

Femtosecond transient absorption measurement of energy and charge transfers in donor-acceptor liquid crystalline dyad and triad

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Abstract: We investigated the energy transfer and charge transfer processes in dyad and triad based on triphenylene (donor) and perylene (acceptor) units by femtosecond transient absorption spectroscopy. Our results demonstrate that energy transfer from triphenylene to perylene occurs in solution and charge transfer is observed in thin films.

OCIS codes: (320.0320) Ultrafast optics; (250.0250) Optoelectronics; (160.4890) Organic materials

1. Introduction

Self-organization and charge transport properties of mesogenic semiconductors make them attractive for organic optoelectronic applications. Here, we are interested in liquid crystalline molecular architectures containing triphenylene and perylene units. Triphenylene derivatives possess a wide energy-bandgap and are known as good electron-donor entities. In addition, triphenylenes self-organize easily in columnar structure and present high charge carrier mobilities. On the other hand, perylene derivatives are known as good electron-acceptor molecules which self-organize in columnar structures exhibiting as well high charge carrier mobilities. Both are interesting materials for organic field-effect transistors and organic solar cells [1-2]. Moreover, perylene fluorescence efficiency is close to 100% in solution.

Here, liquid crystalline dyad and triad incorporating triphenylene and perylene as donor (D) and acceptor (A), respectively, have been characterized (see the inset of Fig.1). These architectures form columnar structures and through annealing process of the spin-coated films, more ordered columnar structures can be achieved.

In this work, temporal behaviors of energy transfer and charge transfer taking place in triphenylene (donor:D) - perylene (acceptor:A) dyad and triad in both solution and thin films are examined by femtosecond transient absorption measurements.

2. Experiment & Results

Femtosecond transient absorption measurements were carried out with 5KHz Ti:Sapphire regen. amplifier laser system. The 325nm pumping beam was obtained from fourth harmonics of 1300nm optical parametric amplifier to excite electrons in D (triphenylene). A white light continuum ranging from 500nm to 760nm was obtained from sapphire plate to monitor the dynamics of energy transfer and charge transfer processes between D (triphenylene) and A (perylene).

In both dyad and triad solutions, the negative signal of $\Delta T/T$ was observed in the spectral range of 675-725nm which is attributed to the perylene excited state absorption [3-4]. Two distinct response times are identified from the transient data: short response times of 10-20ps that we attribute to a resonant energy transfer from D (triphenylene) to A (perylene), and longer response times of 600-800ps related to excited state decay of A(perylene) taking place after the D-A energy transfer. From the Förster energy transfer theory, the energy transfer rate between donor and acceptor molecules has been calculated [5]. The experimental value of energy transfer rate showed good agreement with the theoretical value.

In the annealed thin films of dyad and triad, the negative signal of $\Delta T/T$ in the spectral range of 700-750nm is attributed to the absorption of perylene radical anions [3]. This indicates that a charge transfer (CT) state is formed in both dyad and triad films. Similar to the solutions, two distinct response times were also identified from the transient data. A short response time of 1ps is attributed to the time it takes for an exciton to be dissociated to form a charge transfer state as cation in D (triphenylene) and anion in A (perylene). Decay time of the charge transfer state is 300-400ps as it can be seen from the temporal evolution of $\Delta T/T$ in the spectral range of 700-750nm of Fig. 1.

Our results show that energy transfer from D to A occurs in solution. In thin films, the D and A units are much closer and charge transfer becomes the dominant process.

Overall, this work provides new useful insights to the photophysical properties of liquid crystalline dyads and triads composed of acceptor and donor moieties.

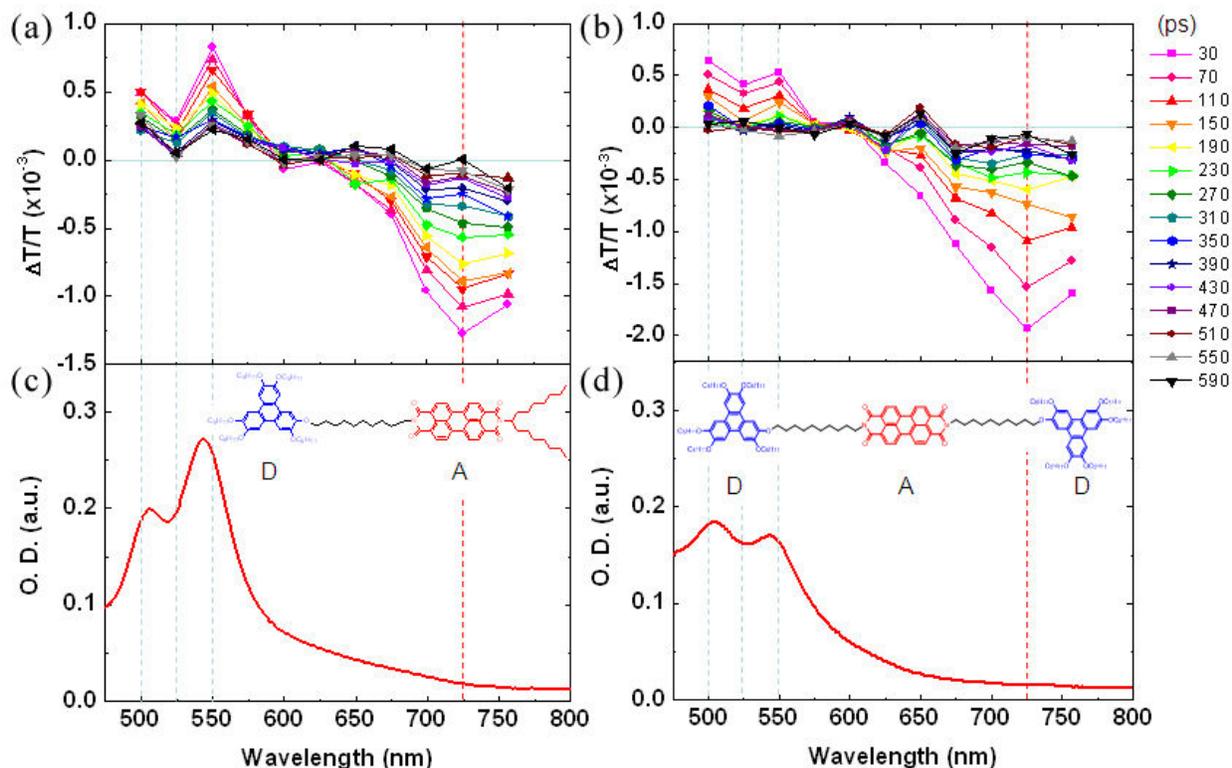


Fig 1 Temporal evolutions of $\Delta T/T$ spectra in the annealed (a) dyad and (b) triad films are shown as long with linear absorption spectra of (c) dyad and (d) triad.

3. References

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