Conversion of natural gas-(coal- or biomass-) derived synthesis gas to transportation fuels and chemical feedstocks via Fischer-Tropsch synthesis

Dragomir B. Bukur

Chemical Engineering Program, Texas A&M University at Qatar, Doha, Qatar

Artie Mc Ferrin Department of Chemical Engineering, Texas A&M University, College Station, TX, USA

The renewed interest in conversion of syngas into hydrocarbons using Fischer-Tropsch synthesis (FTS) is principally due to the concerns about rational use of fossil and renewable resources. Both fossil and renewable resources can be converted into liquid fuels and chemical feedstocks using XTL (X-To-Liquid) technologies, where X can be natural, associated or shale Gas, Coal or Biomass. The heart of the GTL, BTL and CTL processes is the FTS reaction in which syngas is converted to hydrocarbons over a cobalt or an iron catalyst. Cobalt is the catalyst of choice for low temperature FTS and high H_2/CO feed ratio (GTL application), due to its high activity and selectivity towards desired products, as well as the absence of water-gas shift reaction. Iron based catalysts are used to process coal derived synthesis gas (low H_2/CO feed ratio), due to their ability to generate H_2 internally via the WGS reaction.

There are two general types of FTS technology that are currently employed on a commercial scale: high and low temperature Fischer-Tropsch (HTFT and LTFT), where the latter is typically used in the industry for synthesis of liquid fuels. LTFT is characterized by three-phase operation and is mainly conducted in two types of commercial reactors: slurry bubble column (SBCR) and multi-tubular fixed-bed reactors (MTFBR).

The reaction is highly exothermic and heat removal presents one of the main challenges when choosing the reactor type. However, other issues that also have to be considered are catalyst effectiveness, catalyst deactivation and regeneration, pressure drop etc. The major downsides of SBCR are difficult scale-up, separation of active catalysts from wax and catalyst deactivation due to attrition, while the drawbacks of MTFBR are high capital cost, poor heat removal, high mass transfer resistances and high pressure drop. Also, several micro-channel based Fischer-Tropsch reactors for small scale applications have been under development (Compact GTL, Velocys) and are ready for commercialization. Process intensification also improves attractiveness of FTS for conversion of ligninocellulosic biomass into synthetic fuels using BTL technology. The efficiency of the BTL process is strongly affected by the cost related to biomass collection and transport. Design of smaller highly efficient BTL units is expected to significantly improve the cost-efficiency.

Recent developments and trends in XTL technology, including a brief review of kinetic modeling approaches for primary and secondary reactions will be discussed in this lecture.

Dragomir B. Bukur
Professor Emeritus
Department of Chemical Engineering at Texas A&M University
Research Professor Chemical Engineering Program at Texas A&M University at Qatar

Dragomir Bukur graduated with honors at the University of Belgrade (Diploma Engineer degree in Chemical Technology) and received a M. Sc. and Ph. D. degree in Chemical Engineering at the University of Minnesota.

He started his professional career as an Assistant Professor at the University of Novi Sad in Yugoslavia (1975-1978). For nearly two years he was a post-doctoral Research Associate in Chemical Engineering Department at the University of Houston (1979-1980). He worked for one year at Mobil Research and Development Co. in Paulsboro, New Jersey as a Senior Research Engineer, before joining Chemical Engineering Department at Texas A&M University (TAMU) as an Associate Professor in 1981. He was a Visiting Professor at North Carolina State University at Raleigh (1992) and University of New South Wales, Sydney, Australia (2002). From 2005 until his retirement in 2017 he was a Professor at Texas A&M University at Qatar.

His research expertise has been in the areas of catalysis, kinetic modeling and reactor design aspects of coal-to-liquids (CTL) and gas-to-liquids (GTL) processes. Another area of recent work was intensification of steam methane reforming via sorption enhanced chemical looping. His current activities include detailed modeling, simulation and optimization of conventional and milli-structured fixed-bed reactors for FTS.

He has authored or co-authored 116 peer reviewed journal publications, 5 book chapters, and he and/or his associates have made over 160 presentations at national and international conferences. Total number of citations is over 3600, and h-index of 32 (Google Scholar). He has given 60 invited lectures at Universities, corporations and government laboratories around the world, and has served as a consultant for DuPont, Conoco-Phillips and Celanese.

In recognition for his achievements in research, education and service to profession he was elected a Fellow of American Institute of Chemical Engineers (2000), and has received multiple awards for his research contributions from Texas A&M University (Senior TEES Fellow, Halliburton Professorship and Faculty Distinguished Achievements Award for Research). He was a holder of Joe M. Nesbitt Professorship in Chemical Engineering at TAMU from 2006 until his retirement. He served as the Vice-Chairman of Natural Gas Conversion Board (2013-2016), a not for profit organization responsible for organization of triennial Natural Gas Conversion Symposium, and is a member of its International Scientific Board which is responsible for technical excellence of Symposia.