NexantECA

Technology and Costs

Biorenewable Insights: Hydrogen

Hydrogen is one in a series of reports published as part of NexantECA's 2016 Biorenewable Insights program.

Overview

Hydrogen, as a diatomic molecule is among the largest volume chemicals produced globally, primarily by hydrocarbons reforming within the Haber process for ammonia production, but also for refinery processes. About half of hydrogen produced in the United States is used in petroleum refining. The rest is mostly for ammonia production, which is increasing with low natural gas prices, and for various other chemical processes, as an aerospace fuel, in semi-conductor, metal-working, and other high-tech manufacturing, and for fats hydrogenation. A substantial amount is a byproduct of electrolytic processes (chlor-alkali), steam cracking for olefins production, and styrene plants,

Biorenewables feeds are either carbohydrates or triglycerides, both containing little sulfur but much oxygen, which generally needs to be removed in processing if drop-in replacements of hydrocarbon-based chemicals or fuels are to be made. Hydrogenation is one way this objective can be met, such as in the NexBTL process for hydrogenating natural oils and fats to produce renewable diesel. As an introduction to the widespread use of hydrogen in chemical processing, we will review here hydrogen production and use for petroleum refining. This is not to imply that bio-based hydrogen is likely to be used in petroleum refineries, but much more likely in aerospace, bio-based chemicals and transportation end uses. One driver for development of bio-hydrogen production options is that such facilities might be more capable of distributed generation since biomass and other feeds are more ubiquitous than hydrocarbon resources.

It must be noted, however, that while bio-based carbon-containing products can be subjected to radiological testing (for carbon 14 content) there is no such testing available to distinguish bio-based hydrogen from fossil-based.

Hydrogen is an indispensable part of refinery operations, being used to increase the hydrogen content of refined products using processes that add hydrogen or reject carbon. The primary processes that add hydrogen are hydrotreating and hydrocracking. Processes that reject carbon include coking and catalytic cracking. Hydrogen is also used in removing contaminants from low quality crude feeds particularly containing sulfur and nitrogen.

As the availability of light crude oils has declined, and stricter regulations mandating reductions in sulfur content of gasoline and diesel have been instituted, more complex refining operations have been required to meet the needs of the market. A complex refinery has the capability to process heavier, sour (higher sulfur content) crudes and needs more processes such as hydrocrackers to manage sulfur levels in the final fuel products. As a result, complex refineries often do not produce sufficient co-product hydrogen and additional supplies are required from on-purpose units.

Technologies

Hydrogen can be produced in diverse ways including by reforming or partially oxidizing fossil fuels, gasifying biomass, and electrolyzing water, each using a number of different processes. Thermochemical processes use heat in combination with closed-chemical reactions to release hydrogen from organic materials such as natural gas, coal and biomass. Water can be split into hydrogen and oxygen using electrolysis or solar energy (electron or photon-based technologies, respectively). Lastly, microorganisms such as bacteria and algae can produce hydrogen through biological processes.

Process Economics

Cost of production models for USGC, Brazil, Western Europe and China are shown for hydrogen via:

- Wood Waste Gasification
- Corn Stover Gasification
- Steam Methane Reforming
- Biogas Reforming
- Water Electrolysis

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Technology and Costs comprises the Technoeconomics – Energy & Chemicals (TECH) program, the Biorenewable Insights program (BI), and the new Cost Curve Analysis. These programs provide comparative economics of different process routes and technologies in various geographic regions.

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