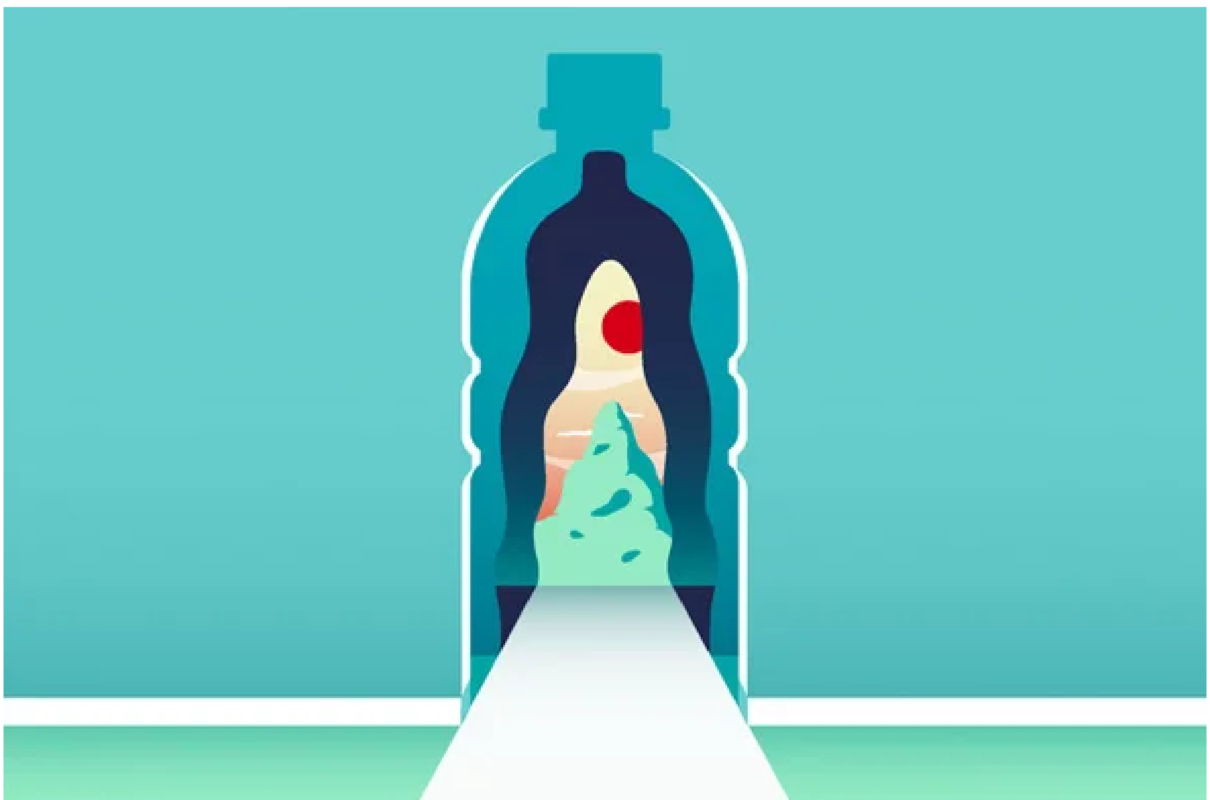
ENVIRONMENT

Bioplastics Could Solve a Major Pollution Problem

Advanced solvents and enzymes are transforming woody wastes into better biodegradable plastics

By Javier Garcia Martinez on July 1, 2019



Credit: Vanessa Branchi

Our civilization is built on plastics. In 2014 alone, industry generated 311 million metric tons, an amount expected to triple by 2050, according to the World Economic Forum. Yet less than 15 percent of it gets recycled. Much of the rest is incinerated, sits in landfills or is abandoned in the environment—where, being resistant to microbial digestion, it can persist for hundreds of years. Plastic debris accumulating in the ocean causes all kinds of problems, from killing wildlife when mistakenly ingested to releasing toxic compounds. It can even enter our bodies via contaminated fish.

Biodegradable plastics can ease these problems, contributing to the goal of a “circular” plastic economy in which plastics derive from and are converted back to biomass. Like standard plastics derived from petrochemicals, biodegradable versions consist of polymers (long-chain molecules) that can be molded while in their fluid state into a variety of forms. The options currently available—mostly made from corn, sugarcane, or waste fats and oils—generally lack the mechanical strength and visual characteristics of the standard kinds, however. Recent breakthroughs in producing plastics from cellulose or lignin (the dry matter in plants) promise to overcome those drawbacks. In an added boon for the environment, cellulose and lignin can be obtained from nonfood plants, such as giant reed, grown on marginal land not suitable for food crops or from waste wood and agricultural by-products that would otherwise serve no function.

Cellulose, the most abundant organic polymer on earth, is a major component of plant cell walls; lignin fills the spaces in those walls, providing strength and rigidity. To make plastics from those substances, manufacturers must first break them into their building blocks, or monomers. Investigators have recently found ways to do so for both substances. The lignin work is particularly important because lignin’s monomers are composed of aromatic rings—the chemical structures that give some standard plastics their mechanical strength and other desirable features. Lignin does not dissolve in most solvents, but investigators have shown that certain environmentally friendly ionic liquids (which are composed largely of ions) can selectively separate it from wood and woody plants. Genetically engineered enzymes similar to those in fungi and bacteria can then break the dissolved lignin into its components.

Companies are building on these findings. For example, Chrysalix Technologies, a spin-off from Imperial College London, has developed a process that uses low-cost ionic liquids to separate cellulose and lignin from starting materials. A Finnish biotechnology company, MetGen Oy, produces a number of genetically engineered enzymes that cleave lignins of different origins into components needed for a wide range of applications. And Mobius (formerly Grow Bioplastics) is developing lignin-based plastic pellets for use in biodegradable flower pots, agricultural mulches and other products.

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Many hurdles must be overcome before the new plastics can be widely used. One is cost. Another is minimizing the amount of land and water used to produce them—even if the lignin comes only from waste, water is needed to convert it into plastic. As with any major challenge, the solutions will require a combination of measures, from regulations to voluntary changes in the ways society uses and disposes of plastics. Still, the emerging methods for producing biodegradable plastic offer a perfect example of how greener solvents and more effective biocatalysts can contribute to generating a circular economy in a major industry.

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