USDA Works With DOE and DOD To Develop Biobased Materials

USDA's Alternative Agricultural Research and Commercialization Center has received royalty payments from two companies. USDA's Agricultural Research Service signed its 500th Cooperative Research and Development Agreement. USDA and the U.S. Department of Energy (DOE) plan biomass demonstration projects for fiscal 1996. USDA's Cooperative State Research, Education, and Extension Service continues to work with the U.S. Department of Defense on the Advanced Materials from Renewable Resources Program. As part of its Alternative Feedstocks Program, DOE has signed agreements with private firms to develop polyols, a plastics monomer, and long-chain dicarboxylic acid monomers from renewable materials.

AARC Center Begins Receiving Paybacks

USDA's Alternative Agricultural Research and Commercialization (AARC) Center has begun receiving royalty payments from two companies. The AARC Center makes repayable investments in private firms to commercialize new industrial (nonfood, nonfeed) uses for agricultural and forestry materials and animal byproducts. The Center requires at least a 50-percent match in funds and negotiates a payback arrangement for each project. Repayments are placed in a revolving fund to be reinvested with other firms.

The Leahy-Wolf Company of Franklin Park, Illinois, has made three royalty payments since March 1995. AARC Center funds were used to help Leahy-Wolf market a biodegradable release agent for concrete forms made from crambe or rapeseed oils for use in the construction industry. The company has established new distributors and is negotiating with a nationwide construction supply business to manufacture the product under license.

Natural Fibers Corporation of Ogallala, Nebraska, is the second firm to begin making royalty payments to the AARC Center. The company uses milkweed floss and goose down to make comforters and pillows. Sales are expected to reach over $1 million in 1995.

The AARC Center is governed by a nine-member Board of Directors, eight of whom represent producer, processing, financial, and scientific interests outside the Federal Government. Seven new members have been appointed since December 1994.

Funding for fiscal 1995 was $6.5 million. Ten projects are to receive funding this year. Some of the projects are:

- The Enbiomass Group, Inc., of Wilmington, North Carolina, is developing biodegradable foodservice packaging, with the functional characteristics of molded polystyrene, for use as plates, cups, and serving packages such as hamburger clamshells. The raw material is popcorn. Binders used in the process are also of agricultural origin—corn, potatoes, sugar, soybeans, and animal glue.
- Scientific Ag Industries of Atlanta, Georgia, is building a plant in Blakely, Georgia, adjacent to one of the world's largest peanut shelling operations, to produce high-grade activated carbon from pelletized peanut hulls. Activated carbon is used as filter material, removing contaminants from air and water.
- PhytoLife Sciences of Dublin, Ohio, is using proprietary electromembrane fractionation separation technology to isolate biologically active compounds from plants, flowers, seeds, aquatic plants, and algae in commercial volumes. The resulting valuable compounds can be used in pharmaceuticals, cosmetics, bioinsecticides, and fungicides.
- Environmental Composite Products, Inc., of Sullivan's Island, South Carolina, is planning to build a manufacturing plant near Barnwell and Aiken, South Carolina, to produce flooring for the intermodal transportation industry (dry containers for ocean freight, vans and flatbed trailers, and railroad cars) and cross arms for the utility industry. The raw materials used in the bonding process are various combinations of paper, paper sludge, nonrecyclable paper and other wood-processing residues. Veneers from underutilized tree species, such as yellow poplar and sweet gum, are also used. Currently, flooring is made from U.S. hardwoods and scarce tropical rain-forest hardwoods.
- Clean Green Polymers of Golden Valley, Minnesota, a wholly owned subsidiary of Environmental Technologies, USA, Inc., will blend 80 percent corn or wheat starch with recycled polymers to create a starch-plastic composite material. The material, which has the appearance and performance of standard plastics, will be injection molded to produce products such as disposable overcaps for bottles, plastic packaging for environmentally friendly products, and plastic parts for ammunition.
- Biorecycling Technologies, Inc. (BTI), of Fontanna, California, will be improving the groundwater around Chino, California, while converting agricultural waste into marketable products. Chino, which is about 50 miles east of Los Angeles, has what is probably the largest concentration

of dairy cows in the world, 300,000 head within a 10-mile radius. About 30 BTI plants will use cow manure to produce organic plant-growth media and potting soils, liquid organic fertilizers, and biogas, which will be used to produce heat or generate electricity.

