Chemistry

Electrochemical superconductors

When the stakes are high, sometimes it's worth gambling on a longshot. In the race to find better ways of combining elements such as yttrium, barium, copper and oxygen to make high-temperature superconductors, that thought has pushed many researchers to try a number of novel techniques for synthesizing these materials. At the University of Illinois at Urbana-Champaign, chemist Andrzej Wieckowski and graduate student Debbie J. Zurawski are betting that electricity may do the job. They are investigating the possibility of using an electrochemical technique for synthesizing superconducting films. In the June JOURNAL OF THE ELECTROCHEMICAL SOCIETY, they report the successful incorporation of barium into a copper oxide film formed on a copper electrode, the first step toward producing a superconducting material.

The researchers dip a clean piece of copper foil into an alkaline barium hydroxide solution. Allowing the voltage applied to the foil to cycle between -1.4 and 0.725 volts produces a dark-colored copper oxide film on the foil. Analysis of the film, about 500 angstroms thick, reveals that it contains roughly one barium atom for every two copper atoms, a ratio close to that necessary for synthesizing a barium- and yttrium-based copper oxide superconductor.

In more recent experiments using a solution that also contains yttrium nitrate, the researchers have trapped both yttrium and barium atoms in a copper oxide film. However, the trick is to end up with the appropriate proportions of yttrium, barium and copper — a goal that hasn't been achieved yet. Once a process for obtaining the correct proportions is established, then the electrochemically deposited material would be carefully dried, fired to a high temperature to create the superconducting phase and heat-treated in oxygen to ensure the right oxygen content. "Right now, the problem is getting a film that doesn't crack up when it dries," says Zurawski.

An electrochemical approach offers the advantage of providing a film with the necessary ingredients already intimately mixed at the atomic level. That degree of mixing could lower the temperature and shorten the time needed to process the film to turn it into a superconductor. Present techniques generally require the use of finely ground powders, which must be fired at a high temperature for a long time to produce the superconducting material.

Inside a chemical soccer ball

When researchers found evidence that a cluster of 60 carbon atoms seemed to be particularly stable, they proposed that the molecule C_{60} has a geometric structure like the pattern on a soccer ball — a geometric shape consisting of 12 pentagons and 20 hexagons. They called the hypothetical molecule buckminsterfullerene (SN: 11/23/85, p.325). If it were to exist, this carbon cage would have an inner cavity large enough to trap a single atom or ion, providing an interesting environment in which to study atomic properties (SN: 12/21&28/85, p.396). Richard E. Smalley and his co-workers at Rice University in Houston have now assembled what they say are convincing experimental data confirming such clusters exist as closed shells capable of trapping metal ions. They report their findings in the June 22 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY.

In their experiments, the Rice researchers created the ion-containing carbon clusters by using a laser to vaporize a graphite disk impregnated with lanthanum, potassium or cesium salts. When these clusters were subsequently irradiated by another laser of sufficient power, they appeared to come apart in two-atom fragments, consistent with the types of carbon-carbon bonds that would be present in a closed, edgeless shell.

Food Science

New way to find contaminants in meat

When certain gases such as carbon dioxide are heated and compressed to densities that resemble liquids, they become "supercritical fluids" and suddenly assume the properties of solvents. Jerry King and his co-workers at the Agriculture Department's Northern Regional Research Center in Peoria, Ill., are adapting supercritical carbon dioxide to dissolve the fat out of meats — and with that fat any pesticides and drugs (such as antibiotics) that may be stored there. Because the method removes all available fat, it's not a technique for decontaminating foods that will be eaten. Instead, researchers envision it as a way for safety analysts to identify contamination when making random inspections of meats.

In tests conducted over the past several months, King pressurized carbon dioxide to between 5,000 and 10,000 pounds per square inch and passed it through samples of lard and ham that had been spiked with pesticides. One to two hours later, the supercritical fluid exited. As it depressurized back into a regular gas, microdroplets of the fat and chemical contaminants rained out, to be collected and quantified.

This process removed nearly 100 percent of the pesticides (lindane, endrin, heptachlor, TDE and dieldrin) present. King says the technique is about three times faster than extraction using conventional solvents and is potentially less costly and more effective at penetrating relatively low-fat meat products such as ham. Unlike chemical solvents, it poses no disposal hazard after use. Moreover, King says, this supercritical extraction is nontoxic — a major reason his agency asked him to explore the technology.

The enzyme for a low-cholesterol diet

By converting one double bond into a single bond, the enzyme cholesterol reductase changes cholesterol into coprostanol. And that change can be important, because unlike cholesterol, coprostanol is not absorbed by the human body. Researchers at Iowa State University in Ames are attempting to isolate and harness cholesterol reductase to lower the cholesterol content of milk, eggs, meats and butter.

Their work initially focused on *Eubacteria*, microbes that contain cholesterol reductase and inhabit the large intestine. They added *Eubacteria* to high-cholesterol foods and incubated them at the microbes' normal temperature — about 98.6°F. While this reduced the foods' cholesterol content 80 percent, it also caused the foods to spoil — an effect due at least in part to the temperature. That's one reason the Iowa researchers want to extract the enzyme and add it to foods directly.

Their most recent work suggests the microbes' conversion of cholesterol involves a three-step process — and possibly the activity of three genes. This suggests that identifying the operant genes and splicing them into other microbes — so that the enzyme could be commercially produced — might prove difficult, says Donald Beitz, a nutritional biochemist leading the work.

So now he's focusing on plants. Though cholesterol is made only by animals, Beitz and his co-workers recently found the enzyme that converts it to coprostanol in the leaves of cucumbers, corn, soybeans and peas. Moreover, their preliminary data suggest coprostanol synthesis by the plant's enzyme, may be a one-step process — involving one gene — and one gene might prove easier to splice into *E. coli* or other bacteria that might be used for commercially mass-producing the enzyme. Beitz envisions the day when the shells of eggs coming down a conveyor belt might be drilled open, injected with the enzyme (and perhaps with a pretreating enzyme) and resealed. By the time an egg is eaten, he says, its cholesterol might be all but gone.