

Editorial

Progress and Perspectives in Converting Natural Gas to Hydrocarbons

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Introduction

Primus Green Energy (PGE) is a green energy company converting natural gas into syngas through methane reforming and then into gasoline and diesel through zeolite technology. Conversion of natural gas to liquid hydrocarbons (GTL) has been the topic of many investigations. The obvious intention is to reduce crude oil requirement in transportation fuels. There are two general approaches in GTL, the methanol-to-gasoline (MTG) process [1] through oxygenates formation and the surface polymerization formation of long chain paraffinic hydrocarbons through Fischer-Tropsch (FT) process [2].

Catalysts, a substance that accelerates chemical reactions by lowering activation energy without itself being affected. In industrial practices, Catalysts with proper structure and formula are developed and employed to boost desired chemistry under proper process conditions. Understanding both catalysts and process is critical to make a technology greener and more economical.

Cu/ZnO and ZSM-5 are commonly used as catalysts for methanol and hydrocarbon synthesis in MTG. Cu/ZnO is a well-known low pressure methanol synthesis catalyst with long lifetime. Its performance can be further improved by lowering nano Cu crystallite size and enhancing the interaction between Cu and ZnO [3]. Zeolites other than ZSM-5 with different porosity can be easily coupled with MTG as catalysts for hydrotreatment such as isomerization and transalkylation [4], leading to synthetic gasoline product with high octane and desirable viscometric properties. Cobalt and iron supported on alumina or silica are commonly used catalysts for FT with a product distribution following Anderson-Schultz-Flory model [5]. However, the broad product distribution causes process control issues and expensive post-treatment [6]. Therefore, the development of hybrid catalysts containing cobalt and zeolites in either a layer-mixing or a bifunctional catalyst has been the latest focus in a combination of syngas polymerization

and zeolite cracking chemistry occurring in the intimacy contact area between these two catalysts [7]. In this way, the syngas conversion is coupled with an interruption of product size so that the statistical distribution of product can be interrupted within the middle distillation range.

The efficient way to generate diesel is through MOGD (methanol-to-olefin and conversion to middle distillate) [8]. For the fixed bed MOGD process, the first reactor converts syngas into methanol and water. The next configuration involves two separated stages: the set of methanol-to-olefin (MTO) reactors and the conversion of olefin-to-distillate (COD) reactor. Low partial pressure of MeOH is favored in MTO while high pressure is favored for COD process. In order to adjust a proper space time, steam is added to lower the partial pressure of MeOH and the amount of water can be removed from condensation after the first stage. The second stage conducts the conversion to diesel through oligomerization reaction. Effective COD requires high concentration of olefins under high system pressure. In order to reach high olefin concentration in COD reactor, an effective removal of water diluent after MTO is necessary. In terms of continuation as an integrated system, the coupling between MTO and COD plays a major role in reactor design. There are two ways to couple these two processes in an economical manner. High olefin stream can be condensed under low temperature and mild pressure conditions, and then liquid olefin is injected directly into the COD reactor. Otherwise a proper window in space time could be found to generate olefin under a mild pressure. Olefin stream could be continuously compressed into the COD reactor to enlarge the molecular size.

The PGE synthetic gasoline has been well demonstrated as a high-quality gasoline which can be directly used as drop-in fuel. The synthetic diesel can be easily mixed in petroleum ultra-low sulfur diesel (ULSD) as blending component. Due to the zero sulfur nature in MOGD process, the PGE diesel generates positive credit in sulfur content. Its narrow composition window with respect to petroleum diesel leads to the formation of smaller fuel droplet size after fuel injector, resulting in more complete

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combustion and less impingement towards the cylinder wall from where it can be scraped into the crankcase oil by piston ring as fuel dilution in engine oil. The complete burning during combustion leads to less emission and the low fuel dilution prevents unwanted interactions between the fuel oxidized species and lube additives.

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