

Efficient Light Harvesting using Carbocyanine dyes in Langmuir Blodgett monolayers

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The fabrication of “light harvesting” structures is important in solar energy research for improving the capture of the dilute incident solar spectrum. A potential method is Förster Resonance Energy Transfer (FRET) that occurs between donor and acceptor molecules in the near field and greatly enhances the absorption step in photosynthesis.^{1–3} Previous work has already showed excitation energy transfer from dyes close to the silicon surface^{4–6} towards the development of a silicon photosensitised silicon solar cell. Dye loaded zeolite structures have demonstrated excitation energy funnelling^{7,8} that can be employed as efficient light harvesting structures. In this presentation we will show the development of a light harvesting monolayer structure based on Langmuir Blodgett films.

To that end a pair of donor-acceptor carbocyanine dyes, DiO (3,3'-Dioctadecyloxycarbocyanine perchlorate) and Dil, (1,1'-Dioctadecyl-3,3,3',3'-tetramethylindocarbocyanine perchlorate) were deposited from mixed chloroform solutions on the surface of quartz slides as a monolayer using the Langmuir Blodgett technique (Figure 1). The absorption and fluorescence spectra of mixed DiO:Dil monolayers were measured for different molecular ratios between the donor (DiO) and acceptor (Dil). The steady state emission spectra show reduction in the donor (DiO) fluorescence intensity, which is an indication of energy transfer. Time resolved fluorescence decays and Fluorescence Lifetime Images (FLIM) were obtained for wavelengths specific to the donor (DiO) and acceptor (Dil) molecules and showed evidence of energy transfer for molecular ratios up to 100:1. We have observed significant quenching of the donor fluorescence (DiO) in both steady state emission spectra (Fig. 3) and lifetime decay curves (Fig. 4) indicative of energy transfer to the Dil molecules.

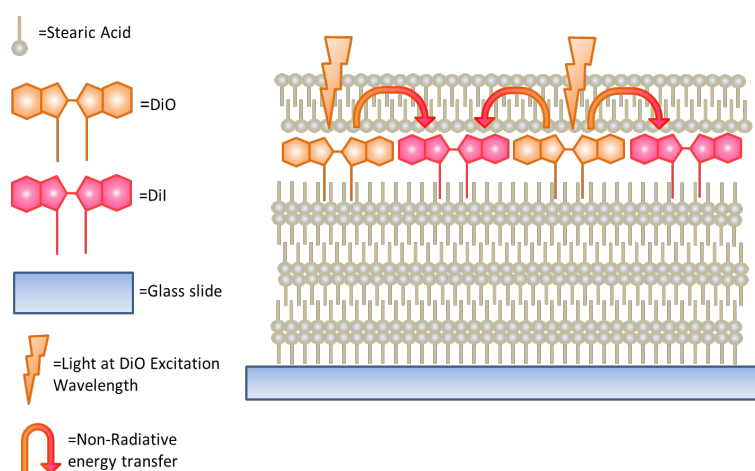


Fig. 1 Schematic of the monolayer structure consisting of six layers of Stearic Acid (SA) followed by the DiO/Dil mixed monolayer and two layers of SA cap added to the quartz slide. Light absorption by the DiO (donor) molecules in the monolayer results in FRET to Dil (acceptor) molecules. The ratio of the DiO:Dil molecules was varied from 1:1 up to 100:1.

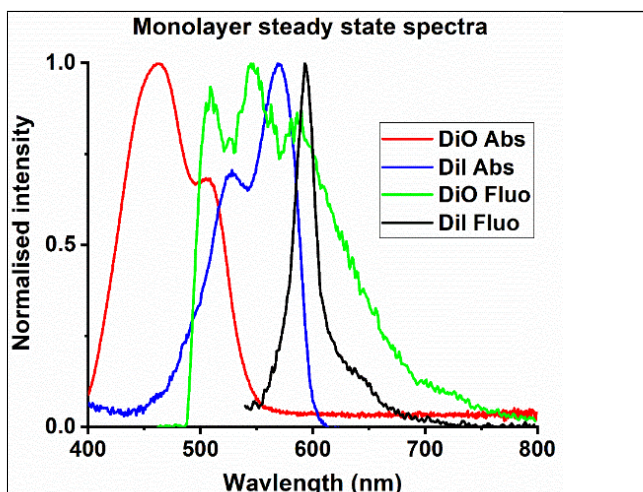


Fig. 2 Normalised absorption/emission spectra of deposited DiO and Dil LB monolayers respectively. There is a significant overlap between the emission of the donor dye (DiO) and the absorption of the acceptor dye (Dil).

