Genetically Altered Plant Produces Plastic

Researchers at Michigan State University (MSU) and James Madison University (JMU) have induced a plant, *Arabidopsis thaliana*, to produce the starchlike substance polyhydroxybutyrate (PHB), a plastic similar to polypropylene, but biodegradable. The feat, reported in the April 24 issue of *Science*, is a significant one because it offers an alternative to using fossil fuels to make plastic, plus the resulting material is biodegradable.

The achievement involved three key genes. Two genes were identified and cloned in 1987 from *Acaligenes eutrophus*, a bacterium that naturally produces PHB. One of the three genes is naturally found in plants. The researchers inserted the other two genes one at a time. They established a new line of *Arabidopsis* with one gene and another new line with a second gene, cross-fertilizing the two lines to create a hybrid with both genes. This hybrid then began making PHB in small amounts throughout its structure—leaves, stems, and roots. The presence of PHB in plant tissue was detected by applying a dye that fluoresces under an intense green light when it is in contact with PHB. The plastic granules show up as reddish-orange dots all through the plant.

Christopher Somerville, professor of botany at MSU and researcher at the Department of Energy's Plant Research Laboratory, said, "This is the first time a plant has been genetically engineered to make something other than a protein." The possibility has been raised that plants may eventually be modified to synthesize other classes of materials such as new pharmaceuticals and unusual proteins and lipids.

Currently, a British firm is using PHB produced naturally by soil bacteria to make biodegradable shampoo bottles. Bacterial PHB, however, costs about $12 a pound compared to $0.50 a pound for plastics derived from petroleum. Somerville estimates that it may become possible to reduce the cost of PHB up to tenfold by growing it in farm crops. For example, since PHB resembles plant starch, a potato might be engineered to store the plastic in its tuber.

However, obstacles remain. *Arabidopsis* plants that produce PHB are stunted, perhaps because the process uses chemicals needed for other functions. The researchers expected to find PHB only in the cytoplasm of the plant cells but it appears in the nucleus and vacuoles as well. "That's mysterious to us because these compartments are surrounded by membranes and it appears that the granules may be able to cross through," Somerville said. "Since something like this has not been observed before, this has become the major scientific question for us."

Silico-Titanates Found to Aid Radioactive Waste Cleanup

A new class of materials, with the ability to selectively extract cesium from solutions, has potential for cleaning up radioactive waste. The materials, silico-titanates, are up to 60 times more efficient than other inorganic materials in removing cesium from radioactive waste solutions similar to those stored at the Hanford site near Richland, Washington. Using these materials could lead to easier, safer handling and disposal of these wastes by allowing for separation and removal of most radioactive constituents.

Silico-titanates were developed from hydrous titanates by R.G. Anthony at Texas A&M University and R.G. Dosch at Sandia National Laboratories based on mid-1970s work on immobilization of high-level radwaste and fossil-fuel catalysis. The layered structures of the new crystalline materials suggested possible application in the radwaste area. When mixed with radwaste, silico-titanates are believed to combine with cesium so that the cesium atoms are sandwiched between layers in the crystalline material. Spacing between the layers can be controlled through the chemical preparation process to accommodate cesium atoms but not smaller sodium atoms.

Sodium-nitrate-containing defense wastes have a much higher concentration of sodium atoms than cesium. The contents of radwaste storage tanks at the Hanford Site consist of a bottom layer of sludge, a middle salt-cake layer, and a top liquid layer, with the bulk of the cesium concentrated in the top two layers.

Methods being studied to treat the waste involve first separating radioactive elements from the bulk of other constituents. In one technique, water is added to a tank

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to liquefy its contents except for the sludge and adding a combination of the original hydrous titanate and the new crystalline titanates. The mixture would combine with both cesium and strontium, which respectively are the primary gamma radiation source and heat producer in the waste. The radionuclides would sink to the bottom, allowing workers to treat the top part of the solution as a low-level radwaste or chemical waste. The concentrated radioactive component could then be more easily extracted and immobilized through vitrification.

Another method calls for pumping the contents out of the tank through a column containing the titanates. The radionuclides would be trapped in the column, while the rest of the waste would flow through for subsequent treatment as a low-level radwaste or chemical waste.

The titanate materials can either be incorporated into a vitreous waste form or converted to a monolithic ceramic.

Patent disclosures have been filed on the materials and the processes used to develop them. The researchers present their work this month at the 204th national meeting of the American Chemical Society in Washington, DC.

