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A SPECIAL REPORT

Chemist's Pursuit of Molecular Beauty May Yield Energy Breakthroughs

By PAUL BASKEN

Omar M. Yaghi's shelves and bookcases are lined with a colorful assortment of plastic models, a seeming kaleidoscope of oversized snowflakes that give his office the whimsical feel of a toy-design workshop.

But the plastic models of molecular structures might hold the secret to virtually pollution-free automobiles and power-generation plants.

Mr. Yaghi, a professor of chemistry and biochemistry at the University of California at Los Angeles, has spent the past two decades pioneering work in a new class of materials called metal-organic frameworks. The idea is to link a metal oxide, a compound that a metal forms with oxygen, to an organic compound, a molecule containing carbon, to produce a latticelike structure capable of capturing and later releasing other atoms and molecules.

"Omar has really been the leader in this area," said Thomas E. Mallouk, a professor of materials chemistry and physics at Pennsylvania State University's main campus.

Potential applications for the discovery are numerous. One that has already been developed involves using a metal-organic framework to store methane, the principal component of natural gas, in an automotive fuel tank. The lattice structure can hold the methane molecules tightly, without the cost of pressurization in a metal tank, and then release them as needed by the vehicle.

"Our materials work like bees in a honeycomb, and the bees all swarm onto the honeycomb," Mr. Yaghi said.

He would like to replicate that technique with hydrogen instead of methane. Hydrogen is even more promising as an automotive fuel because it can be burned without any carbon emissions, or combined with oxygen in a fuel cell to produce only energy and water.

Mr. Yaghi, if successful, would remove one of the leading obstacles to the use of hydrogen in automobiles by finding a storage method that doesn't involve either compression or freezing, neither of which is viable because of factors that include cost and safety.

Hydrogen is one of the most difficult materials to store in a useful form, Mr. Mallouk said, and Mr. Yaghi's metal-organic frameworks "are among the most promising materials for doing that right now."

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Another possible application involves the capture of carbon itself. Carbon in the atmosphere is recognized as the leading cause of human-produced global warming. The United States has enough coal to last more than 200 years, but burning it without safeguards is predicted to accelerate planetary warming, with catastrophic environmental effects.

Mr. Yaghi is seeking a metal-organic framework that could capture carbon as part of the emissions-cleaning system in a coal-fired power plant.

One factor that he recognizes is outside his control, however, is the willingness of others — including companies, governments, voters, and even other researchers — to be more open-minded about possible solutions. "Scientific challenges exist, and they are incredible," Mr. Yaghi said. But it's usually the business and political elements that impede progress.

Such obstacles have taken the form of fellow scientists who did not initially appreciate the potential of the metal-organic frameworks, he said, and were not inclined to support his grant requests while serving on review boards.

With time, that has changed. The Jordanian-born Mr. Yaghi is now listed among the top 10 most highly cited chemists worldwide by the Essential Science Indicators database of Thomson Reuters, covering the past decade.

Even if his anticipated breakthroughs materialize, it's not clear how widely they will affect the world of alternative and renewable energy. Coal plants pose pollution threats beyond their carbon emissions, and hydrogen faces other major scientific and logistical obstacles to its use as an automotive fuel.

As much as he would like to be part of the energy solution, Mr. Yaghi said, his work centers on appreciating the natural beauty of materials on the molecular level, and he is confident that appreciation will keep producing important discoveries.

"I had not set out to make a useful material," he said. "I simply wanted to address a scientific challenge."

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