

Claims:

1. A method of preparing a nano-sized, iron-based catalyst, the method comprising:
 - 5 i) mixing a solution containing an iron salt with a surfactant to form a mixture;
 - ii) adding a basic salt solution comprising a salt of element selected from the group consisting of: alkali metals, alkaline earth metals, transition metals of groups 3 to 7 and 9 to 11 of the Periodic Table of Elements, lanthanides, and combinations of elements thereof, to the mixture to
10 form a precipitate; and
 - iii) calcining said precipitate to form the iron-based catalyst, said iron-based catalyst at least partially comprising said element of said basic salt.
2. The method of claim 1, wherein the basic salt solution comprises
15 hydroxide, carbonate or bicarbonate anions.
3. The method of claim 1, wherein the basic salt comprises an alkali metal or an alkali earth metal.
4. The method of any of the preceding claims, wherein the basic salt is sodium hydroxide, lithium hydroxide, potassium hydroxide, cesium
20 hydroxide, or combinations thereof.
5. The method of any of the preceding claims, wherein the adding step comprises providing a molar ratio of elemental iron to the element of the basic salt of from 1:2 to 1:10.
6. The method of claim 1, wherein the solution of step (i) comprises at least
25 one or more additional salts of a transition metal independently selected from groups 3 to 7 and 9 to 11 of the Periodic Table of Elements.

7. The method of claim 6, wherein the transition metal is Ni, Mn, Mg, Ca, La, Co, Li, K, Ce, or a combination thereof.
8. The method of claim 6, wherein the transition metal salt comprises an anion selected from the group consisting of hydroxide, carbonate, bicarbonate, nitrate, nitrite, chloride, fluoride, bromide, iodide, phosphate, pyrophosphate, perchlorate, and mixtures thereof.
9. The method of claim 6, wherein the transition metal salt is $\text{Mn}(\text{NO}_3)_2$ or $\text{Ni}(\text{NO}_3)_2$.
10. The method of claim 6, wherein the solution of step i) comprises a molar ratio of elemental transition metal to iron of from 1:8 to 1:100.
11. The method of claim 1, wherein the adding step (ii) further comprises introducing a silicate to the mixture and precipitating said Fe-based catalyst in the presence of the silicate to thereby form a silicate-supported Fe-based catalyst.
12. The method of claim 11, wherein the silicate comprises one or more alkoxy groups of 2 to 5 carbon atoms.
13. The method of claim 11, wherein the silicate is tetraethyl orthosilicate.
14. The method of claim 11, wherein the adding step comprises providing a molar ratio of elemental iron to said silicate of from 1:5 to 1:15.
15. The method of claim 1, wherein the precipitated mixture obtained from step ii) is not washed before calcination.
16. The method of claim 1, wherein the iron salt is an iron (II) or iron(III) salt.
17. The method of claim 1, wherein the iron salt comprises an anion selected from the group consisting of nitrate, chloride, fluoride, bromide, iodide, phosphate, pyrophosphate and perchlorate.

18. The method of claim 1, wherein the iron salt is iron (III) nitrate.
19. The method of claim 1, wherein the surfactant is an ionic surfactant.
20. The method of claim 19, wherein the surfactant is a quaternary ammonium surfactant.
- 5 21. The method of claim 1, wherein the surfactant is cetyl trimethylammonium bromide.
22. The method of claim 1, wherein the molar ratio of iron to the surfactant is 1:0.5 to 1:2.
- 10 23. The method of claim 1, wherein the calcining step is carried out at a temperature of 400°C to 600°C for 1 to 3 hours.
24. A nano-sized, iron-based catalyst comprising:
- a) 5-99 wt. % of iron; and
- b) 1-50 wt. % of an oxide of a metal selected from the group consisting of: alkali metals, alkaline earth metals, transition metals of groups 3 to 7 and 9 to 11 of the Periodic Table of Elements, and lanthanides, wherein said metal is not iron,
- based on the total weight of the nano-sized catalyst,
- wherein said nano-sized catalyst has a diameter of 2 to 50 nm.
- 15 25. The iron-based catalyst of statement 24, wherein said metal is present in an amount of 4-50 wt. % based on the total weight of the catalyst.
- 20 26. The iron based catalyst of claim 24, wherein the nano-sized catalyst adopts a spinel crystalline phase.
27. The iron based catalyst of claim 26, wherein the formula of the spinel phase catalyst is FeM_2O_4 .

28. The iron-based catalyst of claim 24, wherein the catalyst further comprises a transition metal selected from groups 3-7 and 9-11 of the Periodic Table of Elements.
- 5 29. The iron-based catalyst of claim 24, wherein the weight ratio of the transition metal to iron is 1:5 to 1:200.
30. The iron-based catalyst of claim 24, wherein the catalyst further comprises a SiO₂ matrix.
31. The iron based catalyst of claim 24, further comprising an oxide of a halogen.
- 10 32. The iron catalyst of claim 31, wherein the oxide of the halogen is present in an amount of about 0.1-50 wt. % based on the weight of catalyst.
33. The iron-based catalyst of any of claims 24-32, prepared according to the method of any of claims 1-23.
- 15 34. A process for the production of light olefins, the process comprising the steps of:
- i) heating the catalyst of any of claims 24-33 in the presence of a gas comprising one or more oxides of carbon and hydrogen to activate said catalyst; and
 - 20 ii) contacting said activated catalyst of step (i) with a gas stream comprising one or more oxides of carbon and hydrogen to partially or fully convert said one or more oxides of carbon to said light olefins, said light olefins comprising between 2 to 4 carbon atoms, wherein methane is substantially absent from said light olefins, or constitutes less than 20% of said light olefins.
- 25 35. The process of claim 34, wherein the oxide of carbon in the gas stream of step ii) is substantially carbon dioxide.