Optimization of High-Efficiency Organic-Inorganic Lead Halide Perovskite Solar Cells via a Novel Polycaprolactone Additive Pathway

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The recent global energy crisis has resulted in a push for the development and commercialization of renewable energy sources, most notably solar cells. In 2009, Kojima et. al. revolutionized the field of photovoltaics by synthesizing the first perovskite-based solar cell (PSC). Perovskites are semiconducting materials with the crystal structure ABX3, whose unique optoelectronic properties make them very suitable as the light-absorbing layer in photovoltaic devices. Techniques used to fabricate these devices, however, often result in poor surface morphology. The goal of this study was to manufacture perovskite layers with fewer defects, resulting in solar cells with higher power conversion efficiencies (PCEs). We investigated the effect of a biodegradable, environmentally-friendly polycaprolactone (PCL) additive on the film quality and photovoltaic performance of methylammonium lead iodide PSCs. The devices were fabricated using spin-coating techniques. Perovskite films were characterized using various imaging and composition tests; PCE quantified overall cell efficiency. The results indicate that PCL additives passivate grain boundary defects and enlarge grain size by controlling perovskite crystallization rate during film formation. The resulting films were smoother and thus exhibited extended charge carrier diffusion length and suppressed charge recombination. The optimal doping concentration, 0.6 mg/mL, increased the efficiency of the device by 39.7% to a PCE of 13.2%. These high efficiency devices fabricated with the novel, biodegradable, and easily-processable PCL dopant suggest its viability as a promising component of commercial, high-efficiency PSCs.

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