Cooperative Singlet and Triplet Exciton Transport in Organic Semiconductors Visualized by Ultrafast Microscopy

Wan Yan, Tong Zhu, and Libai Huang [1]
[1]Department of Chemistry, Purdue University
West Lafayette, IN, USA
Corresponding Author: libai-huang@purdue.edu

Achieving rapid and long-range exciton transport is an important challenge for organic semiconductor because the short exciton diffusion length presents a major limitation for optoelectronic and electronic applications such as light emitting diodes and solar cells. A possible route to enhance exciton diffusion length is using triplet excitons generated from singlet fission because of the long lifetime of triplet exciton. In addition, singlet fission to generate a pair of triplet for a singlet exciton presents a technologically attractive solution to overcome the Shockley-Queisser limit. However, the trade off for using triplet excitons as the energy carriers is that triplet transport occurs through Dexter mechanism with a much slower rate than dipole-dipole Forster mechanisms for singlet exciton. A thorough understanding of the interplay between singlet fission and exciton transport is necessary to correctly assess the potential and challenges in singlet fission.

Here we report direct visualization of both singlet and triplet transport using transient absorption microscopy with 200 fs time resolution and 50 nm spatial precision. These measurements reveal a remarkable more than one order of magnitude enhancement in effective triplet exciton diffusion constant in single crystalline tetracene. This enhancement in triplet exciton transport results from cooperative effects due the equilibrium between singlet fission and triplet fusion. These results establish that there exits an optimal energetics of singlet and triplet excitons in order to maximize both singlet fission and exciton diffusion.

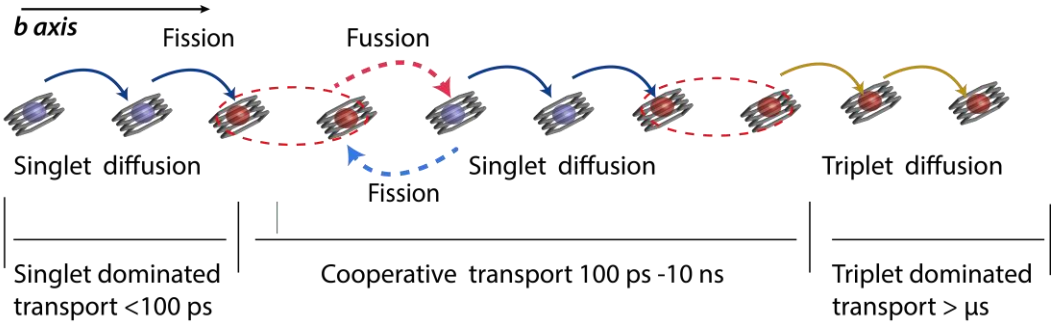

Figure 1: Different regimes of exciton transport in tetracene.