

MATERIALS SCIENCE

Making Molecular Filters More Reactive

mysterious mechanism also shoots out material from the poles of the compact object in high-speed jets, visible at radio wavelengths. Felix Mirabel of the Centre d'Etudes de Saclay, near Paris, and Luis Rodriguez of the Autonomous National University in Mexico City spotted the first of these superluminal jets near a source called GRS 1915+105, located just 40,000 light-years from Earth. GRS 1915+105 was discovered in 1992 when the French-Russian GRANAT satellite detected its highly variable x-ray emission. A few months later, Mirabel and Rodriguez began mapping the radio-emitting material around GRS 1915+105 with the Very Large Array (VLA) in New Mexico. Follow-up observations in 1993 hinted that part of the radio source had shifted across the sky. But at the time, the radio emissions were too dim for astronomers to be sure.

Last March, however, the radio emissions brightened dramatically, and Mirabel and Rodriguez were able to track two blobs of material racing away from a central source at an apparent speed 25% faster than light. At the IAU meeting and in a paper in yesterday's issue of *Nature*, the researchers estimated that the ejected material is actually moving at 92% of the speed of light, and they put its mass at about a third that of the moon. Accelerating it, say Mirabel and Rodriguez, would have required the power of 100 million suns, suggesting that even a quasar in miniature is a formidable thing.

As news of that finding spread this summer, astronomers began to look for other x-ray sources in the galaxy that might be performing similar feats. Just last week, radio astronomers hit pay dirt. Using the VLA to study X-ray Nova Scorpii, an x-ray source that itself was spotted only a month ago by NASA's orbiting Compton Gamma Ray Observatory, Robert Hjellming of the National Radio Astronomy Observatory tracked two rapidly diverging jets. Derek McKay and Michael Kesteven of the Australia Telescope National Facility then estimated that the source lies just 11,000 light-years from Earth, which implies that the jets are flying apart at more than the speed of light.

Nova Scorpii's distance, about a quarter of the distance to the earlier source, along with its strong radio emission, about 10 times more intense, suggest it may be an even better place to study a quasar in miniature. By merging data collected at radio telescopes in Australia, South Africa, California, and Hawaii using a technique known as Very Long Baseline Interferometry (VLBI), researchers hope to make high-resolution radio maps that might reveal clues to the workings of this micro-quasar—and its much bigger brothers.

—Ray Jayawardhana

Ray Jayawardhana is a science writer in Cambridge, Massachusetts.

Organic chemists are on the verge of something big in the manufacture of molecular strainers called zeolites. These nanoscopic filters, used widely by industry, have traditionally been made from porous crystals of inorganic materials such as silicon and aluminum. But zeolites made of organic materials could open up an exciting new range of applications in areas including drug manufacture. Before this can happen, however, organic chemists must be able to control the size of the pores in the zeolite—and so far they've only been able to make extremely small pores.

At last week's American Chemical Society (ACS) conference in Washington, D.C., however, a team led by Jeffrey Moore, an organic chemist at the University of Illinois (UI) at Urbana-Champaign, and Stephen Lee, an inorganic solid state chemist at the University of Michigan (UM) at Ann Arbor, reported making organic zeolites out of large molecules with preformed pores. When these ring-shaped molecules stacked up, they formed channels as large as 17 angstroms in diameter—more than twice the width of the earlier organic record. The discovery opens the door to making organic zeolites with even larger pores, simply by increasing the size of the holes in the prefab building blocks.

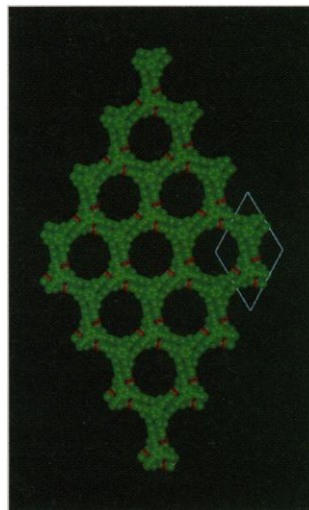
"It's very interesting," says Galen Stucky, a professor of chemistry and materials at the University of California, Santa Barbara. "Historically, inorganics have been used [to make zeolites] because their cost is cheap and you can make them in bulk quantities. But the thing you have with organics is the potential to make small variations [in the building blocks] to control the chemistry of the framework."

The zeolite construction crew started to make their prefab pores using molecules that look like the spokes and hubs of a child's Tinker Toy set. The spokes were rigid acetylene molecules and the hubs, ring-shaped benzenes. UM synthetic chemists Jinshan Zhang and Ziyang Wu connected these chemical Tinker Toys one by one into a hexagon, with benzene hubs at the corners, joined by acetylene spokes. Finally, Zhang and Wu added hydroxyl groups to the outside of each hub; these groups can form hydrogen bonds to join one hexagonal pore to a neighboring one.

When the researchers placed these hexagonal pores in a solution of ethanol and methanol, the hydrogen bonds drew neighboring hexagons together to form a two-dimensional honeycomb pattern. Intermolecular forces caused additional layers to stack up, creating a solid crystal with channels 8

angstroms in diameter. Using similar starting materials, the group also fashioned a more complex 3D building block that led to their second organic zeolite with 17-angstrom channels.

JEFFREY MOORE



Straining for bigger size. Computer image of organic zeolite with 17-angstrom pores shows the oxygen (red) and carbon (green) atoms used in its construction.

With their new organic zeolites in hand, the UI/UM team plans to join reactive molecules to the inside of the pores, giving their strainers highly specific binding properties that can't be built into inorganic zeolites. One such possibility, says Moore, is adding molecules such as amino acids that preferentially bind to one of a pair of mirror-image, or chiral, molecules. Such left- or right-handed molecules are commonly used as drugs, and pharmaceutical manufacturers must

separate such nearly identical twins, as in many cases one molecule is therapeutic while its mirror image is either ineffective or toxic. And currently, the most widely used process for separating left- and right-handed versions of the same molecule requires several chemical stages.

The trick in developing such filters, says chemist Thomas Bein of Purdue University in West Lafayette, Indiana, "will be to add functional groups without affecting self-assembly of the crystal." Unlike inorganic zeolites, in which molecules are held together with rugged covalent bonds, organic zeolites are glued with relatively weak intermolecular forces and hydrogen bonds. And the same reactivity that makes the functional groups candidates for placement inside the pores could potentially affect how the molecules interact. The fragility of these bonds also means that organic filters won't replace inorganic zeolites in high-temperature applications, such as breaking apart the large hydrocarbons in crude oil into the smaller ones used in gasoline. But if organic chemists can manage to add these groups, they'll have a field of zeolite applications all to themselves.

—Robert F. Service