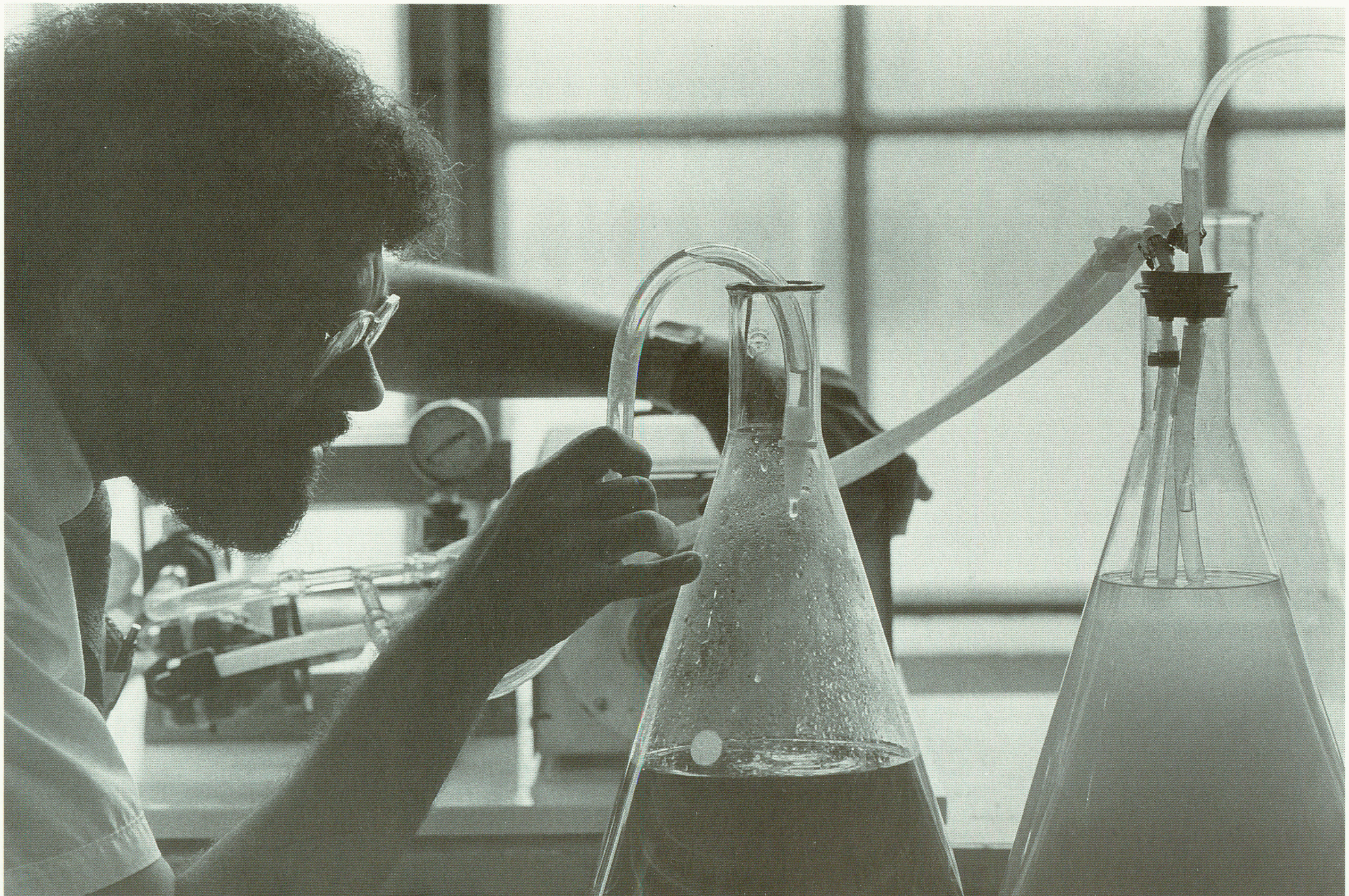
Vegetable Oils in Industry

Like animal fats, domestic vegetable oils, including soybean oil, are excellent sources of many industrial chemicals. The chief reason that more such products are not used by U.S. industry today is the competition from petroleum products, which are generally cheaper. Secondary competition comes from the 2.5 billion pounds of vegetable oils imported by the United States each year, including large amounts of coconut oil, castor oil, and palm and palm kernel oils. As a result, only a fraction of U.S.-produced vegetable oils today are used in manufacturing and for other nonfood, nonfeed purposes. The sole exception is the 200 million pounds of linseed oil extracted from flaxseed here each year. Since it is inedible, all the production goes for industrial purposes.

