Novel Fabrication of Organic Multifunctional Materials via Magnetic Alignment

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Organic polymeric materials have attracted extensive attention for optical devices, consumer electronics, and biomedical tools due to their combination of optical, electrical, mechanical, and biological functionalities. In this study, the alignment of polymer particles under low-level magnetic fields is presented as a new fabrication method for conducting polymer films. Thermodynamics and statistical physics are employed to derive the conditions required for the magnetic alignment of particles in a fluid. Experimentally, bar magnets are used to guide the formation of microscopic structural features whose shapes can be controlled by changing the orientation of the magnetic field direction relative to the substrate plane. Glancing-incidence X-ray diffraction indicates that the magnetic alignment of polymer particles induces crystallization at the top surface with lattice features, and the robust alignment of particles and conductive phases coincides with a quadrupling of the thermoelectric coefficient and doubling of the electrical conductivity. Correspondingly, the Raman spectra indicate higher structural order. When tilted to the light, the films exhibit circular dichroism associated with the helical arrangement of functional groups around magnetically uncoiled polymer backbones. To eliminate macroscopic defects, cracking phenomena are tuned via substrate wetting properties and the polymer volume to substrate area ratio, and two new models are developed for the radial and circular cracking regimes observed. The new fabrication method represents the first demonstration of the alignment of conducting polymers under low-level magnetic fields and opens the route towards more controllable features for multifunctional materials, the cornerstone of engineering advancements.

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Third Award of $1,000