

Biotechnology in Plastics

***A bi-monthly newsletter monitoring developments
in industrial biotechnology that impact the plastics industry.***

Fall 2004

Larry Drumm (BioLarry Consulting) and Maggie Baumann (G.H. Associates) who co-author this newsletter are organizing two sessions on Industrial Biotechnology in Plastics in 2005. The first session will be at the 2005 GPEC conference scheduled for February 24-25 in Atlanta Ga. Sponsored by the SPE Plastics Environmental Division, the conference is designed to cover the latest technologies regarding Plastics and the environment. We are planning a session dedicated to Bio based material technology. Speakers from the following organizations have been invited to participate in the session: Metabolic Explorer, MBI, Cargill, Dupont, Metabolix and The Biotechnology Organization (Bio.org).

The second session will be at ANTEC 2005 that is scheduled for May 1-5 in Boston, MA. The New Technology committee of the SPE has recommended that a New Technology Forum be organized on Industrial Biotechnology and Plastics. We are scheduling a half day session and the following organizations have been invited to participate: Michigan State University (Larry Drzal), Metabolic Explorer, Cargill Dow, Dupont, Metabolix and P&G(Proctor and Gamble).

These companies are leading the way in polymer industrial biotechnology. We expect these sessions to be enlightening!

For more information on both of these programs please visit <http://www.4spe.org> or contact 908-832-2207.

Higher prices for petroleum and natural gas provide incentives to use bio-based polymers

The news over the last few months has been filled with stories about the continued increase in the price of a barrel of oil, the potential shortage and high prices for heating oil and the need for research in alternative energy sources. This news has brought industrial biotechnology into the news. Earlier this month the *Wall Street Journal* ran an article on Biotechnology specifically highlighting Cargill Dow's PLA resin.

The cost to produce bio based resins has been a drawback to their replacement of current petroleum based plastic materials. The surge in energy pricing has made the bio based materials more economic... even the *Wall Street Journal*, a

mainstream business publication has brought attention to this fact e.g. The headline in the *Wall Street Journal* October 12, 2004.

One Word of Advice: Now It's Corn: Plastics Manufactured From the Plant Grow More Appealing Amid Soaring Oil Price

When Dow Chemical Co. and agriculture giant Cargill Inc. merged two years ago to market a plastic made from corn instead of oil, they thought they were tapping into consumers' growing worries about the environment. Lately the interest has shifted to soaring oil prices and fear of global energy shortages.

Oil prices have soared to more than \$50 a barrel this year, driven by worries that terrorism and civil or political strife could disrupt supplies as the world's growing economies stoke demand. It is estimated that sales of the corn-based plastic resin manufactured by Cargill Dow rose **60%** in the first nine months of 2004 from the year-earlier period.

Cargill Dow's corn-based plastic was a hit first in environmentally focused cities such as Portland, Ore., where shoppers at natural-food stores liked the idea of deli goods packaged in plastic containers that could be sent to an industrial compost site. High-end consumers warmed to the idea of pricier pillows and comforters stuffed with natural fibers instead of petroleum by-products.

This year, Wild Oats markets of Boulder, Colo., switched to food containers made from Cargill Dow's Nature Works corn-based plastic in all of its 80 Wild Oats Natural Marketplace stores in the U.S. and Canada. They found that the compostable containers had increased deli sales by about 12%. Pacific Coast Feather Co., of Seattle is a manufacturer of comforters and pillows (Natural Living Brand) made with Dow Cargill's Ingeo® brand corn fiber. You can find their products at retailers such as Linen 'n Things and Marshall Field's. McDonald's Corp. of Oak Brook, Ill., has used the plastic for to-go cups in Europe, and Sony Corp. of Tokyo put it in some models of its Walkman.

The article also cites DuPont with its Sorona® material and its recent announcement to team with Tate and Lyle PLC to develop a biorefinery for Sorona; they also mention the development partnership of BASF with Metabolix of Cambridge MA to make a polyester which is plant based.

Looking at bio-renewable resources is not a new idea. In the 1930s, Henry Ford used soybeans to make plastic parts, such as horns, for his cars, eventually introducing an entire car made from bio-based plastics in the 1940s. But petroleum quickly emerged as the cheaper alternative, relegating the bio-based plastics to niche markets.

In 2002, Cargill Dow opened a plant with the capacity to make 300 million pounds of the corn-based plastic. The company reduced PLA-manufacturing

costs 65% from the first quarter of 2003 to the second quarter of 2004 to well under \$1 a pound. Cargill Dow gains a penny-a-pound advantage for every \$5 increase per barrel in the price of oil according to Kathleen Bader, chief executive of Cargill-Dow.

