Chemistry

Fashioning see-through metal

Do chickens have lips? Do doorknobs yodel? Can metal be transparent? The respective answers are no, no and you wouldn't think so. But it's time to rethink that last one.

The possibility of designing transparent metal films became clear several years ago to scientists at AT&T Bell Laboratories and their colleagues elsewhere. While testing the efficiency of semiconductor devices called photoelectrochemical cells, which gather solar energy to drive chemical reactions, they noticed there was no decrease in the rate of the reaction, which yielded hydrogen in this case, even when the cells were partially covered with platinum catalyst particles — the sites of hydrogen generation. The catalytic metal, deposited on the semiconductor surface as tiny, poorly interconnected metallic islands, behaved as though transparent. Such transparent metal catalysts might improve the efficiency of photoelectrochemical cells made with them, the researchers suggested. Another potential application of transparent metals, one chemist told SCIENCE NEWS, would be for "smart windows" made of see-through metal/polymer composites whose transparency could be varied at will.

Building on the earlier studies, Charles R. Martin and Michael J. Tierney of Texas A&M University in College Station found a way to make thin gold structures transparent to infrared radiation, and they expect to extend the transparency to visible wavelengths. The researchers use a ceramic membrane pocked with tiny, 200-nanometer pores as scaffolding for growing gold microcylinders in an electrochemical bath. They find that membranes with gold-plugged pores transmit about twice as much light as they would if the plugs were opaque. They reported this work in the April 20 JOURNAL OF PHYSICAL CHEMISTRY.

A theory known as the effective medium theory holds that an ensemble of metal microcylinders will be transparent to light of wavelengths much larger than the cylinders' diameter. An optical electric field induces a "screening charge" on the surface of the microcylinders, according to the theory. This prevents them from absorbing the light energy, which effectively gets "squeezed" into voids between cylinders. The result: More light gets through metal films with this type of microstructure than with a more continuous sheet-like structure. To make gold transparent to shorter, visible wavelengths, the researchers need scaffolding with pores 10 times finer than presently available.

Following the bouncing fusion ball

Because of extended inaction by chemist B. Stanley Pons and the cold-fusion players at the University of Utah in Salt Lake City, the Department of Energy's Los Alamos (N.M.) National Laboratory says it has ended negotiations with them for collaborative tests of the claims by Pons and British co-worker Martin Fleischmann of triggering energy-releasing, nuclear-fusion reactions at room temperature by immersing palladium rods in heavy water. "They don't call, they don't write," remarks a Los Alamos spokesman. In another no-confidence vote, the U.K. Atomic Energy Authority's Harwell Laboratory announced it was abandoning its months-old, labor-intensive and costly studies of the claims, despite help from Fleischmann in getting the experiments going.

On a more positive note that researchers say could turn out as misplayed, Los Alamos scientists doing cold-fusion studies have observed higher-than-expected levels of the possible fusion by-product tritium during an experiment, a suggestive but inconclusive sign that fusion reactions may be responsible. The researchers say they will feel confident about the result only after they replicate the finding and rule out alternative sources of the tritium observations.

Mathematics

The straight side of sliced circles

Cut a circle out of a sheet of paper. Then cut the circle into pieces so that the pieces, when fitted back together, form a square having the same area as the original circle. Such a task seems impossible. How do you get rid of the curves? But a Hungarian mathematician has now proved that it is theoretically possible to cut a circle into a finite number of pieces and rearrange them into a square. Miklós Laczkovich of Eötvös Loránd University in Budapest accomplishes this mind-bending feat in a 39-page manuscript now under study by mathematicians throughout the world. So far, no one has detected any flaws in his reasoning.

His work bears on the fundamental questions of what mathematicians mean by the notion of curvature and how they decide when two objects have the same area. The proof shows that present ideas about area are correct but curves and straight lines are so different they can be converted into each other only by using strange manipulations.

The problem solved by Laczkovich relates to an ancient riddle known to Archimedes and other Greek scholars. At issue is whether one can use just a ruler and compass to draw a square with an area equal to that of a given circle. The problem remained unsolved for centuries despite the efforts of numerous mathematicians, both amateur and professional. In the end, the solution hinged on the properties of the number pi, the ratio of a circle's circumference to its diameter. A circle and a square have equal areas only if the ratio between a square's side and a circle's radius equals the square root of pi. In 1882, mathematicians proved that pi is what they call a transcendental number, effectively ruling out the possibility of constructing a square out of a circle using only ruler and compass.

Laczkovich tackled a version of the problem originally devised in 1925 by mathematician and philosopher Alfred Tarski. Tarski removed the ruler-and-compass restriction and asked whether there is *any* way to cut up a circle into pieces that could be rearranged into a square of the same area. In the previous year, Tarski and Stefan Banach had proved a remarkable analog of the same conjecture in three dimensions, showing paradoxically that a sphere could be cut up and rearranged not only into a cube of the same volume but also into a cube of twice the volume. In fact, a sphere sliced up in just the right way could be rearranged into virtually any shape of any size.

Mathematicians who studied Tarski's circle problem strongly suspected no way existed to cut up a circle to make a square without losing even a single point out of the circle. In 1963, Lester E. Dubins, Morris W. Hirsch and Jack Karush of the University of California, Berkeley, proved the problem couldn't be solved by cutting a circle into "ordinary" pieces — which have well-behaved, relatively smooth boundaries — no matter how many such pieces are used.

Laczkovich has now proved that "squaring the circle" is possible, provided that the pieces have the right form. His pieces encompass an array of strange, practically unimaginable shapes. Although some resemble those in an ordinary jigsaw puzzle, others are collections of single, isolated points, curved segments or twisted bits riddled with holes. Remarkably, assembling a square from these pieces of a circle is possible simply by sliding the pieces together. No piece has to be rotated to fit into place. The resulting square has no gaps and no overlapping pieces. Laczkovich estimates this effort requires about 10^{50} pieces — almost as many pieces as there are water molecules in the Mediterranean Sea.

Laczkovich's proof applies not only to circles but to almost any plane figure with a mathematically well-behaved boundary. Any such figure can be cut and rearranged into a square of the same area with no gaps or overlaps.