Advanced Energy Projects

Advanced Energy Projects explore the feasibility of novel, energy-related concepts as they emerge from basic research. Through such research, new ideas acquire better definition and proven potential, facilitating their transition into the applied technology realm.

PLASTIC BATTERIES

Until 1987, the billions of batteries that had been marketed in myriad sizes and shapes all had one thing in common. To make electricity, they depended exclusively upon chemical reactions involving metal components of the battery. But today a revolutionary new type of battery is available commercially. It stores electricity in plastic.

Plastic batteries are the most radical innovation in commercial batteries since the dry cell was introduced in 1890. Plastic batteries offer higher capacity, higher voltage, and longer shelf-life than many competitive designs. Companies are testing new shapes and configurations including flat batteries that can be bent like cardboard. Researchers expect that the new technology will free electronic designers from many of the constraints imposed by metal batteries such as limited recharging cycles, high weight, and high cost.

The development of plastic batteries began with an accident. In the early 1970's, a graduate student in Japan was trying to repeat the synthesis of polyacetylene, a dark powder made by linking together the molecules of ordinary acetylene welding gas. After the chemical reaction took place, instead of a black powder, the student found a film coating the inside of his glass reaction vessel that looked much like aluminum foil. He later realized that he had inadvertently added much more than the recommended amount of catalyst to cause the acetylene molecules to link together.

News about the foil-like film reached Alan McDiarmid of the University of Pennsylvania who was interested in non-metallic electrical conductors. Since polyacetylene in its new guise looked so much like a metal, McDiarmid speculated that it might be able to conduct electricity like a metal as well. McDiarmid invited the student's instructor to join his team in the United States, and this collaboration soon led to further findings. The University of Pennsylvania investigators confirmed that polyacetylene exhibited surprisingly high electrical conductivity.

Scientists recognize that various materials can conduct electricity in different ways. In metals, electricity is simply the manifestation of the movement of free electrons that are not tightly bound to any single atom. In semiconductors, like those that make up transistors and other electronic devices, electricity is the drift of excess electrons to form a negative current or, alternatively, the drift of missing electrons or positive "holes" in the opposite direction to form a positive current. Typically, the excess electrons or the holes are donated by impurity or dopant atoms.

McDiarmid's team reasoned that the ability of polyacetylene to conduct electricity was probably promoted by trace impurities contributed by the catalysts involved in the Japanese student's process. In their laboratory, McDiarmid's team confirmed that it was possible to chemically dope polyacetylene to create either mobile excess electrons or holes. That these electrons and holes could move explained how polyacetylene was able to conduct electricity.

When polyacetylene was exposed to traces of iodine or bromine vapor, the thin polymer film exhibited still higher electrical conductivity. The researchers discovered that by purposefully adding selected impurities to polyacetylene, its electrical conductivity could be made to range widely—behaving as an insulator, like glass, to a conductor, like metal. The discovery that plastics can behave