Due to the increasing price of petroleum based resins due to energy increases, the compostable plastic containers used by Wild Oats are just 20% more expensive than traditional containers as opposed to a 50% premium last year. Sonja Tuitele, a spokeswoman for Wild Oats Markets indicated that this change in the premium played in our decision to expand nationally.

Despite the growing advantage of bio-based plastics, it won't be possible to replace all petroleum based products. There is a lot of infrastructure and PET will likely remain cheaper than their bio-based competitors -- and stronger.

As U.S. oil production is declining, U.S. corn yields are increasing by five billion pounds, or 1.2%, a year according to Inform, a New York-based organization that researches environmental issues.

Thaddeus Herrick at thaddeus.herrick@wsj.com wrote the article for the Wall Street Journal

Biotechnology impacts the manufacture of cellulose

While this is about pulp, there are a lot of cellulosic based plastics that maybe indirectly affected.

Diversa Corporation announced this past July the launch of Luminase enzyme, a product that allows pulp and paper manufacturers to improve the cost and quality of pulp processing. "The launch of Luminase enzyme significantly expands our growing portfolio of fiber modification products. We believe that because of its ability to produce brighter, whiter paper with reduced amounts of chemicals, its ease of use in current pulp and paper manufacturing processes, and its 100 percent biodegradable nature" said Jay M. Short, Ph.D., Diversa's President and Chief Executive Officer. Using Luminase enzyme reduces the need for harsh bleaching chemicals by as much as 28 percent. Luminase enzyme can be used over a wider range of manufacturing conditions, including time, temperature, and alkalinity, than other enzyme products, which makes it useful to a broader range of customers. With more than 65 million tons of bleached kraft pulp fiber and 300 million tons of paper products produced each year worldwide, the launch of Luminase enzyme comes at a time when paper production has reached record levels and environmental regulations for chemicals are becoming more stringent.

Luminase enzyme is a novel xylanase that improves the reactivity of pulp fiber to bleaching chemicals, such as chlorine dioxide. In addition to the cost savings offered by the use of Luminase enzyme, reducing bleaching chemicals can also improve the quality of waste water. Luminase enzyme works over a wide range of customer conditions and works more rapidly, making it easier to use than other

enzyme products.

Luminase enzyme also allows pulp to be bleached to higher brightness than without enzyme, which may create new market or premium product opportunities.

Additional information on Luminase enzyme is available at

<http://www.diversa.com/luminase>.

Diversa Corporation is a leader in applying proprietary genomic technologies for the rapid discovery and optimization of novel protein-based products. Additional information is available at Diversa's website:

<http://www.diversa.com>.

Contacts:

Martin Sabarsky

Corporate Development & Investor Relations, Diversa Corporation

(858) 526-5166

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In addition to new product development and increased sales, industrial biotechnology has the potential to drastically reduce costs and pollution. In another example, industrial enzyme manufacturer Novozymes North America sells an enzyme that can be used by textile manufacturers in place of a chemical process to prepare cotton for dyeing and finishing. The benefits: Mills can cut water, chemical and energy demand for the process by 30% to 50%, and if the entire industry shifted to this process, it would cut water consumption alone by 45 million cubic meters annually, according to BIO (The Biotechnology Industry Organization).

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**Biobased Products: The Sustainability Solution?
Insights from the *Journal of Industrial Ecology* published by the Yale University School of Forestry and Environmental Studies.**

Interest in the use of agricultural products and wastes for energy and industrial materials is growing throughout the world. Optimists foresee a new system of production that will produce a virtuous cycle of benefits for the environment and society. A more pessimistic outlook for the bioeconomy also exists, which foresees the increased use of synthetic fertilizers, a related reduction in water quality, and an increase in soil erosion and greenhouse gas emissions.

Emerging research, published in the prestigious *Journal of Industrial Ecology* (and available free in full text at <http://mitpress.mit.edu/jie/bio-based>) examines the environmental implications—good and bad—of increased use of biobased materials and fuels using the concepts and tools of industrial ecology.

Articles in the special issue analyze the opportunities, processes, and environmental impacts of biofuels, bioplastics, biolubricants, and biosurfactants. Government initiatives to support biobased products are summarized and leading biobased product companies are profiled. Research published in this issue suggests:

- That analysis methods can, without detailed product-specific information, predict the environmental performance of bioproduction strategies such as capacity to displace fossil fuel use. These tools can rapidly screen new processes and identify promising opportunities.
- Making composite materials and plastics from biobased resources is superior to energy production from energy crops, in terms of energy savings and greenhouse gas emissions, when these impacts are computed per unit of agricultural land rather than per unit of product.
- Using ethanol fuel made from corn stover, the residues left over in corn fields after the grain is harvested, to produce a mixture of ethanol and gasoline (known as "E85"), can yield important benefits. For each kilometer fueled by the ethanol, the car uses 95% less petroleum. Total fossil energy use (coal, oil, and natural gas) and greenhouse gas emissions are lower on a life-cycle basis. Air quality impacts are mixed, however, with some pollutants increasing and others decreasing.