Organics Embedded in Sol-Gel Glass

Scientists at the Hebrew University of Jerusalem have found a way to embed a wide range of chemical compounds, including organics, in glass, making possible applications such as sensors for identifying chemicals, contaminants, and pollutants in both water and air. The technique is a refinement of the sol-gel process, a one-step, polymerization method that functions at 70°F, compared to standard glassmaking temperatures which go above 1000°C. The low processing temperature makes it possible to incorporate organic materials that would be incinerated by the usual glassmaking methods.

Hebrew University professor David Avnir of the Department of Chemistry said that the result is a high-surface-area porous glass that permits embedments during molding and later permits pass-through of materials being analyzed. The ceramic-type glass encapsulates the organic compound in a protected environment. The encapsulating process prolongs the life and usability of normally unstable and heat-sensitive enzymes used as catalysts in various biochemical processes in research and industry.

Chemical compounds immobilized in glass are particularly useful for detecting air and water pollutants and for medical applications. Other applications lie in optics and electrooptics. The group has developed photochromic glasses that change color with exposure to light, and glasses that can be used for light-filtering.

Avnir said the glass can also be processed as filmlike coatings on ceramics and metals, making other uses feasible. Because the glass is transparent, photometric trace element analysis is possible through such devices as metal ion indicators and pH indicators covering the entire useful pH range. In analysis work, the target compound penetrates the glass and interacts with the entrapped reagents to form chromophoric groups that can be detected by conventional heat or optical techniques.

The process allows molding glass into any configuration, such as flat glass, beads, cubes, rods, membranes, or thin layers.

Polymer Created from Fullerenes

Scientists Douglas Loy and Roger Assink at Sandia National Laboratories have synthesized a buckminsterfullerene polymer. The polymer, a network of C_{60} fullerene molecules linked by hydrocarbon bridges, was made in a controlled polymerization reaction. The new polymer demonstrates the potential of using fullerenes to create materials that could improve the performance of catalysts or act as catalysts by themselves.

The new structure shows fullerene's proclivity toward radical addition. Xylylene, a di-radical, was reacted with C_{60} to produce a cross-linked, highly branched chain of C_{60} polymer. This was done by heating paracyclophane to 650°C, breaking it down into xylylene monomers. The monomers were then added to C_{60} fullerene in toluene cooled to −78°C. When the solution warmed to room temperature, it produced a brownish precipitate that dried to an insoluble powder. Chemical analysis revealed that for every C_{60} molecule, there were approximately 3.4 xylylene molecules attached. This copolymer was formed from a true polymerization reaction. Other researchers have incorporated C_{60} onto polystyrene, showing that it will attach to existing polymers.

When heated, the new copolymer begins to slowly lose mass at 380°C, but retains two thirds of its mass even at 1000°C. Many polymers de-polymerize at relatively low temperatures, leaving behind a liquid monomer. "This shows that the copolymer is relatively stable and that cross-linking is slowing down its depolymerization," Loy said.

The catalytic properties of the polymer remain unknown. The first step was to see whether the material could be synthesized. "Our goal is to make a soluble polymer by altering the amount of C_{60} used," Loy said.

By using smaller amounts of fullerene and more xylylene, Loy and Assink believe they can create a material more like poly-xylylene but which still retains its C_{60} properties. Poly-xylylene is a polymer commonly used as a specialty coating.

Matijević Receives Honorary Degree

Egon Matijević, Clarkson University Distinguished University Professor and surface and colloid scientist has received an honorary doctor of science degree from Clarkson University "for his brilliant achievements in colloid and surface science, for his profound and extraordinary role in enhancing the quality and international reputation of Clarkson University, and for his inspired teaching."

Matijević was instrumental in the 1965 founding of Clarkson's Institute of Colloid and Surface Science, which he directed from 1968 to 1981, and he helped catalyze the emergence of Clarkson's Center for Advanced Materials Processing and its recognition by New York State as a Center of Advanced Technology.

Matijević joined Clarkson in 1957 after a year as a research fellow at Cambridge University. He has authored more than 400 scientific papers and delivered 46 plenary and keynote lectures in 16 countries.

Among honors he has received are Clarkson's Distinguished Teaching Award and appointment as its first Distinguished University Professor, honorary doctor of science degrees from Lehigh University and Poland's Maria Curie-Sklodowska University, and membership in the Croatian Academy of Arts and Sciences, and the Academy of Ceramics.

