Claims

1. A method of forming a catalyst precursor, comprising the steps of:
(a) forming a precipitate from a slurry, wherein the slurry comprises (i) a mixture of an iron precursor, at least two promotor precursors and a solvent and (ii) a solution of an alkali base; and
(b) calcining the precipitate to form the catalyst precursor,
wherein the at least two promoter precursors are selected from the group consisting of cobalt, nickel, gallium, germanium, indium, tin, zinc, cadmium, antimony, titanium, manganese and combinations and hydrates thereof.

2. The method of claim 1, wherein said forming step (a) comprises the steps of:
(a1) mixing the iron precursor, the at least two promotor precursors, and the solvent to form the mixture;
(a2) adding the solution of the alkali base into the mixture of step (a1) to form the slurry.

3. The method of claim 1 or 2, wherein the iron precursor is selected from the group consisting of iron (III) nitrate, iron (III) chloride, iron (III) sulfate, iron (II) nitrate, iron (II) chloride, iron (II) sulfate and combinations thereof.

4. The method of any one of claims 1 to 3, wherein the at least two promotor precursors comprises a gallium salt.

5. The method of any one of claims 2 to 4, further comprising a step of:
(a3) adding an additive to the mixture after said mixing step (a1) but before said adding step (a2).

6. The method of any one of claims 1 to 5, wherein the solution of the alkali base and the mixture have a weight ratio in the range of 1:0.1 to 1:10.

7. The method of any one of claims 2 to 6, wherein in said adding step (a2), the solution of the alkali base has a concentration in the range of 0.4 M to 0.6 M.

8. The method of any one of claims 1 to 7, wherein said forming step (a) comprises heating and drying the slurry to form the precipitate.

9. The method of any one of claims 1 to 8, further comprising a step of:
(a4) filtering the precipitate before said calcining step (b).

10. The method of any one of claims 1 to 9, wherein said calcining step (b) comprises calcining the precipitate at a temperature in the range of 200 ℃ to 500 ℃.

11. A catalyst precursor comprising iron oxide, at least two promoters and a salt, wherein the at least two promoters is a metal oxide of a metal selected from the group consisting of cobalt, nickel, gallium, germanium, indium, tin, zinc, cadmium, antimony, titanium, manganese and combinations thereof.

12. The catalyst precursor of claim 11, wherein the at least two promoters comprises a cobalt oxide.

13. The catalyst precursor of claim 11 or 12, further comprising an additive.

14. The catalyst precursor of any one of claims 11 to 13, wherein the salt comprises an alkali metal cation selected from potassium, sodium, cesium, rubidium, lithium and combinations thereof.

15. A method of forming a catalyst, comprising the step of carburizing the catalyst precursor of any one of claims 11 to 14.

16. The method of claim 15, further comprising a step of diluting the catalyst precursor with a catalyst support before the carburizing step.

17. The method of claim 15 or 16, further comprising a step of reducing the catalyst precursor before the carburizing step.

18. A catalyst comprising ε-Fe_2C, an alkali metal element and at least two additional metals, wherein the at least two additional metals is selected from the group consisting of cobalt, nickel, gallium, germanium, indium, tin, zinc, cadmium, antimony, titanium, manganese and combinations thereof.

19. A process of converting CO_x and H_2 into hydrocarbons using the catalyst of claim 18, wherein x is 1 or 2.