Highly Conjugated Porphyrin-Based Structures for Energy Conversion Applications

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Abstract: Semiconducting organic π-conjugated oligomers and polymers define an important class of energy conversion materials that impact organic photovoltaics, dye-sensitized solar cells, and solid-state devices that take advantage of photon upconversion strategies. In order to realize next-generation high efficiency organic (excitonic) solar cells, several challenges must be overcome. These hurdles include engineering materials that: (i) feature enhanced absorptive overlap with the solar spectrum, (ii) support large exciton mobilities, (iii) manifest high quantum yield dissociation of excitons into free charge carriers, (iv) display significant charge delocalization lengths, and (v) express substantial charge mobilities for both holes and electrons. This presentation will discuss how collective oscillator photophysics can be exploited to design materials that both increase solar spectral coverage, feature substantial exciton diffusion lengths, and possess substantial excited-state lifetimes. Electronic and electron spin resonance spectroscopy demonstrates that these porphyrin-based materials feature substantial polaron delocalization lengths and high magnitude charge mobilities. Modification of these structural motifs realizes novel chromophores having both long-wavelength absorptivity and long-lived triplet excited states, which have exceptional utility as sensitizers for NIR-to-visible fluorescence upconversion via triplet-triplet annihilation (TTA) photochemistry.