NAE Names New Officers

The National Academy of Engineering (NAE) has announced its 1992 officers and councillors, and a new home secretary and two new members of the governing council. The chair and two councillors, elected for three-year terms, have been re-elected. The terms began July 1.

The new home secretary is Simon Ostrach, professor of engineering at Case Western Reserve University. His term will last four years. The two councillors, elected for three-year terms, are Harold K. Forsen, senior vice president and manager of the Bechtel Technology Group, Bechtel Group Inc., and Sheila E. Widnall, associate provost and professor of aeronautics and astronautics at the Massachusetts Institute of Technology.

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Those re-elected are Richard M. Morrow, retired chair and CEO, Amoco Corp., chair, for two years; Lew Allen Jr., chair, the Charles Stark Draper Laboratory, councillor, for three years; and Leo J. Thomas, group vice president and president, imaging, Eastman Kodak Co., councillor, for three years.

Peppas Receives Clemson Award

Nicholas A. Peppas, professor of chemical engineering at Purdue University has received the 1992 Clemson Award for Basic Research from the Society for Biomaterials. The award recognizes exceptional contributions to the basic knowledge and understanding of the interaction of polymers and the biological environment.

Peppas' work in polymers has found applications in the development of biomaterials, controlled release of drugs, contact-lens technology, artificial kidneys, and microelectronics

Author or co-author of eight books and more than 300 publications, Peppas has been with Purdue since 1976. He has been recognized by several professional organizations for his research, and has won six awards for teaching excellence.

ASME Urges Enhanced Federal Role in Standards

The American Society of Mechanical Engineers (ASME) would like the U.S. government to play a larger role in the setting of codes and standards and agrees with the Congressional Office of Technology Assessment (OTA) that a public corporation or public-private institute should oversee U.S. standards and certification activities.

Oscar J. Fisher, ASME's senior vice president for codes and standards, said that ASME has called for greater government involvement for several years and that the American National Standards Institute can't provide the needed planning for a quasi public institute with a higher international profile, nor provide objective due process supportable in the courts. "In general, the present participation of U.S. voluntary standards organizations in the international arena lacks strong leadership, is loosely structured, and has limited effectiveness," he said, drawing on ASME's negotiations with the European Community to suggest that only government-to-government communications can adequately represent U.S. interests in international standards.

A government-affiliated standards body is supported by the OTA's recent report, *Global Standards: Building Blocks for the Future.* The body would serve as the necessary forum to develop national policies and strategies on standards-related issues. This would include establishing positions representing U.S. interests regarding standards in negotiations with governments abroad.

AT&T, PBS Conduct Science Via Satellite

The program, "Live From AT&T Bell Laboratories," was broadcast by the Public Broadcasting System via satellite this spring to millions of students in order to encourage interest in science careers and promote excellence in science and math education during National Science and Technology Week (April 26–May 2).

Viewers "toured" Bell Labs and were provided looks at what makes science interesting, for example, the world's fastest laser, the construction of a satellite, and the mathematics of juggling. The program was developed for students in middle school and was broadcast to PBS's 340 affiliates.

Besides Bell Lab researchers, Walter Massey, the director of the National Sci-

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ence Foundation, participated in the program and discussed the importance of science and math education. Program host Arno Penzias, Nobel laureate and vice president of research at Bell Labs, said, "Unless we actively enhance existing science and math literacy levels, we will continue to ensure the erosion and ultimately the collapse of our nation's technology base. The 'Live From Bell Labs' broadcast seeks to reach a generation of America's young people and galvanize their interest in science careers."

Municipal Waste Ash Vitrification Studied

A technology demonstration program begun this spring seeks to determine if the combustor residue (ash) from municipal waste can be turned into safe, useful products on a commercial scale. Researchers from the Center for Research and Technology Development of the American Society of Mechanical Engineers (ASME) are working with investigators at the U.S. Bureau of Mines Research Center in Albany, Oregon to study vitrifying the ash into a black, glassy onyx-like substance that is dense and grainless. Previous research suggests that vitrification may produce a material that is chemically stable, environmentally acceptable, and may be used as architectural tile, as construction aggregate, or for other applications.

Using new techniques, the engineers are altering an existing Bureau of Mines electric-arc furnace for the project by providing an air pollution control system for any fumes produced by the device. The fumes will be then be characterized.

The objectives of the demonstration are to determine the technical feasibility of the process on a commercial scale, provide information on operating parameters and possible constraints, confirm the technology's environmental acceptability, identify and characterize the process effluents or emissions, identify a number of beneficial uses for the vitrified products, and develop economic data.

