Bio-Butadiene Technology

Overview

The Lummus/Synthos Bio-Butadiene unit produces a raw butadiene product from a renewable ethanol feedstock via a two-step catalytic process. The raw butadiene product is then sent to a Lummus/BASF Butadiene Extraction unit to produce a high purity butadiene product.

The unit also produces the following by-product streams which are utilized as ISBL fuel sources for a Dowtherm A heater: a hydrogen rich vent stream, a light hydrocarbon vent stream, an ethyl acetate rich liquid stream, an ethyl acetate rich vacuum vent stream, a C6+ hydrocarbon stream, and a diethylether rich stream.

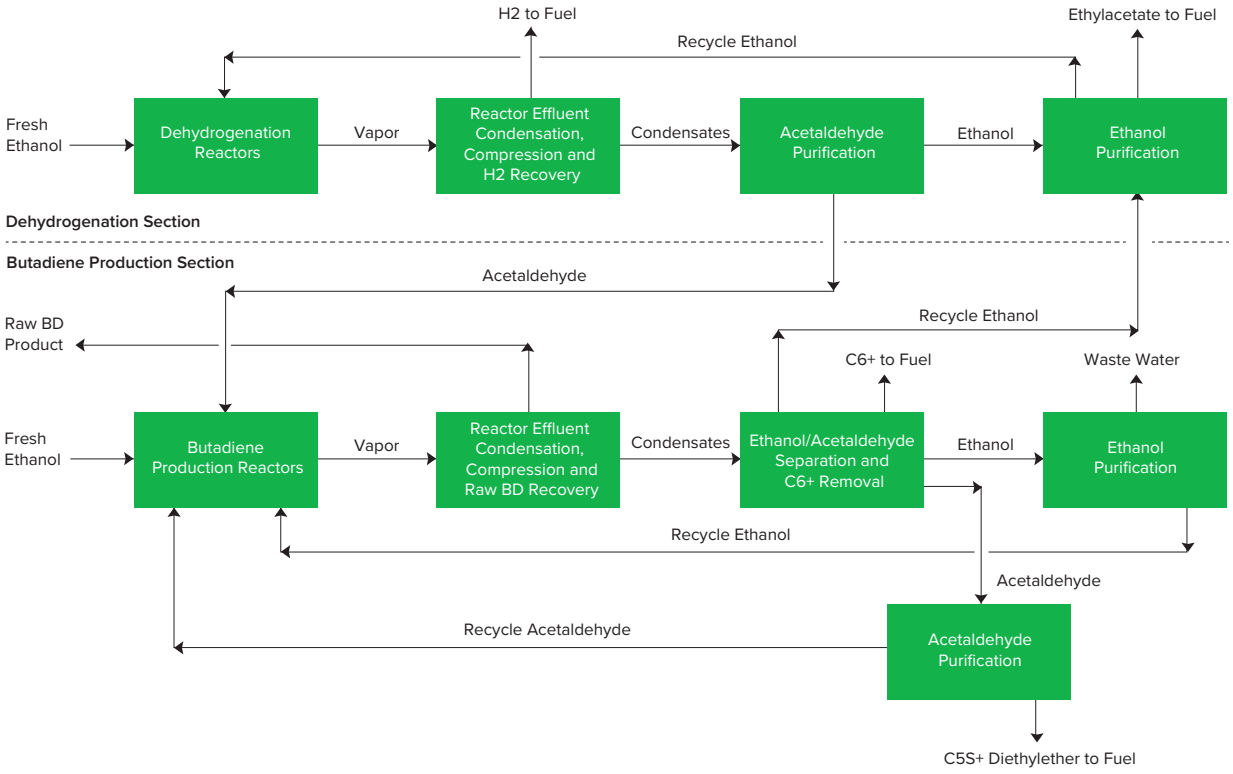
The dehydrogenation system consists of two fixed-bed reactors, one in operation and one on stand-by / regeneration. The Dehydrogenation Reactors are operated adiabatically with a vapor phase feed at pressures between 0.5 and 2.0 barg in a down-flow mode. The ethanol dehydrogenation reaction is a catalytic dehydrogenation of ethanol to acetaldehyde This reaction is a reversible reaction and at the reaction conditions used, conversion of 23% can be reached. Due to the close approach to equilibrium and the stoichiometry of this reversible reaction, low operating pressures are favored. The dehyro reactors are designed for 19% conversion of ethanol to acetaldehyde with a selectivity of approximately 91%.

The butadiene production system consists of three fixed-bed reactors in parallel, with two reactors in operation and one on stand-by / regeneration. Each reactor has two catalytic beds and is operated adiabatically with vapor phase feeds at pressures between 0.6 and 1.4 barg in a down-flow mode. In the main feed mixture, the molar ratio of ethanol : acetaldehyde is set between 2.0 and 4.0

Advantages

Process Features	Process Benefits
Ethanol is used as a feedstock	Renewable feed source
High ethanol conversion	Reduced equipment cost
High ethanol to acetaldehyde selectivity	Reduced ethanol consumption
Internal fuels recovered for process heating	Reduced utility cost

Block Flow Diagram



Process Description

The Bio-Butadiene production process is based on a two-step reaction scheme which effectively separates the unit into two distinct sections:

Dehydrogenation Section

Acetaldehyde is produced by catalytic dehydrogenation of bio-ethanol, where up to 23% ethanol conversion and up to 93% selectivity of ethanol to acetaldehyde can be achieved. This is an endothermic reaction that takes place in adiabatic packed-bed reactors.

The separation of the reactor effluent occurs in the following operational steps:

- Reactor Effluent Condensation, Compression and H2 Recovery
- Acetaldehyde Purification
- Ethanol Purification

Unreacted ethanol is recovered and recycled to the reactors as a vapor feed and an acetaldehyde product of 98 wt% min purity is produced.

An Ethyl Acetate stream from the Ethanol Purification step and an H2 vent from the H2 Recovery step are recovered and used as ISBL fuels.

Butadiene Production Section

A bio-butadiene product is produced by catalytic reaction of a mixture of bio-ethanol and acetaldehyde. This is a slightly endothermic reaction which takes place in adiabatic packed-bed reactors.

The separation of the reactor effluent occurs in the following operational steps:

- Reactor Effluent Condensation, Compression and Raw BD Recovery
- Ethanol/Acetaldehyde Separation & C6 Removal
- Ethanol Purification
- Acetaldehyde Purification

A final raw butadiene product is produced with a purity of about 91 wt%. Unreacted ethanol is recovered and recycled to the both the Dehydrogenation and butadiene production reactors. In addition, recycle acetaldehyde is recovered and sent back to the butadiene production reactors.

Heavy and light hydrocarbon streams from this section are recovered and used as ISBL fuels.

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