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Blue Hydrogen Production Via Catalytic Aquathermolysis Coupled with Direct Carbon Dioxide Capture Via Adsorption

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Abstract : Hydrogen has been gaining a lot of global attention as an uprising contributor in the energy sector. Labeled as an energy carrier, hydrogen is used in many industries and can be used to generate electricity via fuel cells. Blue hydrogen involves the production of hydrogen from hydrocarbons using different processes that emit CO_2. However, the CO_2 is captured and stored. Hence, very little environmental damage occurs during the hydrogen production process. This research investigates the ability to use different catalysts for the production of hydrogen from different hydrocarbon sources, including coal, oil, and gas, using a two-step Aquathermolysis reaction. The research presents the results of experiments conducted to evaluate different catalysts and also highlights the main advantages of this process over other blue hydrogen production methods, including methane steam reforming, autothermal reforming, and oxidation. Two methods of hydrogen generation were investigated including partial oxidation and aquathermolysis. For those two reactions, the reaction kinetics, thermodynamics, and medium were all investigated. Following this, experiments were conducted to test the hydrogen generation potential from both methods. The porous media tested were sandstone, ash, and prozzolanic material. The spent oils used were spent motor oil and spent vegetable oil from cooking. Experiments were conducted at temperatures up to 250 C and pressures up to 3000 psi. Based on the experimental results, mathematical models were developed to predict the hydrogen generation potential at higher thermodynamic conditions. Since both partial oxidation and aquathermolysis require relatively high temperatures to undergo, it was important to devise a method by which these high temperatures can be generated at a low cost. This was done by investigating two factors, including the porous media used and the reliance on the spent oil. Of all the porous media used, the ash had the highest thermal conductivity. The second step was the partial combustion of part of the spent oil to generate the heat needed to reach the high temperatures. This reduced the cost of the heat generation significantly. For the partial oxidation reaction, the spent oil was burned in the presence of a limited oxygen concentration to generate carbon monoxide. The main drawback of this process was the need for burning. This resulted in the generation of other harmful and environmentally damaging gases. Aquathermolysis does not rely on burning, which makes it the cleaner alternative. However, it needs much higher temperatures to run the reaction. When comparing the hydrogen generation potential for both using gas chromatography, aquathermolysis generated 23% more hydrogen using the same volume of spent oil compared to partial oxidation. This research introduces the concept of using spent oil for hydrogen production. This can be a very promising method to produce a clean source of energy using a waste product. This can also help reduce the reliance on freshwater for hydrogen generation which can divert the usage of freshwater to other more important applications.

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