Physical Sciences

Taking apart a single molecule

IBM Almaden Research Center

The scanning tunneling microscope, invented only a few years ago, is already an important tool for obtaining images that reveal the locations of individual atoms on surfaces (SN: 10/25/86, p.262). Lately, scientists have also been investigating the use of the same apparatus for altering surface structures and for manipulating matter at the atomic level. Now a team of researchers at the IBM Almaden Research Center in San Jose, Calif., reports success in pinning small organic molecules to a graphite surface. The researchers also have evidence indicating that they were able to split a pinned molecule into smaller pieces — perhaps the most delicate chemical surgery yet performed.

"We've all learned about molecules in school," says John S. Foster, who led the research. "We'd like to see them firsthand, and we'd like to try to take them apart and put them back together firsthand. That's the ultimate goal."

The key component of the scanning tunneling microscope is an extremely sharp needle that rides just above the surface being scanned. As the needle skims the surface, electrons flow between surface atoms and the needle. By continually adjusting the needle's height to keep the current constant, researchers obtain an image of the surface.

Foster and his colleagues found that by applying a brief electrical pulse—about 4 volts for 100 nanoseconds—through a needle dipped into a small liquid droplet lying on a graphite surface, they could pin individual organic molecules such as phthalates (see molecular model shown in top photograph) to the surface. Then, using the microscope (shown below the molecular model), they could obtain an image of the organic molecule against a graphite background (bottom photograph).

"We're using short pulses to manipulate matter, and we think we can undo what we've done," says Foster. "But it's not a fully reliable process." The result of applying an electrical pulse is somewhat unpredictable. Often, a second pulse applied near a pinned molecule erases the molecule from the surface. Sometimes, however, only a piece of the molecule disappears. This suggests that the molecule had been cleaved.

What causes certain organic molecules to stick to graphite also isn't known yet. The process works with some types of molecules and not with others. "Clearly, more theoretical and experimental work is necessary to determine the mechanics of the process," the researchers report in the Jan. 28 NATURE. "Although much work remains to be done, we believe that tunneling microscopy is on the threshold of a revolution in manipulating atoms and molecules for a variety of purposes."

Previous surface-alteration studies by other researchers had focused, for example, on depositing small groups of germanium atoms on a germanium surface. In other words, they used the apparatus to "write," then "read," an atomic message. "The work of Foster [and his colleagues]," says J.B. Pethica of Oxford University in England, "represents a significant attempt at the much more important and difficult problem of the direct manipulation of the structure of biological materials."

Technology

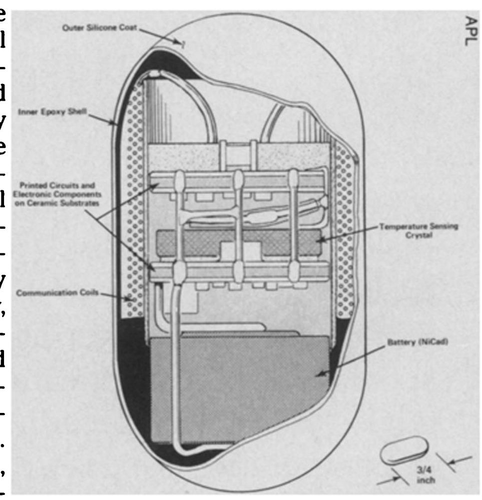
Space lasers may benefit blood banks

Researchers are using dyes and lasers to kill disease-causing viruses, including the one that causes AIDS, in stored blood. The Department of Defense, which financed part of the research, is touting the laser technique as a positive spin-off of its "Star Wars" program. In fact, in research published in the January/February TRANSFUSION, the system is reported to have a 100 percent viral kill rate without any detectable damage to normal blood elements — a better kill rate than its parent system is expected to have against incoming Soviet missiles.

More thorough screening of donated blood has successfully reduced the risk of viral contamination. But screening procedures are expensive and time-consuming, may generate false results and are altogether incapable of detecting some viruses. The new treatment, developed by a team of researchers at the Baylor (Tex.) Research Foundation, Southern Methodist University in Dallas and the Southwest Foundation for Biomedical Research in San Antonio, treats flowing suspensions of blood with a light-sensitive dye and a narrow-wavelength xenon arc lamp. The dye preferentially binds to the protein envelopes that enclose the viral particles. When the dyed viruses are exposed to laser light, a chemical reaction occurs that destroys them.

The method is effective against measles virus, herpes simplex virus type 1, cytomegalovirus and the AIDS-causing human immunodeficiency virus at a flow rate of about one pint every 15 minutes. The researchers say it may also prove effective against other viruses with similar envelopes, such as hepatitis B, Epstein-Barr virus and human lymphotropic virus type 1. They predict it will be ready for use in blood banks within the next two to five years.

Subjects swallow space-age monitors



APL

Researchers are performing clinical trials on an ingestible, silicon-coated capsule that may someday take the place of more cumbersome medical monitors. The 3/4-inch capsule contains a telemetry system, battery, crystal temperature system and four ceramic substrates with electronic components. When swallowed, the disposable capsule senses internal temperature and sends the information via telemetry signals to a receiving coil that can be sewn into a T-shirt. The shirt is wired to a data-analyzing computer. A newer version will have additional channels for sensing heart rate, acidity, electrical conductivity and pressure — the latter a measure of gastric motility.

The device is being developed by a team of engineers at the Johns Hopkins Applied Physics Laboratory in Laurel, Md., with input from physicians, military personnel and other researchers interested in using ingestible monitoring systems. The work is funded by NASA.

Program manager Russel Eberhart says the team is working on an ambulatory receiver the size of a calculator that can record for a day and then download transmitted data to a computer for analysis. Says Eberhart: "Technology has finally caught up with the size of the gastrointestinal tract."