POPULAR SCIENTIFIC ABSTRACT

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Routes for enhancing long-term stability and mechanical properties of organic solar cells

Organic photovoltaic devices (OPV) are nowadays among the most promising alternative energy sources thanks to record efficiencies extending beyond 18 %, low production costs, low environmental impact and completely new integration possibilities due to free-form design. However, their great potential is shadowed by their relatively low stability when exposed to combined light, oxygen and heat. Furthermore, to utilize them in truly flexible or even stretchable applications, their otherwise intriguing mechanical properties needs to be further improved. This PhD thesis focuses on degradation and stability of OPV devices, and it presents in this respect results on promising stabilization routes for two OPV constitutive layers, namely the active layer and the interlayer. The first main section focuses on additive assisted stabilization of OPV reporting the successful utilization of two naturally occurring additives such as beta-carotene and astaxanthin in the active layer of fullerene-based OPV devices. Beta-carotene improved of 6-folds and 21-folds the accumulated power generation of PTB7:[70]PCBM ad P3HT:[60]PCBM respectively, owing to its singlet oxygen quenching and radical scavenging abilities. Moreover the burn-in degradation of the [70]PCBM-based devices was here assigned to singlet oxygen based degradation. Furthermore, the synthetization of a new additive molecule covalently bonding the antioxidant Astaxanthin and the silicone oil PDMS was shown to successfully stabilize the PTB7:[70]PCBM system, improving the accumulated power generation of 140 % and at the same time reporting improved mechanical properties of the active layer. Both of the presented routes presents clear stabilization improvements beyond state-of-the-art, and the it is the first demonstration of synergistic improvement of the photochemical stability and mechanical properties of OPV using additives. The second main section describes the influence of interlayers on the long-term OPV devices stability. Non fullerene OPV with sputtered TiO_x as ETL layer reported higher device stability compared with the reference ones based on nanoparticle ZnO. Absorption measurements at the ETL/active layer interface associated this improved stability with the degradation of the ITIC at the metal oxide interface. ITIC at the TiO_x interface showed almost no absorbance loss over 20 days of degradation, which is in contrast to the typically used ZnO based interlayers. Perovskite-based solar cells (PSC) have in the past few years been reporting record high efficiencies exceeding 25 %, however multiple degradation processes and device instabilities are limiting their commercialization. Moreover, being a new technology, a large variety I the types of degradation mechanism of the PSC devices are reported, which challenge the investigations in this field. The last part of the PhD thesis is reporting the effects of electrical bias on the degradation and, in particular, dynamics of recovery mechanisms of PSC solar cells when degraded to different stages of their initial efficiency. Open-circuit light degradation at elevated temperature resulted in further dark degradation, i.e. a drop-in-dark effect, instead of a dark recovery process. Devices degraded in SC conditions showed no dark degradation, and instead full recovery within a one day light/dark cycle. However, the application of an electrical bias after the light degradation diminished or totally eliminated the dark degradation effect, and thus supported the full device recovery. While the drop-in-dark effect has been reported on in the literature, the use of the electrical bias also supports to unravel the origin of this effect, and it is here demonstrated, for the first time, that the degradation mechanisms is related to ion migration and the utilized interlayers. Overall, this thesis gives insights into degradation and especially stabilization of new emerging organic and perovskite solar cells and show new routes for stabilization of both active layers and interlayers, leading to device lifetime improvements