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Harnessing Biology, And Avoiding Oil, For Chemical Goods

By YUDHIJIT BHATTACHARJEE

THE next time you stop at a gas station, wincing at the $3.50-a-gallon price and bemoaning society's dependence on petroleum, take a step back and look inside your car.

Much of what you see in there comes from petroleum, too: the plastic dashboard, the foam in the seats. More than a tenth of the world's oil is spent not on powering engines but as a feedstock for making chemicals that enrich many goods — from cosmetics to cleaners and fabric to automobile parts.

In recent years, this unsettling fact has motivated academic researchers and corporations to find ways to make bulk chemicals from renewable sources like corn and switchgrass. The effort to tap biomass for chemicals runs parallel to the higher-stakes research aimed at developing biofuels. Researchers hope that the two will come together soon to help replace petroleum refineries with biorefineries.

"As petroleum prices go up and climate change becomes a serious concern, the economy will have no choice but to switch to a chemical base derived from plant materials," said Dr. Richard Gross, director of the Center for Biocatalysis and Bioprocessing of Macromolecules at Polytechnic University in Brooklyn.

The chemical industry is beginning to make that transition, at least for a few products. One success story is a method developed by DuPont, with Genencor, to ferment corn sugar into a substance called propanediol. Using propanediol as a starting point, DuPont has created a new polymer it calls Cerenol, which it substitutes for petroleum-sourced ingredients in products like auto paints.

Similarly, the biotech giant Cargill has begun manufacturing a polymer from vegetable oils that is used in polyurethane foams, which is found in beddings, furniture and car-seat headrests. Cargill says that using the polymer does more than save crude oil and reduce carbon emissions: the foam it produces has a more uniform density and load-bearing capacity.

Researchers say these products are a good beginning, but that new cost-effective processes are needed before biorefineries can replace all petroleum-based chemicals. Many of the solutions, they say, could come from novel ways of harnessing biology.

That's what John Frost and Karen Draths, a husband-and-wife team of chemists, showed in the late 1990s when they engineered micro-organisms that could convert glucose into aromatic alcohols — compounds traditionally produced from a petroleum product and used to make plastics.

Dr. Frost said that the research had been inspired by his fascination with microbes as a child, when his father, a dentist, described the work of patients who happened to be chemists. "I thought this was pretty cool stuff," he said.

Dr. Frost and Dr. Draths, who left their jobs as professors at Michigan State University in December 2006 to start Draths Corporation, have more recently developed a microbial process for making phloroglucinol, a chemical to replace formaldehyde, a carcinogen, in adhesive resins. The company is also commercializing a way to make nylon entirely from renewable feedstocks like starch and cellulose.

"In this approach," Dr. Frost said, "what was last growing season's carbon dioxide is this quarter's carbon used for the manufacture of chemicals and polymers."

To make biobased manufacturing economically appealing, researchers are also determining ways to reduce the energy costs of transforming hydrocarbon building blocks like sugars and alcohols obtained from biomass into polymers. Dr. Gross and his colleagues at Polytechnic University have been using enzymes for that goal — making, among other things, a biodegradable polyester coating.

Some researchers are exploring renewable feedstocks as a source for novel materials, which could provide another economic incentive to companies to pursue biobased chemical production.

Dr. George John, a chemist at the City College of New York, and others, for example, have designed a polymer gel for drug ingestion using a byproduct of the fruit industry as a starting point. By adding an enzyme to the gel, which breaks it down over a few hours, the researchers can control the release of the drug after it is swallowed.

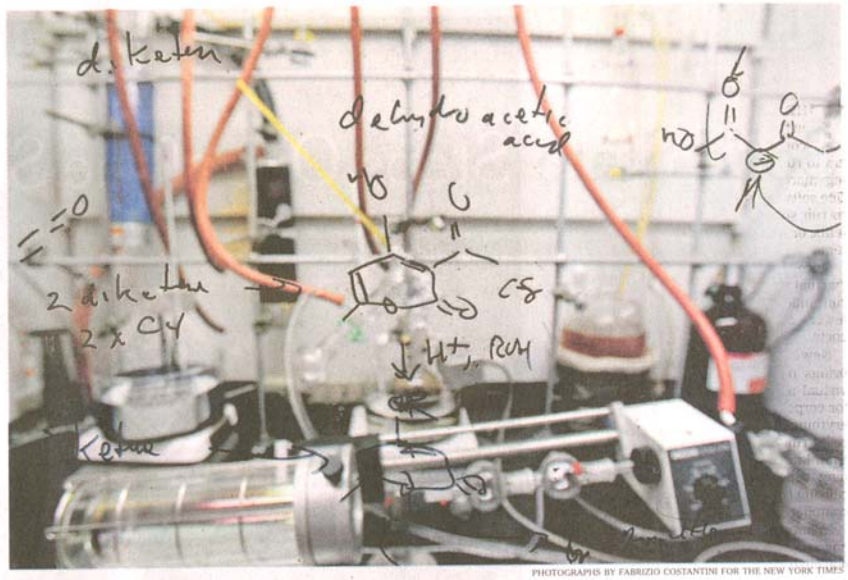
More players are expected to enter the field as rising oil prices force countries to increase production of biodiesel, providing a bigger supply of the byproduct glycerol.

"It could prove to be a very valuable commodity," said Keith Simons, a chemist who consults for the Glycerol Challenge, a project started by a group of British companies and universities. The $3.6 million-a-year effort is aimed at developing catalysts and other technologies that will use glycerol as a feedstock "for making various downstream chemicals," Mr. Simons said.

The payoffs from developing biobased chemicals could be huge and unexpected, said Dr. John Pierce, DuPont's vice president for applied biosciences-technology. He pointed to DuPont's synthesis of propanediol, which was pushed along by the company's goal to use the chemical to make Sorona, a stain-resistant textile that does not lose color easily.

Soon DuPont scientists realized that bioderived propanediol could also be used as an ingredient in cosmetics and products for de-icing aircraft. The high-end grades that are now used in cosmetics are less irritating than traditional molecules, Dr. Pierce said, and the industrial grade used in de-icing products is biodegradable, which makes it better than other options.

"It looks like we found a bit of a gold vein," he said.



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INVENTIVE John Frost, left, and his wife, Karen Draths, in their company lab. The scientists there use the glass shield, above, as a board on which to write chemical formulas.