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Fischer-Tropsch synthesis of biomass-originated fuels: Reaching the ideal performance in production of high-quality bio-diesel

Nima Moazami
University of Birmingham, UK

Liquid fuels produced from biomass via Fischer-Tropsch (FT) synthesis have great potential to produce high-performance, environmentally friendly clean and high-quality transportation fuels; mainly due to the absence of aromatic compounds, SOx and NOx. Currently, there are three main aspects for consideration regarding the FT synthesis processes. Firstly, there exists the FT synthesis reaction mechanism, the details of which are still not fully understood. Furthermore, from the outlook of chemical engineering, there is the design and scale-up of the commercial FT synthesis plant in which studies of the comprehensive mathematical modelling of the reactor hydrodynamics, reaction kinetics mechanisms as well as optimization study play significant roles. In fact, to reach the ideal performance of the FT synthesis process, a precise comprehensive mathematical modelling along with chemical reaction kinetics mechanisms that can describe the product distribution of FT synthesis is essential. This research has been focused on production of biodiesel (ultra-clean transportation fuels) from biomass via Fischer-Tropsch synthesis process at the presence of supported cobalt catalyst (37%Co/SiO_2). The aim was to develop a comprehensive mathematical model of a catalytic fixed-bed reactor along with comprehensive chemical kinetics model of Fischer-Tropsch synthesis reaction mechanism in order to investigate the conversion, as well as productivity and selectivity of gasoline, diesel and wax based on required application as this process can play a major role in solving the world's current energy problems and is crucial to industrial practice, being a prerequisite for industrial process design, optimization and simulation. Therefore, a novel kinetic mechanism along with comprehensive novel mathematical model of the fixed-bed catalytic FT synthesis reactor was established. The results indicated that the novel developed kinetic model based on a combination of alkyl/alkenyl mechanism for FT reactions (for production of n-paraffins and α-olefins compounds) along with formate mechanism for WGS reaction can provide the most accurate predictions. In order to enhance the performance of the FT synthesis process, first the parametric studies were performed to numerically investigate the effects of operating conditions on the catalytic performance of the fixed bed FT synthesis reactor over 37%Co/SiO_2. The reaction temperature, total pressure, space velocity and H_2/CO molar ratio were tested to see how effective they are. Those parameters that have the most significant effects were then included in the multi-objective optimization process in MATLAB programming software using advance Non-dominated Sorting Genetic Algorithm (NSGA–II) to optimize the productivities and conversion. My advance codes and optimization process gave rise to a set of trade-off optimal solutions known as Pareto-optimal solutions. As a result, the Pareto-front solutions were established in order to be used as a dynamic database for the specific requirement. Different operating conditions from the obtained database were selected which privileged the optimization of a particular output for example increasing the production of bio-diesel fuel, increasing the conversion rate of bio-syngas species (CO and H_2), decreasing of CO_2 emissions and decreasing the production of undesired CH_4 and lighter hydrocarbon compounds.

Biography

Nima Moazami achieved his MEng degree with First Class Honors (Highest Academic Achievement in UK) and received his PhD degree in Mechanical Engineering at University of Birmingham, Birmingham, UK. He has been focusing on three major research projects i.e. Biomass-To-Liquid production via Fischer-Tropsch Synthesis, on-broad catalytic fuel reforming of gas and liquid fuels for hydrogen production and Organic Rankine Cycles for waste heat recovery. He is so determined to excel in these fields and generally in alternative fuels and renewable energies and to continue his work to advance the fields. His goal was always to make and will be making original scientific contributions vital and beneficial to the world as a whole. He has his expertise in mathematical modelling and simulation analysis and passion in production of ultra-clean transportation fuels and reducing emissions of particulate matter, CO and hydrocarbons, SOx and NOx as well as solving the world's current energy problems.

nxm958@alumni.bham.ac.uk
nm.nimamoazami@gmail.com

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