CLAIMS

1. A process for producing H_2, the process comprising a step of contacting water, an iron-containing coal combustion product, and a CO_2 source selected from the group consisting of CO_2 and a CO_2 precursor thereby producing H_2, wherein the process is performed in a reactor in the absence of external heating, wherein the internal pressure of the reactor reaches a value from 40 Bar to 350 Bar.
2. The process of claim 1, which is performed at a temperature of 100ºC or less.
3. The process of claim 1 or 2, which is performed at a temperature of -5°C to 50°C.
4. The process of any one of claims 1 to 3, which is performed with no addition of external electric energy.
5. The process of any one of claims 1 to 4 further comprising a step of collecting the produced H_2.
6. The process of any one of claims 1 to 5 further comprising a step of post-treating the produced H_2.
7. The process of claim 6, wherein post-treating comprises at least one of gas separation, filtration, liquification and drying.
8. The process of any one of claims 1 to 7, wherein the produced H_2 has purity of at least 85%.
9. The process of any one of claims 1 to 8, wherein the water is in a liquid phase.
10. The process of any one of claims 1 to 9, wherein the water is selected from the group consisting of tap water, sea water, partially purified water, deionized water, distilled water, brackish water, and waste water.
11. The process of any one of claims 1 to 10, wherein the iron-containing coal combustion product is selected from the group consisting of coal ash, fly ash, bottom ash, boiler slag, heavy oil ash, and a mixture or combination thereof.
12. The process of any one of claims 1 to 11, wherein the iron-containing coal combustion product originates from a power plant, a fuel boiler, or from cement production.
13. The process of any one of claims 1 to 12, wherein the iron-containing coal combustion product comprises a divalent iron oxide, a trivalent iron oxide or a combination thereof.

14. The process of any one of claims 1 to 12, wherein the iron-containing coal combustion product comprises a trivalent iron oxide.

15. The process of any one of claims 1 to 12, wherein the iron-containing coal combustion product comprises at least one of iron(II) oxide (FeO), iron(II,III) oxide (Fe_3O_4), and iron(III) oxide (Fe_2O_3).

16. The process of any one of claims 1 to 15, wherein the iron-containing coal combustion product comprises from 2% to 40% iron oxide w/w.

17. The process of claim 16, wherein the iron-containing coal combustion product further comprises from 25% to 75% silicon dioxide w/w.

18. The process of any one of claims 1 to 17, further comprising pretreating the iron-containing coal combustion product prior to the step of contacting water, an iron-containing coal combustion product, and a CO_2 source.

19. The process of claim 18, wherein pretreating comprises at least one of milling the iron-containing coal combustion product and enriching the iron content of the iron-containing coal combustion product.

20. The process of any one of claims 1 to 19, wherein the CO_2 source is a CO_2 gas.

21. The process of claim 20, wherein the CO_2 gas is originated from at least one of pure industrial CO_2, flue gas, a CO_2-producing plant, and atmospheric CO_2.

22. The process of claim 21, wherein the CO_2 gas is atmospheric CO_2 and the process further comprises atmospheric CO_2 sequestering.

23. The process of any one of claims 1 to 19, wherein the CO_2 source is dry ice.

24. The process of any one of claims 1 to 19, wherein the CO_2 precursor is selected from the group consisting of carbonic acid, a carbonate, a bicarbonate, and a mixture or combination thereof.

25. The process of any one of claims 1 to 24, which is a batch production process.

26. The process of any one of claims 1 to 24, which is a continuous production process.

27. The process of any one of claims 1 to 26, which is performed at a pH of 6.5 or less.

28. The process of any one of claims 1 to 27, further comprising adding an anti-caking agent to the reactor.

29. The process of claim 28, wherein the anti-caking agent is selected from the group consisting of tricalcium phosphate, powdered cellulose, magnesium stearate, sodium ferrocyanide, potassium ferrocyanide, calcium ferrocyanide, calcium phosphate, sodium silicate, silicon dioxide, calcium silicate, magnesium trisilicate, talcum powder, sodium aluminosilicate, potassium aluminum silicate, calcium aluminosilicate, bentonite, aluminum silicate, stearic acid, polydimethylsiloxane, and a mixture or combination thereof.

30. The process of any one of claims 1 to 29, comprising (a) dispersing an iron-containing coal combustion product in water; and (b) adding a CO_2 source to the dispersion of step (a) thereby generating a reaction.

31. The process of any one of claims 1 to 29, comprising (a) supplementing CO_2 from a CO_2 source to the water; and (b) adding an iron-containing coal combustion product to the water supplemented with CO_2 of step (a) thereby generating a reaction.

32. The process of any one of claims 1 to 31, further comprising a step of adding an acid to the water.

33. The process of claim 32, comprising the steps of (a) dispersing the iron-containing coal combustion product in water; (b) adding hydrochloric acid to the dispersion of step (a); and (c) adding a CO_2 source to the dispersion of step (b) thereby producing hydrogen.

34. The process of any one of claims 1 to 33, further comprising CO_2 capture and storage.