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Renewable Liquids as Steam Cracker Feedstocks

PERP 09/10S12

Report Abstract
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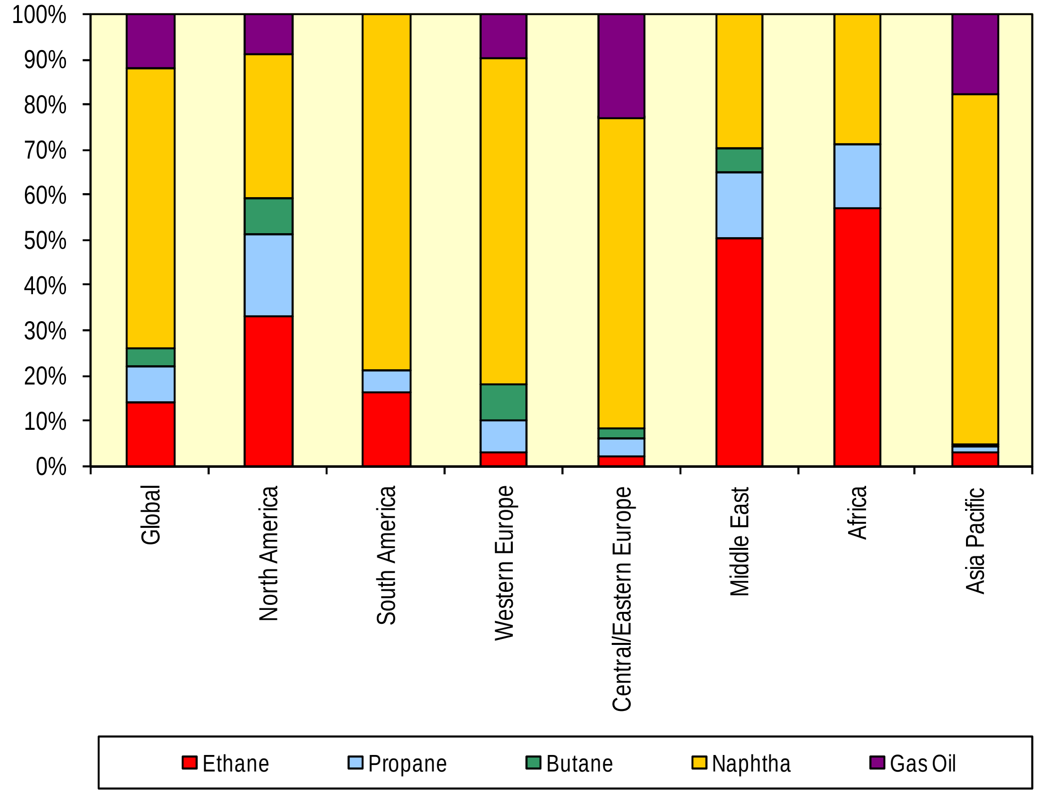
INTRODUCTION

Naphtha is an important feed source for steam crackers. The global steam cracker portfolio is dominated by naphtha crackers (although the proportion identified as designed for this hydrocarbon feed has decreased over the last 30 years). The Figure below provides a summary of the breakdown of steam cracker feeds by region. As expected, naphtha feedstocks dominate in most of the regions. The notable exceptions are found in the Middle East and Africa.



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Typically, the naphtha employed in steam cracking is petroleum-based. However, other sources of naphtha are becoming available and are being considered as feeds for steam cracking. Nexant has carried out an analysis and review of the use of a renewable naphtha (or bio-naphtha) feed via the Fischer-Tropsch route to produce a "green" or renewable ethylene product via steam cracking.

Biomass is a renewable alternative to fossil raw materials in production of liquid fuels and chemicals. Development of more efficient biomass conversion processes for better quality fuel and chemical products is considered a key step toward wider use of renewable fuels and chemicals. Although biofuels development has received more attention and government support in recent years, there is growing recognition that biologically derived chemicals will advance more quickly than biofuels because value-added chemicals command higher profit margins than biofuels.

Naphtha is a distillation product of crude oil (petroleum) refining, co-produced along with diesel and jet fuel etc. Naphtha comprises molecules with a carbon chain length ranging from about C_5 to C_9. Naphtha has applications as a feedstock for the production of gasoline, fertilizer, and olefins used in production of polymers and other chemical products. In particular, paraffinic naphtha is considered a highly desirable feed for steam crackers due to its high ethylene and propylene yields. Production of naphtha from renewable sources would enable the transition to a green chemical industry without the need to develop new chemistries and build new production facilities.

