Argonne NATIONAL LABORATORY

Bioprocessing Technology

NEW

MEMBRANE-BASED SEPARATIVE BIOREACTOR

INTEGRATES BIOCONVERSION AND DOWNSTREAM PROCESSING

2002 R&D 100 Award Winner

BENEFITS

- Direct capture and concentration of charged products to avoid pH swings
- pH controlled reactions
- Avoid product inhibition for continuous production
- Fermentations without buffering
- Reduced waste streams
- Removal of charged impurities creating higher purity products
- Sequential reactions for continuous rather than batch processing.

APPLICATIONS

- High purity organic acids used in making fibers for carpets and fabrics
- Production of "green" organic solvents (used in cleaning materials) which are environmentally friendly.

STATUS

Argonne is seeking:

- Industrial partners to apply this platform technology to specific bioprocessing applications.
- Industrial partners to scale-up the resin wafer materials.

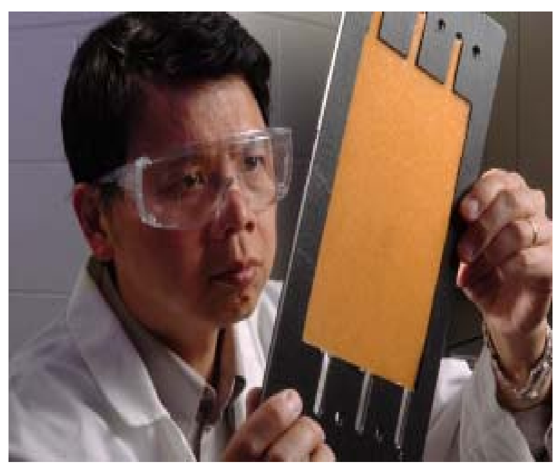
Biotechnology, with its environmentally friendly characteristics, is changing the way business is conducted within the chemical industry. Argonne National Laboratory is helping to lead this change.

The Opportunity

In the U.S., organic chemicals are used in the production of a wide-range of products, from plastics to solvents. Typically, these chemicals are produced from fossil fuels (natural gas and petroleum).

Biological feedstocks and bioprocessing offer distinct advantages over traditional chemical processing including more benign solvents and temperature conditions, and lower energy usage. However, even though there are significant advantages to these processes, there are some significant technical and economic barriers to overcome before widespread acceptance by industry can be achieved. One such barrier is the complexity of separation and purification of the products in the downstream processing sequence. Other barriers include product inhibition and the stability of the biocatalyst.

The Solution



An Argonne researcher examines an EDI wafer used in the acetic acid production process.

Argonne researchers have developed a novel membrane-based separative bioreactor that has the ability to directly capture high-purity products from pH controlled fermentations without the need for neutralization. This technology can play an important role in the biotechnology arena because as the fermentation progresses, notably those that produce organic acids, the accumulation of acid lowers the pH until the organism stops producing additional acid. The ability to produce concentrated organic acid rather than dilute acid reduces the step of concentrating the acid, resulting in downstream savings, both in cost and energy.

Currently, a base is added during the fermentation to neutralize the acid by converting it to a salt. The salt must then be removed from the process and converted back into the organic acid by reacting with another acid. This recovery produces waste gypsum that must be disposed. Removing this neutralization and re-conversion step is important because it eliminates the cost of the acid and base used in the process, and the disposal of waste gypsum, which is both a financial and environmental cost.

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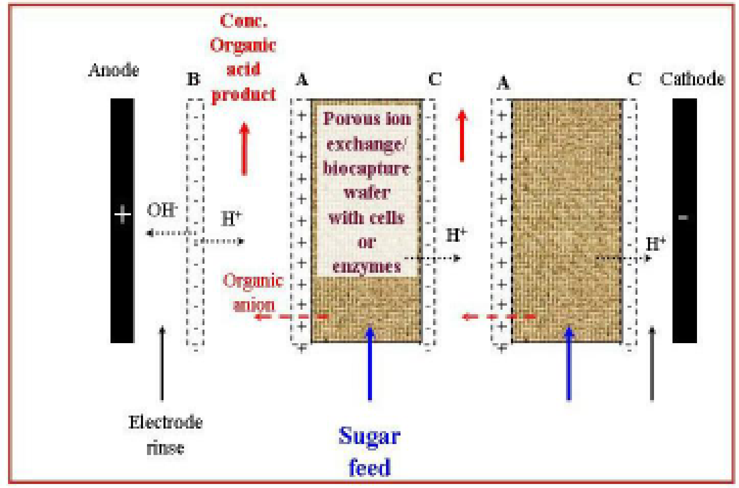
ABOUT ARGONNE TECHNOLOGY TRANSFER

Argonne National Laboratory is committed to developing and transferring new technologies that meet industry's goals of improving energy efficiency, reducing wastes and pollution, lowering production costs, and improving productivity. Argonne's industrial research program, comprising leading-edge materials research, cost-saving modeling, and unique testing and analysis facilities, is providing solutions to the challenges that face U.S. manufacturing and processing industries.

How the Argonne Bioreactor Operates



Argonne scientists used electrical force to transport organic acids away from the biocatalyst across an ion-exchange membrane and into a concentrate chamber, very similar to normal metabolism processes for handling acids. To provide the electricity in a cost efficient fashion, researchers turned to electrodeionization (EDI). EDI is an established commercial technology for producing high-purity water. Previously, Argonne scientists modified EDI so that it could be used for desalination of chemical and agricultural products. To accomplish this, researchers molded loose ion exchange resin beads into a porous resin wafer, enabling the capture of charge salts and acids at dilution levels with high energy efficiency and significantly reduced waste streams compared to conventional processing. This became the basis for the Argonne's separative bioreactor.

Researchers also realized that although direct enzyme immobilization on membranes provided excellent product separations, insufficient enzyme density limited the overall performance. In order to increase the density, the scientists integrated enzyme immobilization technology into the porous resin wafer and created a material that can efficiently produce and remove organic acids.

As Argonne designed its separative bioreactor, researchers incorporated enzyme capture resin beads into the resin wafer. Sugars were converted by the immobilized biocatalyst to the target acids, and the product was electrically transported into a concentrate channel. This resulted in reactions occurring without buffering or neautralization.

Argonne's immobilization technology also allows in-situ stripping and replacement of degraded enzymes without disassembling the system. Typically the life of the enzyme is shorter than that of the membrane unit. By avoiding disassembly for enzyme replacement, significant savings can potentially be realized, due to elimination of this labor-intensive step of the process.

Argonne's initial analysis indicates that its separative bioreactor will dramatically reduce the cost of producing chemicals by bioconversion. Biobased products that are not currently economically feasible could prove practical in the near future with this technology.