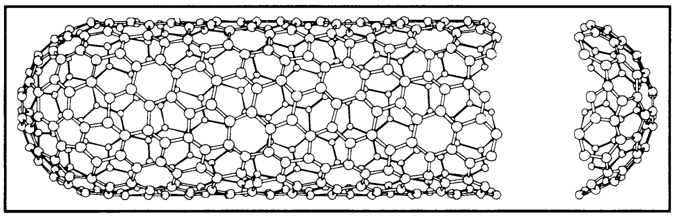
Simple Recipe Yields Fullerene Tubules

Scientists who first observed hollow, all-carbon molecules, called fullerenes, in the shape of microscopic tubes have now developed a method to produce large quantities of this interesting new form of the material.

Since the discovery of fullerene tubules last November (SN: 11/16/91, p.310), several theorists have predicted that these new carbon fibers could strengthen materials better than graphite fibers and could work as molecular-scale wires or as catalysts – if they could be produced in large quantities.

Now they can be. While trying to chemically modify fullerenes by producing them in helium, Thomas W. Ebbesen and P.M. Ajayan, materials scientists with NEC Corporation's Fundamental Research Laboratories in Tsukuba, Japan, found they could make several grams of tubules all at once. They describe their simple recipe in the July 16 NATURE.

R. Saito/NATURE



Computer image shows fullerene tubule's carbon atoms as a spiraling honeycomb, with pentagons at the tips.

"It's an invitation for people to find out anything they can about these materials," says John W. Mintmire, a theorist at the Naval Research Laboratory in Washington, D.C.

"Anyone who has a [fullerene] generator can make these things very easily," adds Lai-Sheng Wang, a physical chemist at Rice University in Houston. "The key now is to be able to control the process to make longer fibers."

Ebbesen and Ajayan make the tubules with a procedure similar to that used to produce fullerenes. They place two graphite rods in a helium-filled reaction vessel. Keeping the pressure at two-thirds that of the atmosphere, they apply a voltage between the carbon rods and cause the smaller rod to emit carbon, up to 75 percent of which builds up on the larger rod, they say. That carbon deposits as a cylinder that grows a few millimeters per minute.

When the scientists first examined a cross-section of this inch-long, quarter-inch-wide cylinder with an electron microscope, they saw it consisted of a hard, gray, metallic shell that was chock full of black fullerene nanotubes and microscopic carbon particles. Those insides represent about 25 percent of the starting carbon, a higher yield than fullerene syntheses, they report. The nanotubes range from 2 to 20 nanometers in diameter and measure several thousand nanometers long.

Because the tubes form only inside the cylinder, temperature and cooling rate must be critical to their formation, Ebbesen and Ajayan say.

These tubules should be stiffer than carbon fibers and should possess interesting electronic properties. Already, the NEC researchers have shown that their sample conducts electricity better than other carbon materials, Mintmire notes.

Theorists have concluded that some tubules should conduct electricity, while others of different diameters will act as semiconductors. "This is very surprising," says Mildred S. Dresselhaus, a solid-state physicist at the Massachusetts Institute of Technology.

According to Dresselhaus, a second Japanese group is working out another way to grow nanotubes from the vapor phase of carbon. Neither approach makes single tubes, however, and the typical tubes-within-tubes arrangement may prove difficult to study. "We don't have a lot of techniques to work with these nanometer-[size] things," says Dresselhaus.

– E. Pennisi

Radio jets and the 'Great Annihilator'

More than a decade ago, when the space-borne Einstein Observatory detected X-rays from a body near the center of our galaxy, that object seemed a rather ordinary radiation source. However, researchers later identified it as one of the most powerful emitters of high-energy photons, called gamma rays, in our galaxy (SN: 5/11/91, p.294). Known as 1E1740.7-2942, this body appears to intermittently spit out a torrent of gamma rays. But the exact origin of these emissions has remained a puzzle.

Now, French astronomers examining this body at radio wavelengths say their work can explain how some of these gamma rays are produced. Using the Very Large Array radiotelescope near Socorro, N.M., the team found that 1E1740.7-2942 has a compact, radio-wave-emitting core that radiates in sync with the gamma rays. In addition, the core appears to send out beams of charged particles along two equal, opposite jets.

Both the jets and the intense gamma rays suggest that this enigmatic Milky Way resident is a burned-out "mini-quasar" that may have a star-size black hole lurking at its center, the astronomers note. "The mass and other parameters may differ from a quasar, but the physics is the same," says I. Felix Mirabel at the Centre d'Etudes de Saclay in Gif-sur-Yvette. He and his colleagues detail their findings in the July 16 NATURE.

In a commentary accompanying the NATURE article, E. Sterl Phinney of the California Institute of Technology in Pasadena cautions that the jets may not belong to 1E1740.7-2942. Instead, they may represent part of a distant radio galaxy that happens to reside in the same part of the sky. But if the jet finding does prove correct, it would account for some of the unusual properties of gamma rays emitted by 1E1740.7-2942, Phinney notes.

The Milky Way object sporadically spews out two patterns of gamma rays: high-energy photons that cover a broad band of wavelengths and those that cover a much narrower band. Both patterns peak at the wavelength of photons created when an electron collides with and annihilates its antimatter counterpart, a positron. That earlier finding prompted scientists to dub 1E1740.7-2942 the "Great Annihilator."

The broad-band emission represents the collision of positrons with nearby, warm electrons that have a wide range of kinetic energies. In contrast, the narrower-band emission requires a colder medium. The extended radio jets found by Mirabel's team suggest that beams of positrons emitted by the Great Annihilator slam into electrons located in a cold, dense molecular cloud about three light-years away. Gamma rays produced in such collisions would have the narrow-wavelength feature observed.

Despite extensive studies, astronomers have found similar radio jets in only one other X-ray source in the Milky Way. But Mirabel contends that jets could have eluded detection if they are weak and relatively diffuse. His team recently found indications that another strong Milky Way source, known as GRS1758-258, also has radio jets, Mirabel says. "Perhaps we have [previously] been missing this kind of phenomenon," he notes. *– R. Cowen*