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Efficient Light-driven Long Distance Charge Separation and H₂ Generation in Semiconductor Quantum Rods and Nanoplatelets

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Quantum confined semiconductor nanocrystals (0D quantum dots, 1D quantum rods and 2D quantum platelets) have been intensively investigated as light harvesting and charge separation materials for photovoltaic and photocatalytic applications. The efficiency of these semiconductor nanocrystal-based devices depends on many fundamental processes, including light harvesting, carrier relaxation, exciton localization and transport, charge separation and charge recombination. The competition between these processes determines the overall solar energy conversion (solar to electricity or fuel) efficiency. Semiconductor nano-heterostructures, combining two or more material components, offer unique opportunities to control their charge separation properties by tailoring their compositions, dimensions and spatial arrangement. Further integration of catalysts (heterogeneous or homogeneous) to these materials form multifunctional nano-heterostructures. Using 0D, 1D and 2D CdSe/CdS/Pt heterostructures as model systems, we directly probe the above-mentioned fundamental exciton and carrier processes by transient absorption and time-resolved fluorescence spectroscopy. We are examining how to control these fundamental processes through the design of heterostructures to achieve long-lived charge separation and efficient H₂ generation. In this talk, we will discuss a new model for exciton dissociation by charge transfer in quantum dots (i.e. Auger assisted electron transfer), mechanism of 1D and 2D exciton transport and dissociation in nanorods, and key factors limiting H₂ generation efficiency in CdSe/CdS/Pt nanorod heterostructures.