But the price and availability of petroleum and foreign oilseeds can change in a hurry, and there is every reason to believe that industrial demand for chemicals from U.S.-produced fats and oils, many of which have properties missing in petroleum, will increase in the years ahead. To this end, the Northern regional laboratory has devoted a substantial share of its resources over the years to finding new industrial uses for soybean, linseed, and other agricultural oils. Many of the products NRRC and other regional researchers have developed since 1940 are already being manufactured today.



In New Orleans, a chemist experiments with a new method of modifying cottonseed oil for industrial use.

During the 1980's, for example, vegetable oils, including 200 million pounds of soybean oil, contributed about 90 percent of the oils used in fabric softeners, 45 percent of the oils in surfactants and 40 percent in various coatings, 20 percent of the oils in synthetic lubricants; 15 percent in plastics additives, and 10 percent in chemicals used in agriculture. Small amounts were also used in making adhesives and in engineering thermoplastics. New processes for converting vegetable oils into industrial products seem likely to increase the use of surplus soybean oil still more during the 1990's. (See "Focus on the Future," p. 147, for some recent innovations.)

Epoxidized oils. During World War II, a team of scientists at the Eastern laboratory found a way to insert oxygen atoms into carbon-hydrogen chains of animal fats in a process called epoxidation. In the process, they helped found a new industry. Epoxidized oils, when used as plasticizers, blend well with commonly used resins. They also eliminate the need for poisonous salts of lead, barium, or cadmium in vinyl plastics, which turn the plastics cloudy or opaque. The epoxidized esters developed at Wyndmoor made possible the manufacture of flexible vinyl plastics.

Before the ERRC research, vinyl had been unstable and inflexible. It turned brittle, especially in direct sunlight. The stable and bendable new plastics could be used for scores of new products, including upholstery and floor coverings, and their manufacture soon expanded into a billion-dollar industry. Soybeans, however, and not animal fats, supply some 75 percent of the 50,000 tons of epoxidized oil now used annually for this purpose.

Polyamide resins from dimer acids. Research begun at the Northern lab in the 1940's led to commercial production and use of polyamide resins prepared from dimer acids. (Dimers are molecules containing identical pairs of simpler molecules.) The dimer acids were derived from soybean and other vegetable oils. For a time during the war, an NRRC resin was manufactured and marketed by two companies under the trade name Norelac, from the words "Northern Regional Lacquer." It was a hard, transparent, thermoplastic resin useful in lacquers and adhesives. Today polyamide resins are used as hot-melt adhesives for shoe soles, book bindings, solders to close seams in cans, and packaging. The widely used 2-tube glues containing epoxy resins and polyamide curing agents also use polyamides developed from the NRRC research. Other uses include moisture-proof coatings, paints for porous surfaces like concrete and cinder blocks, and special-purpose inks. U.S. production of dimer acids today totals about 330,000 tons per year; over half of this is used for polyamides.

Cyclic fatty acids. So-called soybean soapstock consists of soy fatty acids that occur as a byproduct of making edible soybean oil. In the mid-1960's, NRRC scientists investigated the production of cyclic fatty acids from the linolenic acid in soybean soapstock and linseed oil. In time, research yielded five kinds of cyclic acids, each with special characteristics of possible interest to industry. One acid, for example, is nearly as effective as erucamide as an antiblock agent to prevent sheets of polyethylene film from sticking together. Another acid can be made into nontoxic alcohols for use in cosmetics. Many promising applications of cyclic acids have yet to be realized.

Nylon 9. In the late 1960's, chemists in Peoria converted soybean or linseed oil derivatives into a versatile new raw material. Working under a USDA contract, a Minneapolis firm developed several ways to use the new material to produce a variety of industrial products. One was nylon 9, a tough plastic especially suited for use in electrical insulation and gears, bearings, cams, and similar parts.

