Composite materials are widely used for organic electronic devices including ambipolar transistors and solar cells. Ordering of molecular packing in these composites are expected to enhance charge transport property as well as exciton generation/dissociation ability, leading to greatly improved device performance. Here, we describe how to prepare, from solutions, composites with single-crystallinity for organic electronics. On one hand, organic single-crystalline planar heterojunctions are grown in a single step from a mixed solution of p-type and n-type molecules. These junctions exhibited ambipolar charge transport characteristics and a significant photovoltaic effect. On the other hand, bulk heterojunctions are constructed with nanofibers incorporated inside single crystals. For example, crystallization of 6,13-bis(triisopropylsilylethynyl)-pentacene (TIPS-pentacene) from solutions in the presence of fluorescent nanofibers of a perylene bisimide derivative (PBI) leads to formation of composites with nanofiber guest incorporated in the crystal host. In spite of the binary composite structure, the TIPS-pentacene still maintains the single-crystalline long-range order. As a result, the incorporation of the PBI guest introduces the additional function of fluorescence but does not significantly reduced the charge transport property of the TIPS-pentacene host, exhibiting field-effect hole mobility as high as 3.34 cm$^2$V$^{-1}$s$^{-1}$ even though about 26% of the channel area is taken over by the nanofibers. As such, this work provides a facile approach toward high-performance multifunctional organic electronic materials.

Keywords: Single crystals, Composites, Bio-inspired

References:


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