

Photonic Antenna System for Light Harvesting, Transport, and Trapping

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A photonic antenna system is an organized multi-component arrangement in which several chromophoric molecular species absorb the incident light and channel the excitation energy (not charges) to a common acceptor component. Imaginative attempts different from ours have been presented in the literature to build an artificial antenna. Multinuclear luminescent metal complexes, multichromophore cyclodextrins, Langmuir Blodgett films, dyes in polymer matrices and dendrimers have been investigated. Some sensitization processes in silver halide photographic materials and also the spectral sensitization of polycrystalline titanium dioxide films bear in some cases aspects of artificial antenna systems. For references see [1]. However, to our knowledge the systems reported by us [1-5] are the first artificial photonic antenna which work well enough to deserve this name. They are of a bi-directional type, based on zeolite L as a host material, and able to collect and transport excitation over relatively large distances. The light transport is made possible by specifically organized dye molecules which mimic the natural function of chlorophyll. Zeolite L crystals consist of a continuous one-dimensional tube system. We have filled each individual tube with successive chains of different joined but non interacting dye molecules. Light shining on the cylinder is first absorbed and the energy is then transported by the dye molecules inside the tubes to the cylinder ends.

A schematic view of the photonic antenna is illustrated in Figure 1. The monomeric dye molecules are represented by rectangles. The dye molecule which has been excited by absorbing an incident photon transfers electronic excitation to another one. After a series of such steps the electronic excitation reaches the trap which are pictured as dark gray rectangle. The energy migration is in competition with spontaneous emission, radiationless decay and photochemically induced degradation. Very fast energy migration is therefore crucial if a trap should be reached before other processes can take place. The energy quantum can be guided to the next reaction step once it has been captured by the trap. These conditions impose not only spectroscopic but also decisive geometrical constraints on the system.

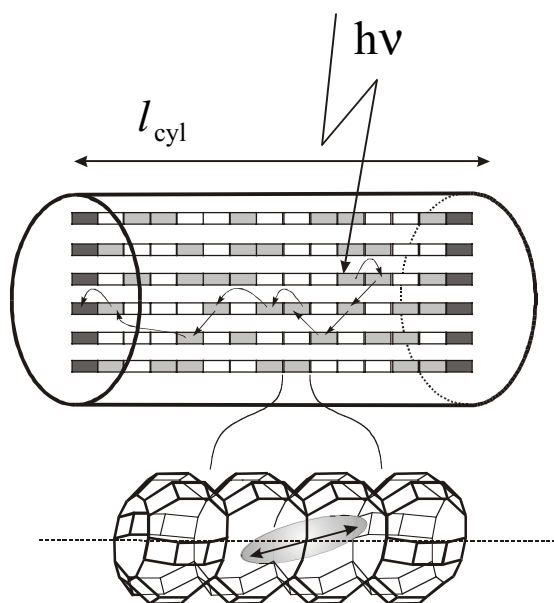


Figure 1: Representation of a cylindrical crystal consisting of organized dye molecules acting as donors (light gray rectangles) and acceptors acting as traps at the front and the back of each channel (dark gray rectangles). The enlargement shows a detail of the zeolite L channel with a dye molecule and its electronic transition moment, the orientation of which with respect to the long axis depends on the length and shape of the molecules.[1,3,6,7]

We have recently shown how fine tuning of the size of zeolite L crystals in the range of 30 nm up to 3000 nm can be realized by changing the composition of the starting gel for otherwise constant reaction condition. It was thus possible to extend the investigations on energy migration in pyronine loaded zeolite L crystals as donor molecules, modified with oxonine as luminescent acceptors at the crystal ends. The extended zeolite materials now available lead to a large improvement of the energy migration efficiency.[5]

We were interested to reverse the scheme in Fig. 1 and to have an acceptors dye in the center, and the donors at both ends because such systems could become useful for analytical purposes or for developing a new generation of LED's. It turned out that it is indeed possible to prepare such materials and to do stationary energy migration experiments on an ensemble and space and time resolved measurements on single crystals.[8]

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