Sucrose partial esters. New sweeteners and changes in U.S. demand made sucrose, or cane or beet sugar, into an inexpensive surplus crop in the 1960's. Starting in 1969, chemists at the New Orleans lab chemically modified sucrose with fatty acids to produce new compounds called sucrose partial esters. For a time, the Food and Drug Administration declined to permit their use in U.S. foodstuffs, and after the processes were patented, the esters were used chiefly in Japan. Today FDA allows their use in this country, and they are now being incorporated in baking and biscuit mixes, baked goods, substitute dairy products, frozen dairy desserts, and whipped milk products. A highly publicized fat substitute was developed from ARS research on sucrose partial esters.

Caulking and many other nonfood products are manufactured today using vegetable oil derivatives instead of petroleum.

ERRC chemists have developed a group of multipurpose chemicals called isopropenyl esters from fatty acids. They can be used to make paper and cotton repel water, to coat glass to reduce breakage in bottling lines, and in other applications where they have proven superiority to chemicals now in use. The process for making one of the most promising of these chemicals—IPS, or isopropenyl stearate—yields IPS that is 90 percent pure.

High-pressure oil additives. In the mid-1980's, Peoria chemists discovered a new class of compounds that can help make extreme-pressure lubricant additives. New tetrasulfide compounds, derived from vegetable oils or petroleum, are used to treat the lubricants, which may then be used as crankcase or transmission oils, cutting or extruding oils, and continuous steel casting lubricants. The lubricants are effective substitutes for restricted sulfurized sperm whale oil.

New processes for new products. Peoria scientists have developed new, reusable compounds that catalyze processes for making several useful chemical derivatives from fatty acids. These catalysts have opened up new possibilities for use of fatty materials derived from vegetable oils, and many new compounds with commercial potential have already been prepared. Some of them would make good plasticizers for vinyl plastics; others are suited for urethane coatings, rigid urethane foams, coating resins, and lubricants.

Another new approach that may someday pay off uses microorganisms and their enzymes to break down soybean oil into new substances. One bacterium, *Klebsiella pneumonaiae,* feeds on glycerol, a common byproduct of animal fat and vegetable oil processing. Through fermentation, the microbe produces a chemical that converts glycerol to acrolein, which is easily converted to acrylic acid, a building block of acrylic plastics, fabrics, and paints. Acrylic acid is made from petroleum and is much in demand. The Peoria process, still being modified, is not yet competitive in price.

Linseed Oil

Linseed oil is the only inedible oil of commercial value still produced in any significant amounts in the United States. More than 80 percent of the flax from which it is extracted is grown in North Dakota, with the rest of the Nation's acreage in South Dakota and Minnesota. The location of the growing area for flax made it the responsibility of the Northern center to find ways to increase the usefulness of linseed oil to industry.

In the 1950's, linseed oil, when used as a drying agent in white paint and enamel, turned yellow when applied in areas not exposed to direct sunlight. It took several years of research at NRRC before the complex chemistry of this after-yellowing was fully understood. Minute amounts of oxidizing chemicals formed in a two-step operation were responsible. Once the mystery was solved, however, small amounts of chemicals were added to the paint to inhibit the yellowing process. An accelerated test was also developed to measure the yellowing properties of oils.

As the 1960's began, the market for linseed oil in exterior paints was starting to slip because of the introduction of petrochemically based synthetic emulsion paints, which were easier to apply, had less odor, and could be cleaned up with water. NRRC and a linseed oil trade association worked together to develop linseed oil emulsion paints, since the oil was known to provide superior protection. Paints were successfully formulated by 1961 that combined the advantages of exterior oil-based coatings with the superior handling and easier application of synthetic emulsion paints. Within 4 years, this research, which cost less than half a million dollars in public funds, had been valued at more than $37 million.

An unusual use for linseed oil was discovered in 1961 by Peoria scientists working with highway researchers. The widespread use of salt to remove snow and ice was causing more and more damage to concrete roads and bridges. One type of damage, called scaling, occurs when thin pieces of concrete break way from the surface. Another type, spalling, occurs when thick pieces break way. Both types of damage, which are accelerated by salt, are most likely to occur when the concrete is new.

Researchers found that a compound consisting of equal volumes of mineral spirits and boiled linseed oil cuts down on spalling. Later, they discovered that spraying an emulsion of linseed oil and water on freshly laid concrete not only acts as a curing compound but subsequently prevents scaling. Within a few years, some 35 State highway departments and many toll and bridge authorities reported using the linseed oil mixtures on roads and bridges. They continue in use today, particularly in northern States where salt is used repeatedly to melt ice during the winter.