

Broadband Dye-Zeolite L Composites for Luminescent Solar Concentrators

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The concept of luminescent solar concentrators (LSCs) can be traced back to the 1970s and involves using inexpensive polymer-based devices to concentrate sunlight onto photovoltaic cells. [1] In an LSC light is absorbed by organic luminescent chromophores dispersed within the polymer matrix and re-emitted at longer wavelength. Due to the difference in refractive index between the polymer matrix and the surrounding medium (i.e. air), a large amount of emitted photons will be trapped in the LSC by total internal reflection, which will wave-guide the photons towards the edges of the device (see Fig. 1). An important property of LSCs is that they can be efficiently used under diffuse light conditions. - There are, however, several major challenges that kept LSCs from being widely used: e.g. limited stability of the luminescent organic species, high self-absorption, and poor understanding of the parameters governing device efficiency. The advent of advanced host-guest materials and sophisticated photon transport simulation models renewed interest in this technology. [1,2]

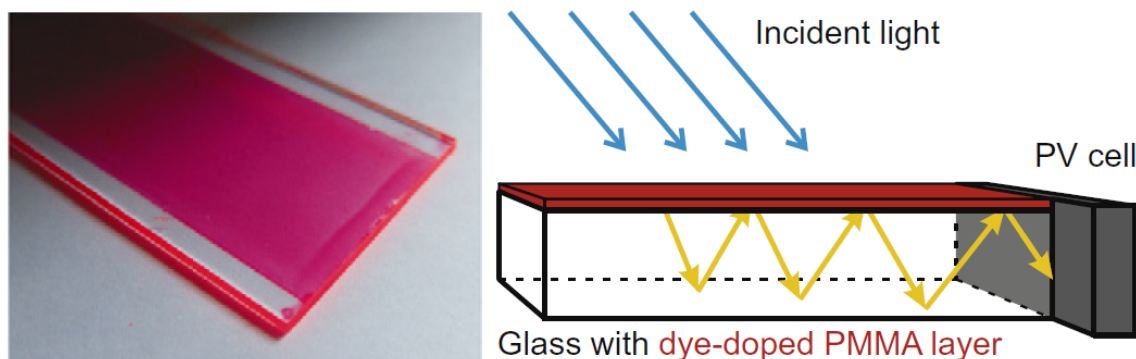


Fig. 1. Photograph and operational principle of an LSC based on a thin dye-doped polymer film. Incident light (blue arrows) is absorbed by the dyes inside of the zeolite L crystals and the re-emitted light is guided toward the edges by total internal reflection (yellow arrows). [2]

Our approach to these issues lies in using highly organized dye-zeolite composites with photonic antenna functions. [3-6] The key idea is to minimize self-absorption by reducing the spectral overlap between light absorption and emission. To reach this goal, multi-dye loaded zeolites are prepared where a Förster Resonance Energy Transfer (FRET) cascade absorbs light over a large spectral range and transports the energy to a final acceptor emitting in the NIR range. A schematic representation of such a material (also called *ZeoFRET*®) is given in Fig. 2. After absorption of the incident light by the high local concentration of donors (green ellipses), the energy is transported by FRET to an acceptor (red ellipse). Once the excitation

energy has reached the lower energy acceptor, it cannot be transferred back and is either emitted as a photon at longer wavelength or lost radiationlessly. By using large donor-to-acceptor ratios and dyes with high luminescence quantum yields, one can reach high absorptivity while maintaining a low final acceptor concentration and thus minimizing the problem of self-absorption in LSCs. The other great advantage of such systems is the increase in photostability of the organic chromophores observed by embedding them into inorganic hosts.

The most recent achievements in the development and sealing of multi-dye zeolite L systems and their potential use for LSCs will be given in this presentation.

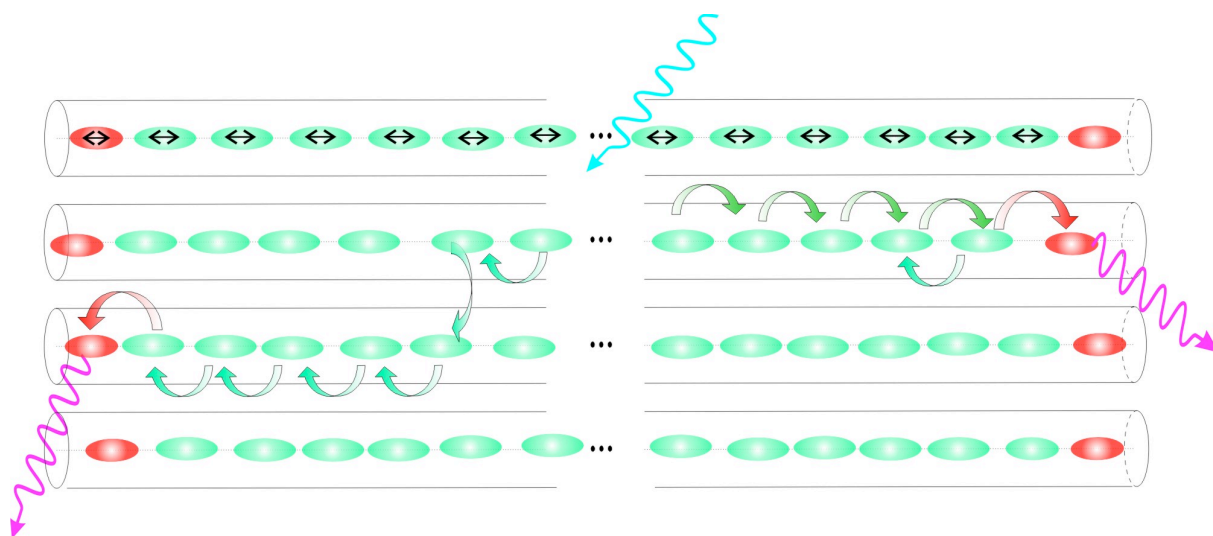


Fig. 2. Schematic overview of an artificial photonic antenna prepared by sequential insertion of dyes into zeolite L channels. The green dyes act as donor molecules that absorb the incoming light and transport the electronic excitation energy via FRET to the red acceptors shown at the ends of the channels on the right. The double arrows indicate the orientation of the ETDM.

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