

Supporting Information for

Amphiphilic Fullerenes Modified 1D ZnO Arrayed Nanorods-2D Graphene

Hybrids as Cathode Buffer Layers for Inverted Polymer Solar Cells

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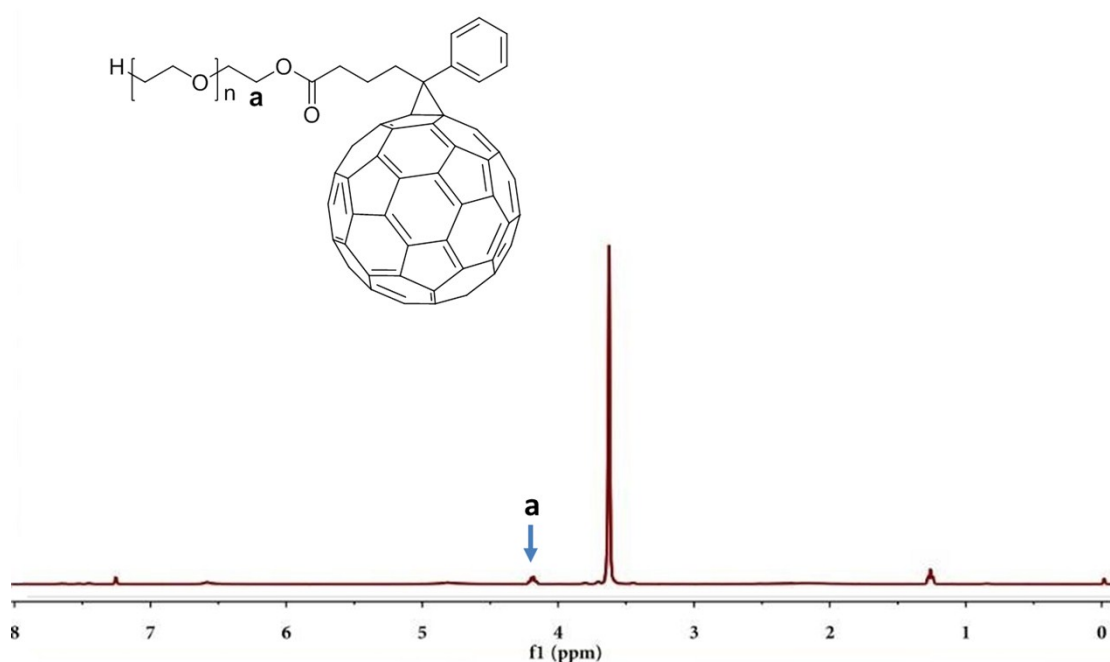


Figure S1. ¹H NMR spectrum of C60-PEG and the inset is the molecular structure of C60-PEG.

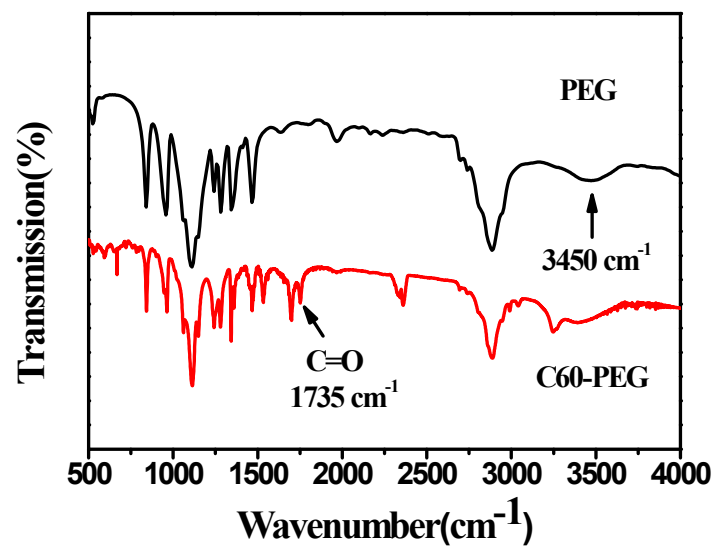


Figure S2. FT-IR spectra of PEG and C60-PEG. The broad peak at 3450 cm⁻¹ (O-H stretch) gets weaker, and a sharp peak at 1735 cm⁻¹ (C=O stretch) appears, which clearly identifies the covalently bonded fullerene to the chain end of PEG.

