BIOMASS TO SYNGAS CATALYSIS-RENEWABLE PROCESS FOR FISCHER-TROPSCH LIQUID FUELS

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The purpose of this AIChE-100 technical communication is to present recent advances on multifunctional and multiphase reactors, and corresponding catalytic reaction-separation lines. These include permreactor and permeator configurations for low carbon renewable hydrocarbons and biomass feedstocks for high-yield conversion to hydrogen and carbon oxide mixtures, and subsequently to Fischer-Tropsch liquid fuels.

We analyze and elaborate on new process designs and operations for steam and CO_2 low carbon-hydrocarbon and biomass reforming, and the water gas shift. This analysis includes work in the design of new inline experiments and process operations. Also, the best parameter selection and optimization of such experiments for the final design and operation of the reformer. The proposed operations and catalysis advancements are of recent significance in the area of multifunctional reactors, including environmentally benign hydrocarbon and biomass conversion and abatement to valuable syngas (such as hydrogen and hydrogen-carbon oxides mixtures), [1,3,5].

Simultaneously, the reaction products, such as synthesis gas (mainly the H_2 and CO product mixture) are used for direct chemical syntheses such as high-yield liquid fuels, [6,7]. Moreover, alternative reaction products such as H_2 and CO_2 mixtures, coming out of the reforming reactor can be used as well for instantaneous liquid fuel synthesis with the selection of the proper catalysts [1,5].

Further objectives of these studies is the optimal development of multifunctional and multiphase processes and reactors with increased processing capacity and efficacy, conversion, separation, and additional utilization (e.g., through recycling streams and side feeds) of primary and secondary biomass-feedstocks and their related byproducts [1,5].

Permselective and adsorptive type processes with permeators and reactors can be used as example, in both the early purification stages of low carbon hydrocarbons and biomass derived gases from various contaminants (such as, NH_3, H_2S, HCl, HBr) as well as in the main conversion and upgrading sections of these feedstocks. Various improved materials, including ceramics, high Tg-polymers, types of carbons and composite materials can be used in the above selective operations for the final recovery of H_2, and H_2, carbon oxide mixtures from the reacted exit streams. For low conversion reformers a membrane permeator, made usually by polymer membranes, is suitable to be used after the reformer for gas separation purposes [1,5,8]. The rejected from the permeator gases, such as hydrocarbons, methane and/or carbon monoxide streams can be recycled into the inlet of the reformer or gas shift reactor for increasing the process yield and efficiency via the unreacted gas utilization and conversion.

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Secondary reaction products, as example these of H_2 and CO_2 can be also converted directly into liquid fuels. However, in an alternative route, after the CO_2 condensation and removal, pure hydrogen (H_2) is recovered and used in respective energy (e.g., fuel cells) and synthesis (e.g., hydrogenation) applications [9].

Furthermore, we seek to design and operate multifunctional and multiphase reactors and processes which eliminate the greenhouse gases emissions from the biomass source. Carbon dioxide (CO_2) is a main component of abundant hydrocarbon feedstoks including biomass, and byproduct of all fossil and synthetic hydrocarbon combustion processing, and as such needs to be recovered and concentrated or utilized and converted in the downstream [1,3-5,8].

There are described and proposed processes which seek for an in-situ carbon dioxide conversion and abatement of its negative greenhouse effects by utilizing alternative biomass reaction routes and special catalysts in the permreformer or reformer, as the direct reforming of methane with carbon dioxide in an all dry catalysis reforming process. The synthesis gas product, is separated by various techniques, namely membrane processes and can be used directly for chemical synthesis or as continuous fuel in fuel cells [1-3,5]. Chemical synthesis routes include liquid fuels production which is under continuous investigation.

With these reaction routes, biomass from various sources including forest and agricultural sources can be a valuable renewable feedstock for liquid fuels. Special care is given for catalysts selection in the reformer and Fischer-Tropsch reactor to avoid deactivation from carbon deposition from long hours in the stream. Special nickel classes of low quality nickel catalyst enriched with earth metals are used in the reformer, while appropriate catalysts are selected and experimented for the liquid fuels reactor, [1,8]. The economics of the process is deemed competitive.

Related modeling of such multifunctional reactors for the described applications is under way to describe their functionality, operational range, and working capacity in detail. The models used, simulate relevant acquired data and predict conditions for best multifunctional module and process operation by variation of several intrinsic parameters. Kinetic and transport parameters used in modeling can be obtained experimentally by separate kinetic and transport experiments. The described reactors and process configurations and their proposed applications seek to perform multiple reactive and catalytic unit operations within a single or integrated module which make them advanced in comparison with up to now proposed and utilized conventional reactors, [5]. Additionally, these operations are environmentally friendly as they produce no adverse chemicals or toxic gases.

In addition, objective of the above pilot plant and modeling studies is turnkey process development for advancing biomass conversion and selectivity, with increased hydrogen and syn-gas generation and flowing capacity, and increased overall biomass conversion efficiency. Further target elements are improved biomass processing, with economic and environmental consideration and efficient utilization for the proposed reformer and liquid fuel reactor designs. Also, the continuous utilization of primary and secondary biomass feedstocks and their derived byproducts to yield liquid fuels [1,3].

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