

Design and Operating Principles for Bioprocesses

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The application of biotechnology to the chemical process industries (CPI) has grown significantly in the past decade and now offers viable pathways to manufacture a range of high-volume chemicals, many of which can serve as drop-in replacements for traditional petroleum-derived chemicals. Bio-based processes have some unique characteristics compared to traditional chemical processes, and that, when combined, have the potential to lower capital and operating expenses per ton of capacity, while enabling the use of alternative feedstocks. Bioprocesses can often deliver more sustainability while meeting existing quality criteria. This column provides an overview of the differences between bio-based and traditional processes.

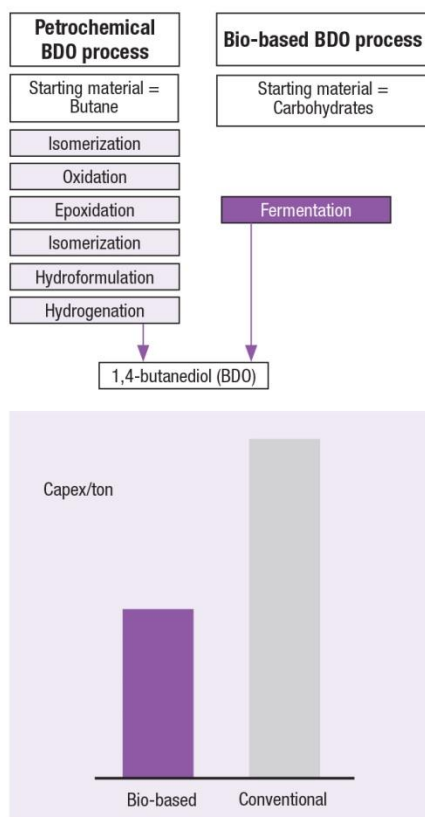


FIGURE 1: A petrochemical-based route to butanediol is compared to Genomatica's bio-based BDO process. Fewer unit operations, fewer byproducts and gentler operating conditions can result in lower capital expenditures (capex) per ton of capacity for bio-based processes. This can enable economical deployment of smaller plants

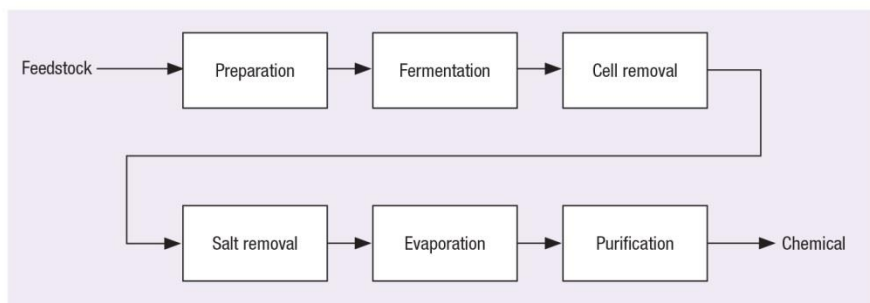


FIGURE 2: This block flow diagram shows the sample operations for a generic bio-based process

Simple plant design

Biotechnology has the ability to engineer microorganisms so a single unit operation (fermentation) can replace multiple chemical reaction steps and efficiently convert feedstock into desired molecules, such as butadiene, caprolactam or butanediol. Bioprocess feedstocks can include various carbohydrates or cellulosic biomass, as well as traditional petrochemical feedstocks, including C1 sources.

Process differences

The following items represent some potential advantages that can be realized with bio-based processes.

Fewer unit operations. Fermentation by microorganisms means that a single unit operation can, in some cases, replace complex reaction sequences in conventional processes.

Fewer byproducts. Biological systems tend to be very selective, meaning that organisms can produce exactly the chemical of interest, rather than a mixture of hydrocarbons. This can increase overall process yield, reduce the number and volume of byproducts and thereby decrease the associated separation costs. Selectivity can sometimes even improve final product quality.

Gentler operating conditions. Fermentations run at near-ambient temperatures and pressures, so plant equipment is less costly.

Differentiated products. Chemicals made with bio-based processes, especially those made from renewable feedstocks, typically have a smaller environmental footprint, allowing producers to better meet increasing customer demands for sustain-

able products, and often increasingly stringent pollution regulations.

New operating procedures. Bio-based processes often require different operating know-how than traditional petrochemical processes. Examples of this specialized expertise include the need for aseptic operation of the fermentation, process control of a biological system, different separation and purification operations, process chemistry in aqueous streams, and new options for process integration and energy minimization. Even firms with deep process engineering and petrochemical-plant operating experience will benefit from working with experts in designing and operating integrated end-to-end bioprocesses.

Biotechnology: a useful tool

Going forward, biotechnology will increasingly become a useful component of the toolkit and production portfolio of CPI companies. The increased use of biotechnology will be driven by its ability to provide added flexibility and cost benefits. Fully realizing the potential of a bioprocess to reduce capital and operating costs often requires changes in the way plants are designed and operated. These changes can be readily addressed by collaborating with bioprocess experts. ■

Editor's note: This column was provided by Genomatica Inc. (San Diego, Calif.; www.genomatica.com), a leading innovator in biotechnology for the chemical industry. The author is Michael Japs, director of commercial technology development for Genomatica. The company is adept at harnessing biotechnology to develop new, advantaged processes for major chemicals, as well as custom solutions for its partners. The firm is a recipient of the 2013 Kirkpatrick Award for Chemical Engineering Achievement. Japs can be reached at mjaps@genomatica.com.