The process involves vitrifying several 20-ton "lots," each equivalent to the residue from burning 100 tons of municipal waste, about the amount of trash produced daily by 30,000 Americans. By studying the process at this scale, the engineers will gather data needed to optimize design and operating conditions for plants capable of process combustion residues produced by a city of 200,000 to 300,000 people.

Collaborating in the program are the New York State Energy Research and Development Authority, the U.S. Department of Energy, the Electric Power Research Institute, several local and Canadian agencies, and 18 corporate sponsors.

Center For Advanced Materials Processing Dedicated at Clarkson

In operation since September, Clarkson University's 190,000 square-foot Center For Advanced Materials Processing (CAMP) building was officially dedicated May 16. The center's five-year strategy calls for expanding CAMP to a world-class interdisciplinary research and education program in materials technology based on Clarkson's expertise in colloid and surface science and engineering. Design and construction of the building cost $24.5 million, and the university plans to provide an additional $10.8 million in research equipment for the building.

Another aspect of CAMP's strategy is the transfer of technology through company visits to the center, symposia, conferences, publications, presentations, patents, exchanges of scientists and graduate students, providing assistance to small businesses, and collaborative research projects with industry, academic institutions, and the government.

Corning to Acquire Biosym Technologies

Corning Incorporated, New York, announced that it has agreed to acquire Biosym Technologies, Inc., a San Diego, California, scientific software company.

Corning president and chief operating officer Roger G. Ackerman said the acquisition allows Corning "to expand into an area of rapid growth with revolutionary implications for every kind of materials science."

Founded in 1984, Biosym specializes in the development, marketing, and support of computer-aided molecular design (CAMD) software worldwide. CAMD software streamlines the processes of discovering, developing, and testing new drugs, chemicals, and materials through research at the atomic level using various forms of computer simulation and graphical manipulation.

CRADA Facilitates Development of Tantalum Capacitor Microwave Sintering

AVX Tantalum Corporation and Oak Ridge National Laboratory have agreed to jointly develop a method for sintering tantalum capacitors for increased quality and reliability.

The first step in making a tantalum capacitor is the process of heating a tantalum powder compact to a rigid yet porous state. Through the cooperative research and development agreement (CRADA), com-

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pacted tantalum anodes will be sintered under various conditions in the microwave furnaces at the Oak Ridge laboratory and the Oak Ridge Y-12 Plant, and the manufacturing and testing process at AVX Tantalum will be completed. If successful, the process could improve the quality and reliability of tantalum capacitors and also create an important industrial application for microwave sintering.

Tantalum capacitors are used in the military and with other types of applications that require high reliability. The largest single market for tantalum capacitors is in cardiac pacemakers.

HFIR Pressure Vessel Tested at Oak Ridge

A hydrostatic proof test of the High Flux Isotope Reactor's (HFIR) pressure vessel at Oak Ridge National Laboratory has confirmed the reactor's ability to operate for 10 operating years from the time of the test. An operating year is equivalent to 365 days that the reactor is actually at full power, currently about 17 calendar months. The maximum power level of the HFIR is 85 MW.

A previous hydrostatic proof test was performed in August 1987 while the reactor was shut down amid concerns about embrittlement of the vessel. Even though this earlier test established the vessel's ability to be used for 10 operating years before another test would be needed, the Department of Energy (DOE) decided the test should be performed at the end of every operating year as an added measure of confidence. The latest hydrostatic test was the first since the reactor received DOE authorization to resume full power operations in May 1990.This test was performed at approximately twice the reactor's normal operating pressure of 468 psi. The pressure vessel, which contains an enriched uranium fuel when the reactor is operating, is 20 feet high and 8 feet wide, and its three-inch-thick walls are made of carbon steel clad on both sides with stainless steel.

The reactor's primary purpose is to produce transuranium isotopes for use in the nation's heavy-element research program. The HFIR is the Western world's only source of californium-252 and other transuranium isotopes for research and medical purposes.

About 200 users of the HFIR's neutron-scattering facilities are accommodated annually. Neutron scattering is used to investigate the magnetic properties of materials thought responsible for superconductivity. Oak Ridge's Analytical Chemistry Division operates a neutron activation analysis facility at the HFIR. This facility was used last year to prove that President Zachary Taylor did not die of arsenic poisoning. The reactor is also used to test materials under neutron and gamma irradiation. These test results are used to improve designs of nuclear power plants and space power systems, and for basic research on materials properties.

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