Robert Anex, associate professor of agricultural and biosystems engineering at Iowa State University in Ames, Iowa, USA, served as the guest editor for the special issue. Support for the special issue was provided by the U.S. National Institute of Standards and Technology (NIST). Yale University School of Forestry & Environmental Studies, New Haven, Connecticut 06511-2189 USA Tel: 203.432.6949 Fax: 203.432.5556 <http://mitpress.mit.edu/JIE> indec@yale.edu

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Recently *Industry Week* published an article reviewing the Industrial Biotechnology meeting held this past April in Orlando. The article complimented Brent Erickson, vice president of the Industrial and Environmental Section of the Biotechnology Industry Organization (BIO), as actively engaged in introducing traditional manufacturers to the emerging world of industrial biotechnology. This movement, dubbed "the third wave" of biotechnology in the United States and "white biotechnology" in Europe, is increasingly seen as being as influential to the future of manufacturing as the Internet. It is infiltrating a wide range of industries -- chemicals, autos, plastics, consumer products, textiles, paper, pharmaceuticals -- and is bringing change to all phases of production, from inputs to finished goods to pollution control to packaging.

Futurist and author Daniel Burrus told the nearly 500 attendees at the first World Congress on Industrial Biotechnology and Bioprocessing in Orlando in April, which drew scientists and manufacturing executives from around the world. "We are going to redefine multiple industries, without question. I can put my reputation on the line and say it will happen." Erickson has described it in another way, "We are witnessing the creation of a new infrastructure based on biology instead of old rust belt technology and petroleum."

More and more frequently the result is a marketable product that is manufactured at a lower cost and with less environmental impact. This happened, for instance, in the 1970s when manufacturers of laundry detergents started to replace

polluting phosphates with cell-derived enzymes, which reduced undesirable waste, improved the product (the enzymes removed stains better) and literally shrunk the size of the product, which saved on transportation and packaging costs.

Today, widespread biology-based product reengineering is occurring in the making of packaging, vitamins, clothing, auto parts, drugs and other goods at a faster-than-ever rate because of bioinformatics, the application of super-computing techniques to biology. It's the same technology that opened the door for the mapping of the human genome.

BIO released a report in June 2004, "***New Biotech Tools for a Cleaner Environment***," released in June by the Washington, D.C.-based trade group. The purpose of the report was to make chemical engineers and product development specialists aware of the tools that are now available for deployment. Industrial biotech is an example of where there is a lag between availability and widespread use of a new technology.

Industrial biotechnology has the potential through new products and platforms to produce cost savings equal to or greater than the savings manufacturers have gained from forces such as lean manufacturing and information technology.

Henry Ford and George Washington Carver were two early visionaries who saw the potential in using renewable feedstocks, but they did not have the biotech-power tools we have at our disposal today -- genomics, proteomics and bioinformatics. Companies need to understand these tools otherwise they may have trouble competing over the next 5-10 years.

Companies such as Degussa AG, DSM NV, Dow Chemical Co. and Du Pont & Co. are players in this field, with products already on the market. Additionally, companies such as Eastman Chemical Co. and Procter & Gamble Co. are establishing biotechnology units. Biotech offers the potential as a key to competing against Asia and for innovation in the chemicals and plastics industries.

Anti-Bio Movement in Europe has been a hurdle.

Despite the demonstrated evidence of bio-based manufacturing, several factors are blocking this wave. The most frustrating for its proponents is public opinion that these products and processes are harmful. That's why the movement has been dubbed "white biotechnology" in Europe, to distinguish it from genetically modified food products (green biotech), which caused an uproar there when first introduced, and indeed are banned.

Additionally, funding is often a problem, both from the private and public sectors. Investing in a new manufacturing process and chain of suppliers is a huge

commitment for a manufacturing company, and often the processes are not understood.

However the shrinking margins of the chemical industry in recent years and the growing globalization of the industry, has forced management to learn more about industrial biotechnology.

Industrial Biotechnology Products

The following is a list of recent innovations that include food packaging, clothing, detergent ingredients and car parts recently promoted by the Industrial environmental Section of the Biotechnology Industry Organization.

