World Business Council for Sustainable Development

Case study 2004

Cargill Dow LLC
Nature works for NatureWorks™ PLA

A dozen years ago, scientists at Cargill got the idea of converting lactic acid made from corn into plastic while examining possible new uses for materials produced from corn wet milling processes. In the past, several efforts had been made to develop plastics from lactic acid, but with limited success. Achieving this technological breakthrough didn't come easily, but in time the efforts did succeed. A fermentation and distillation process using corn was designed to create a polymer suitable for a broad variety of applications.

As an agricultural based firm, Cargill had taken this product as far as it could by 1997. The company needed a partner with access to plastics markets and polymerisation capabilities, and began discussions with The Dow Chemical Company. The next step was the formation of the joint venture that created Cargill Dow LLC.

Cargill Dow's product is the world's first commercially available plastic made from annually renewable resources such as corn:

- NatureWorks™ PLA is a family of packaging polymers (carbon-based molecules) made from non-petroleum based resources.
- Ingeo is a family of polymers for fibers made in a similar manner.

By applying their unique technology to the processing of natural plant sugars, Cargill Dow has created a more environmentally friendly material that reaches the consumer in clothes, cups, packaging and other products.

While Cargill Dow is a stand-alone business, it continues to leverage the agricultural processing, manufacturing and polymer expertise of the two parent companies in order to bring the best possible products to market.

How it's made

The basic raw materials for PLA are carbon dioxide and water. Growing plants, like corn, take these building blocks from the atmosphere and the soil. They are combined in the plant to make carbohydrates (sucrose and starch) through a process driven by photosynthesis. The process for making NatureWorks PLA begins when a renewable resource such as corn is milled, separating starch from the raw material. Unrefined dextrose, in turn, is processed from the starch. Future technology enhancements may eliminate the milling step and allow for the use of even more abundant agricultural by-products.

Cargill Dow turns the unrefined dextrose into lactic acid using a fermentation process similar to that used by beer and wine producers. This is the same lactic acid that is used as a food additive and is found in muscle tissue in the human body.
Through a special condensation process, a lactide is formed. This lactide is purified through vacuum distillation and becomes a polymer (the base for NatureWorks PLA) that is ready for use through a solvent-free melt process.
Development of this new technology allows the company to "harvest" the carbon that living plants remove from the air through photosynthesis. Carbon is stored in plant

starches, which can be broken down into natural plant sugars. The carbon and other elements in these natural sugars are then used to make NatureWorks PLA.

Cargill Dow manufactures PLA at its plant in Blair, Nebraska. This world scale production facility allows Cargill Dow to meet rapidly growing international demand for the product. This new plant has also seen the creation of new jobs and a new market for producers of agricultural crops. Its location proved to be a perfect fit based on a number of factors, including its proximity to existing wet milling operations, access to transportation and the available work force.

At full capacity, the production facility will produce 300 million pounds of PLA per year (136,080 metric tons). To produce this, 750 million pounds (340,200 metric tons) of corn (with 15% moisture) are required. The total 2002 US corn for grain production was 9 billion bushels or 504 billion pounds (1 bushel = 56 pounds = 25.4 kg). So, at full capacity Cargill Dow will take 0.15% of the total corn for grain production in the USA — less than one-fifth of one percent.

Cargill Dow uses Number 2 Yellow Dent corn, the most common corn variety, with more than 80% of the crop grown to feed animals. No. 2 Yellow Dent corn can also be used to make food products like dextrose and fructose (used as sweeteners in a wide range of food products) and is considered safe as a raw material for human food products.

On average, approximately 2.5 kg of corn (at 15% moisture) are required per kg of PLA (or 2.5 lbs/lb of PLA). The difference (1.5 kg corn) is not all waste. Some is simply water, some of it ends up in other corn wet mill products such as germ oil, corn gluten meal and corn gluten feed, and a part compensates for the yield losses in the different processes.

NatureWorks PLA does not contain genetically modified material, nor does its production require any.

How it’s unmade

NatureWorks PLA fits all disposal systems and is fully compostable in commercial composting facilities. With the proper infrastructure, products made from this polymer can be recycled back to a monomer and re-used as a polymer. Thus, at the end of its life cycle, a product made from NatureWorks PLA can be broken down into its simplest parts so that no sign of it remains.

Competitive products

PLA is now actively competing with traditional materials in packaging and fiber applications throughout the world; based on the technology's success and promise, Cargill Dow is quickly becoming a premier player in the polymers market. This new polymer now competes head-on with petroleum-based materials like polyester.

A wide range of products that vary in molecular weight and crystallinity can be produced, and the blend of physical properties of PLA makes it suited for a broad range of fiber and packaging applications. Fiber and non-woven applications include clothing, fiberfill, blankets and wipes. Packaging applications include packaging films and food and beverage containers.

As NatureWorks PLA polymers are more oil- and grease-resistant and provide a better flavor and aroma barrier than existing petroleum-based polymers, grocery retailers are increasingly using this packaging for their fresh foods. As companies begin to explore this family of polymers, more potential applications are being identified. For example, PLA

possess two properties that are particularly useful for drape fabrics and window furnishings. Their resistance to ultraviolet light is particularly appealing as this reduces the amount of fading in such fabrics, and their refractive index is low, which means fabrics constructed from these polymers can be made with deep colors without requiring large amounts of dye. In addition, sportswear makers have been drawn to the product as it has an inherent ability to take moisture away from the skin and when blended with cotton and wool, the result is garments that are lighter and better at absorbing moisture.

More Environmentally friendly production

PLA combines inexpensive large-scale fermentation with chemical processing to produce a value-added polymer product that improves the environment as well. The source material for PLA is a natural sugar found in plants such as corn and using such renewable feedstock presents several environmental benefits. As an alternative to traditional petroleum-based polymers, the production of PLA uses 20%-50% less fossil fuel and releases a lower amount of greenhouse gasses than comparable petroleum-based plastic; carbon dioxide in the atmosphere is removed when the feedstock is grown and is returned to the earth when the polymer is degraded.

Because the company is using raw materials that can be regenerated year after year, it is both cost competitive and environmentally responsible.

The technology has received many awards including the Discover Award for Environmental Innovation, presented by the Christopher Columbus Fellowship Foundation. Further, the U.S. Department of Energy awarded Cargill Dow more than US$ 2 million for continued research and development of the company's fermentation process for utilization of renewable resources. The funding was awarded in support of the President's Executive Order to triple the use of bio-based products and bio-energy by 2010.

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) is a coalition of international companies united by a shared commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. Our members are drawn from more than 35 countries and 20 major industrial sectors. We also benefit from a Global Network of 40 national and regional business councils and partner organizations involving more than 1,000 business leaders globally.

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