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ScienceDirect
Chemico-Biological Interactions 166 (2007) 10–14
Chemico-Biological Interactions
www.elsevier.com/locate/chembioint

Butadiene production process overview☆

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Available online 26 January 2007

Abstract

Over 95% of butadiene is produced as a by-product of ethylene production from steam crackers. The crude C4 stream isolated from the steam cracking process is fed to butadiene extraction units, where butadiene is separated from the other C4s by extractive distillation. The amount of crude C4s produced in steam cracking is dependent on the composition of the feed to the cracking unit. Heavier feeds, such as naphtha, yield higher amounts of C4s and butadiene than do lighter feeds. Crackers using light feeds typically produce low quantities of C4s and do not have butadiene extraction units. Overall butadiene capacity is determined by ethylene cracker operating rates, the type of feed being cracked, and availability of butadiene extraction capacity. Global butadiene capacity is approximately 10.5 million metric tons, and global production is approximately 9 million metric tons [Chemical Marketing Associates, Inc. (CMAI), 2005 World Butadiene Analysis, Chemical Marketing Associates, Inc. (CMAI), 2005]. Crude C4s are traded globally, with the United States being the only significant net importer. Finished butadiene is also traded globally, with the largest exporters being Canada, Western Europe, Saudi Arabia and Korea. The largest net importers are Mexico, the United States and China.

The global demand for butadiene is approximately 9 million metric tons [Chemical Marketing Associates, Inc. (CMAI), 2005 World Butadiene Analysis, Chemical Marketing Associates, Inc. (CMAI), 2005]. Production of styrene–butadiene rubber and polybutadiene rubber accounts for about 54% of global butadiene demand, with tire production being the single most important end use of butadiene synthetic rubbers. Other major butadiene derivatives are acrylonitrile–butadiene–styrene (ABS) and styrene butadiene latex (about 24% of demand combined).

Keywords: Butadiene; Steam cracking; Extractive distillation; Styrene–butadiene rubber; Polybutadiene

1. Introduction

1,3-Butadiene (butadiene) is a colorless gas at room temperature with a characteristic hydrocarbon odor. It is a hazardous chemical due to its flammability, reactivity and toxicity. Butadiene is a major product of the petrochemical industry and an important building block for many consumer and industrial products. The largest use of butadiene is in the production of synthetic rubbers.

Butadiene is traded globally, and global demand is expected to grow at about 3% through the end of this decade. In 2004, the global demand was expected to exceed 9 million metric tons [1].

2. Butadiene production

2.1. Production of crude butadiene

Butadiene (C_4H_4—CAS Number 106-99-0) is commonly produced by three processes [2]:

- Steam cracking of paraffinic hydrocarbons (as a co-product of ethylene manufacturing);

☆ International Symposium—Evaluation of Butadiene and Chloroprene Health Risks, Charleston, SC, September 20–22, 2005

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0009-2797/$ – see front matter © 2007 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.cbi.2007.01.009

- catalytic dehydrogenation of *n*-butane and *n*-butene (Houdry process); and
- oxidative dehydrogenation of *n*-butene (Oxo-D or O-X-D process).

The most important of the three is the steam cracking process, which accounts for over 95% of global butadiene production. In the steam cracking process, butadiene is one of the co-products in the production of ethylene and is purified by a butadiene recovery process. On purpose production of butadiene is not significant. The remainder of this discussion will focus on the steam cracking process. A description of the other production processes can be found elsewhere [2–4].

In the steam cracking process, the feedstocks (ethane, propane, butane, naphtha, condensate or gas oil) are fed to a pyrolysis (steam cracking) furnace where they are combined with steam and "cracked" at temperatures between 1450 and 1525 °F (790–830 °C). This steam cracking produces a pyrolysate composed of hydrogen, ethylene, propylene, butadiene and other important olefins plant co-products. The pyrolysate is quenched to remove the high-boiling components; compressed to remove the C5 and higher components as a raw pyrolysis gasoline; and then dried. The resulting material (predominantly hydrogen and C1–C4 components) is taken through a series of distillation steps to separate the hydrogen, methane, ethylene (and other C2 components) and propylene (and other C3 components), leaving the crude C4s or crude butadiene. Fig. 1 shows a typical olefins plant and the flow of butadiene up to crude butadiene.

