A mono-substituted cyclopentadiene having the following formula:

C_5H_5-$R(F)_m$ {  }

wherein $m \geq 0$; C_5H_5 represents a cyclopentadienyl (Cp) ring where one hydrogen is substituted $R(F)_m$; $R(F)_m$ is connected to any one of the carbon atoms of the Cp and selected from

i. a C_1-C_8 linear or branched, saturated or unsaturated hydrocarbyl group;

ii. a C_1-C_8 linear or branched, saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine atom;

iii. a silyl group [SiR'_3] with R' being selected from H, a C_1-C_4 saturated or unsaturated hydrocarbyl group;

iv. a silyl group [SiR'_3] with R' being selected from H, F, a C_1-C_4 saturated or unsaturated fluorohydrocarbyl group containing at least one fluorine atom; and

v. an amino group [$–NR^1R^2$] with R^1 and R^2 each being independently selected from H or a C_1-C_6 linear or branched, saturated or unsaturated hydrocarbyl group.

~~30~~29. The mono-substituted cyclopentadiene of claim ~~29~~28, wherein R is selected from n-Pr, i-Pr, n-Bu, i-Bu, 2-Bu, n-Pent, i-Pent, 2-Pent, n-Hex, i-Hex, 2-Hex, n-Hept, i-Hept, 2-Hept, $–CF_3$, –1,1,1-trifluoropropane (–1,1,1-PrF_3), –1,1,1-trifluorobutane (–1,1,1-BuF_3), or –1-fluorobutane (–1,1,1-BuF).