Organic Photovoltaics with External Antennas

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The structures and processes of photosynthesis are evolved, highly efficient, robust, and possess high power density. We attempt to leverage these characteristics by incorporating photosynthetic architectural motifs into organic semiconductor solar cells. We adapt the organization of processes in photosynthesis and introduce a synthetic light harvesting structure into an organic photovoltaic so that it couples light energy to the active device area by near field energy transfer. Light energy absorbed in an artificial antenna layer is transferred to an artificial reaction center in the interior of the solar cell. The energy transfer is of the Förster type, mediated by surface plasmons polaritons. While the introduction of the antenna necessarily adds a step to the energy transduction process, decoupling photon absorption and exciton dissociation can be exploited to increase each separately.

We have experimentally examined the efficiency of energy transfer for this process. We utilize a film of photoluminescent chromophores placed immediately adjacent to an organic solar cell with dual silver electrodes as an antenna layer. We predict and verify that energy transfer can occur in technically relevant device structures with energy transfer efficiencies of approximately 50% and demonstrate this transfer result in increased quantum efficiency.

Figure 1: The device structure utilized in these studies is composed of aluminum tris(8-hydroxyquinoline), bathocuproine, copper phthalocyanine, 3,4,9,10-perylenetetracarboxylicbisch-benzimidazole, 4-dicyanomethylene-2-methyl-6-(p-dimethylaminostyryl)-4H-pyran, and silver. To tune the emission of the Alq3 antenna it was doped with either CuPc or DCM at 1% weight ratio.

Figure 2: The comparison of devices with functional (dotted line) and nonfunctional (solid line) antennas demonstrate external energy transfer. Devices with functional external Alq3 antenna layers (dotted line) exhibit an increase in external quantum efficiency over the wavelength range where Alq3 absorption occurs (dashed line). The photocurrent spectra are identical outside the spectral range where Alq3 absorbs. Functional antennas employ the laser dye, X = DCM, whereas nonfunctional antennas employ the quencher X = CuPc).