A Blend Approach to P3HT Based Field Effect Transistor Performance Enhancement via Inclusion of 2,5-bis(3-dodecylthiophen-2-yl)thieno[3,2-b]thiophene

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Organic field effect transistors (OFET) are attracting significant attention due to their facile processability, chemical tunability and low cost for producing large area electronics. Both small molecules and polymers have been widely studied for this purpose. Small molecules usually provide superior electronic properties, but suffer limitations associated with crystal grain boundaries and high vacuum deposition steps. Polymers, however, demonstrate excellent film uniformity, but experience problems related to chain entanglements and broad polydispersity which inhibit crystallization. In this work, we are engaged in studying semiconducting small molecule-polymer blend thin-films and their applications in field-effect transistors. In contrast to traditional devices using a single component, the blend thin-films can take advantage of the pros of polymers and small molecules while simultaneously diminishing the impact of their cons. According to experimental results, electrical characteristics of OFET devices can be improved by using polymer-molecular semiconductor blend thin-films as the active layer. We demonstrated that incorporation of the small molecule, 2,5-bis(3-dodecylthiophen-2-yl)thieno[3,2-b]thiophene (BTTT-1), into poly(3-hexylthiophene) (P3HT) polymer thin-films can enhance the charge carrier mobility and lead to approximately a 20-fold decrease in threshold voltage. The performance enhancement was dependent on the small molecule volume ratio, and was maximized at a critical oligomer concentration of about 50%. This thin-film blend combines the high charge transport properties of the crystalline small molecule semiconductor with the facile solution processability of the polymer component. In this investigation, BTTT-1 was selected because of its planar symmetrical fused aromatic rigid frame, i.e., thieno[3,2-b]thiophene, which promotes the formation of highly ordered crystalline domains and relative to a single thiophene ring structure in the P3HT backbone, thienothiophene is more stable to oxidation. Moreover, the

alkyl side chains may facilitate interdigitation and formation of a compact lamellar structure. By taking advantage of these features, the crystalline small molecule might enhance P3HT molecular ordering. Alternatively, the polymer matrix might serve as a bridge between the solution processed small molecule crystalline domains to decrease the impact of crystal grain boundaries. Correlations between molecular ordering and the charge transport characteristics of resultant thin-films with respect to the polymer:small molecule volume ratio will also be presented and discussed.