he advantages claimed for plastics made from biodegradable polymers over conventional plastics produced from fossil-based fuels are well known. Production of bioplastics uses less energy than production of petroleum-based plastics and generates considerably smaller amounts of greenhouse gases. In the degradation process, bioplastics remain nontoxic. Petroleum prices are unstable—or rising. Compostable wastes can provide significant savings in terms of waste management and energy consumption on many levels, from the large-scale plastics industry looking to manufacture a more responsible product to the individual consumer buying everyday necessities for the family. Metabolix, the second-largest producer of biopolymers in the United States, says that its plastics are biodegradable in composting bins, wetlands, and oceans (1).

So far, bioplastics have found niche applications in the product-packaging and food industry, but they are not yet extensively used in agriculture or in the replacement of conventional plastic materials. However, the potential exists to branch out into multiple fields, the biomedical industry, for example. There, in some special cases like tissue scaffolds and drug delivery, bioplastics can be intrinsically linked with the biomedical industry’s unique requirements for biocompatibility and degradation.

Sustainable polymers can be produced from a variety of mainly plant resources, but there is increasing interest in the use of polysaccharides like starch, which are used in products that better replicate the durability and flexibility of conventional plastics. Starch is low in cost, widely available from wheat, corn, legumes, and tubers, and useful for different applications in food manufacturing, textiles, and adhesives.

**TPS: Producing a Superior Starch**

Starch is a linear polysaccharide made up of repeating glucose groups with an average length of between 500 and 2000 glucose units, though the actual length is dependent on plant source (2). Typically, starch consists of two major molecules in varying amounts but typically 25% amylose and 75% amylopectin. The linkage of amylose to plasticizers such as sorbitol and glycerine allows starches to become flexible and produce a range of different characteristics when the amount of plasticizer is varied. The addition of nonvolatile and high-boiling hydrophilic plasticizers, such as glycerol or other polyols, to pure starch allows the heated molecules to behave like a thermoplastic synthetic polymer and reduces the water content to <1%, resulting in thermoplastic starch (TPS), the most widely used bioplastic today, accounting for 50% of the market (1).

While other starch-based bioplastics will have starch contents ranging from 1% to greater than 90%, TPS must have amylose content greater than 70%. Any amount lower than 70% is characterized as weak in the plastic matrix, and it will make it vul-
nerable to biological attack. However, high-starch-content plastics such as TPS will readily disintegrate when coming into contact with water. Weaknesses can be improved by preparation of blends with other synthetic polymers or composites using natural reinforcing materials.

The production of TPS employs the use of conventional plastics-processing machines such as extruders, internal mixers, or injection molders, which transform the pure starch into a plasticized starch. This provides a wide range of cost advantages to plastics processors looking for cleaner alternatives to petroleum-based technologies but who do not have the capital to make extensive modifications or overhaul their factories. However, even though processors can use standard processing equipment for TPS production, it is important that traditional petroleum-based plastics such as polyethylene or polypropylene are not added to mixtures to make molding easier. This will render the product poor in quality or incompletely biodegradable.

Replacing Fossil Fuels

Thermoplastic starch polymers are low-cost materials that have a wealth of applications in the marketplace. Commonly used in film for shopping bags, bread bags, overwrap, flushable sanitary product backing material, and mulch film, TPS is also suitable for coatings, cutlery, and other packaging, and could be used to replace petrochemical thermoplastics in other short-time-range applications.

Bioplastics like TPS can also offer an opportunity to double their return to a factory through use as a fuel source at the end of their lifecycles. Various thermoplastic starch materials have entered the marketplace as reliable alternatives to petroleum-based plastics. Plastarch Material (PSM), used for a multitude of products, is a biodegradable, thermoplastic resin derived from more than 80% cornstarch that is modified to produce high heat-resistant properties. The high heat tolerance of PSM makes it a good fit for such applications as thermoforming, injection molding, blown film, and foaming. Also, it can be disposed of through incineration, resulting in a nontoxic residue that can be used as fertilizer. Companies that produce this material, like Plastic Ingenuity Inc. of Cross Plains, Wisconsin, USA, also use 100% bioadditives in the product to ensure its quality and sustainability. In 2008, Cerestech, Inc., of Montreal, Quebec, Canada, introduced several TPS blends called Cerelay™ to the marketplace. Starches derived from corn, wheat, and tapioca are used to produce the low-cost, high-performance blends that emit greenhouse gases in amounts up to 90% less than those from polyethylene. Applications for the resin grades include film and injection-molded products. The first commercial product was a blend of linear low-density polyethylene and TPS for a new sustainable can liner produced by Pitt Plastics, Inc.

