BIOTECHNOLOGY SPARKS AN INDUSTRIAL REVOLUTION

BIOTECHNOLOGY INDUSTRY ORGANIZATION

In June 2004, the Biotechnology Industry Organization (BIO), Washington, D.C., USA issued a report, "New Biotech Tools for a Cleaner Environment," which shows industrial biotechnology is facilitating a new industrial revolution that can bring a cleaner future with better products at lower cost. This report presents national data projections for the environmental and energy saving impacts resulting from this "third wave" in biotechnology. The report, prepared by BIO and independent consultants, highlights benefits already being realized in several major industrial sectors, including pulp and paper production, textiles, and transportation fuel. For instance, if an industrial biotechnology process is used to bleach paper pulp it can reduce the amount of chlorine chemicals used during production by 10 to 15%, and, if used industry-wide, it can reduce bleaching-related energy uses by 40%.

"New Biotech Tools is the first major effort in the United States to identify leading-edge biotech processes and the benefits they are producing," said Brent Erickson, BIO's vice president for industrial and environmental biotechnology. "We are witnessing the creation of a new infrastructure based on biology instead of older rust belt technology and petroleum, through the coupling of modern industrial biotechnology and manufacturing.

"This radical shift in industrial production is more robust, adaptable and inherently cleaner than old-line manufacturing methods," he continued. "'New Biotech Tools for a Cleaner Environment' provides a first look at the potential impact this technology can have to significantly 'green' the industrial landscape while helping companies cut costs and bring new consumer goods to market."

"Getting pollution prevention results at a reduced cost is the preferred approach to increased environmental protection," said Ken Zarker, chair of the National Pollution Prevention Roundtable. "We look forward to the huge potential for the responsible use of industrial biotechnology in the future. "

American industry spends billions of dollars annually on technology systems to manage waste and capture pollution emissions. Industrial biotechnology—the use of genetically enhanced microorganisms (GEMs) and enzymes—offers a new cost-effective way to prevent the creation of pollution in the first place. Among the report's findings:

- Industrial biotechnology now enables the production of ethanol transportation fuel from corn and cellulosic biomass such as crop residues (corn stover, wheat straw, rice straw, etc.). It is estimated that bioethanol from cellulose generates eight to 10 times as much net energy as is required for its production, and one gallon of cellulosic ethanol can replace 30 gallons of imported oil equivalents.

  Biotechnology process changes in the textile finishing sector can reduce water usage by about 17% to 18%. Textile mills may potentially reduce water consumption by as much as 30% to 50% through the use of biotechnology.
- Bioplastics, which may be used to make products ranging from clothes to eating utensils to car parts, are biodegradable. If widely used, bioplastics may reduce plastics in the waste stream by up to 80 %. If all plastics were made from bio-based polylactic acid, oil consumption used in the manufacturing process would decrease by 90 to 145 million barrels per year.
- Biotechnology process changes using GEMs in the

WHAT YOU WILL LEARN

- **Overview of BIO's new report on biotechnology.**
- **New biotech application in pulp and paper.**
- **Industrial biotech projections.**

ADDITIONAL RESOURCES

- **Biotechnology Industry Organization, 1225 Eye Street NW, Suite 400, Washington, DC 20005. Phone: +1 202 962-9200, email: info@bio.org, www.bio.org.**
- **Bajpai, Pratima, "Biotechnology for Environmental Protection in the Pulp and Paper Industry," (1998): Executive Summary, available at www.environmental-center.com/publications/springer/3540656774.htm.**
- **"Enzymatic Treatment of Paper Fines," available at www.swin.edu/au/ebc/bioremediation.html.**
- **Vigsoe, Dorte, Espen Jürgensen, and Morten Kvistgaard, "The Assessment of Future Environmental and Economic Impacts of Process-Integrated Biocatalyst," European Commission Joint Research Center, (2002): 8.**

nutraceutical and pharmaceutical sector during production of riboflavin (vitamin B2) can reduce associated carbon dioxide emissions by 80% and water emissions by 67%. Changes in the production of the antibiotic cephalexin reduce carbon dioxide emissions by 50%, energy demand by 20%, and water usage by 75%.

- The market share of the biotechnology method of vitamin B2 production increased from 5% in 1990 to 75% in 2002.