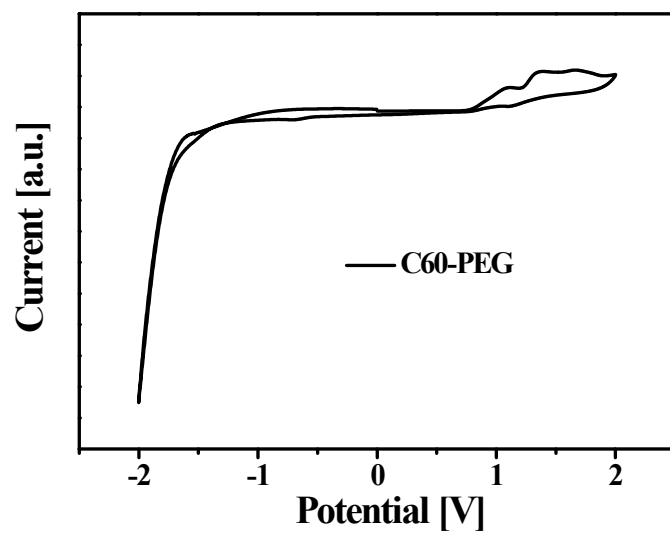


Figure S3. Cyclic voltammetry Curve of C60-PEG.

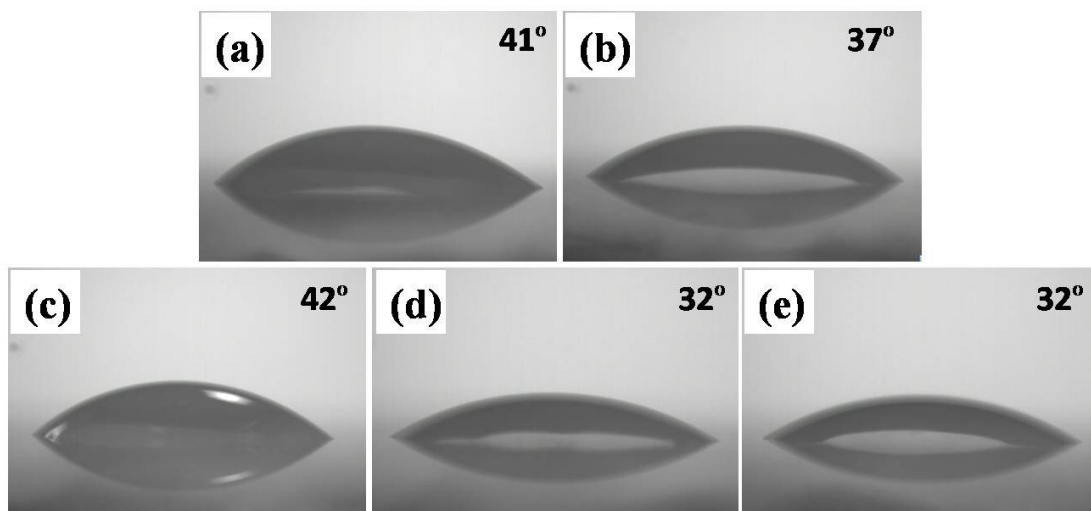


Figure S4. Measured water contact angle between a drop of deionized water on (a) ZnO ANs, (b) C60-PEG/ZnO ANs, (c) ZnO ANs@RGO, (d) C60-PEG/ZnO ANs@RGO, and (e) C60-PEG/ZnO ANs@RGO treated by plasma.

