A Molecule to Catch the Sun

The photosynthetic process in green plants and certain bacteria is the photochemist's grail. Mimicking this paragon of reliable and efficient conversion of light energy to work is the target of much solar energy research.

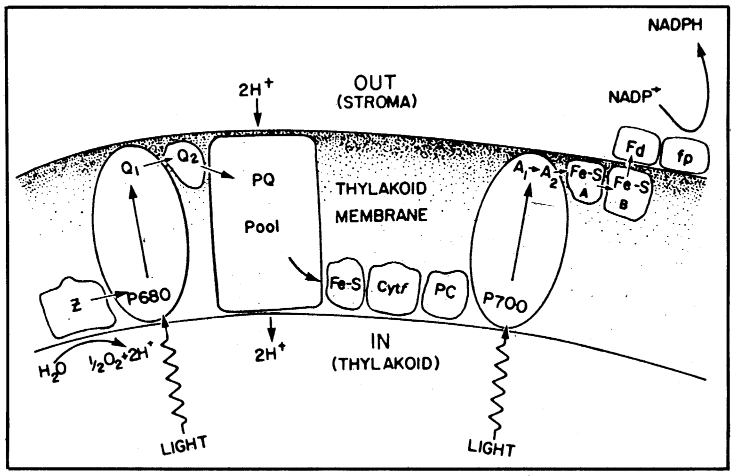
Photochemists now are one small ring closer to the bull's-eye on that target: The first step of plant photosynthesis has been simulated in a synthetic molecule. In plants, the conversion of light to stored energy (sugar and starch) begins when sunlight "excites" a chlorophyll molecule contained in a protein reaction center. The excited chlorophyll (the donor molecule) releases an electron that travels across the reaction center to an acceptor molecule. James R. Bolton and colleagues of the University of Western Ontario in London, Ontario, have simulated this electron transfer — the first and fundamental step of photosynthesis — in a single molecule they call "P-Q."

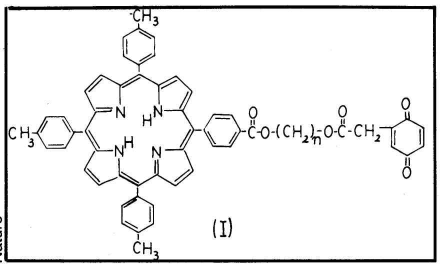
P-Q, first synthesized by Paul Loach and colleagues at Northwestern University in Evanston, Ill., is a porphyrin (P) linked to a quinone (Q) by a chain of carbons and hydrogens. The complex porphyrin end of the molecule resembles chlorophyll. The simpler quinone end of the molecule is an analog of nature's electron-acceptor molecules. When illuminated, an intramolecular electron transfer occurs from the P to the Q end, creating the state P^{+}/Q^{-}. When the light is turned off, the electron returns to the P end, completing the simulated first step of photosynthesis.

For P-Q to achieve the electron transfer, however, requires more than the flick of a light switch: P-Q must be placed in an environment similar to the protein reaction center that houses chlorophyll and acceptor molecules in plants. Bolton and colleagues report in the July 17 NATURE their finding of such an environment — a frozen methanol plus 2 percent chloroform solution maintained at a temperature close to the melting point of methanol. "Having the methanol just below its melting point means that the structure of the solid is quite loose," Bolton explains. "This allows the molecule some degree of flexibility that may have something to do with the way it is able to get the electron across."

And the crossing electron, or electricity, "could be developed as a significant power source," Bolton says. Devices that convert light into electricity are solar cells. Bolton says a solar cell employing the P-Q molecule may prove to be more efficient than the commercially available silicon cell, in which an electron ejected from a silicon atom flows into an external circuit to generate electrical power.

Electron transfer in the molecule shown below mimics the first step of photosynthesis. In green plants that first transfer occurs between a chlorophyll (P680) and acceptor (Q_1) molecule in a protein matrix (oval figure).





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John S. Connolly of the Solar Energy Research Institute in Golden, Colo., agrees that the P-Q molecule has potential applications in the field of solar energy conversion. But, he warns, the degree of this potential depends in part on the nature of the excited state of the P-Q electron. An excited electron has maximum potential energy in what is termed a "singlet state." If the electron undergoes a "spin-flip" — which is one way of "relaxing" its excited singlet state — it loses 30 to 50 percent of its energy before it can be tapped. Ideally, therefore, "We want to do photochemistry out of the electron singlet state," Connolly says.

Although preliminary analysis indicates the excited electron of P-Q is in the preferred singlet state, that is "a detail at this point," Bolton says. "The important thing is that we have a model that seems to mimic natural photosynthesis," he explains. "At this state, we're just happy it works." □

Rare quake strikes Kentucky

"Scientifically, it's a curiosity." That's how one geologist summed up the moderate-sized earthquake that struck northern Kentucky on July 27. For practical purposes, however, the quake may be a nuisance to those, such as the Nuclear Regulatory Commission, who once considered the region to have little risk of seismic activity.

The temblor, estimated at magnitude 5.1 and centered near Maysville, Ky., is a member of a little-understood seismic species — an eastern U.S. earthquake. In contrast to most major U.S. quakes, such as those in California that occur along well-defined faults, earthquakes in the central and eastern United States usually cannot be linked to a specific fault or geologic structure. In addition, mid-continent quakes strike less often, are usually smaller, but affect a wider area than their western counterparts — most likely because the shock waves are transmitted farther through the thicker, cooler crust.

The July 27 quake is a curiosity because of its size and location. Magnitude 5 tremors are considered rare east of the Rockies, and the largest quake in the general region, recorded in 1933, measured 4.2, says Sudarshan Singh of St. Louis University. Moreover, almost no seismic activity has been recorded in northern Kentucky. "There are a number of faults in the area, but they are [very deep] and were never thought to be active," says Mark Zoback of the U.S. Geological Survey. In the hopes of linking the quake to a specific fault, scientists are looking for ground surface damage and adding seismographs in order to catch any aftershocks that may help indicate the source of the earthquake.

The quake is a nuisance because it may alter previous seismic risk assessments of the area, suggests Arch Johnston of the Tennessee Earthquake Information Center in Memphis. Such assessments are used by the NRC in siting plants and are based on historical seismicity, he explains. The NRC's Andrew Murphy says, however, that a magnitude 5 earthquake is "not totally unexpected in the area," but adds that the quake will become "another important data point" in assessing the long-distance effects of eastern quakes. □