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 of a tertiary phosphonium salt in a solvent; and

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

wherein 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 40 - 80% excess amount of the cyclopentadiene monomer is used relative to the amount of the halide.

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

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.

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.

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

10. 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.

11. 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.

12. The method of claim 11, wherein the alkyl metal compound is selected from MeLi or BuLi.

13. 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.

14. The method of claim 13, wherein the metal hydride MH, wherein M is selected from K, Na, Sr, Ba, Ga, In, Y or Yb.

15. The method of any one of claims 1 to 4, wherein the solvent is a furan solvent selected from THF, or Me-THF.

16. 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-trifluorobutyl-cyclopentadiene (C_5H_5-1,1,1-3F-C_4H_6, C_5H_5-3F-Bu).

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).

18. 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).

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).

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

21. 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)).

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

23. 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).