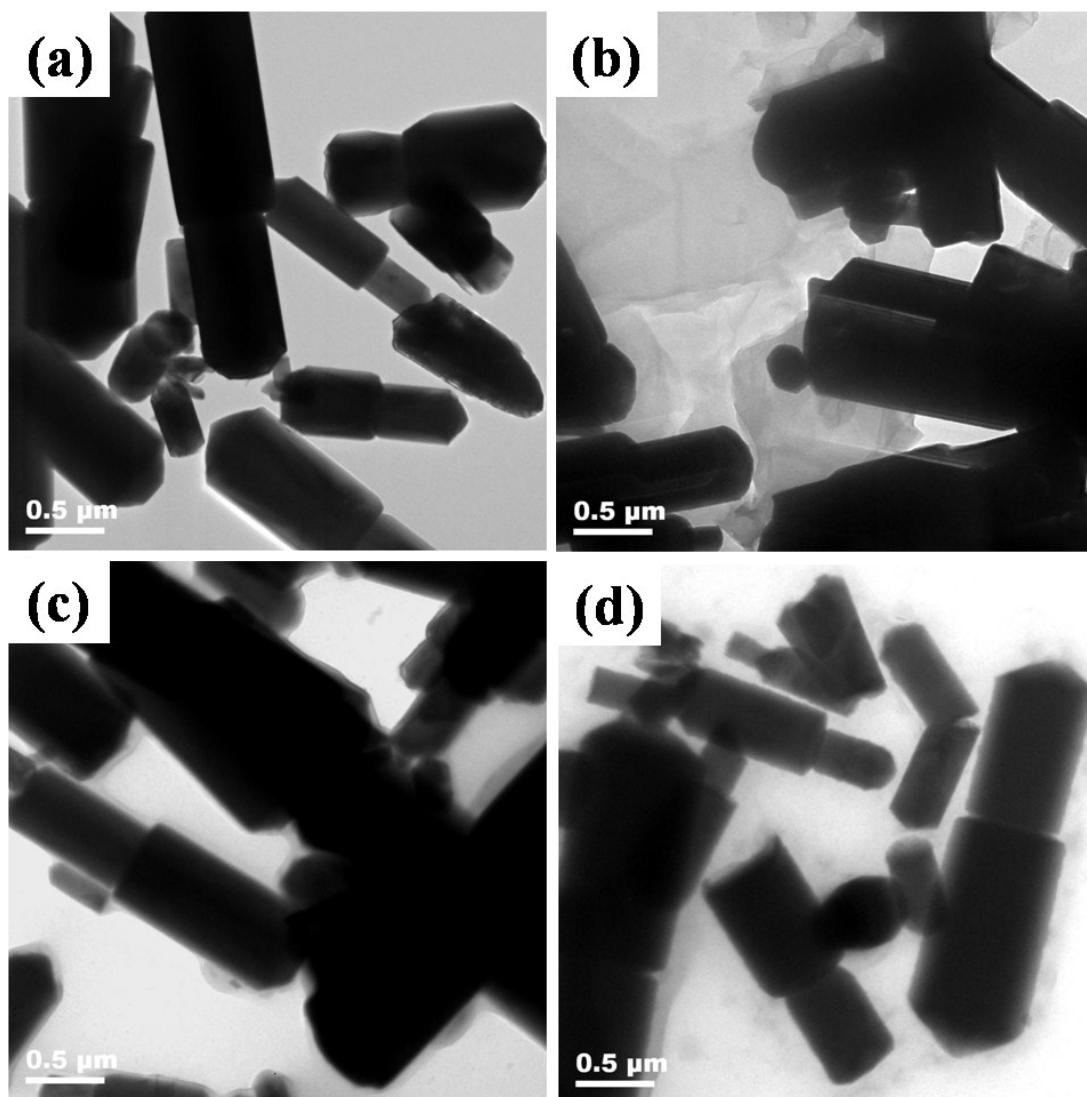


Figure S5. TEM images of (a) ZnO nanorods, (b) ZnO nanorods/PVP decorated RGO, (c) ZnO nanorods/C60-PEG and (d) ZnO nanorods/PVP decorated RGO/C60-PEG.

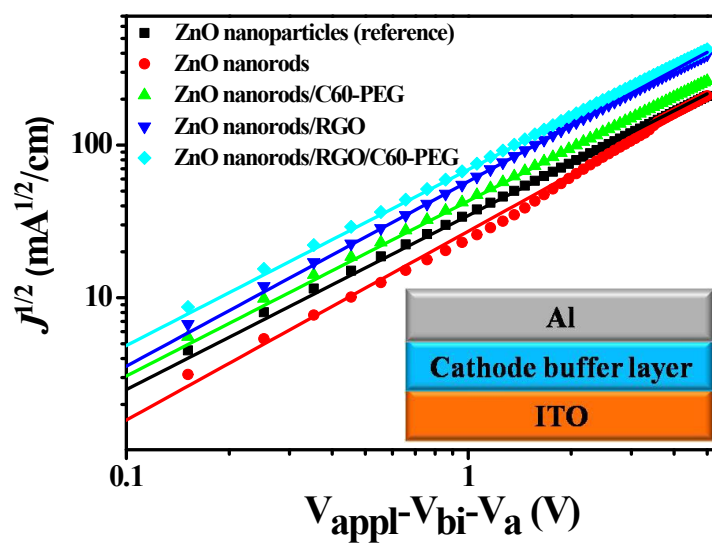


Figure S6. Log J vs. log V plots for Mott–Gurney SCLC fitting of the electron-only devices with a structure of ITO/cathode buffer layer/Al. Inset shows the configuration of the electron-only device.

