

First step to converting solar energy using 'artificial leaf'

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An international team of researchers has modified chlorophyll from an alga so that it resembles the extremely efficient light antennae of bacteria. The team was then able to determine the structure of these light antennae. This is the first step to converting sunlight into energy using an artificial leaf.

The researchers will be publishing an article on their research findings in the online Early Edition of the *PNAS* journal in the week starting 29 June. The Leiden University (The Netherlands) researcher Swapna Ganapathy has obtained her PhD based on this subject, under the supervision of Professor Huub de Groot, one of the initiators of the research.

Forests at nano scale

They are the subject of dreams: artificial forests at nano scale. Or pavements and motorways where gaps in the surface are filled with pigment molecules that collect sunlight and convert it into fuel and other forms of - clean - energy. But before this can happen, artificial photosynthesis systems first have to be developed that work both quickly and efficiently.

Two things are needed to generate fuel from sunlight: an antenna that harvests light, and a light-driven catalyst. The article in *PNAS* is about the first of these: the antenna.

Imitating light antennae of bacteria

The fastest light harvesters are to be found in nature: in green leaves, algae and bacteria. The light antennae of bacteria - chlorosomes - are the fastest of all. They have to be capable of harvesting minimal quantities of light particles in highly unfavourable light conditions, such as deep in the sea. These chlorosomes are made up of chlorophyll molecules. The art is to imitate these systems very precisely.

German colleagues from the University of Würzburg in Huub de Groot's team modified chlorophylls from the alga *Spirulina*, such that they resembled the pigments of bacteria. De Groot's Leiden group then studied the structure of these semi-synthetic light antennae.

Nanotechnology

De Groot: ' Nanotechnology and supramolecular systems are becoming increasingly important, but it is very difficult to determine their structure. So-called cartoons are frequently made that give a schematic indication of what their structure could be.'

De Groot and his colleagues successfully determined the detailed molecular and supramolecular structure of their artificial self-assembled light antennae. They did this using a combination of solid state NMR and X-ray diffraction (see attachment). X-ray diffraction enabled them to determine the overall structure and NMR allowed them to penetrate deeply into the molecules.

Stacking of molecules

De Groot: 'We already knew that the light antennae in bacteria form a structure rather like the annual rings of a tree trunk. The molecules in

these semi-synthetic antennae seem to stack in a different way; they are flat. But this, too, is one of four ways we had thought in advance were possible.

New approach

The researchers still have to determine how the light antennae of modified *Spirulina* chlorophylls work in practice. De Groot: 'This is a completely new approach in this field.'

The new insights are coming in quick succession. Last month, De Groot, with an international team made up partly of different members, also reported a breakthrough in *PNAS*. In that article he showed how - also with a combination of NMR and another technique, namely electron microscopy - he had resolved the structure of the [light](#) antennae of the [bacteria](#) themselves. This allowed the researchers to explain how the antennae were able to function so quickly and so efficiently.

More information: Zinc chlorins for artificial light-harvesting self-assemble into antiparallel stacks forming a microcrystalline solid-state material Swapna Ganapathy, Sanchita Sengupta, Piotr K. Wawrzyniak, Valerie Huber, Francesco Buda, Ute Baumeister, Frank Wurthner, and Huub J. M. de Groot *PNAS* online Early Edition

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