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Solution processed ZnPc hole-transporting layers for photovoltaic devices

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During four past decades, research on Organic Photovoltaic Devices (OPV) has progressed using a few standard materials which were not initially designed for this purpose but for other applications such as tainting, paint or xerography. The enhancement of the photo-generation of charges in a phthalocyanine in the presence of an electron-acceptor had been reported in 1980. Since Tang's first report in 1986 of a hetero-junction bilayer organic solar cell composed of Cu-phthalocyanine and a perylene derivative the field has expanded rapidly and recently includes a wide variety of small molecule solar cells containing phthalocyanines or porphyrins as dyes, conjugated polymers as the p-type donor phase and C₆₀ or perylene derivatives as the acceptor phase. Most Metal Phthalocyanines (MPcs) are usually highly insoluble and need to be processed by vacuum deposition. Zinc phthalocyanine (ZnPc) is a particularly attractive sub-class of Pcs given the elemental abundance, very low toxicity levels and low band gap (~1.7 eV) well-matched to the incident solar spectrum. However, to date not report exists on the use of solution processed ZnPc as dyes in photovoltaic devices, therefore many research activities focused on synthesizing soluble phthalocyanines by adding functional groups to the molecule. Unfortunately, most of the substituted phthalocyanines are not as stable as the unsubstituted compounds and their electronic properties are also different from those of the unsubstituted phthalocyanine. Here, we report the solubility of ZnPc in the mixture of formic acid and N-methyl-2-pyrrolidone and its use for solution processing of Schottky and BHJ photovoltaic devices with photovoltaic open circuit voltage and short-circuit current density higher than if it is obtained by the vacuum evaporation method. Various characterization techniques were employed to estimate the structural and optical features of ZnPc hole-transporting layers, including XRD, FTIR and UV-VIS-NIR spectroscopy. In addition, the photovoltaic parameters of fabricated photovoltaic devices was estimated from current-voltage characteristics taken at 300 K using a Keithley 2400 source meter, under different illuminations.

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