Table S1. Electron mobility of (a)ZnO nanoparticles, (b) ZnO nanorods, (c) ZnO nanorods/C60-PEG, (d) ZnO nanorods/PVP decorated RGO, and (e) ZnO nanorods/PVP decorated RGO/C60-PEG with the structure of ITO/cathode buffer layer/Al.

Devices	1	2	3	4	5
μ_e (cm ² V ⁻¹ s ⁻¹)	2.49×10 ⁻⁴	1.51×10 ⁻⁴	2.96×10 ⁻⁴	3.93×10 ⁻⁴	4.97×10 ⁻⁴

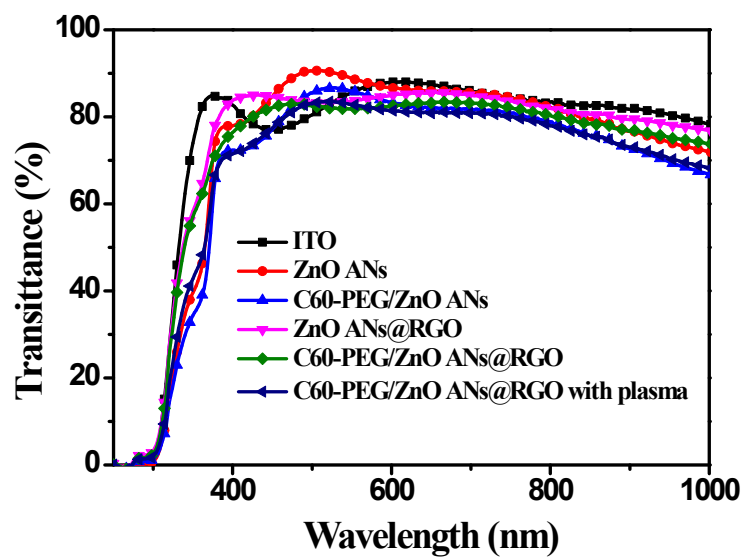
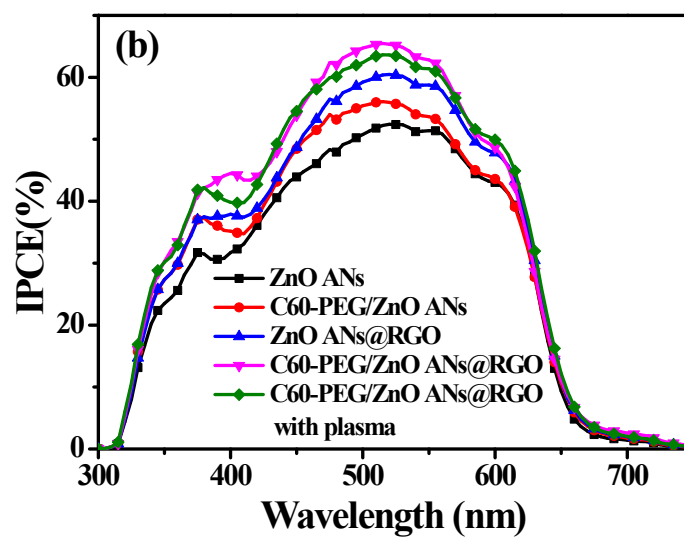
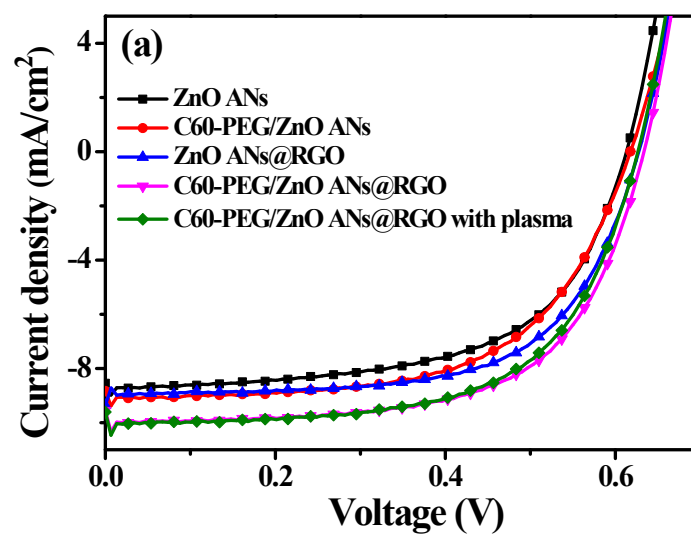


Figure S7. Optical transmission spectra of pristine ITO, ZnO ANs, C60-PEG/ZnO ANs, ZnO ANs@RGO, C60-PEG/ZnO ANs@RGO and C60-PEG/ZnO ANs@RGO treated by plasma on ITO substrate.