TECHNOLOGY

Renewable fuels technologies are discussed:

- Syntroleum's Bio-Synfining™ Process is discussed including product qualities.

Due to concerns with limited resources of petroleum-based fuels, the demand for using renewable feedstock, such as vegetable oils and animal fats, to produce hydrocarbon fuels has increased. Capitalizing on its extensive synthetic fuels production experience, Syntroleum Corporation has announced next generation synthetic biofuels made possible by the company's proprietary Bio-Synfining™ process. Bio-Synfining™ is a proven process with successful testing of over 400 000 gallons synthetic diesel and jet fuel. Syntroleum claims that Bio-Synfining™ is able to use a wide variety of renewable feedstocks such as vegetable oils, fats, and greases.

The Bio-Synfining™ process is an adaptation of Syntroleum's Synfining® technology and product upgrading experience and is used to processes triglycerides and/or fatty acids from fats and vegetable oils with heat, hydrogen and proprietary catalyst to make renewable synthetic diesel, renewable synthetic jet fuel, naphtha or LPG. The process consists of 4 steps: pretreatment, hydrotreating, isomerization, and distillation.

- A UOP process producing at least one fuel from at least two different types of renewable feedstocks is discussed.

Steam Cracking of Renewable Naphtha Technology is discussed:

Hydrocarbons in the naphtha (gasoline) boiling range make very desirable feeds for the production of ethylene and a wide range of byproducts.

Since these types of feeds are complex hydrocarbon mixtures composed of many individual components, it has been found to be extremely unwieldy to estimate overall yields by adding the contribution of each of the many individual feed components. The difficulty in obtaining all the individual component yield curves is compounded by the need to establish relative cracking severities for each component. Consequently, most practitioners have developed empirical correlations based on factors that best characterize each feed. Yield versus conversion curves for each feedstock are drawn, assuming that the feed is composed of only one component.

In general, naphthas are classified as either paraffinic or naphthenic. Although overly simplified, this approach provides an easy way to establish how a particular naphtha might best be used. Naphthenic feeds are best suited for catalytic reforming, which builds rings and dehydrogenates naphthenic components to aromatics. Paraffinic feeds, particularly straight chain normal paraffins, are generally preferred as steam cracker feeds because of their relatively high selectivity to ethylene.

To appreciate the economics of naphtha steam cracking, it is essential to understand how the yields of ethylene and the various byproducts vary with conversion. This topic is discussed further in the report.

ECONOMICS

The cost of production of ethylene via steam cracking is reviewed for three full range naphtha (FRN) feedstocks:

- Renewable naphtha
- Gas T0 Liquids (GTL) naphtha
- Generic Petroleum-based naphtha.

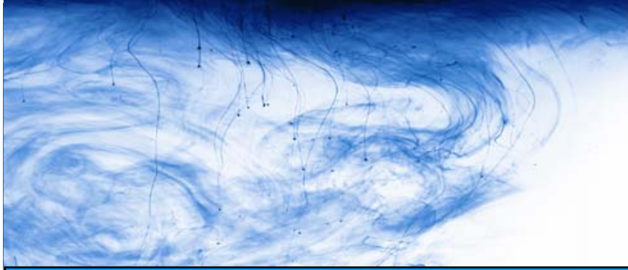
Various sensitivity analyses have been carried out including the effect of varying the cost of naphtha feedstocks on steam cracker costs of production (while other production costs are kept constant), examining the sensitivity of the ethylene cost of production as a function of investment and analysing the effect of economy of scale. The two biggest sources of byproduct credits are polymer grade (PG) propylene and butadiene. The sensitivity of these products was analyzed. The sensitivity of the ethylene economics to operating severity employing a renewable naphtha feed was also carried out.

COMMERCIAL APPLICATIONS

Ethylene end use markets are diverse, owing to the wide spectrum of derivatives. These end use markets include: wire and cable insulation; consumer, industrial and agricultural packaging; woven fabrics and assorted coverings; pipes, conduits and assorted construction materials; drums, jars, containers, bottles and the racks in which to hold them; antifreeze; and solvents and coatings. Demand growth is therefore dependent on numerous end markets. United States ethylene demand chart is shown below.

- Supply, demand, trade tables and analysis are given for the United States, Western Europe and Asia Pacific.

- Capacity tables are given for each of the above regions detailing company, plant location, specific site capacity and steam cracker feed type utilized.



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