Making chicken wire of molecular size

Nine years ago, chemist Orville L. Chapman had one question in mind when he traveled to Germany on a fellowship: "If God would give me one molecule to make, what would that molecule be?" His goal ever since: to build an 80-carbon molecular ball, a lesser-known member of a recently recognized class of spherical molecules called fullerenes.

In Honolulu this week, at the International Chemical Congress of Pacific Basin Societies, Chapman reported making molecular-scale "chicken wire" and other exotic materials, all of which have recently emerged from his efforts to develop a step-by-step laboratory method for building his chosen molecule.

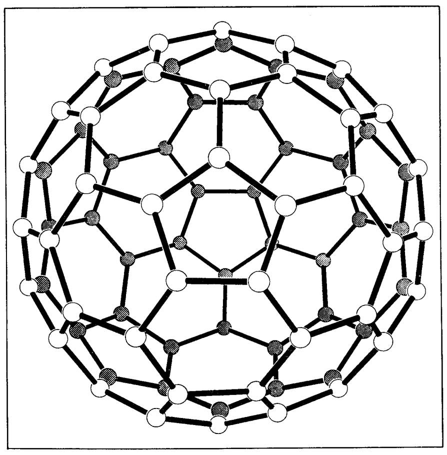
Most famous of the fullerenes is buckminsterfullerene, a 60-carbon, soccer-ball-shaped molecule whose interlocking hexagonal and pentagonal facets resemble the geodesic domes designed by engineering visionary R. Buckminster Fuller. For about five years, researchers have been assembling evidence that the diminutive soccer balls and other carbon spheres form in the sooty wake of laser-zapped graphite. The remarkably stable C-60 molecule forms in almost any soot-producing environment, notes fullerene chemist Richard E. Smalley of Rice University in Houston. It may even populate interstellar space (SN: 1/28/89, p.56).

Rather than relying on laser blasts, which produce fullerenes through unknown mechanisms, Chapman aims to design sequences of chemical reactions for methodically assembling both the C-60 and C-80 spheres. "We're trying to make halves of these molecules and then put those halves together" — a goal that remains elusive, says the University of California, Los Angeles, researcher.

Those efforts have, however, led to the discovery of structurally exciting molecules that might serve as ingredients for new materials, such as selectively permeable membranes for filtering gases from liquids, or for very hard materials of remarkably low weight, Chapman told SCIENCE NEWS.

The molecular chicken wire — which Chapman named azite because it incorporates nitrogen (once called azote) from the reaction environment during its formation — begins as small, triangular molecules that virtually self-assemble when dissolved in an organic solvent. "It's a structure that wanted to be," Chapman says. The chicken-wire molecules aggregate into azite, a black, ceramic-like material about as hard as quartz yet only three-fifths as dense.

Chapman also reports making all-carbon polymers with molecular weights hovering around 18,000 daltons, comparable to small proteins. Growing in three dimensions, these soluble megamolecules bind oxygen and, to a lesser degree, carbon dioxide.


Chapman

This 80-carbon molecular sphere tops Chapman's wish list of molecules to make.

"All we've ever had are infinite network polymers [of carbon], such as graphite and diamond," Chapman says. Though the all-carbon polymers contain well over 1,000 atoms, "these things are stable molecular forms of [pure] carbon," he says. And, while he has yet to coax any of his structures into a sphere, Chapman says he expects the pursuit to yield more surprises and, eventually, some practical new materials. — *I. Amato*

Cold fusion — or something

Despite widespread skepticism about earlier claims, some research teams continue to conduct cold fusion experiments. Several of these described mysterious results last week at the San Francisco meeting of the American Society of Mechanical Engineers.

"Anomalous effects have been seen often enough that the phenomena can't be explained away as artifacts," says Charles D. Scott of Oak Ridge (Tenn.) National Laboratory. For instance, Gordon E. Michaels of Oak Ridge reports evidence of anomalously large amounts of heat emerging from his group's Pons-Fleischmann-type electrolysis experiments, which involve palladium electrodes immersed in heavy water (SN: 4/1/89, p.196). In addition, Scott told SCIENCE NEWS, the group intermittently detected neutrons and tritium, two predicted products of fusion reactions involving heavy water. He notes that the sporadic effects, which defy conventional wisdom, disappear in experiments using regular water.

Peter L. Hagelstein of MIT proposes a "coherent fusion theory" to explain these and other anomalous observations. Such results, he suggests, could stem from unconventional nuclear reactions that produce low-energy photons and thus yield an unconventional profile of fusion products. □

Forcing the details of contact charging

When two different surfaces are brought into contact and then separated from each other, they often end up oppositely charged. Such electrostatic charging occurs when balloons rub against sweaters, shoes shuffle across carpets and toner particles in photocopiers bump into carrier beads. Now, with the aid of a novel instrument for pinpointing the location of small amounts of excess charge on an insulating surface, researchers are getting their best look yet at what happens during contact electrification.

Despite its everyday occurrence and technological importance, contact electrification has long mystified scientists. The main questions concern whether two materials in contact exchange electrons, ions or charged bits of material and precisely where those mobile charges end up when the materials are separated.

"If it were possible to identify such sites with near-atomic resolution, then a deeper understanding of the [contact] electrification process might result," Bruce D. Terris and his colleagues at the IBM Almaden Research Center in San Jose, Calif., write in the Dec. 11 PHYSICAL REVIEW LETTERS.

To locate charges deposited by a single contact between a metal and an insulator, Terris and his group use a specially modified force microscope. This scanning microscope's key element is an L-shaped piece of nickel wire mounted so that its sharp tip hangs over a sample. The wire vibrates with a characteristic frequency, and any forces acting on it change this frequency. A special modification of the basic instrument allows researchers to locate and distinguish between positive and negative charges in a single scan across a surface.

"It's a new way to look at [contact electrification]," Terris says.

Initial experiments involved contact between the microscope's nickel tip and a thin sheet of a polymer known as polymethyl methacrylate. Although results varied somewhat from trial to trial, the researchers found that charged areas were often substantially larger than the expected contact area and contained both positive and negative charges.

"This bipolar charging is a surprising result and, to our knowledge, has not been observed in previous [contact charging] experiments," they report.

At present, the force microscope can detect clusters of charge equivalent to three electrons with a spatial resolution of 2,000 angstroms. "Our hope is to develop more sensitive techniques so you can really look at specific sites on a surface to see where and what the charge is," Terris says. — *I. Peterson*