- Stramit USA of Perryton, Texas, is using wheat and other cereal straws to manufacture insulated construction panels, primarily for nonload-bearing walls. The company is using machines and technology imported from Europe.

ARS Signs 500th Research Agreement With Industry

USDA's Agricultural Research Service (ARS) reached a technology-partnership milestone in fiscal 1995 with the signing of its 500th Cooperative Research and Development Agreement (CRADA). Authorized under the Technology Transfer Act of 1986, CRADA's allow joint collaboration between government scientists and industry to develop particular discoveries. The 500th CRADA, with Mycotech Corporation of Butte, Montana, enlists bioengineers and fermentation experts from ARS' National Center for Agricultural Utilization Research in Peoria, Illinois, to develop delivery systems incorporating a Mycotech-developed fungus for biological control of the sweetpotato whitefly, *Bemisia tobaci*. At the same time, the partnership is helping stimulate economic growth in rural America.

The agency's long standing record of developing new uses for starch and other carbohydrates continues. ARS scientists in Albany, California, entered into a CRADA with Mobil Chemical Company of Canadaigua, New York, for developing disposable starch-based products. ARS and Mobil are evaluating unique ways of processing starch to improve its adaptability to conventional plastic-processing equipment with the goal of producing low-cost, single-use items.

ARS scientists in Peoria, Illinois, have filed a patent application for the production of unique starch-encapsulated lipid spheres. The spheres have potential uses as fat substitutes, seed coatings, and protective coatings for young roots and shoots, as well as potential uses in wood adhesives and a great variety of other food and nonfood applications. In many instances, the spheres also can serve as vehicles for carrying active ingredients and other beneficial compounds.

In addition, ARS scientists at Wyndmoor, Pennsylvania, entered into a CRADA with Michigan Biotechnology Institute (MBI) of Lansing, Michigan, to develop specific end-use products from plasticized pectin/starch films first discovered and studied by ARS scientists. The films can be made in edible form and have potential in many food and nonfood applications. Under the CRADA, ARS and MBI researchers are working together to fabricate various articles from these films for evaluation.

Also in fiscal 1995, ARS filed a patent application on a method to process chicken feathers into fibers that can be used in a variety of ways, such as making paper-like products, textiles, filters, and seedling cups. This invention helps add value to a waste material from poultry processing that traditionally has been used in feed.

A patent has been issued to ARS for a process to manufacture nonallergenic rubber latex from domestic plant species such as guayule, milkweed, and goldenrod. Licensing negotiations are now underway. These nonallergenic rubber polymers have important applications in the production of products that come in contact with human skin, such as the rubber gloves used by medical professionals.

ARS scientists and engineers in Beltsville, Maryland, are collaborating with companies in several industries to convert urban and industrial wastes into useful products, such as soil amendments and wallboard. The objective is to eliminate these waste materials from landfills and other disposal sites and turn them to productive use.

Partnerships with industry were not the only alliances formed in fiscal 1995. ARS led a team of USDA agencies in negotiating a formal agreement with the U.S. Department of Energy (DOE) on new and creative measures to solve agricultural problems using the combined talents and scientific disciplines of both departments. The USDA agencies involved include the Agricultural Marketing Service; Animal and Plant Health Inspection Service; Cooperative State Research, Education, and Extension Service (CSREES); Food Safety and Inspection Service; Forest Service; and Natural Resources Conservation Service. USDA Secretary Dan Glickman and DOE Secretary Hazel O'Leary are scheduled to sign a Memorandum of Understanding with the goal of facilitating cooperative technology, research, development, transfer, utilization, and commercialization efforts.

To further enhance technology transfer, ARS' Office of Technology Transfer and the State of Florida began working as partners in fiscal 1995 to develop an infrastructure to support economic development that would benefit, not only Florida's companies, but its farmers as well. Florida's network of 67 county-wide economic development field offices will provide ARS with enhanced information and access to the State's industries. Similar partnerships are being forged with 17 other States.

OENU Involved In Joint Energy Projects

USDA, in an effort coordinated by the Office of Energy and New Uses (OENU), will help DOE launch a series of biomass demonstration projects beginning in fiscal 1996. USDA participated as a full partner in designing the Request for Proposals (RFP), entitled Biomass Power for Rural Development, and will participate in awarding project funding. Over 350 groups have requested the RFP. DOE's funding for the selected projects is anticipated to be $80 million over a 6-year period with up to five awards expected. USDA indicated a willingness to leverage DOE's funds with existing USDA programs and authorities where appropriate. A panel was held to determine leading candidates. Final announcement of winners is awaiting clarification of DOE's 1996 budget.