Plate made from Plastarch materials was produced using current plastics-processing technologies. When discarded, products made from Plastarch materials can be incinerated to produce a residue that can be used as fertilizer. Plastic Ingenuity, Inc.

In the everyday consumer’s life, disposable cutlery—forks, knives, cups, and plates—made from biodegradable vegetable starch is now appearing in more homes and businesses. Companies like California-based Cereplast are making resins primarily designed for products that will be composted. When composted, a plastic made from Cereplast’s resin will dissolve in 180 days. In a normal landfill, the material will dissolve in two to three years, while petroleum-based plastics will require 100 years or more. Plastics-industry giants are partnering with Cereplast and other bioplastics engineers to modify already existing plastic products. In 2006, Solo, the disposable-cup manufacturer, worked with Cereplast to coat their cups in Cereplast’s materials, replacing the petroleum-based film typically used.

Starch Marches On

Technology developers are continuing to expand upon thermoplastic starch technology and develop new methods for combining starch with polymers to create lower-cost options for the plastics industry. A new material called Plantic®, based on corn and produced in Australia by Plantic Technologies, is being used by companies like DuPont as a completely biodegradable and organic alternative to conventional plastics. Plastic material is unique in that the polymer that is utilized in the plasticizing process, primarily in injection molding, is also a completely organic material grown in a field. The high-amylose starch used by Plantic Technologies undergoes a chemical modification process called hydroxypropylation prior to the manufacture of the actual material. This process slows the retrogradation that occurs in cooling, and plasticizes the starch, making it behave like a thermoplastic and increasing its shelf life by years.

Currently, Plantic material is applied mainly in the area of packaging materials. The first commercial use of Plantic is in packaging and
who said POTATO

display trays that look, feel, and function the same as traditional plastic trays. The trays are made completely from the renewable Plantic material and also will dissolve in water. Plantic Technologies is looking to collaborate with DuPont to enter the U.S. market by producing resins and sheet materials for the packaging of cosmetics, personal-care products, and food products. In December 2009, Plantic Technologies announced that it will establish a manufacturing facility in the United States in collaboration with National Starch LLC. This move, the company says, will help shorten the supply chain of Plantic material and reduce costs for U.S.-based plastics processors and chemical firms seeking to use it.

Other global chemical manufacturers are using their recently created bioplastics divisions to introduce new products that help spread the use of renewable materials in the plastics industry. Arkema recently announced the development of Pebax® Rnew100, a high-performance 100% biobased thermoplastic elastomer entirely derived from renewable resources. Teknor Apex, of Rhode Island (USA), recently introduced Terraloy™ BP-18003A, a blend of up to 30% thermoplastic starch with high-impact polystyrene (HIPS), and Terraloy MB-18003A, with up to 50% TPS content. Both products can be used in typical HIPS applications like cutlery and disposable razors, among other consumer products.

With global demand for bioplastics predicted to rise to 900,000 tons worth US$2.6 billion by 2013, it is no wonder that more chemical companies are beginning to develop the materials that plastics processors will use in more products (3). A growing consumer demand for more environmentally sustainable products has helped encourage innovation in the bioplastics sector, producing low-cost and highly biodegradable alternatives to petroleum-based products. Thermoplastic starch fits well into this particular niche, as a completely renewable plant-based material that replicates and expands upon properties like flexibility and durability found in petroleum-based plastics. Also, its ability to be processed in existing plastics-fabrication equipment makes it an economical option for plastics processors.

References
3. “Global Demand for Bioplastics To Reach 900,000 Metric Tons in 2013,” World Bioplastics, The Freedonia Group, Inc. (released Nov. 9, 2009).
Learn more about the latest advancements in Automotive Engineering Plastics during this one-day technical conference and exhibition in metropolitan Detroit, co-sponsored by the Detroit Section and the Automotive Division of the Society of Plastics Engineers (SPE®) International.

The conference features a strong slate of technical presentations and is attended by more than 200 key automotive professionals and decision makers.

Keynote speakers will address critical automotive trends and some of the major innovative new opportunities being initiated by the industry. The keynote speakers are Vivek Jain, Ph.D., MBA, Global R&D Director, Ticona Engineering Polymers; Michael Britt, Group Engineering Plastics, Group Vice President, BASF Corporation; Dale Gerard, Ph.D., Senior Manager NA Materials, General Motors.

Engineering polymers provide solutions to the demands for greater fuel economy, lower part cost, lighter weight, durability and styling. Isn’t it time you joined the movers?

WHEN:
Tuesday, April 27, 2010
WHERE:
MSU Management Education Center
Troy (Detroit area), MI USA
REGISTER, SPONSOR, PRESENT:
www.speautomotive.com,
www.spedetroit.com
contact Patricia Levine
SPE Automotive Division
+1.248.244.8993
email p.levine@yahoo.com