

ZeoFRET® Materials for Solar Energy Conversion Devices

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ZeoFRET® materials are highly organized dye-zeolite inclusion compounds with photonic antenna function. After efficient absorption of the incident light by high local concentrations of dye molecules, the energy is transported by Förster resonance energy transfer (FRET) to an acceptor species. The organization of the dye molecules in the nanochannels of the zeolite crystals can be extended to the macroscopic scale, leading to systems with high optical anisotropy. The dye components of the ZeoFRET® materials are chosen according to the desired application [1]. High donor-to-acceptor (d/a) ratios and multi-donor systems are promising as active species in luminescent solar concentrators [2]. High d/a ratios thereby open possibilities to reduce self-absorption while maintaining efficient light-harvesting. An illustration of a zeolite L (ZL) channel with a d/a ratio of 50 is shown in Figure 1. We have synthesized materials according to this concept. Figure 2 shows the absorption and emission spectra of ZeoFRET® samples with d/a ratios of 33 and 52. In the latter case, one channel of ZL contains approximately 150 donor dyes and on average 1.5 acceptor dyes at each channel end [3].

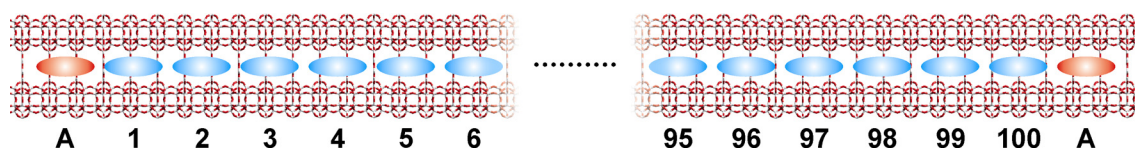


Figure 1. A nanochannel of ZL containing 100 donor dyes and one acceptor dye at each channel end. The donor dyes absorb the incoming light and transfer the energy to the acceptor dyes, which subsequently emit light in a wavelength range where the donor molecules do not absorb.

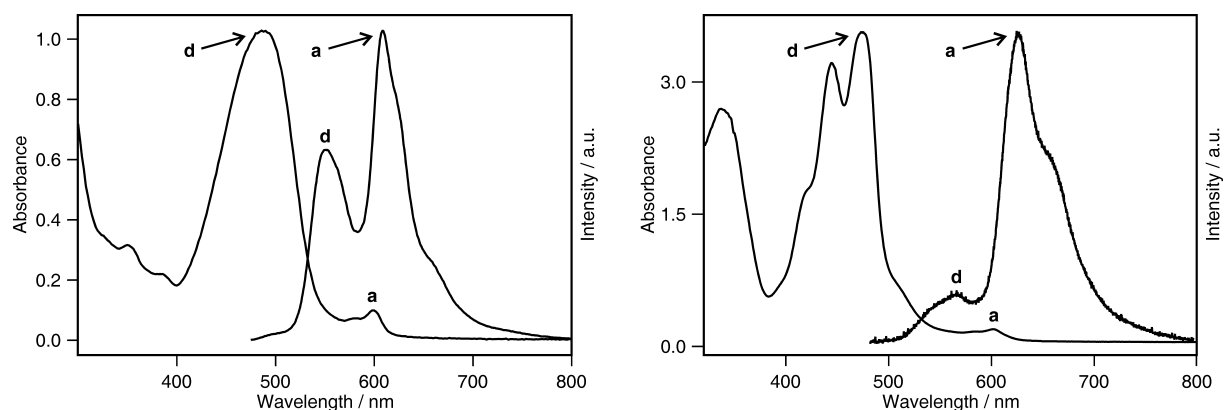


Figure 2. Left: Absorption and emission spectrum of a ZeoFRET® sample with a d/a ratio of 33. Right: Absorption and emission spectrum of a ZeoFRET® sample with a d/a ratio of 52. For both samples, the emission was measured upon selective excitation of the donor at 450 nm.

Dye combinations with zinc phthalocyanine (ZnPc) molecules that are specifically placed at the entrances of the zeolite nanochannels are of interest for the sensitization of ZnPc-based solar cells [4]. However, selectively adsorbing ZnPc molecules at the channel entrances of ZL is challenging. We have investigated van der Waals, electrostatic, and covalent binding, and developed methods that lead to a placement of the respective ZnPc at the ZL channel entrances in each of the three cases [5,6]. Channel entrance adsorption of a ZnPc with a cationic tail was found to be the most convenient route, making use of the exchange of charge-compensating cations in the ZL channels (Figure 3). Energy transfer from molecules in the ZL channels to the ZnPc molecules (acting as stopcocks) was observed [6].

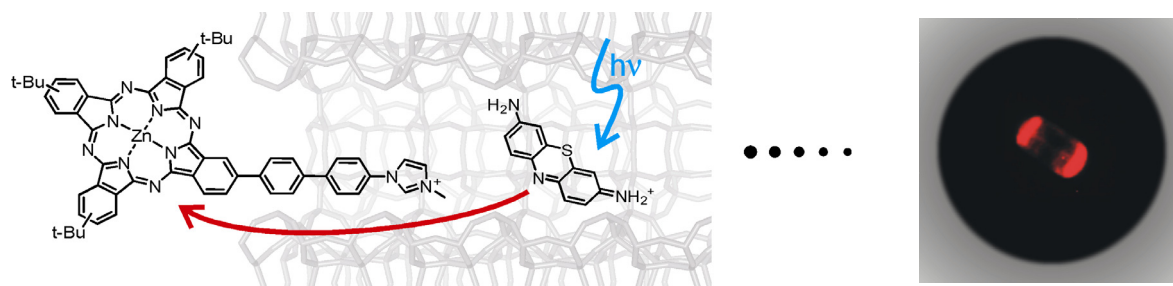


Figure 3. Left: Energy transfer from a thionine donor to a ZnPc stopcock with a cationic tail. Right: Fluorescence microscopy image of a ZL crystal (ca. 5 μm long) with ZnPc stopcocks located at the channel entrances.

References:

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