A Novel Methodology to Assemble Organic Nanomaterials via Magnetophoretic Alignment

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Conducting polymers (CPs) combine the electronic properties of semiconductors with the biocompatibility and mechanical properties of polymers. However, the capabilities of CPs are limited by inefficient charge transport due to inhomogeneous morphologies. While template-based methods, dopant incorporation, and film post-treatment have been shown to improve the electrical conductivities of CPs, these approaches result in a complex preparation process and a low thermoelectric response. In this study, a facile bottom-up fabrication method was developed to obtain reproducible nanostructures and microstructures of poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS) for the simultaneous enhancement of electrical conductivity and thermoelectric response. PEDOT:PSS films were fabricated from PEDOT:PSS dispersions on glass substrates under uniform, low-level (mT) magnetic fields. Scanning electron microscopy (SEM) images identified the alignment of robust nanorods when the thin film was parallel to the applied fields and the formation of dendritic microstructures when the film was perpendicular to the applied fields. The structural features gave rise to charge transport pathways such that the thermoelectric response increased five-fold along the direction of the previously applied magnetic field and the electrical conductivity doubled. The circular dichroism spectra of PEDOT:PSS films, measured by polarization-dependent transmission spectroscopy, indicated the existence of polarons and bipolarons that gave rise to paramagnetism. The results obtained represent the first demonstrations of nanostructuring via magnetophoresis of CPs under low-level magnetic fields and extend the range of methods that may be utilized to control the bottom-up assembly of nanomaterials.

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