# Profile emerges of well-rounded molecule

Buckyballs are really on a roll. Just six months after the publication of a remarkably simple recipe for making copious quantities of these unique, symmetric molecules, researchers have accumulated sufficient data to fill in important details of the substance's intriguing chemical and physical behavior.

As originally envisioned by its discoverers, a buckyball, or buckminsterfullerene molecule, consists of 60 carbon atoms arranged so that the atoms sit at the vertices of a polyhedron that matches the geometric pattern on a soccer ball (SN: 12/8/90, p.357). The new results confirm the predicted structure to a spectacular degree.

"It was too beautiful to be wrong," says chemist Harold W. Kroto of the University of Sussex in Brighton, England, who in 1985 contributed to the discovery and tentative identification of buckminsterfullerene ($C_{60}$).

Other recent findings shed light on the substance's behavior as a crystalline solid and suggest reasons for its apparent absence in interstellar space. Last week, more than two dozen researchers described their latest work with $C_{60}$ and related fullerenes at a special session of an American Physical Society meeting in Cincinnati.

The now-standard method for manufacturing solid $C_{60}$ produces a fine, black powder resembling soot or powdered graphite (SN: 10/13/90, p.238). Unlike soot and graphite, however, buckminsterfullerene dissolves in benzene to form a solution with a distinctive magenta color. From such solutions, researchers have managed to grow needle-shaped crystals up to 1 millimeter in length.

Studies of these crystals reveal that $C_{60}$ molecules pack together as if they were perfectly smooth balls rather than faceted polyhedra with preferred orientations. "The internal symmetry of the molecule apparently does not influence the symmetry of the solid," says Robert M. Fleming of AT&T Bell Laboratories in Murray Hill, N.J.

This evidence suggests that $C_{60}$ molecules spin as they sit in their positions in a well-defined crystal lattice. Computer simulations lend credence to that picture. "We can see how easy it is to induce rotations," says Jerzy Bernholc of North Carolina State University in Raleigh. "Almost no matter what you do, these molecules like to roll."

Cooling the solid from room temperature to 77 kelvins, the temperature of liquid nitrogen, stops the spinning. But spectroscopic measurements show that this cessation of spinning doesn't occur uniformly. Some molecules apparently stop spinning early, while others keep rotating during the cooling process.

"Why they would be rotating in one part of the solid and not elsewhere is really not understood," says Donald S. Bethune of the IBM Almaden Research Center in San Jose, Calif. "But by the time you get to 77 kelvins, all of them are pretty much locked [in place]."

Researchers have also looked at the effect of pressure on solid $C_{60}$. "It has some remarkable pressure properties — a very nonlinear compressibility," Fleming says. Initially, the material has about the same compressibility as graphite, but as the pressure increases, the compressed solid attains or perhaps even surpasses the hardness of diamond.

Armed with newly obtained $C_{60}$ spectra, several teams of researchers have searched for traces of buckminsterfullerene in potential natural sources such as chimney soot, meteorites, and interstellar dust and gas. "The bottom line is that we haven't found it yet," reports Donald R. Huffman of the University of Arizona in Tucson.

That leaves a puzzle. "Since $C_{60}$ is so easy to produce by vaporizing carbon in a helium environment," Huffman asks, "why is it not observed in abundance by means of interstellar spectroscopy? Why has it not been detected on Earth?"

One reason may be that the molecules exist as ions, solid grains, or molecules trapped on grains instead of as free molecules. Such modified forms would absorb wavelengths of light different from those absorbed by free molecules. "We don't know the ion spectrum well yet," Huffman says.

Laboratory experiments also reveal that hydrogen — a major constituent of stars and interstellar gas clouds — inhibits fullerene growth. Furthermore, oxidation may account for the destruction of terrestrial $C_{60}$.

"There is a great opportunity for vast amounts of it to be made, but it's a question of how well it survives," says Richard E. Smalley of Rice University in Houston.

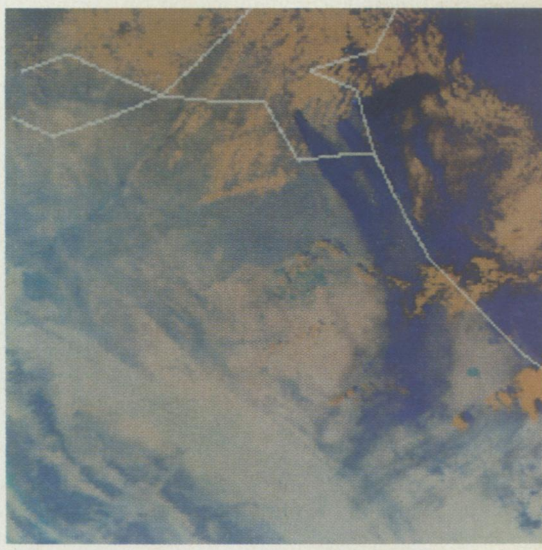
"After just a few months, we know a lot about $C_{60}$ as a molecule and as a solid," says Donald M. Cox of the Exxon Research and Engineering Co. in Annandale, N.J. But chemists have barely started to explore the possibility of modifying buckyballs by adding atoms of elements such as hydrogen or chlorine to their surfaces and using them as the basis for building more complicated molecules, he notes.

"That's where the future will be," Cox says. "Either this molecule will be merely a unique molecule or it will be like the benzene of organic chemistry — the prototypical molecule of fullerene chemistry."

"We're still at the point of cataloging and data collecting in trying to understand how this material works," Fleming says. "I'm pleased we've been able to understand what we've seen so far, but it's still early, and new things are coming out all the time."

*— I. Peterson*

## Satellite depicts Kuwaiti oil-well fires



NASA Langley

*Though the war has cooled off under a conditional ceasefire, the fires set in hundreds of Kuwaiti oil wells have yet to cease burning. The blazes could persist for years, spewing smoke and gas laden with carbon and sulfur compounds. This image, taken by the NOAA-11 meteorological satellite on Feb. 21 and obtained by Science News on March 22, shows two dark plumes of smoke from burning oil wells in southern Kuwait. The plumes, partially hidden by clouds (yellow areas), have drifted more than 300 kilometers into Saudi Arabia.*

*Atmospheric chemists at NASA's Langley Research Center in Hampton, Va., use the satellite to track the smoke and to analyze its contents. The dark plumes in the image indicate that smoke from the fires in Kuwait contains much more soot than forest-fire smoke, which appears white or gray in satellite images, says Langley's Joel S. Levine. Kuwaiti oil is especially noxious when it burns, he notes, because it contains more sulfur and carbon than other types of oil.*

*Because the fires are not intense enough to send soot into the stratosphere, they pose regional health hazards but no threat of a global "nuclear winter," Levine told Science News. "That's good for the globe," he says, "but not so good for those living in the Gulf region."*