EDITORIAL

Expanding the Uses of Enzymes

At the recent AAAS meeting in Boston a symposium organized by Rex Montgomery of the University of Iowa* provided a glimpse of interesting areas where microbiology, biochemistry, and chemistry can be employed in a multidisciplinary approach to practical uses of enzymes. One thrust was efforts to convert food-processing wastes into higher value products. Another was applications of a spectrum of enzymes derived from various microorganisms to obtain useful substances. This approach sometimes involved reactions catalyzed by enzymes in media other than water. The topics treated in the symposium have long-term as well as near-term relevance, for gradually the world will become more dependent on products formed from feed stocks originally derived from plants.

Improving the value of agricultural products and dealing effectively with food-processing wastes are of special interest in Iowa and are well supported there. The multidisciplinary group of faculty scientists active in biocatalysis and bioprocessing research at the University of Iowa and the part of the Biotechnology Byproducts Consortium there is one of the strongest such groups anywhere. An example of the many objects of their research is corn oil. This lipid is rich in the 18-carbon oleic acid. Through microbial oxidation of the double bond, oleic acid can be converted specifically into hydrostearic or ketostearic acid. These can be employed as lubricants, surfactants, and plasticizers as well as in other ways. A wide variety of yeasts, fungi, and bacteria that can catalyze the oxidative reactions have been identified.

Lard, which consists mainly of fatty acids combined with glycerin, is another object of research at the University of Iowa. Many Americans now avoid a high-fat diet. Thus, demand for lard has fallen to the point where it has become a food-processing orphan by-product. A single abattoir in Iowa produces 150 million pounds of lard a year. What to do with it? One alternative is to dissect it into its components, one of which is the 16-carbon, straight-chain palmitic acid. An enzyme present in a strain of yeast cleaves only palmitic acid from lard. Other yeasts have enzymes specific for freeing remaining 18-carbon acids.

Enzymes can facilitate specific reactions of carbohydrates with other chemicals with a minimum of undesirable by-products. Sucrose contains eight potentially reactive OH groups. Ordinary chemistry tends to lead to uncontrolled, undesirable cross-linking. When the appropriate enzyme is employed, one site only on the sucrose reacts with certain chemicals to form monomers that can be isolated and subsequently polymerized to make interesting, highly hydrophilic polymers. A variant of this procedure involves enzyme-catalyzed trans-esterification of monosaccharides with vinyl acrylate, with the reaction conducted in pyridine. The resultant esters are isolated and subsequently polymerized. The hydrophilic polymers are lightly cross-linked to form materials capable of holding 50 times their weight of water. The polymer would be largely biodegradable.

In contrast to the earlier conventional view, some enzyme-catalyzed reactions proceed better in nonaqueous media than in water. Advantages of using other media include: increased solubility of nonpolar substrates, shifts in equilibria to favor synthesis over hydrolysis, suppression of water-dependent side reactions, and elimination of microbial contamination. To perform well in polar media, most enzymes seem to require the presence of 1 to 2 percent of water in the reaction mixture. Reactivity and selectivity of the enzymes in nonaqueous media may be improved by recombinant DNA protein engineering, which has been successful in enhancing catalytic activity of enzymes in water.

Microbiologists have long known that many microorganisms synthesize a wide range of compounds, using carbohydrates as the sole energy and carbon sources. Biotechnology companies such as Genencor International are exploiting these synthetic capabilities to obtain specialty chemicals. One of these is indigo, which is used for dyeing denim. In ancient times, indigo was obtained from plants. During the last century, it was synthesized chemically from toxic chemicals, including aniline, formaldehyde, and sodium cyanide. Through bioengineering, a strain of *Escherichia coli* has been created that produces substantial amounts of tryptophan, converts it to indole, and finally to indigo. Indigo produced by *E. coli* will soon be on the market competing with dye synthesized by the older industrial method.

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