PULP AND PAPER APPLICATIONS

Industrial biotechnology companies have discovered new ways to harness several enzymes to improve various pulping processes. Enzymes used in bleaching allow the process temperature to be lowered and reduce the need for rinsing. These changes significantly reduce the amount of chlorine and energy used, thereby reducing the production costs, emissions of toxic chlorine residues (such as dioxin), and emissions of carbon dioxide from energy generation. Another biotechnology process could increase pulp production productivity by 30% from the same amount of wood (*Pulp & Paper Magazine*), further reducing energy demand and emissions. Approximately 155 million metric tons of wood pulp are produced worldwide, and approximately 260 million metric tons are projected to be produced in 2010. (Pratima Bajpai)

Biotechnology does more than reduce pollution associated with paper production. One biotechnology enzyme can speed papermaking by 5% ("Enzymatic Treatment of Paper Fines"). Other enzymes can be used to improve the deinking process for recycled paper fibers. Because ink is fused onto paper fibers during printing and copying, deinking recycled fibers is a difficult and resource-intensive process. In this application, biotechnology has proven more effective than the traditional process. Improved deinking could allow greater quantities of recycled paper to become an economically viable feedstock for new paper production. Recycled fibers are easier to process than virgin fibers; therefore, increasing the use of this feedstock has the joint benefits of reducing the need to harvest trees and reducing paper-related wastes, emissions, and energy consumption.

INDUSTRIAL BIOTECHNOLOGY PROCESS

A report by the Organisation for Economic Co-operation and Development (OECD) looked at two alternative processes using biotechnology products to improve bleaching while reducing the use of chlorine products.

1. An enzyme called xylanase is applied before bleaching, replacing the chlorine-containing compounds in the first stage of the five-stage elemental-chlorine-free bleaching sequence. Biotechnology process changes in the production and bleaching of pulp for paper reduce the amount of chlorine *chemicals necessary for bleaching by 10%–15%*. The subsequent stages include a number of washing steps and an alkaline extraction stage. One study estimated that the potential energy savings of industry-wide application of this process in the European paper industry would result in a carbon dioxide emissions savings of between 155,000 and 270,000 tons annually. (Dorte Vigsoe, et al)
2. White rot fungus is used in a preprocess step to break down the lignin in the wood cell wall structure. Wood chips are injected with the fungus and a growth medium, allowed to incubate for 2 weeks, and then treated using the traditional chemical or mechanical process. Because the wood cell walls get broken down during this preprocess treatment, it is less resource intensive to bleach the pulp. Biotechnology processes *cut bleaching-related energy uses by 40%*—a savings that has the potential to create additional pollution reductions.

BARRIERS TO DEPLOYMENT

A recent report released by the European Commission Joint Research Center noted that although the "prospective for economic and environmental benefits in the sector of pulp and paper is good," (Dorte Vigsoe, et al) there are still many factors that will impair industry-wide use of these techniques. The main barrier in the industry is what the report calls conservative thinking. "Conservative thinking" is a term used to describe the lack of knowledge of biocatalysts among managerial staff at companies, including a lack of familiarity with the existing chemicals and process, and the lack of suppliers and advertising of biocatalysts in the mills. Additional barriers to full use of the biotechnology process include international competition, which leaves little room for investments in new technology, and little demand. (Dorte Vigsoe, et al)

INDUSTRIAL BIOTECH PROJECTIONS

Despite these barriers, the future for industrial biotech in the pulp and paper industry looks bright. Major pulp and paper companies are already exploring a pulping process based entirely on enzymes. Ultimately, biotech pulping could end up replacing the kraft pulping process, providing a much cleaner and cheaper process by virtue of lower environmental compliance costs.

"New Biotech Tools for a Cleaner Environment" is the first report to provide new industrial biotech projections for environmental improvement and energy conservation based on data from the U.S. Environmental Protection Agency (EPA) and the Organisation for Economic Co-operation and Development (OECD). The report discusses the evolution of industrial biotechnology, pollution prevention policy and the increasing potential for industrial biotechnology to offer new and revolutionary ways to foster sustainable economic development, as well as possible environmental policy changes that can enhance the adoption of this technology. The full report, "New Biotech Tools for a Cleaner Environment," can be found on BIO's web site. **S!**