Typically, olefins plants are designated light (gas) crackers or heavy (liquid) crackers. Light crackers use ethane and propane as the feedstock and produce very low quantities of C4s and heavier co-products, including butadiene. Heavy crackers use naphthas, condensates, or gas oils as feedstocks and produce much greater quantities of butadiene and heavier co-products. An ethane cracker produces about 2 lb of butadiene per 100 lb of ethylene, while a naphtha cracker will produce about 16 lb per 100 lb of ethylene [1]. For this reason, most light crackers do not have butadiene recovery units. The crude butadiene produced in the light crackers is either recycled to the cracking furnaces or is collected for transfer to a butadiene recovery unit. Depending on plant operation and feedstock used, the butadiene content of the crude butadiene is typically between 40 and 50%, but can be as high as 75%.

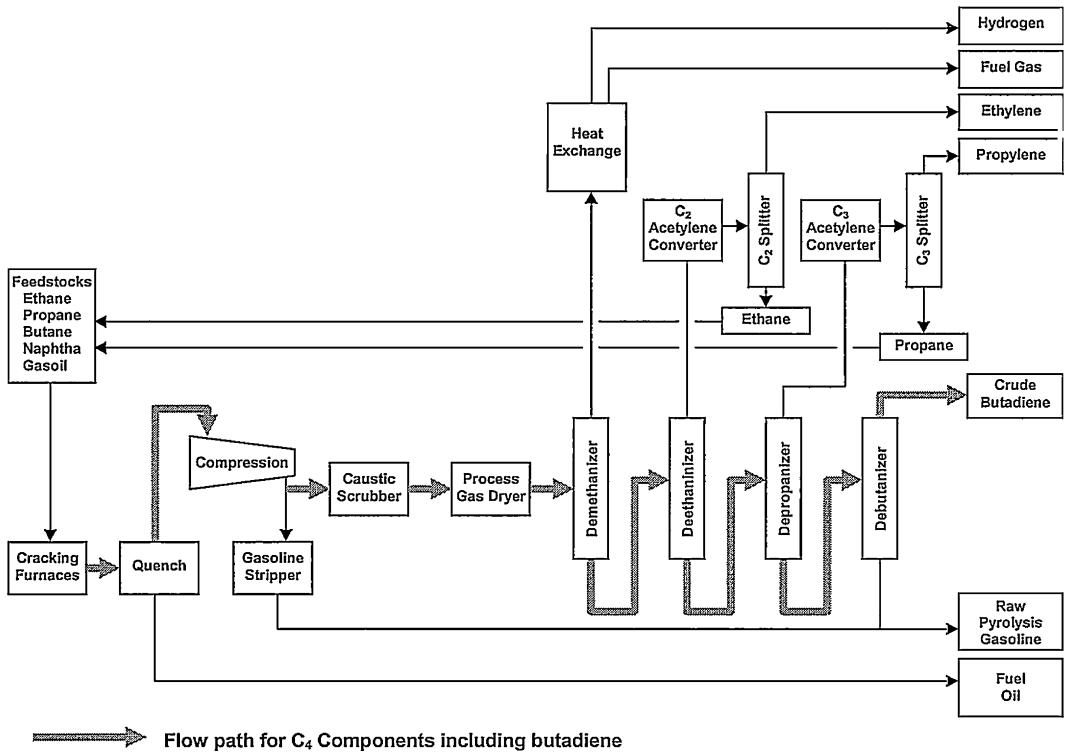

Fig. 1. Typical olefins plant (from ACC Olefins ChemSTAR Panel—Butadiene Product Stewardship Manual).