Filling and fathoming fullerene molecules

Just as jelly-filled doughnuts have extra appeal, so do metal-filled fullerenes. Several research groups report that they have inserted up to four metal atoms into these cage-like, all-carbon molecules, paving the way for a new class of fullerene materials.

Other new successes in understanding and manipulating fullerenes include isolating large fullerenes, making fullerene polymers and chemically modifying the 60-carbon version called the buckyball. Chemists described these results at last week's Materials Research Society meeting in Boston.

Mark M. Ross and his colleagues at the Naval Research Laboratory in Washington, D.C., made fullerenes with one or more yttrium atoms inside and studied them with two kinds of mass spectroscopy. They created the material by using a laser to vaporize yttrium powder in a chamber with graphite and fullerenes. The researchers suspect that the laser causes a fullerene molecule to open up and trap a metal atom, explains Ross. Sometimes, two or more of the opened, metal-filled fullerenes collide to form a larger molecule with multiple atoms inside.

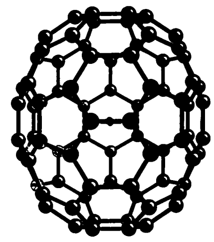
At the University of California, Los Angeles, a group led by Robert L. Whetten has created numerous metal-filled fullerenes — predominantly 80-carbon molecules containing two lanthanum atoms each. The team finds that while high-speed fullerenes bounce back when they collide with silicon surfaces, those with metal atoms inside do not rebound as readily.

Constantino S. Yannoni and his colleagues at IBM's Almaden Research Center in San Jose, Calif., made microgram quantities of various fullerenes containing lanthanum, scandium or yttrium atoms. When they heated the resulting materials, they discovered that one form of the 82-carbon fullerene had converted into another form, with the metal still inside. The IBM group used electron spin resonance spectroscopy to analyze the distribution of electrons in these substances and found that the metal atoms inside give up a total of three electrons to the fullerene, Yannoni says.

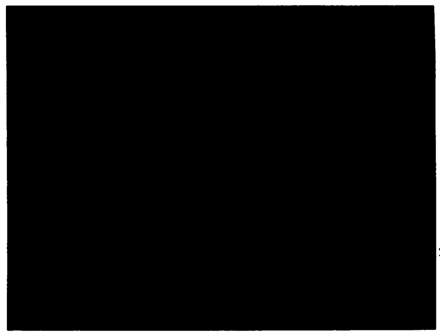
"These [new reports] are the first independent confirmations that metal-containing fullerenes have been made," notes Richard E. Smalley, whose group at Rice University in Houston first reported putting atoms inside a buckyball (SN: 8/24/91, p.120).

Researchers get a variety of sizes when they create metal-fullerene complexes. The Rice team's most common product is the 82-carbon molecule with one lanthanum or yttrium inside, says Smalley. He and his co-workers believe they have also produced molecules with four lanthanum atoms lined up like peas in a long fullerene pod. He notes, however, that no one yet has successfully separated filled from empty fullerenes for further study.

Computer models of turtlene (near right) — a 78-carbon fullerene resembling a turtle shell — and a 110-carbon fullerene with four lanthanum atoms inside (far right).



Whetten/UCLA



Smalley/Rice Univ.

Organic chemist Fred Wudl says his group at the University of California, Santa Barbara, can add up to six carbon atoms, one at a time, to a buckyball without destroying the molecule's soccerball shape or properties.

In addition, Wudl says he and his colleagues are working on two kinds of fullerene polymers. One strings the fullerene molecules like pearls in a necklace; the other dangles them from a central backbone like charms from a bracelet. Douglas A. Loy at Sandia National Laboratories in Albuquerque, N.M., also reports making a buckyball polymer.

Paul J. Krusic, a materials scientist at the Du Pont Central Research and Development Experimental Station in Wilmington, Del., says his team finds buckyballs "extraordinarily reactive to free radicals." This ability to soak up charged molecules suggests that fullerenes may prove useful as catalysts. — *E. Pennisi*

False-color image hints at Gaspra's origin

Black-and-white is nice, but color really makes a difference.

Last month, NASA released the first close-up image of an asteroid: a black-and-white photo of a body called 951 Gaspra. The Jupiter-bound Galileo spacecraft took that photo through a green filter (SN: 11/23/91, p.326). This week, the space agency released two color portraits of Gaspra, created by combining Galileo images taken through violet, green and near-infrared filters. These color images offer several new clues about the surface composition and origin of the body, says Galileo researcher Joseph Veverka of Cornell University.

NASA/JPL

False-color portrait of the asteroid 951 Gaspra. Blue patches denote areas of highest infrared absorption.

Viewed in a mix of hues that approximates natural light, the yellowish, nearly uniformly colored asteroid appears covered with rocks somewhat less gray than rocks on the moon. A second, false-color portrait enhances the subtle variations in color across the surface of Gaspra.

Veverka notes that the infrared-dark patches on Gaspra coincide with ridges and the freshest craters. He and other researchers say this finding bolsters speculation that a type of rocky covering, called regolith, blankets most of Gaspra's surface to a depth of perhaps 1 meter. The dark patches near craters, Veverka says, may represent areas where an impact has scraped away the regolith, exposing material — possibly the mineral olivine — that absorbs near-infrared light. Dark patches on ridges may indicate regions where regolith has rolled downhill and exposed the underlying rock.

While both moons of Mars and the Jovian moon Amalthea display a similar regolith pattern, the tentative finding on Gaspra puzzles some astronomers, Veverka notes. They had theorized that the asteroid's rocks were too hard to fragment into regolith. Moreover, Gaspra should lack the gravity to hold this soil on its surface. Veverka argues, however, that such models may need revision.

Gaspra's muted color variations, most of which can be accounted for by regolith, hint that the asteroid represents an intact chunk from a primitive, chemically uniform parent — some object whose composition has remained unaltered since the solar system formed, Veverka says. But Michael J. Gaffey of the Rensselaer Polytechnic Institute in Troy, N.Y., cautions that Gaspra's small size suggests an alternative lineage: It may represent a chip off some uniform layer within a chemically diverse parent.

Higher-resolution images from Galileo — not expected until next spring because of continuing problems in transmitting data to Earth — could settle such speculation, Veverka says. — *R. Cowen*