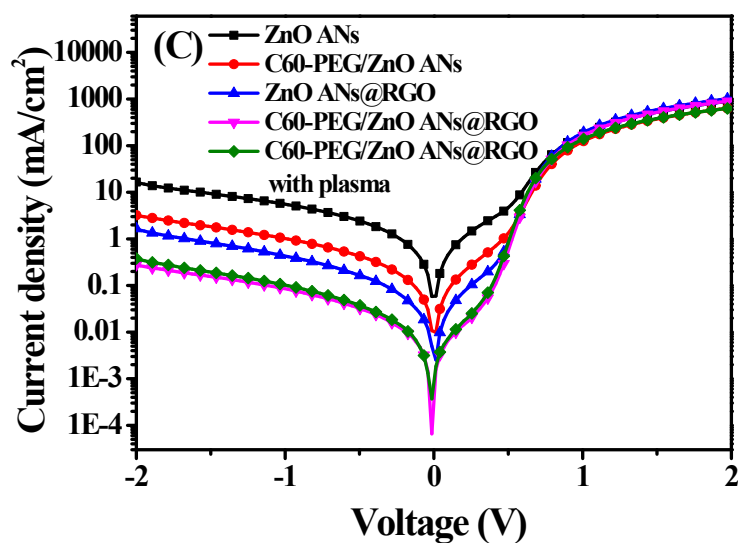


Figure S8. Performance of devices under simulated AM 1.5 G ($100 \text{ mW} \cdot \text{cm}^{-2}$) illumination. (a) Illuminated J - V characteristics, (b) IPCE spectra of the devices ITO/cathode buffer layer/P3HT:PC₆₁BM/MoO₃/Ag. (c) J - V curve under dark of the devices ITO/cathode buffer layer/ P3HT:PC₆₁BM /MoO₃/Ag.

Table S2. Photovoltaic parameters of the devices with ITO/ cathode buffer layer/ P3HT:PC₆₁BM/ MoO₃/ Ag structure. (a) ZnO ANs, (b) C60-PEG/ZnO ANs, (c) ZnO ANs@RGO, (d) C60-PEG/ZnO ANs@RGO and (e) C60-PEG/ZnO ANs@RGO treated by plasma cathode buffer layer.

Device	J_{sc} [mA cm ⁻²]	V_{oc} [V]	FF [%]	PCE [%]
a	8.55	0.612	61.0	3.2 ± 0.2
b	8.83	0.617	61.7	3.4 ± 0.1
c	9.36	0.626	61.1	3.6 ± 0.2
d	9.55	0.633	65.9	4.0 ± 0.1
e	9.61	0.626	64.8	3.9 ± 0.1

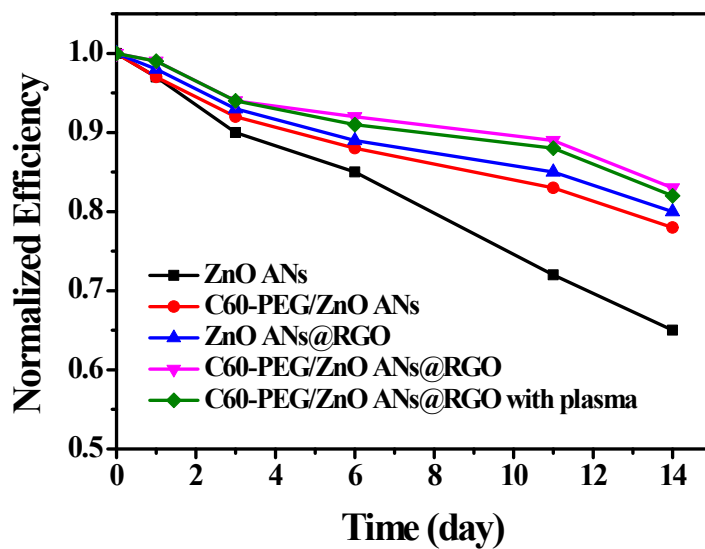


Figure S9. Normalized efficiency decay of inverted devices with the cathode buffer layer of ZnO ANs, C60-PEG/ZnO ANs, ZnO ANs@RGO, C60-PEG/ZnO ANs@RGO and C60-PEG/ZnO ANs@RGO treated by plasma.