Chemistry

Changing the colors of the signals

Fireflies owe their flashy method of communication to the enzyme called luciferase, which catalyzes a chemical reaction producing the familiar chartreuse glow. Now, researchers have found that switching just one amino acid in luciferase can dramatically change the color of that light.

At one specific position on luciferase, Sidney M. Hecht and his colleagues at the University of Virginia in Charlottesville replaced the amino acid serine with each of a variety of other amino acids. Previous work had indicated that light production depends in part on this amino acid. In test-tube experiments, these substitutions altered the wavelength of light produced, often shifting the color from the usual yellow-green to a red-orange, the team reports in the July 31 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY.

Luciferase converts the chemical luciferin into oxyluciferin, which emits light when it decays from an excited energy state. Fireflies aren't the only creatures who find this feature useful. Scientists have harnessed the luciferase gene to genes in bacteria to provide a visual signal when those bacterial genes turn on. Seeing whether a protein is being synthesized is as easy as watching the bacteria light up (SN: 08/12/95, p. 108). Having luciferase produce different colors would be "very interesting from a biotechnology perspective," Hecht says.

Although no one knows exactly what luciferase looks like, and therefore how it works, one of the group's observations provides a clue to the enzyme's three-dimensional structure. Substituting chemically modified serines—even negatively charged or very bulky ones—rather than different amino acids didn't alter the color of the light. This lack of effect suggests that serine lies on the surface of the molecule, Hecht argues. If the serine were inside, substituting a modified version of the amino acid would almost certainly alter the enzyme's shape enough to change the color of the light produced, he says.

Moreover, the technique used in this work to modify or substitute serine in luciferase can be applied to many other proteins, Hecht adds. Being able to make such specific changes would allow scientists to study a wide variety of biochemical processes more precisely.

Designer hormone can do double duty

Scientists have taught insulin—the pancreatic hormone that regulates blood sugar level and carbohydrate metabolism—to perform an interesting new trick.

By modifying four of insulin's amino acids, researchers at the Medical University of South Carolina in Charleston and New York University Medical Center in Tuxedo made it act like relaxin, a hormone that relaxes the uterus during pregnancy.

The changes cost insulin most, but not all, of its usual activity, so that the modified molecule has two unrelated biological functions. To describe this duplicity, the scientists coined the term "zwitterhormone," based on "zwitterion," a molecule containing both positively and negatively charged groups. They describe the work in the July 30 BIOCHEMISTRY.

Insulin and relaxin interested the group, says Erika E. Büllesbach, a biochemist at South Carolina, because their three-dimensional structures were very similar even though their amino acid sequences weren't. They thought it would be fun to see if they could trade reactivities, she says. It's been more difficult, however, to make relaxin behave like insulin, she reports.

Though no immediate application for this research exists, Büllesbach speculates that far in the future, zwitterhormones could serve as dual activity drugs. For example, a person who needs to control diabetes might also benefit from relaxin's effect of improving blood circulation through the capillaries. With a zwitterhormone, only one drug would be necessary.

Materials Science

Buckyball additives improve lubrication

Molecules shaped like spheres conjure up images of microscopic ball bearings that can reduce friction between tiny moving components.

When researchers discovered the buckminsterfullerene molecule in 1985, they thought they had found the ideal candidate for such a role. Consisting of 60 carbon atoms, this molecule is a nearly perfect sphere. In the crystalline solid state, it spins at a rate dependent on temperature, while remaining in its position in the crystal lattice.

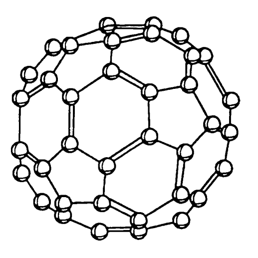
Those hopes were dashed when subsequent experiments demonstrated that buckyballs are not particularly good lubricants. Now, a team of chemical engineers and chemists has discovered that C_{60} molecules dissolved in the organic solvent toluene greatly reduce the friction between the liquid and the surface across which it flows.

This finding suggests that the addition of buckyballs to conventional lubricating fluids may enhance their performance. Jacob N. Israelachvili, Fred Wudl, and their coworkers at the University of California, Santa Barbara report their results in the Aug. 8 NATURE.

The researchers measured oscillating, attractive forces between a pair of smooth, transparent sheets of mica immersed in toluene as the distance between the surfaces was varied. When the liquid contained small quantities of C_{60} molecules, the forces between the mica plates changed in a manner suggesting that thin layers of buckminsterfullerene molecules had settled on the mica surfaces. The molecular spheres allowed the liquid to pass easily between the mica sheets, "giving rise to flow behavior that is totally different from conventional fluid flow through narrow pores," the researchers note.

A possible explanation of this result is that the adsorbed layer of molecules is only weakly bound to the surface and, as in the crystalline solid, the buckyballs may be rotating rapidly, allowing toluene molecules to slide by easily.

In contrast, measurements of the forces between a pair of solid layers of C_{60} in the absence of a liquid confirm that the molecules by themselves offer no significant reduction in friction. "The results . . . indicate that C_{60}, although not a good lubricant, shows great promise as an additive," Israelachvili and his colleagues conclude.



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In this schematic diagram of a buckminsterfullerene molecule, carbon atoms sit at the 60 vertices of a rounded geometric form known as a truncated icosahedron.

Carbon onions put on the pressure

A new technique of making diamonds out of soft graphite generates the huge pressures needed by simply letting carbon itself do the squeezing.

Florian Banhart and Pulickel M. Ajayan at the Max Planck Institute for Metal Research in Stuttgart, Germany, formed diamonds less than 50 nanometers in diameter in the cores of carbon onions, small particles consisting of multiple concentric layers of graphite. Heating the onions to about 700°C and bombarding them with an electron beam triggered atomic rearrangement in the carbon layers, causing them to contract, the researchers say. "In effect, the carbon onions act as nanoscopic pressure cells for diamond formation," they note in the Aug. 1 NATURE.

At this point, it's unclear whether larger diamonds could be made this way, but the method provides scientists with a window into how graphite changes to diamond. Also, studies are under way to see if other materials can be slipped into the carbon onions and then squeezed, Banhart says.