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Exciton Fission and Fusion in Organic Materials for Enhanced Solar Energy Conversion Efficiencies

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ABSTRACT

Repackaging photon energy through downconversion and/or upconversion can boost solar energy conversion efficiencies by 30% or more. In organic semiconductors, the Frenkel character of the excitons leads to energetically separate singlet and triplet bands, providing an ideal set of energy levels for exciton fission (leading to energy downconversion) and exciton fusion (leading to energy upconversion). Singlet exciton fission in organic molecular crystals is studied using time-resolved transient absorption, photoluminescence and magnetic field effects. Non-equilibrium spin state distributions can play an important role in both the ultimate triplet yield and the observation of experimental quantities like delayed fluorescence. Upconversion, where a pair of triplet excitons fuse into a high-energy singlet state, presents the inverse problem of populating the triplet states to initiate the process. To improve upconversion in at long wavelengths, triplet state sensitization using semiconductor nanocrystal sensitizers and conjugated organic ligands has been demonstrated to be an effective strategy. In the solid state, we find that upconversion in certain molecular crystals can occur even in the absence of sensitizers, possibly due to the presence of low-energy intermolecular states.

BIO:

Prof. Bardeen received his B.S. in chemistry from Yale University in 1989 and a Ph.D. in chemistry from UC Berkeley in 1995 under Charles V. Shank. After a post-doc with Kent Wilson at UC San Diego, he became an assistant professor at U. Illinois, Urbana-Champaign in 1998 and moved to the Chemistry Department at UC Riverside in 2005. He is a physical chemist who uses laser spectroscopy to study exciton dynamics in organic photovoltaic materials, the application of photoreactive molecular crystals as mechanical actuators, and the photochemistry of sunscreen molecules. His awards include the Camille and Henry Dreyfus New Faculty Award, the 3M Non-Tenured Faculty Award, the Research Corporation Research Innovation Award, the National Science Foundation CAREER Award, and a Sloan Research Fellowship.