A Recyclable Car: Toyota Japan has developed its own plant-derived plastics, Toyota Eco-Plastics, and has used them to manufacture spare-tire covers and floor mats for the Raum, a vehicle the company is producing with as much recyclable material as possible. Additionally, says Toyota Japan, the fact that the plastics don't emit carbon dioxide during their manufacture offsets CO₂ produced in other parts of the manufacture of the vehicle.

Taking Ideas To Market: Procter & Gamble Co., Cincinnati: In March, P&G announced a joint venture with Japanese company Kaneka Corp., to complete research and bring to market a portfolio of Nodax products. Nodax is a bio-based, biodegradable plastic. The two companies have been working together since an earlier agreement was made in 2001.

Washing With Less Energy: Novazymes, Denmark, has developed Stainzyme, which the company says can remove difficult stains and retain the colors of clothes. Stainzyme is distinct from other detergent enzymes because it works at low temperatures and with less washing. It is being marketed to detergent manufacturers.

Reducing Textile Waste: Diversa Corp., San Diego: In June, Diversa announced the U.S. launch of Cottonase enzyme for cotton-based textile processing. The global market for textile processing enzymes is \$125 million, according to Diversa, which will manufacture the product and market it worldwide through regional distributors. The enzyme can replace a process that in the past has produced more waste and more noxious waste.

For more information contact:

Lauren Pannenbacker
Coordinator
Industrial and Environmental Section
Biotechnology Industry Organization
1225 Eye Street, NW, Suite 400
Washington, DC 20005
202-962-6641

Developments in Europe

On July 6, 2004 the EU Commission (1) announced the industry led technology platform on sustainable chemistry (2) which brings together the leading chemical industries with the new emerging biotechnology sector. "Today we recognize that there are several life science revolutions taking place and that biotechnology has an important contribution to make to a sustainable and competitive chemical industry. The 1500 new biotech companies that base their research in life sciences are creating a new knowledge based *bio-economy*," says Johan Vanhemelrijck, Secretary General of EuropaBio, the European association for bioindustries.

This new Technology Platform is an initiative by CEFIC (3), the European Chemical Industry Council, and EuropaBio. The platform will be a multi-stakeholder forum, involving other industrial stakeholders such as the textile industry, detergents, the pulp and paper industries, and is designed to develop a European strategic research agenda and carry out joint research projects.

Industrial Biotechnology or 'white biotech' is a multidisciplinary technology, which can be used to produce goods on an industrial scale, while respecting the environment and has shown to be good for people, planet and profit. The technology uses all the tricks that life and nature provide to produce goods like antibiotics, detergents, plastics and fuels.

Six different bioprocesses (4) were submitted to the environmental scrutiny of independent peer reviewers, among them the Oeko-Institute from Freiburg, a scientific institute with a high reputation among environmentalists. Using a bioprocess to produce antibiotics was shown to result in a 65% reduction in materials and energy use while making a 50% cost saving. In the case of Vitamin B2, an 8 step chemical process can be reduced to a one step fermentation process, saving 40% on costs and reducing environmental impact by the same amount. "This technology is helping to improve the quality of life in a sustainable society. We are just seeing the beginning of the positive impact of improved life science knowledge," says Johan Vanhemelrijck. "The biotechnology industry is also using biomass to produce bio-energy, bio-plastics, bio-textiles, which means it also has the potential to become a new client for agriculture."

For more information, contact

Adeline Farrelly Tel: +32 2 735 0313 Direct: +32 2 739 1174 Mobile: +32 475 93 17 24

Email: a.farrelly@europabio.org

Notes for Editors

- (1) EU Commission press release
http://europa.eu.int/comm/press_room/index_en.htm
- (2) Brochure “A European Technology Platform for Sustainable Chemistry”
www.cefic.org
- (3) CEFIC press release www.cefic.org
- (4) White biotechnology – a gateway to sustainability
http://www.europabio.org/upload/documents/wb_100403/Innenseiten_final_screen.pdf

About EuropaBio

EuropaBio, the European Association for Bioindustries, has 35 corporate members operating worldwide and 24 national biotechnology associations representing some 1500 small and medium sized enterprises involved in research and development, testing, manufacturing and distribution of biotechnology products.

<http://www.europabio.org>

References: The stories in *Biotechnology in Plastics* come from a variety of sources including Company/Organization Press Releases, Interviews, and trade publications, e.g. *Plastics News*, *Industry Week* and newswires.

From more information contact:

Maggie Baumann
G.H. Associates
908-832-2207

Larry Drumm
BioLarry Consulting
856-256-7617