Renewable Natural Gas Production from Biomass and Applications in Industry

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Abstract : For millennials, biomass has been the most important source of fuel used to produce energy. Energy derived from biomass is renewable by re-growth of biomass. Various technologies are used to convert biomass to potential renewable products including combustion, gasification, pyrolysis and fermentation. Gasification is the incomplete combustion of biomass in a controlled environment that results in valuable products such as syngas, biooil and biochar. Syngas is a combustible gas consisting of hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), and traces of methane (CH_4) and nitrogen (N_2). Cleaned syngas can be used as a turbine fuel to generate electricity, raw material for hydrogen and synthetic natural gas production, or as the anode gas of solid oxide fuel cells. In this work, syngas as a product of woody biomass gasification in British Columbia, Canada, was introduced to two consecutive fixed bed reactors to perform a catalytic water gas shift reaction followed by a catalytic methanation reaction. The water gas shift reaction is a well-established industrial process and used to increase the hydrogen content of the syngas before the methanation process. Catalysts were used in the process since both reactions are reversible exothermic, and thermodynamically preferred at lower temperatures while kinetically favored at elevated temperatures. The water gas shift reactor and the methanation reactor were packed with Cu-based catalyst and Ni-based catalyst, respectively. Simulated syngas with different percentages of CO, H_2, CH_4, and CO_2 were fed to the reactors to investigate the effect of operating conditions in the unit. The water gas shift reaction experiments were done in the temperature of 150 ˚C to 200 ˚C, and the pressure of 550 kPa to 830 kPa. Similarly, methanation experiments were run in the temperature of 300 ˚C to 400 ˚C, and the pressure of 2340 kPa to 3450 kPa. The Methanation reaction reached 98% of CO conversion at 340 ˚C and 3450 kPa, in which more than half of CO was converted to CH_4. Increasing the reaction temperature caused reduction in the CO conversion and increase in the CH_4 selectivity. The process was designed to be renewable and release low greenhouse gas emissions. Syngas is a clean burning fuel, however by going through water gas shift reaction, toxic CO was removed, and hydrogen as a green fuel was produced. Moreover, in the methanation process, the syngas energy was transformed to a fuel with higher energy density (per volume) leading to reduction in the amount of required fuel that flows through the equipment and improvement in the process efficiency. Natural gas is about 3.5 times more efficient (energy/volume) than hydrogen and easier to store and transport. When modification of existing infrastructure is not practical, the partial conversion of renewable hydrogen to natural gas (with up to 15% hydrogen content), the efficiency would be preserved while greenhouse gas emission footprint is eliminated.

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