

## Industrial biotechnology

# Better living through chemurgy

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Illustration by David Simonds



### Efforts to replace oil-based chemicals with renewable alternatives are taking off

FORTY years ago Dustin Hoffman's character in "The Graduate" was given a famous piece of career advice: "Just one word...plastics." It was appropriate at the time, given that the 1960s were a golden age of petrochemical innovation. Oil was cheap and seemed limitless. Since then, scientists have kept on coming up with wondrous new products made from petroleum that helped to ensure, in the words of one corporate slogan, better living through chemistry. Even so, someone offering advice to today's promising graduates might invoke a different, uglier word: chemurgy.

This term, coined in the 1930s, refers to a branch of applied chemistry that turns agricultural feedstocks into industrial and consumer products. It had several successes early in the 20th century. Cellulose was used to make everything from paint brushes to the film on which motion pictures were captured. George Washington Carver, an American scientist, developed hundreds of ways to convert peanuts, sweet potatoes and other crops into glue, soaps, paints, dyes and other industrial products. In the 1930s Henry Ford started using parts made from agricultural materials, and even built an all-soy car. But the outbreak of the second world war and the shift to wartime production halted his experiment. After the war, low oil prices and breakthroughs in petrochemical technologies ensured the dominance of petroleum-based plastics and chemicals.

But now chemurgy is back with a vengeance, in the shape of modern industrial biotechnology. Advances in bioengineering, environmental worries, high oil prices and new ways to improve the performance of oil-based products using biotechnology have led to a revival of interest in using agricultural feedstocks to make plastics, paints, textile fibres and other industrial products that now come from oil.

This form of biotechnology has not attracted as much attention as biotech drugs, genetically modified organisms or biofuels, but it has been quietly growing for years. BASF, a German chemical giant, estimates that bio-based products account for some €300m (\$470m) of sales in such things as "chiral intermediates" (which give the kick to its pesticides). The sale of industrial enzymes by Novozymes, a Danish firm, brings in over €950m a year, about a third of it from enzymes for improving laundry detergents. Jens Riese of McKinsey, a consultancy, reckons industrial biotech's global sales will soar to \$100 billion by 2011—by which time sales of biofuels will have reached only \$72 billion.

Will this boom really prove to be more sustainable than the first, ill-fated blossoming of chemurgy? One potential problem is that oil-based polymers are very good at what they do. Early bioplastics melted too easily, or proved unable to keep soft drinks fizzy when they were made into bottles. Pat Gruber, a green-chemistry guru who helped start NatureWorks (a pioneering biopolymers firm) says customers are sometimes too risk-averse to retrain staff or modify equipment to accept a new biopolymer—even if it is cheaper or better.

It seems likely that oil-based products will be around for a long time in some applications. But the big advances in oil-based polymers happened decades ago, whereas the number of patents granted for industrial biotechnology now exceeds 20,000 per year. Such is the pace of innovation, says Tjerk de Rooter, chief executive of Genencor, a industrial-biotech firm that is now a division of Denmark's Danisco, that processes that once took five years now take just one. And Steen Riisgaard, the boss of Novozymes, insists that new technologies can indeed push old ones out of the way, provided they are clearly superior (and not just greener). Brewers raced to adopt Novozymes' novel enzymes, for example, in order to cash in on the Atkins Diet craze with "low carb" beers.

A second potential obstacle is that incumbent companies will quash the fledgling new technologies. But concern about oil's reliability as a feedstock means that even oil-dependent incumbents are interested in alternatives. Oil companies such as Royal Dutch Shell and BP see novel bioproducts not as threats but as useful tools for blending into, and possibly extending, remaining oil reserves. And chemicals giants such as Dow and DuPont are also big fans of novel industrial biotechnologies. Chad Holliday, DuPont's boss, is sure that Sorona, his firm's new biofibre, will be a multi-billion dollar product and "the next nylon". DuPont expects its sales of industrial biotechnology products to grow by 16-18% a year, to reach \$1 billion by 2012.

Perhaps the biggest worry is that today's industrial-biotech boom is an artefact of the soaring price of oil. If the oil price plunged and stayed low, the boom would surely turn to bust. Short of outright collapse, however, even a sharp price drop need not burst the biotech bubble. Mr Riese has scrutinised the economics of sugar and oil—the chief rival feedstocks—and concludes that the "bio-route" will be cheaper even at an oil price of \$50-60 a barrel. Brent Erickson of BIO, an industry lobby, argues that "this was happening long before the oil-price spike—\$100 oil is just gravy." Industry bosses agree, noting that the flurry of projects now approaching commercial use were deemed viable and initiated a few years ago, when the oil price was closer to \$40 a barrel.

For proof that industrial biotech is ready for the big time, look to Brazil. The country already has a large and efficient industry producing ethanol fuel from sugar cane. Now rival consortia are rushing to build plants to turn sugar cane into bioethylene. This is striking. Unlike many other industrial biotech efforts which target niche markets, this is an assault on the \$114 billion market for ethylene, the most widely produced organic compound of all.

Erin O'Driscoll of Dow, a chemical giant now investing in Brazilian bioethylene, says the firm is confident the technology is ready for commercialisation. The chief reason for such optimism is that industrial biotechnology is better and cheaper than it was back in the heyday of chemurgy. Dow has even come up with a material made from soyabean oil that it plans to sell to carmakers to replace oil-based foam. Ford and his friend Carver would be proud.