stopping the light exposure, thus giving the researchers control over the shape and size of the nanoparticles.

"When you go from a sphere to a prism you get new properties—new optical properties, electrical properties, chemical properties, and catalytic properties," said Mirkin, who is the George B. Rathmann Professor of Chemistry at Northwestern. "It's the same material, but a different shape and size. And that makes all the difference."

Polythiophene Nanowires Written onto Si Wafers

Chemists at Duke University have prepared polythiophene nanowires on semiconducting and insulating Si wafers using an atomic force microscope-based direct-writing technique: electrochemical dip-pen nanolithography. Faculty members J. Liu and M.W. Grinstaff and graduate students B.W. Maynor and S. Filocamo report in the January 30 issue of the *Journal of the American Chemical Society* that 3,4-ethylenedioxythiophene (EDOT) can be electrochemically polymerized at an AFM tip/Si surface interface to afford well-defined sub-100-nm wires of poly-EDOT. To pattern these nanostructures, an EDOT-coated AFM tip is translated across the Si wafer while a negative bias voltage is applied to electrochemically polymerize the monomer. Nanowire morphology is controlled by applied voltage and tip translation speed.

According to Grinstaff and Liu, the capability to pattern poly-EDOT on insulating surfaces provides a means to use this polymer in future nanodevices. When combined with other micro- and nanofabrication techniques, this approach provides opportunities for designing and developing devices for a wide range of applications in the electronics, pharmaceutical, and biotechnological industries, they said.

Supercritical-Fluid-Extraction Method Cleans Radioactive-Contaminated Soil

By applying a ligand-assisted supercritical-fluid-extraction method, chemists at the Idaho National Engineering and Environmental Laboratory have decontaminated a sample of soil spiked with ^{239}Pu and ^{241}Am. They used pressurized, heated carbon dioxide and an added metal-binding chemical compound to clean the soil, removing >69% of the plutonium and americium.

As reported in the October 2001 issue of *Radiochemica Acta*, a chemical agent added to the carbon dioxide flowed through the soil and grabbed the plutonium and americium, whisking the compound back into the fluid-like carbon dioxide. The carbon dioxide was then shunted out of the soil and depressurized, dropping the compound into a vial on its way back into the atmosphere. The researchers added ethanol and said they could add different chemical agents to improve the efficiency of the extraction.

The chemists reported that the supercritical-fluid-extraction method leaves the soil intact. Chemist Robert Fox said that other methods used, such as nitric-acid extraction, dissolved 25% of the soil mass. He said, "Dissolving soil in nitric acid creates a radioactive sludge that must still be disposed of."

The chemists said that the effectiveness of the supercritical-fluid-extraction method in removing radioactive elements from the soil depends partly on the chemistry of the soil. Soil particles are made up of minerals from rocks and clay, which react differently with radioactive elements. They said plutonium that is bound near the surface of a particle is easier to remove than that bound inside the mineral lattice.

In follow-up experiments, the researchers were able to remove close to 100% of the contamination. While they confirmed that their spiked soil serves as a suitable surrogate for a real-world sample, the chemists acknowledge that weather and aging can affect the chemistry of the materials bound to the soil.

Fox said, "We also want to have a fundamental understanding of the chemistry that occurs—why does it work that way, and what is inhibiting it from working faster and better."

Nanoscale Computing Machine Built with DNA Molecules

A group of scientists headed by Ehud Shapiro of the Computer Science and Applied Mathematics Department and the Biological Chemistry Department at the Weizmann Institute of Science, Israel, has used DNA molecules to create a nanocomputer. As reported in the November 22, 2001, issue of *Nature*, Shapiro and graduate student Yaakov Benenson used a solution consisting of DNA molecules and two naturally occurring DNA-manipulating enzymes: Fok-I and ligase. Fok-I functions as a chemical scissors, cleaving DNA in a specific pattern, whereas the ligase enzyme seals DNA molecules together.

The research team used the four DNA bases A, G, C, and T to encode the input data as well as the program rules underlying the computer "software." Both input and software molecules were designed to have one DNA strand longer than the other, resulting in a single-strand overhang called a "sticky end."

Two molecules with complementary sticky ends can temporarily stick to each other—known as hybridization—allowing DNA ligase to permanently seal them into one molecule. The sticky end of the input molecule encodes the current symbol and the current state of the computation, whereas the sticky end of each "software" molecule is designed to detect a particular state–symbol combination. A two-state, two-symbol automaton has four such combinations. For each combination, the nanocomputer has two possible next moves, to remain in the same state or to change to the other state, allowing eight software molecules to cover all possibilities.

The researchers reported that in each processing step, the input molecule was hybridized with a software molecule that had a complementary sticky end, allowing ligase to seal them together using two ATP molecules as energy. Then the Fok-I detected the recognition site in the software molecule.

It cleaved the input molecule in a location determined by the software molecule, thus exposing a sticky end that encoded the next input symbol and the next state of the computation. Once the last input symbol was processed, a sticky end encoding the final state of the computation was exposed and detected, again by hybridization and ligation, by one of two "output display" molecules. The resulting molecule, which reported the output of the computation, was made visible to the human eye by gel electrophoresis.

While the nanocomputer is too simple to have immediate applications, the researchers said it may pave the way for future computers that can operate within the human body with biological and pharmaceutical applications. □

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