Increased Open-Circuit Voltage and Efficiency in Small Molecule Organic Solar Cells Through the Use of a 56-π Electron Acceptor – Methano Indene Fullerene
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Small molecule organic solar cells (SMOSCs) have made great strides in recent years and efficiencies are now on par with their polymer:fullerene counterparts. However, in all efficient solution processed bulk heterojunction (BHJ) SMOSCs to date the fullerene acceptor has been PC71BM, which is unfavorable as it has a relatively low lying LUMO that minimizes the open-circuit voltage ($V_{OC}$). ($V_{OC}$ is proportional to the difference between the HOMO of the donor and LUMO of the acceptor). This approach however has proved far from trivial in the case of polymer:fullerene devices, where a concomitant decrease in the short-circuit current density ($J_{SC}$) is typically observed with most polymer donors blended with high-LUMO fullerene derivatives.

Here we demonstrate the application of a high-LUMO 56-π fullerene derivative, methano indene fullerene (MIF), in SMOSCs using a diketopyrrolopyrrole donor (DPP(TBFu)$_2$). MIF comprises of asymmetrical adducts where one adduct is indene and the other is dihydromethano and has previously demonstrated high efficiencies with P3HT. DPP(TBFu)$_2$:MIF devices are found to have a much improved $V_{OC}$ (1.03 V) without any significant decrease in the $J_{SC}$ (9.5 mA/cm$^2$), which allows efficiencies of 5.1% to be obtained. In comparison DPP(TBFu)$_2$:PC$_{61}$BM devices showed a $V_{OC}$ of 0.88 V, $J_{SC} = 10.1$ mA/cm$^2$ and an efficiency of 4.5%. Atomic force microscopy and x-ray diffraction studies show that DPP(TBFu)$_2$:MIF form a well intermixed BHJ and MIF does not hinder the growth or crystallinity of DPP(TBFu)$_2$.