Harnessing Biology, And Avoiding Oil, For Chemical Goods

BY TUDOR R. BRIATACARISE

If, next time you stop at a gas station, winning at the $3.50-a-gallon price and extending society's dependence on petroleum, take a 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 quarter of the world's oil is spent on producing oxides but as a feedstock for making chemicals that enrich many of the goods we use daily, from cosmetics to cleaners and more in automobile parts.

In recent years, this unsettling fact has motivated academic researchers and corporations to find ways to make chemicals from renewable sources like corn and switchgrass. The effort to fulfill the promise of the higher-stakes research aimed at developing biofuels. Researchers hope that this will come together soon to help replace petroleum refining 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 Grot, director of the Center for Biocatalysis and Bioprocessing at Macromolecular 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 propylene glycol. Using propylene glycol as a starting point, DuPont has created a new polymer it calls Cereplas, 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 polythene foams, which is found in badgers, 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, did in the late 1990s when they engineered microorganisms that could convert glucose into aromatic alcohols — compounds traditionally produced from petroleum and used in plastics.

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

"In this approach," Dr. Frost said, "the bacteria that convert sugars into carbon dioxide is this quarter's carbon source for the manufacture of chemicals and polymers."

To make bio-based materials 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 polyethylene. Dr. Frost and his colleagues at Polytechnic University have been using enzymes for that goal of 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 bio-based 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 larger supply of bio-products in general.

"It could prove to be a very valuable commodity," said Keith Simons, a chemist who works for the Glycol Chal- lenge, a project started by a group of British companies and universities. The 2 billion-a-year effort is aimed at de- veloping catalysts and other tech- nologies that will use glycerol as a bio-based chemical "for making various downstream chemicals," Dr. Simons said.

The profits from developing bio- based chemicals could be huge and un- expected, said Dr. John Pierce, DuPont's vice president for applied bio- chemistry technology. He pointed to DuPont's synthesis of propylene glycol, which was pushed along by the company's goal to use the chemical to make Sorona, a stain-resistant textile that does not form coke easily.

"If we can think of something that we can make from these ingredients, there are a lot of companies and people who are off on this," Dr. Pierce said. And the producers of the ingredients could also use the technology to make industrial products instead of petroleum-based products. "It just makes sense," Dr. Pierce said. "It makes sense for the environment, it makes sense for the consumer, and it makes sense for the consumer's pocketbook.

Dr. Frost and Dr. Draths, who left their jobs as professors at Michigan State University in December 2006 to start Draths Corporation, were recently awarded a patent for making phloroglucinol, a chemical to replace formaldehyde, in a reaction in which proteins are combined to form a polymer. Dr. Frost and his colleagues at Polytechnic have been using enzymes for that goal of making, among other things, a biodegradable polyester coating.

"We've been working on this for years," Dr. Frost said, "and we think we're close to having a way to make this polymer from renewable feedstocks like starch and cellulose."