Concentration-Dependent Effects of 4-Fluorophenylboronic Acid on P3HT:PCBM Organic Solar Cells

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Organic solar cells (OSCs) have promising potential as next-generation photovoltaic technologies due to their lightweight structures, mechanical flexibility, low-cost production, and compatibility with solution-based large-area processing. However, the photovoltaic performance of conventional donor-acceptor systems is largely dependent on the morphology, optical properties, and charge-carrying characteristics of the photoactive layer. Therefore, additive engineering has become an effective approach to modify active layer properties and improve device performance.

In this study, the effect of 4-fluorophenylboronic acid (1F) concentration on the structural, optical, morphological, and photovoltaic properties of P3HT organic solar cells was systematically investigated. Different concentrations of 1F were incorporated into the P3HT photoactive layer, while dopant-free devices were used as reference systems. The addition of fluorinated boronic acid (1F) dopant was investigated as a strategy to modify the molecular organization and surface morphology of the active layer, reduce defect-induced losses, and facilitate more efficient charge generation and transport. The optical absorption, structural properties, and surface morphology of pure and 1F-modified active layers were analyzed using UV-Vis spectroscopy, X-ray diffraction (XRD), and atomic force microscopy (AFM). The photovoltaic properties of the fabricated devices were evaluated under simulated sunlight through current density-voltage measurements.

The concentration-dependent behavior of 1F revealed an optimum dopant concentration where the balance between active layer morphology, light absorption, charge generation, and charge transport was improved. The obtained results developed an alternative approach to additive engineering for improving P3HT photovoltaic parameters using fluorinated boronic acid additive.

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