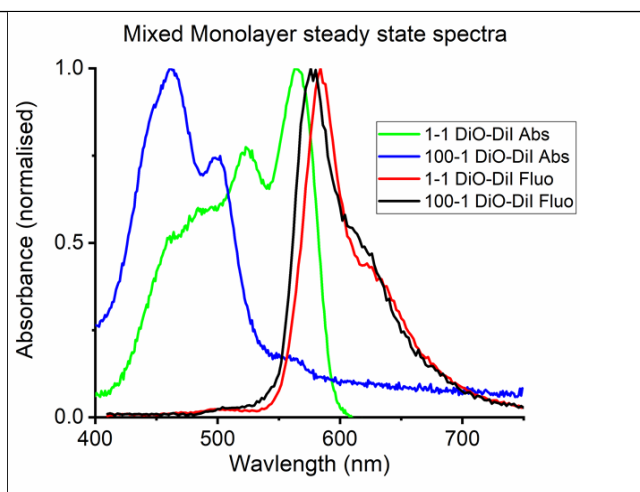


Fig. 3 Normalised absorption/emission spectra of deposited DiO:Dil mixed LB monolayers for mixing ratios 1:1 and 100:1 respectively. In both cases there is a significant reduction in the emission of the DiO (donor) fluorescence indicating efficient energy transfer.

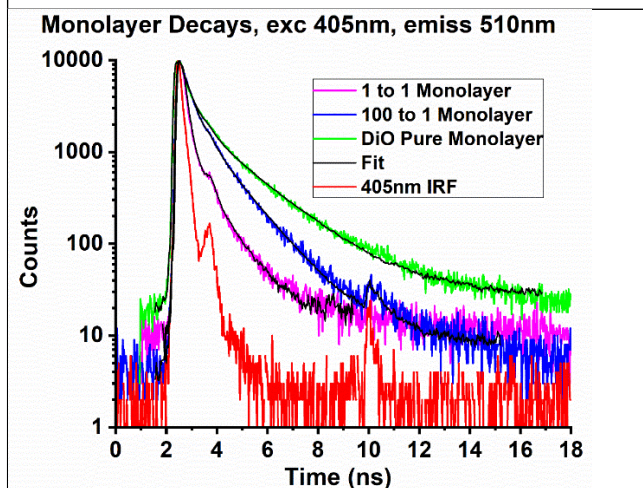


Fig. 4 Time resolved emission decay curves of deposited DiO:Dil mixed LB monolayers for mixing ratios 1:1 and 100:1 respectively at 510 nm (donor emission channel). The unquenched decay curve for DiO monolayer is shown for reference as well. The stearic acid monolayers. There is a uniform lifetime shortening of the donor decay curve (DiO) is shown to indicate efficient FRET to Dil acceptor molecules.

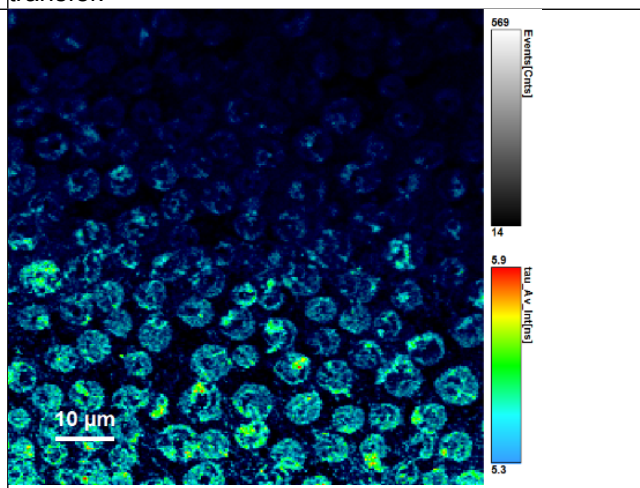


Fig. 5 Fluorescence Lifetime Image (FLIM) of a DiO monolayer deposited on a quartz substrate. The DiO molecules are shown to aggregate in circular domains within the monolayer if they are sandwiched between stearic acid monolayers. There is a uniform lifetime shortening of the donor decay curve (DiO) is shown to indicate efficient FRET to Dil acceptor molecules. A picosecond diode (405 nm) was used as excitation source.

References

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