

Processing Strategies for Structural Control in Organic Solar Cells
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Organic solar cells have been proposed as low-cost and sustainable alternatives for power generation. To realize the low cost aspects of organic solar cells, conventional vacuum deposition technologies are to be replaced with solution processing. To this end, our group has focused on (a) the design and engineering of solution processable conductive polymers as anodes replacements in organic solar cells; (b) the development of an inverted architecture that dramatically enhances the air stability of organic solar cells; and (c) the manipulation and control of the phase separation characteristics of the photoactive layer to improve device performance.

Conductive polymers, like polyaniline, are generally doped with small-molecule acids. Though highly conductive, such materials are not processable. To overcome this intractability, polymer-acid dopants have replaced small-molecule acids. While the introduction of polymer acids render the conductive polymer solution processable, such gains in processability are thus frequently accompanied by reduced conductivities. With a post-processing solvent-annealing treatment, however, we have been able to dramatically improve the electrical properties of polymer-acid doped conductive polymers; these polymers make efficient anodes in organic solar cells.

Conventional organic solar cells are notoriously unstable in air; device failure is frequently reported several days after it is exposed to air. To improve the air stability of organic solar cells, we constructed our devices in an inverted manner utilizing sol-gel derived titania as the electron transport layer. These devices are air stable for >6 months; the incorporation of titania also introduces interesting transient photovoltaic characteristics to our device.

To further improve the efficiencies of organic solar cells, we have introduced fractional amounts of additives within the photoactive layer of the device. Depending on the hydrophobicity of the additives, they preferentially segregate into the electron donor phase, effectively enhancing phase separation between the electron donor and electron acceptor. This change in morphology increases charge separation; we see a two-fold increase in the short-circuit current in such devices over those without additives in the photoactive layer.