SCIENCE NEWS of the week

Fullerenes Found in Old Rock, Space

A Russian geochemist who happened to notice similarities between his micrographs and those of an officemate has uncovered the first evidence that the round, all-carbon molecules called fullerenes occur naturally on Earth.

During the past two years, chemists have made and modified a potpourri of fullerenes in the lab. At the same time, many scientists have searched in vain for signs of naturally occurring fullerenes in meteorites, coal and all kinds of soot.

Now, Semeon J. Tsipursky, working with geochemist Peter R. Buseck at Arizona State University in Tempe, has found 60- and 70-carbon fullerenes in the film that lines tiny cracks of a shiny black rock called shungite. The researchers report the finding in the July 10 SCIENCE.

Using high-resolution transmission electron microscopy, Tsipursky first noted that some shungite images contained the same array of white circles and black centers that characterized micrographs of synthetic fullerene samples. Buseck then sent a variety of samples to chemist Robert L. Hettich at Oak Ridge (Tenn.) National Laboratory. Using mass spectrometry, Hettich analyzed them without knowing that any came from a natural source. He confirmed the presence of fullerenes.

To rule out any possibility that fullerenes had formed when he used a laser to vaporize fullerenes from the samples for mass spectrometry, Hettich repeated the analysis, but this time vaporized fullerenes by heating the powder with a stainless steel probe.

"You will not see fullerenes if they are not in the sample," says Hettich. He also looked at a variety of other kinds of carbon-containing materials under the same conditions and found no fullerenes in any except the shungite. "And it's not in trace level amounts," he notes.

More than just the finding of natural fullerenes has caught the eye of fullerene experts. "I am not surprised that C_{60} has been found in terrestrial deposits, but I am somewhat surprised that it appears in such a pure crystalline form," comments Harry Kroto of the University of Sussex in Brighton, England. "It probably will point to new methods of making C_{60}."

Chemists typically produce these molecules by vaporizing carbon to form a soot containing a mixture of carbon compounds. On shungite, fullerenes may have formed as a solid layer. "We've only found one way to produce them; maybe nature has found other ways," says Wolfgang Krätschmer, a physicist at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany. He helped develop bulk synthesis of fullerenes.

Fullerenes require very high temperatures and specific chemical conditions to form. Thus, if found to be common, their presence could tell geologists much about the environment during the time when these carbon molecules came into existence, Buseck says. "But it's a big puzzle at this point," he adds.

Buseck has one small piece of the carbon-rich shungite, obtained in 1985. To verify the presence of fullerenes, researchers must procure more of the 600-million-year-old rock — no easy task, since it exists only outside the remote Russian town of Shunga, near Finland.

But more such discoveries seem likely. Just last month, another group reported finding fullerenes among microscopic debris left by a very small meteorite that had collided with a satellite. The extraterrestrial fullerenes showed up during a comprehensive analysis of debris in a dented piece of the Long-Duration Exposure Facility (LDEF), which orbited Earth for about five years, says Filippo Radicati di Brozolo, a chemist at Charles Evans & Associates in Redwood City, Calif.

Like Hettich, Radicati di Brozolo took many precautions to ensure that fullerenes did not form during the analysis. In addition, his team showed that these round molecules probably came from the tiny space rock itself rather than forming when the carbon-rich meteorite struck LDEF. He and his colleagues described their findings at the Second LDEF Post-Retrieval Symposium, held in San Diego.

— E. Pennisi

Nanotechnology yields transparent magnet

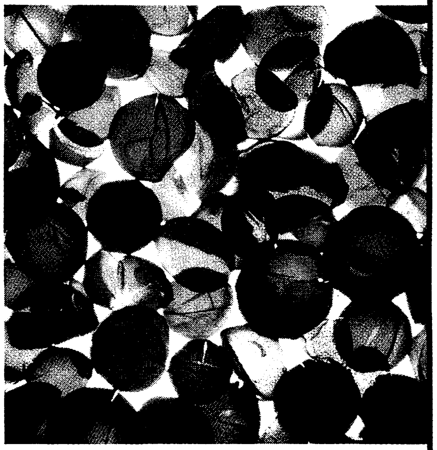
Scientists searching for new materials have created one that not only exerts a strong magnetic force at room temperature but also conducts light.

Ronald F. Ziolo, a chemist at the Xerox Webster Research Center in Webster, N.Y., and his colleagues made a new version of iron oxide, the stuff of rust, but also — in a slightly different form — a coating for audio cassettes and video tapes. Typically, iron oxide absorbs light. But unexpectedly, tiny iron oxide particles measuring 2 to 10 nanometers across become three to 10 times more transparent than the bulk form, the group reports in the July 10 SCIENCE.

Ziolo initially hoped to create transparent magnetic particles for use in duplicating color images. But this nanocomposite works so well that it shows promise as a medium for information storage or as a coolant in magnetic refrigerators, he says.

This material outperforms transparent iron fluoride and iron borate compounds, which are only weakly magnetic. Moreover, the other known transparent magnetic materials work only at extremely low temperatures, says Ziolo.

The small size of the iron oxide crystals leads to the stronger magnetic properties, he adds. Each contains just one magnetic domain, so the crystals stick to a magnet but not to each other. Thus, in a magnetic field, all the magnetic moments line up and work together to create a strong magnetic pull. Larger particles contain multiple domains, so some moments effectively cancel others out, weakening the magnetic properties.



Ziolo *et al.*/Xerox

Microscopic orange beads of new, see-through magnet.

Working with materials scientists from Cornell University in Ithaca, N.Y., Ziolo makes these orange magnetic beads in an ion-exchange resin used commercially as a water softener. "The resin is very critical to giving you the size and type of particle needed," he says. Ziolo thinks this technique will also prove useful for making a variety of new nanocomposites.

First, the researchers add iron to the polymer resin. Next, they oxidize the iron, then wash and dry the particle-laden polymer. By repeating this process nine more times, they can increase the iron content from less than 10 percent to about 40 percent, says Ziolo. With each repetition, the magnetic strength increases because the added iron makes new particles instead of enlarging existing particles.

— E. Pennisi