Plants point the way to renewable energy

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Natural solution: new molecules mimic photosynthesis

GENUINELY renewable energy has moved a little closer, now that chemists have developed molecules that should function just like two key components of the photosynthetic apparatus of plants.

In the US researchers have created a molecule that mimics the photochemical "reaction centre" that converts light into a form of energy that plants can use to make sugars, Meanwhile, chemists in Germany and Japan have produced a molecular array that works like the natural light-harvesting "antenna complexes" that funnel energy towards this reaction centre.

In a photosynthesising cell, molecules of chlorophyll are joined together by proteins to form arrays, each containing hundreds of chlorophyll molecules. Within each chlorophyll is a large disc-shaped section called a porphyrin, which can absorb photons of light. When it does so, one of its electrons becomes excited to a higher energy level. This excitation-though not the excited electron itself-is then passed from molecule to molecule towards the centre of the complex.

At the complex's heart lies the reaction centre, which contains a "special pair" of chlorophyll molecules-so named because they shed an excited electron to an electron-accepting molecule bound to them, rather then merely transferring its excess energy. The electron acceptor is a molecule of quinone, a chain of several aromatic carbon rings bearing a carbonyl (CO) group on each side. The electron transfer provides the energy to drive the reactions that build sugars from carbon dioxide and water.

The key feature of the special pair, says Kenneth Suslick of the University of Illinois in Urbana-Champaign, is their close alignment, which brings the porphyrin groups from the two molecules to within 0.3 nanometres of one another. At this distance, electrostatic effects allow the porphyrin pair to assume a positive charge and give up an electron to the quinone.

In nature a scaffolding of cell components such as proteins clamps the chlorophylls in place, just the right distance apart. Building this scaffolding from scratch is not practical, so chemists have tried to tie porphyrins together by creating chemical bridges between their edges.

The best they had managed until now was a spacing of 0.5 nanometres, which Suslick says is not close enough. But in this week's issue of Angewandte *Chemie* (vol. 35, p 1223), he and his colleagues report that they have achieved the desired spacing by a different means. Rather than trying to join the porphyrins at their edges, the chemists removed a metal atom that sits at the centre of each of the two porphyrins and replaced them with a single ion of zirconium, linked to both molecules.

Like a natural special pair, Suslick's molecule has a quinone group bound to one of the porphyrins. The researchers have yet to confirm that electron transfer can take place in their molecule, but the quinone should accept an electron. "Ours is the first chemical system that is a structurally well-defined mimic of the photosynthetic reaction centre," says Suslick.

Suslick says the molecular mimics could be used to build photocells that are twice as efficient as current solar panels, which rely on inorganic photosensitive materials. These are at best only 15 % eff cient "This compares poorly with photosynthesis," he says.

Even better performances might be obtained if Suslick's molecule could be combined with a mimic of natural antenna complexes, developed by Alfred Holzwarth and his team at the Max Planck Institute for Radiation Chemistry in Mullheim, working with Japanese colleagues at Ritsumeikan University in Shiga.

Their molecules are self-assembling, and contain between 50 and 100 porphyrins. Just like the chlorophylls in a natural antenna complex, these porphyrins absorb energy from light,. and funnel it to a single point in the array *(Angewandte Chemie,* vol *35,* p *772).* Holzwarth and his colleagues linked their antenna complex mimic to a porphyrin-type unit from a photosynthetic bacterium. But it may be possible to link the array to Suslick's special pair to produce an artificial photosynthetic set-up.