ペロブスカイト太陽電池の効率向上に向けたフラーレン誘導体の利用

Use of Fullerene Derivatives for Creation of New Perovskite Solar Cells

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In this presentation, we discuss the use of C_{60} and fullerene derivatives for improvement of performance in perovskite solar cells (PVSCs). C_{60} and a fullerene derivative, PCBM are generally used as electron transport layers (ETLs) in inverted PVSCs. In our research, we used C_{60} as an ELT in normal structure PVSCs, where a perovskite layer was sandwiched by an electron-collecting C_{60} ELT and a hole-collecting single-walled carbon nanotubes (SWCNTs) electrode. The SWCNTs electrode was modified with small molecule organic semiconductors or semiconductive polymers to enhance hole-transporting ability and barrier property. These carbon-sandwiched PVSCs showed 17% PCE, when P3HT was applied to SWCNTs films. On the other hand, when we used spiro-MeOTAD instead, long-lived PVSCs were realized.

Methano-indene-fullerene (MIF, $C_{60}(CH_2)$Ind) was used as an ELT in inverted PVSCs.[1] The planar p–i–n device with a NiO-diethanolamine/$CH_3NH_3PbI_3$/MIF structure showed 18.1% PCE with high open-circuit voltage (V_{OC}) of 1.13 V and fill factor (FF) of 0.80. This high performance is attributed to high-lying LUMO level and small volume of the indeno group that can provide short fullerene–fullerene contact distance for high electron mobility.

A fullerene derivatives, PCBM was interpenetrated into SWCNTs film network to create a SWCNTs cathode. This is contrast to the fact that SWCNTs are usually hole-collecting anode with p-doping. We fabricated both-carbon PVSCs with a structure of substrate/CNT:P3HT/PEDOT:PSS/$CH_3NH_3PbI_3$/CNT:PCBM by using both P3HT-wrapping SWCNTs and PCBM-penetrating SWCNTs films as anode and cathode, respectively. The both-carbon PVSCs are flexible and can be used entirely without vacuum process, which is advantageous cost-effective production.

Finally, we utilized lithium-ion-containing [60]fullerene, $Li^+@C_{60}$ TFSI (NTf_2; bis(trifluoromethanesulfonyl)imide) salt as a dopant to spiro-MeOTAD in PVSCs. We demonstrated 10 times higher stability than the conventional devices with commonly used LiTFSI. We ascribe this improvement to hydrophobicity of the fullerene cage and oxygen-capture ability of the neutral $Li@C_{60}$ that forms electron transfer from spiro-MeOTAD to $[Li^+@C_{60}]TFSI^-$ in the doping process.

References

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