Tiny bioreactors speed up enzyme reaction

Carbon dioxide, when heated and squeezed into a fluid phase intermediate between a liquid and a gas, makes a great solvent for carrying out chemical reactions. By tweaking its temperature and pressure, chemists can control the properties of this supercritical fluid to a degree not possible in liquid solvents.

Many substances that dissolve in water, however, don't dissolve well in carbon dioxide. Chemists have been looking for ways around this limitation by adding long polymer molecules called surfactants to the mix. Surfactants surround water-friendly compounds, encapsulating them in spherical blobs that can dissolve in carbon dioxide (SN: 8/16/97, p. 108).

Now, Frank V. Bright and his colleagues at the State University of New York at Buffalo have carried out an enzyme reaction within these tiny spheres. The reaction progressed much faster inside these nanobioreactors than it did in a mix of water and supercritical carbon dioxide without surfactants, says Bright. He presented his group's findings last week at a meeting in Dallas of the American Chemical Society.

The SUNY researchers chose to look at the enzyme cholesterol oxidase, which speeds the breakdown of cholesterol into hydrogen peroxide and a compound called cholestenone. Bright and his colleagues also added another enzyme, catalase, to the reaction to remove the hydrogen peroxide.

In their experiment, the researchers used perfluoropolyether molecules as surfactants when they added water, oxygen, and the two enzymes to carbon dioxide. Under pressure, the carbon dioxide turned into a supercritical fluid, and the surfactant molecules gathered together to form spheres surrounding pockets of water and other components. The scientists then added cholesterol and monitored the enzyme reaction by measuring the amount of cholestenone produced.

It's not surprising that enclosing the reaction inside the spheres speeds it up, says Bright. The spheres hold the enzyme and cholesterol molecules very close together, making it easier for them to react.

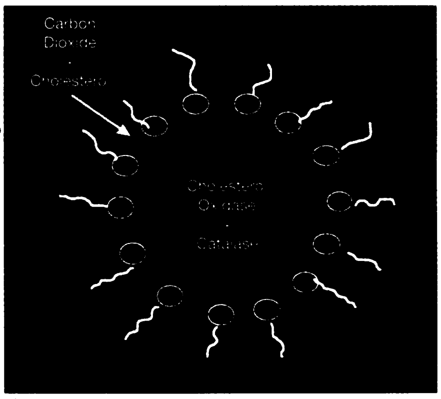
Studying them inside these spheres instead of floating free in a liquid may provide a more accurate picture of how they work. "When [an enzyme] is in the body, it's usually bound to a membrane," Bright says. "That environment is very different from liquid water."

With this technique, chemists can carry out a reaction in water while reaping the advantages of using carbon dioxide as a controllable medium. Carbon dioxide not only has tunable properties but is also environmentally benign, says Steven M. Howdle of the University of Nottingham in England.

Also, Bright notes, this system is good for studying and carrying out reactions which have starting materials that dissolve in water but products that don't. "You can do part of the reaction in the water pool, then the product off-loads out of the pool into the [carbon dioxide] phase."

The next challenge is getting proteins out of the spheres without destroying them, Bright says. Lowering the pressure causes the spheres to fall apart, but their contents may do the same. —*C. Wu*

Bright/SUNY-Buffalo



Surfactant molecules—whose heads attract water and whose tails attract carbon dioxide—form a tiny sphere containing water and two enzymes. Cholesterol diffuses into the sphere from the surrounding carbon dioxide and reacts with cholesterol oxidase.

Mutualisms seen as partnerships for barter

Trees and fungi routinely swap sugar for fertilizer, but ecologists have not been able to explain how such mutualisms evolve. Now, researchers have developed a theory that explains how these positive interactions between species may arise.

When a species is even slightly better at acquiring one resource than another, the organism will often do better by specializing in the first resource and trading for the second, propose Mark W. Schwartz and Jason D. Hoeksema of the University of California, Davis. In two species with complementary needs and abilities, a mutualism can readily develop.

Nina Wurzburger/Univ. of Calif., Davis

A biological trading association: The orange mycorrhizal fungi coating the root tips of Bishop pine are visible when viewed through a dissecting microscope.

It sounds like economics 101 because it is. "I've taken a very old economic model and applied it to a biological model," says Schwartz, coauthor of a report on mutualism published in the April ECOLOGY.

Even though the analogy between barter and mutualistic associations seems obvious, it is a new way of thinking, says Judith L. Bronstein of the University of Arizona. "Mutualisms have always gotten much less attention than antagonisms like competition or predation."

Schwartz agrees that most ecological theory focuses on competitive interactions and predator-prey relationships. When researchers explored mutualisms with those models in the 1970s, he says, they generated unrealistic results—the species' populations spiral to infinity.

The models also predicted that conditions favoring the rise of mutualisms are rare. Because such beneficial associations are actually common in nature, Schwartz adds, these models weren't much help and ecologists put them aside.

Schwartz and Hoeksema base their model on a common mutualism between fungi and plants. Mycorrhizal fungi grow into the roots of many plants, including all conifers, many forest trees, and many grasses (SN: 4/30/88, p. 285). The fungi and plants exchange nutrients. Plants are more efficient than fungi at capturing carbon, in the form of carbon dioxide, and converting it to energy-rich sugars. Fungi excel at foraging for phosphorus, a soil nutrient included in many fertilizers because it is so hard for plants to obtain. The scientists' model predicts that both the plant and the fungus will get more of the resources they need by trading than by going it alone.

"If I make pants better than you make boots, it's obvious that we stop making two things [each] and we just trade," Schwartz says. "The tricky bit is if you make pants and boots better than I do, but I make boots better than I make pants. It's still better from me to stop making pants altogether and trade my boots for your pants. . . . I'm still going to get more pants back than I would if I made them on my own. . . . The only real constraint is that I can't be equally bad at making everything."

Mutualisms can still arise even if they render only small gains to the participants, Schwartz says. The model also predicts that when those gains vanish, barter should stop. Such alterations in fungus-plant interactions do occur, note the researchers. When soils have high amounts of phosphorus, mycorrhizal associations decrease. —*M.N. Jensen*