Just One Word: Plastics

In the 1960s hit movie "The Graduate," there is a classic line about a possible career choice for a young college graduate. The student is given the following advice: "Plastics." Now in the 1990s, this may refer to the laboratory options for a new breed of enzymologists as well. Indeed, the immobilization of catalytic enzymes in polymer matrices is an area of intense research, with applications for the food, chemical, pharmaceutical, and agricultural industries.

SIGHTINGS

Many methods have been developed for the incorporation of enzymes into an insoluble matrix that houses a local aqueous environment. These consist of entrapment, covalent attachment, and adsorption. There are instances, however, when the enzyme is needed to function in nonaqueous, organic solvents as well. Wang *et al.* have just reported a method for incorporating enzymes into plastics so that they retain activity in organic solvents (*1*). Others have previously linked enzymes to acrylic polymers by covalent attachment of amphiphilic polyethylene glycol molecules to the enzyme (*2*). These biocatalytic plastics had activity both in aqueous and organic environments, but the activity of the enzyme was significantly decreased when immobilized in this matrix. The approach of Wang *et al.* remarkably yields enzymatic activity close to the activity of the enzyme in its native state.

The enzyme (chymotrypsin or subtilisin) was first chemically acryloylated by treatment with acryloyl chloride. This covalent modification generates polymerizable functionalities on the protein. Native enzymes are insoluble in organic solvents, so the team next mixed the protein with a surfactant. Noncovalent ionic bonds are then formed between the enzyme and the surfactant, producing an enzyme preparation soluble in an organic solvent (such as hexane or toluene). To this reaction, they added vinyl monomers with polymerization achieved by free-radical initiation. In the end, the team created a plastic material with an active enzyme embedded in it. The resultant catalytic activity is about 10 times less than the activity of the native enzyme in aqueous environment. The real breakthrough, however, was that the activity in an organic solvent is similar to the activity of the free enzyme in the ion-paired form in the presence of surfactant. These biocatalytic plastics are highly stable in organic solvents such as hexane. They can be left at room temperature for several months (*3*) without much loss of activity.

While scientists continue to find new ways to increase the activity and stability of such biocatalytic plastics, several future applications can be imagined. The use of enzyme-containing plastics for nonaqueous biotransformations could include peptide synthesis and acylation of sugar-containing compounds like carbohydrates and (deoxy)nucleosides. They could also include the incorporation of proteases into the coating of containers or ultrafiltration membranes to prevent the adhesion of proteins on the surface of such devices; self-cleaning house paints, where an enzyme hydrolyzes the resins that fall down from trees; or ship hull coatings to prevent the adhesion of particles to boats. The applications seem limitless.

–Richard Peters and Robert Sikorski

References

1. P. Wang *et al.*, *Nature Biotechnol.* **15**, 789 (1997).
2. Z. Yang *et al.*, *J. Am. Chem. Soc.* **117**, 4843 (1995).
3. J. S. Dordick, personal communication.

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Tech Traps

The community of science is one of the best wired groups, with Internet access available to most researchers in their labs. However, if you work for a university, a company, or government there are usually rules specifying the nature of the content that can be viewed over the Net. There may be free speech on the Net, but not free listening.

NET TIPS

If you use the Net for checking out lab Web sites, databases, science news, and other work-related sites, don't worry, you are fine. If you deviate (pun intended) from these areas, you may be setting yourself up for some trouble. Individuals have been fired or reprimanded for surfing in nonscientific sites. How do they get caught? Easy. We all leave digital trails on our computer and in cyberspace. There are obvious ones such as URL bookmarks, but the Net technology itself also keeps clues. Here are three.

Every time you go to a Web site, files are transferred to your hard drive where they are stored in a file called a cache. This is used by the browser when you return to a site; you don't actually go to the Net again, you get the document from your local cache. The cache can be found with the other preference and helper files that a browser uses. Almost every picture or piece of text that is displayed on your browser screen ends up in the cache. When you

(continued on page 1850)