Workshops were held in Vermont, Minnesota, and Alabama to offer and receive comments on biomass energy. Follow-up

meetings were held in California, Missouri, and Florida. These forums took place in areas likely to apply for funding. USDA experts, led by OENU, discussed how existing USDA authorities could be used in the context of the forthcoming RFP. The response from utilities, farm groups, and environmentalists was very favorable.

Based on an economic analysis OENU conducted with the White House, DOE, and the U.S. Environmental Protection Agency (EPA), production of liquid fuel and electricity from biomass is possible in several areas of the country. If technology development and feedstock yield improvements are successful, biomass energy could provide farmers with new market opportunities and rural America with a new industrial base.

OENU teamed up with DOE's Biofuels Systems Division to conduct a life-cycle study of biodiesel production in the United States. The main purpose of the study is to produce an analytical framework for evaluating energy use, environmental effects, and input costs of biodiesel production in the United States on a life-cycle basis. Life-cycle analysis evaluates a product or activity through all of its stages—from raw material access through manufacturing to consumer use and waste management (recycling or disposal). This concept is often referred to as a cradle-to-grave assessment.

The study will require detailed data on farm production, extraction and processing of raw materials, manufacturing, transportation, and distribution. An industry/government working group—including USDA, DOE, EPA, Ecobalance, Inc., and the National Biodiesel Board—was established to collect data, develop assumptions, create scenarios, and define boundary conditions for the life-cycle analysis. This study also includes a parallel effort to develop a life-cycle model for petroleum diesel. The two models will be used to compare net energy use, environmental effects, and life-cycle costs of petroleum diesel versus biodiesel.

CSREES Continues Collaborations with DOD

In 1991, the U.S. Department of Defense (DOD) began working with CSREES on a program to develop biodegradable polymers. DOD interest stemmed from the 1987 Marpol Treaty, which stipulated that, beginning in 1995, ocean dumping of plastic is prohibited unless it is marine degradable. This research expanded on a decade-old alliance to develop a domestic source of natural rubber for aircraft and land-based-vehicle tires. Three years of funding yielded a new generation of degradable polymers with functionality that mimics petroleum-based plastics. However, their purchase price is two to three times higher than petroleum-based products.

In 1993, DOD began exploring the possibility of moving beyond rubber and starch polymers to a full range of industrial products made from plant and animal materials. The Advanced Materials from Renewable Resources (AMRR) program was established to focus on applied research, development, and precommercial work in seven areas: engineering nylons, biodiesel fuel, functional fluids, oil-selective adsorbents, flexible paints and coatings, natural biocides and biocidal coatings, and vegetable-oil epoxides. This program opened a broad interaction between USDA and DOD. For example, CSREES is working with the U.S. Army Tank Automotive Command's Technical Insertion Program, which will test agriculturally based industrial products for military acceptability.

A number of products developed or improved under the AMRR Program are undergoing testing; for example:

- The Mobility Technology Center at Fort Belvoir, Virginia, is evaluating environmentally acceptable hydraulic fluids, most of which are based on vegetable oils. Laboratory testing should be completed in fiscal 1996. Field testing in fiscal 1997 and revision of military specifications will allow military procurement of these products.

- Fort Belvoir also is evaluating potential replacements for P-D-680 solvents, which are used for dry cleaning and degreasing. Many candidates are based on renewable resources such as terpenes, limonene, and vegetable-oil methyl esters. Revised specifications are expected by the end of fiscal 1996.

- An evaluation of biodiesel by the Tank Automotive Research, Development, and Engineering Center (TARDEC) in Warren, Michigan, at the Army's proving ground in Yuma, Arizona, has been completed. When mixed as a 20-percent blend with JP-8 fuel, biodiesel reduced emissions and improved acceleration in five types of trucks. Other tests have shown that biodiesel serves as a lubricant when blended with low-sulfur diesel. Laboratory testing at Fort Belvoir is ongoing.

- The University of Arizona has signed a nonexclusive agreement with Merck and Company to test a guayule-resin fraction for activity against a pathogenic fungus.

- Field studies, conducted at Virginia State University to evaluate glucosinolates in rapeseed meal as a pesticide for black rot in peanuts, show that best results were achieved when the meal was used as an extender for the conventional pesticide, thereby, reducing the amount of chemical required and enhancing its efficacy.

