Chemistry

'Buckyball' II: The game continues

In just a few months, the newly discovered molecule C_{60} – buckminsterfullerene, or "buckyball" for short – has become the center of a wide range of theoretical and laboratory investigations (SN: 11/23/85, p. 325). This molecule appears to have a geometric structure like the pattern on a soccer ball. Its high degree of symmetry indicates that the molecule is probably quite stable and may have some unusual properties.

The molecule, essentially a hollow sphere, has a diameter of about 7 angstroms. This provides an inner cavity that may be large enough to hold various atoms. Reporting in the Dec. 11 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, a group of chemists now says it has evidence for the formation of a stable complex consisting of a single lanthanum atom surrounded by a C_{60} carbon shell.

In their experiments, chemist Richard E. Smalley and his colleagues at Rice University in Houston used a laser to vaporize spots on a graphite disk impregnated with lanthanum ions. The ejected carbon clusters were ionized and carried in a stream of helium gas through a mass spectrometer. The resulting measurements showed the presence of various carbon clusters, several of which included a single lanthanum atom. None of the clusters appeared to pick up a second metal atom.

There's room inside the molecule for atoms as large as uranium, says Smalley. "It's incredible that there should be a stable molecule with such a large vacuum inside," he says. "It's like a little, portable vacuum system." The chemists are finding that some atoms, such as calcium, are easy to get inside the carbon spheres, but others, such as iron, don't seem to fit in very well.

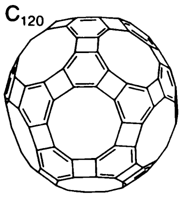
If a way can be found to synthesize C_{60} molecules on a large scale, then "the chemical and practical value of the substance may prove extremely high," the researchers say. "It would be a very bizarre substance," adds Smalley. A mass of uranium-containing buckyballs, for instance, would be as easy to cut as butter. Compounds like $C_{60}F_{60}$, if they can be created, may be "superlubricants." However, no one yet knows how stable the molecules would be when two or more come together.

Nevertheless, buckyballs could be created under the violent conditions that accompany exploding carbon-rich stars. These cosmic soccer balls could be sites for chemical processes leading to the formation of interstellar molecules. The researchers also speculate that this especially stable and symmetrical carbon structure provides a possible catalyst or intermediate in the chemical processes that led to the origin of life on earth.

Recent results suggest that many carbon clusters containing an even number of atoms, from 40 to beyond 80, are also relatively stable and remarkably unreactive. They, too, may be closed spheroidal shells, says Smalley. C_{70}, for instance, probably incorporates an extra band of hexagons to give the molecule an egg-shaped structure.

"The more we think about it," says Smalley, "the more we think this has a lot to do with the mechanism for the generation of soot." Soot particles tend to be spherical. Each one may have a buckyball at its core.

C_{120}



Haymet

Theoretical chemist A.D.J. Haymet of the University of California at Berkeley suggests that the molecule C_{120} may also be stable. Like C_{60}, it is highly symmetrical. However, the carbon atoms at each vertex are not in identical environments, says Smalley, but in mirror-image arrangements.

"Every day there's a new thing to puzzle over, wonder about or think of," says Rice's Robert F. Curl. "It's really been exciting. It captures the imagination because the symmetry is so beautiful."

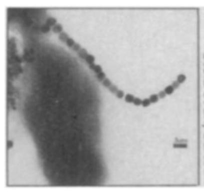
Earth Sciences

Stefi Weisburd reports from San Francisco at the meeting of the American Geophysical Union

Marine magnetite made by bacteria

Magnetite, the iron oxide mineral used in the earliest compasses, becomes imprinted with the earth's magnetic field after it has been heated to high temperatures. This is why geologists interested in the past orientation of the geomagnetic field typically study rocks that were heated up or churned out by volcanoes. Yet geologists also find small magnetite particles in marine sediments that have never been subjected to the requisite high temperatures. "No one has really come up with a good way to explain how this particular component of magnetite gets there," observes John F. Stolz.

Some scientists have suggested that this magnetite is produced by marine invertebrates called chitons, which grind down their magnetite-containing teeth when eating algae embedded in limestone. But Stolz and others have more recently come to believe that the main source of the magnetite in marine sediments is bacteria. Such "magnetotactic" bacteria, able to orient themselves in the geomagnetic field by building an internal compass or chain of magnetic particles, have been found in beach sands and lakes (SN: 4/26/80, p. 267). Now Stolz, Shih-Bin R. Chang and Joseph L. Kirschvink at Caltech in Pasadena, Calif., have discovered live magnetotactic bacteria and their magnetite chains in the open sea, from sediment cores taken 598 meters underwater in the Santa Barbara basin. Stolz's conclusion that the magnetite grains in these sediments were made by bacteria is based on the grains' distinctive, highly regular shape and their size, 50 to 150 nanometers in diameter. This is the optimum size for recording the earth's magnetic field, says Stolz. The alignment of smaller grains would be upset by thermal vibrations, and larger grains would have a smaller net magnetic moment.



Stolz et al./Caltech

Magnetite chain.

Scientists think the magnetotactic bacteria may use the geomagnetic field, which tends to point into or out of the earth, to find their way toward the oxygen-poor sediment layers in which they like to live. If so, traces of magnetotactic bacteria in the rock record might be used as indicators of past oxygen depletion. Stolz next plans to look for magnetotactic bacteria in Pacific cores taken 6,000 meters underwater. Their presence at such depths could indicate that these bacteria play an important role not only in producing magnetic marine sediments but also in the planet's iron cycle. For now at least, says Stolz, "in the marine environments we've looked at, [the bacteria] are almost the sole source of the ultrafine-grain magnetite in marine sediments today."

New data resolve a stressful problem

Five years ago, when Mary Lou Zoback of the U.S. Geological Survey in Menlo Park, Calif., and Mark D. Zoback of Stanford University compiled stress measurements of the North American continental crust, they were left with a perplexing problem: Compressive stresses along the Eastern Seaboard ran in a northwest direction, while stresses in the rest of the continent, out to the Rocky Mountains, were oriented toward the northeast (SN: 6/14/80, p. 372). Moreover, both of the two main theories explaining why the continent is stressed predicted northeast stress from the Atlantic to the midcontinent.

"When we did the original compilation we included everything we could get our hands on because there wasn't much data," says Mary Lou Zoback. Now, with many more and better stress measurements, the Zobacks report that stresses along the East Coast range between north-45° east to north-70° east. The revised North American stress data still do not reveal which of the stress theories is correct, but at least the stress pattern puzzle has been resolved.