CHEMICALS

Project Fact Sheet

ISOBUTANE ISOMERIZATION MEMBRANE REACTOR

BENEFITS

- Lowers capital cost of butane isomer separation by 50 to 75 percent compared to distillation
- Saves substantial energy by reducing use of distillation columns

APPLICATIONS

The primary application for the developed membrane reactor technology is within the petrochemical refining industry to produce clean, high-octane gasoline. Successful implementation in the refining industry may lead to the emergence of several new applications.

MEMBRANE REACTOR SYSTEM PROVIDES ISOBUTANE COST-EFFECTIVELY

The petrochemical refining industry is seeking alternatives to methyl tert-butyl ether (MTBE), a gasoline additive used to increase oxygen content, by developing reformulated gasoline comparable to current MTBE blends. To accomplish this, the industry is investing in alkylation and related technologies to reduce the octane loss experienced by reformulated gasoline. Isobutane, which is formed by isomerization of n-butane, is an essential ingredient in the production of alkylates and is in chronically short supply in most refineries. The current process to produce isobutane uses a large, energy-intensive distillation column to recycle unconverted n-butane to the reactor. To increase the efficiency and cost-effectiveness of the isomerization process, project partners are developing a membrane reactor that will drastically reduce the capital and operating costs associated with n-butane separation while producing a 95 percent pure isobutane product stream.

Currently, two-thirds of the capital and operating costs of the isomerization process are associated with the downstream separation of the isobutane (to be sent to the alkylator) from the unreacted n-butane (to be recycled in the isomerization reactor) using a distillation column. The membrane reactor system being developed will more efficiently separate a highly pure isobutane product from n-butane, thereby reducing the energy and cost requirements.

MEMBRANE UNIT

Membrane separation unit used in the reactor system to produce 95 percent pure isobutane.

Project Description

Goal: The goal of this project is to develop an improved n-butane isomerization process utilizing an n-butane/iso-butane selective membrane to separate the butane mixture generated in an n-butane isomerization reactor. This will produce a more than 95 percent pure isobutane product and an n-butane concentrate stream to be recycled to the reactor.

This project will use a membrane permeable to n-butane, methane, ethane, propane, and hydrogen, but relatively impermeable to isobutane. In processes using this membrane, the 60 percent isobutane isomerization mixture, at reactor pressure of 200-300 psia and temperature of 100-150°C, is separated into a 95 percent isobutane product and an n-butane-rich permeate. Cooling the membrane permeate vapor mixture to 30°C lowers the vapor pressure to 50 psia and condenses the vapor, spontaneously generating the pressure difference required to drive the membrane process. The hydrogen and light hydrocarbon byproduct gases that also permeate the membrane are removed, and a liquid pump recycles the n-butane-rich condensate to the front of the reactor.

Progress and Milestones

Early stage research resulted in the development of thin-film composite membranes for the separation of n-butane/isobutane in refineries. Targets were met for mixed gas n-butane flux and n-butane/isobutane selectivity of the membranes. Results showed that a wide variety of glassy polymers could be used for the separation.

The overall goal of current research is to bring the technology to an initial field test. Specifically, project partners are focused on accomplishing the following milestones:

- Build composite membranes and membrane module
- Perform parametric membrane/module study
- Survey potential licensors and users
- Develop a field test strategy
- Prepare process designs including technical and economic evaluations

Commercialization

As part of the commercialization strategy, Membrane Technology and Research will pursue arrangements with one or more of the major process licensors of butane isomerization plants. Collaborations potentially could range from support for field demonstrations to marketing and sales agreements.

Project Partners

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