- Through TARDEC, Wright-Patterson Air Force base is testing urethane-type packaging foam made from lesquerella oil. The foam, developed at the University of Southern Mississippi, showed excellent shock absorbing properties.

- Through TARDEC, the Army is testing a guayule, epoxy-amine, peelable coating on metal panels at Cape Kennedy, Florida, for corrosion protection during exposure to fog and salt. The coating was developed at the University of Southern Mississippi.

- TARDEC testing of guayule-rubber truck tires at the Yuma Proving Ground is expected to be completed this fall. Results thus far show guayule tires to be comparable to tires made from hevea rubber.

In July 1995, a USDA team headed by CSREES held discus-

sions with officials at the U.S. Army Environmental Center (AEC) in Edgewood, Maryland, to explore scientific collaboration in industrial products, remediation of contaminated soils, and other areas. AEC is a technology testing and demonstration center that specializes in heavy metals, ground water quality, unexploded ordnance, and numerous other environmental problems. During the discussions, the USDA team was looking for possible applications of agricultural technology to solve defense mission needs and for applications of defense technology to solve agricultural mission needs.

DOE's Alternative Feedstocks Program Is a Collaborative Effort

The Alternative Feedstocks Program, administered by DOE's Office of Industrial Technologies, is comprised of various industrial partners and five DOE laboratories: Argonne National Laboratory (ANL), Idaho National Engineering Laboratory (INEL), National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest Laboratories (PNL). The program's mission is to promote cost-effective utilization of renewable biomass resources as feedstocks in the manufacture of high-volume chemicals and high-value products through cost sharing of research.

Within the last 9 months, the program has achieved significant growth. Some recent projects include:

- PNL is in the last year of a 3-year CRADA with International Polyol Chemicals, Inc. (IPCI), a small business located in Redmond, Washington. The goal is to complete sufficient process development to allow commercialization of IPCI's process for production of polyols—propylene glycol, ethylene glycol, and other diols—from glucose. PNL is providing expertise in selective catalytic processing. USDA's AARC Center also is involved with the project.

- ANL, NREL, ORNL, and PNL continue their joint research and development project, with assistance from MBI, to demonstrate the feasibility of producing succinic acid from cornstarch. The succinic acid could then be used as a feedstock for manufacture of commodity plastics, synthetic fibers, food additives, and solvents for paints and paint removers. The consortium is currently evaluating several opportunities to collaborate with private industry.

- In July 1995, INEL entered a CRADA with General Electric (GE) to explore opportunities to develop an alternate method of producing a plastics monomer. GE is a world class developer, producer, and marketer of engineering thermoplastics. INEL has expertise in engineering, selecting, and optimizing microorganisms to maximize chemical activity. Together, this team hopes to commercialize a novel approach to polymer production, based on renewable feedstocks.

- Recently, DOE entered into a cooperative agreement with GE for biosynthesis of long-chain dicarboxylic acid monomers from renewable feedstocks. GE will use molecular biology techniques to construct gene banks and select genes needed to produce an improved biocatalyst. Bioprocess development also will be performed to identify substrates, optimize bioprocess conversion conditions, screen product separation technologies, and determine overall process economics. In developing applications, GE will determine the suitability of monomers prepared from different substrates for the preparation of target polymers and characterize the resulting polymer properties.

- NREL's clean fractionation process has attracted a major industrial partner who is interested in cellulosic material applications. A formal signing of a CRADA is expected in the near future. This project will focus on the separation of woody biomass into separate fractions—lignin, cellulose, and hemicellulose—with little or no cross contamination. The fractions can then serve as starting materials for chemicals production. Potential products include a wide range of cellulose-based materials, such as rayon and acetate fibers, thermoplastics, laminates and films, coatings, and additives to paint and drilling muds.

- NREL is nearing a formal CRADA with a state agency, a small business, and a university to develop biobased levulinic acid. The industrial partner will build a 1-ton-per-day pilot plant to convert paper mill sludge into levulinic acid. The consortium, lead by the New York State Energy Resources Development Authority, will explore opportunities to improve and commercialize the conversion of the levulinic acid into commodity and specialty chemicals, such as fuel and polymer additives and agrochemicals. [Ron Buckhalt (AARC Center), (202) 690-1633; Wilda Martinez (ARS), (301) 504-6275; James Duffield (OENU), (202) 501-6255; Carmela Bailey (CSREES), (202) 401-4640; and Gloria Kulesa (DOE), (202) 586-8091]