Dye-Nanochannel Composites for Solar Energy Conversion Devices

Gion Calzaferri
Department of Chemistry and Biochemistry, University of Bern, Freiestrasse 3, Bern, Switzerland

Sunlight is the fundamental energy source sustaining life on earth by providing it with about 178'000 TW. This exceeds largely our current *technical power consumption*, which amounts to about 15 TW. The production of food, oxygen, and fossil fuels depends on the conversion of solar into chemical energy by biological photosynthesis. This process converts the abundant raw materials sunlight, water, and carbon dioxide into reduced organic species and oxygen. The processed materials serve in turn as food or fuel for all life forms. Natural photosynthesis is the essential process for life on earth, but the overall thermodynamic efficiency for the production of fuel is low and depends very much on optimal soil, temperature, and humidity conditions. Natural photosynthesis has many other important tasks to fulfill than just conversion of solar light into a chemical fuel. A long-standing challenge has therefore been the development of an artificial photosynthetic system that is specialized on the energy conversion process.

Green plants have developed very sophisticated and highly efficient tools for harvesting light and transporting electronic excitation energy in their antenna system to the reaction center. The antenna consists of regular arrangements of chlorophyll molecules held at fixed positions by means of proteins. Light absorbed by any of these chromophores is transported to the reaction center, providing the energy necessary for the chemical processes to be initiated. A green leaf consists of millions of such well organized antenna devices.

We report the synthesis and properties of artificial antenna that are built by incorporating dyes into the one-dimensional channels of zeolite L (ZL). ZL crystals feature strictly parallel nano sized channels arranged in hexagonal symmetry. These channels can be filled with suitable guests. Geometric constraints imposed by the host structure allow achieving supramolecular organization of fluorescent guests such that light harvesting within the volume and radiationless transport of the electronic excitation energy via FRET to a well positioned acceptor occurs.

The new antenna composites are currently tested for applications in luminescent solar concentrators (LSC). Chances are good that the losses responsible for the so far low efficiency of such devices can be eliminated so that the performance needed can be achieved, to use LSC for e.g. extending the range of applications of photovoltaic solar cells.

Photon-Harvesting Host-Guest Antenna Materials. G. Calzaferri, S. Huber, H. Maas, C. Minkowski; *Angew. Chem. Int. Ed.* **2003**, *42,*3732-3758.
Mimicking the Antenna System of Green Plants. G. Calzaferri, K. Lutkouskaya; *Photochem. Photobiol. Sci.* **2008**, *7,* 879 – 910.
Designing Dye-Nanochannel Antenna Hybrid Materials for Light Harvesting, Transport and Trapping. G. Calzaferri, et al.; *ChemPhysChem* **2011**, *12*, 580-594.
Manipulation of Energy Transfer Processes within the Channels of L-Zeolite. G. Calzaferri, A. Devaux in *SUPRAMOLECULAR PHOTOCHEMISTRY; Controlling Photochemical Processes. Eds.* V. Ramamurthy, Y. Inoue, John Wiley & Sons, N. J., US **2011**, *Chapter 9*, p. 285-387.
Nanochannels: Hosts for the Supramolecular Organization of Molecules and Complexes G. Calzaferri; *Langmuir,* **2012**, *28*, 6216. dx.doi.org/10.1021/la3000872.