Chemistry

A polymer to burn

Usually, polymers burn slowly, more like a candle than a rocket. Before combustion can occur, the polymer must break down, and this polymer degradation process generally requires a continuous supply of energy. Now, two Indian chemists have found a polymer that releases energy when it breaks down. Once a sample is ignited, the polymer degradation sustains itself, proceeding automatically. The polymer, poly(styrene peroxide), then burns at a rate comparable to that of solid rocket fuels.

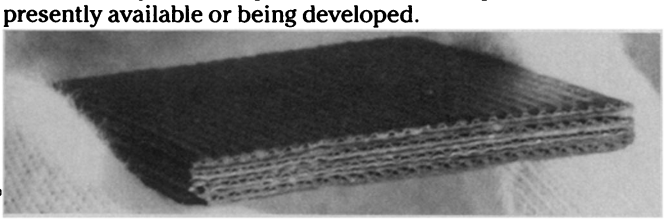
The researchers found two major degradation products, benzaldehyde and formaldehyde, which are themselves combustible. They discovered that introducing additives to the polymer can either accelerate or decelerate degradation and burning. The addition of nitrobenzene, for instance, slows both stages but appears to have no effect on how the degradation occurs.

This rare example of an autocombustible polymer, say Kaushal Kishore and T. Mukundan of the Indian Institute of Science in Bangalore, is "an ideal candidate" for development as a special fuel. Their report appears in the Nov. 13 NATURE.

Fueling with a lightweight

Researchers at the Argonne (Ill.) National Laboratory have designed and built a fuel cell that has produced the highest electrical current density ever recorded for an all-solid fuel cell. According to Argonne, this new, lightweight energy source, if scaled up, could deliver twice the power and fuel economy supplied by an internal combustion engine of equal weight. "For the power it produces," says Darrell C. Fee, who leads the team developing the cell, "it is so lightweight that it could even power airplanes someday."

A fuel cell delivers energy by converting a fuel such as hydrogen, methane, gasoline or alcohol directly into electricity by way of chemical reactions that release electrons. The Argonne solid-oxide fuel cell owes its efficiency to a special honeycomb construction in which all of the cell's active parts — electrodes, electrolyte and conductor — consist of thin, ceramic pieces bonded together like corrugated cardboard (see photo). The result is a compact, self-supporting structure that can be stacked easily. It takes up less room than comparable fuel cells presently available or being developed.



Argonne Natl. Lab.

So far, Argonne researchers have tested cells, a few inches across, that generate up to a watt of power. Several years of further research and development are needed to make the cell practical, says Fee.

Toughening up polymer composites

Chemical engineer E. Bruce Nauman of the Rensselaer Polytechnic Institute in Troy, N.Y., has invented a chemical process for making tougher composite materials. The process, called "compositional quenching," involves dissolving two incompatible polymers — ones that have the same kind of relationship that oil has with water — in a common solvent and then heating the mixture quickly under pressure.

The result is a new composite material that is tougher than many polymers and other composite materials now available. Such a material's greater resiliency, says Nauman, would make it useful for football helmets and automobile bodies.

Technology

Electronic retina and 3D electronics

A conventional integrated circuit is made up of thousands of horizontally connected electronic components embedded in the surface of a silicon wafer. Japanese scientists from seven corporations, who are participating in a 10-year government research project, are stacking these electronics-loaded wafers and integrating the layers with vertical connections in order to make unconventional circuits. Shoei Kataoka of the Sharp Corporation in Nara, Japan, reports in the IEEE ELECTROTECHNOLOGY REVIEW 1986 on his own and others' recent work on using three-dimensional integrated circuits for "intelligent" artificial retinas.

In place of biological photoreceptors such as rod and cone cells, the Japanese scientists use a layer of electronic photosensors. Instead of the the eye's bipolar, horizontal and amacrine cells, which process the information gathered by the rods and cones, the electronic retina has "signal transfer gates, memories, logic gates and driver circuits," each on its own silicon layer.

From the biological retina, preprocessed signals travel to deeper areas of the visual system via ganglion cells whose axons comprise the optic nerves. The output of the electronic retina will be sent to deeper areas of a computer embedded within the same three-dimensional chip, where it can be processed further. Kataoka comments that the device might be used as "an eye and brain, in a robot." "By 1990," he adds, "prototypes of one-chip intelligent imaging devices will be completed."

Optical probes for biomolecule detection

A physician of the near future might draw a few drops of blood from the fingertip of a patient suffering from some bacterial or viral infection. The physician then might spread the sample onto a disposable, antibody-coated test strip and wait a few minutes to make sure the antibodies grab as many antigen molecules as they can. After rinsing away the rest of the sample, the physician, still in the office, would place the strip into a $500, shoebox-sized optical scanner that would shine light onto the strip and monitor the angle and intensity of the reflections. If the scanner's readout was consistent with the patient's symptoms, the physician might come to an immediate diagnostic conclusion.

Existing immunodiagnostic techniques often involve sophisticated instrumentation and methods, expensive chemicals and highly trained personnel. Now, the Ares-Sorono Group, a pharmaceutical and diagnostic company based in Boston and Switzerland, is developing a new, inexpensive diagnostic technology that physicians can use in their own offices. Scenarios like the one above could be possible by 1990, says Erol Caglarcan, a spokesman for Ares-Sorono, which is developing the technique in collaboration with PA Technology, a British scientific consulting firm.

Company scientists are using a physical phenomenon called surface plasmon resonance for directly detecting specific infectious viruses and bacteria in samples of blood or other body fluids. Plastic or glass strips are coated with a thin film of silver followed by a layer of monoclonal antibodies that recognize only specific infectious agents. When light is beamed onto the test strip's surface, the silver's electrons undergo a collective motion known as a surface plasmon.

Since this motion draws off energy from the light beam, reflections from the surface are significantly lower in intensity. If present, antigens — the infectious agents — bind to the antibodies, and the properties of the test strip surface are altered, resulting in changes in reflection angle and intensity. From these differences, Caglarcan says doctors will be able to determine what infectious agents are present in patients.