Supporting Information for:

Hybrid Carbon Nanotube Networks as Efficient Hole Extraction Layers for Organic Photovoltaics

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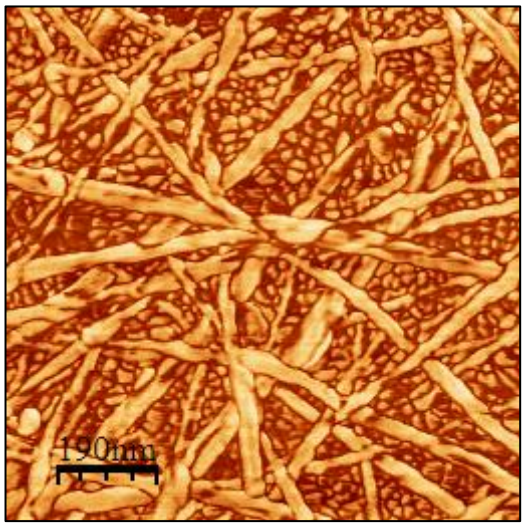

Figure S1. A magnified AFM phase image of a ~0.5 mg ml^{-1} solution spin coated on ITO/Glass at a spin speed of 1500 rpm. The scan area is 973nm x 973 nm. The image displays the well percolated and dispersed networks of nanohybrids on substrates.

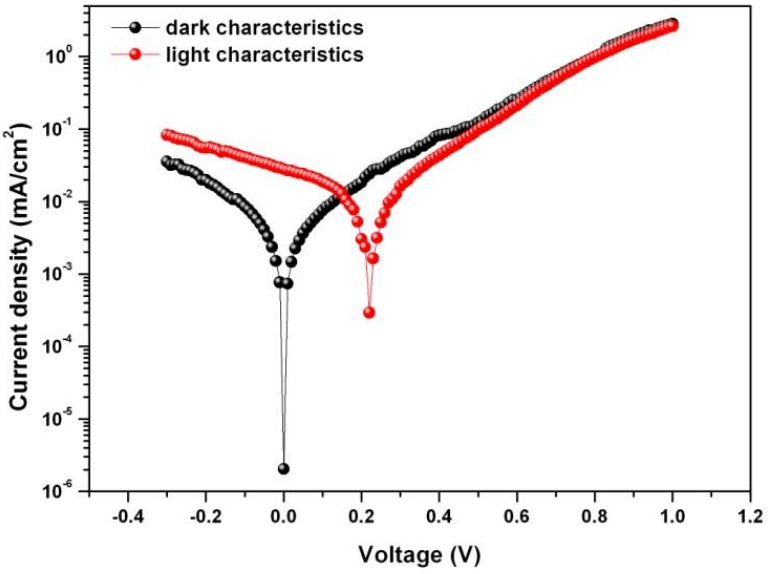

Figure S2. The response of the "hole only" nanohybrid incorporated device under dark condition and upon illumination with AM 1.5G simulated light. The observed merging of light and dark characteristics at ~ 0.5 V indicates the built in potential of the system to be at this value.

Fabrication of hole only devices for hole mobility calculations

To calculate the hole mobility of OPV devices incorporating nanohybrids and PEDOT:PSS as the hole transport layer (HTL), devices were fabricated using the following procedure.

Nanohybrids incorporated device: A portion of rr-P3HT/s-SWNT solution (~0.02 mg ml^{-1}) was spin coated on cleaned ITO coated glass (as given under methods section) at a speed of 1500 rpm for 1 minute and was annealed at a temperature of 120°C for 10 minutes.The active layer consisting of PTB7/$PC_{70}BM$ was spin coated at 1000 rpm for 2 mins on top of the rr-P3HT/s-SWNT film where the active layer thickness is 100 nm.

PEDOT:PSS incorporated device: A diluted solution of PEDOT:PSS was spin coated on cleaned ITO coated glass (same cleaning procedure as above) at a speed of 5000 rpm for 40seconds to obtain a thickness of 4 nm and was annealed at a temperature of 155°C for 10 minutes. The active layer consisting of PTB7/PC70BM was spin coated at 1000 rpm for 2 mins on top of the PEDOT:PSS film where the active layer thickness is 100nm.

PTB7/$PC7_0$BM active layer: A mass of 10.00 mg of PTB7 (1-material Chemscitech Inc.) and 15.00 mg of PC70BM (99% pure; Solenne) were added to 1.0 ml of chlorobenzene/1,8-diiodooctane (97:3 vol%) and the solution was stirred overnight at 70°C after which filtering of the solution was carried out using a 0.2 μm filter.

Afetr slow drying of the active layers in a glove box (MBRAUN), the devices were transferred to a thermal evapourator outside glove box where 10 nm of MoO_x was deposited through thermal evpouration at a rate of ~0.2 Å s^{-1}. The devices were then transferred to a thermal evaporator inside the glove box where 80 nm of Al (80 nm) was then thermally evaporated under vacuum of < $3x10^{-6}$ mbar yielding a device with area 54 mm^2. Current density – Voltage (J-V) measurements were performed using a Keithley 2400 at room temperature.

Hole mobility calculations based on SCLC model

Field independent Mott-Gurney equation:[1]

$$J = \frac{9}{8}\varepsilon_0\varepsilon_r\mu\frac{(V - V_{bi})^2}{L^3}$$

Was used to calculate the hole mobilities of the devices where, J is the current density, ε_0 is the permitivity of free space, ε_r is the relative permittivity of the organic layer (considered as 3),[1] V is the applied potential, V_{bi} is the built in potential, L is the thickness of the device and μ is the hole mobility. V_{bi} was calculated considering the intersection point of the dark and light current-voltage curves of hole only devices.

The μ value of both types of devices were estimated based on the linear region of figure. S3 where J is proportional to $(V\text{-}V_{bi})^2$ (space charge limited region).

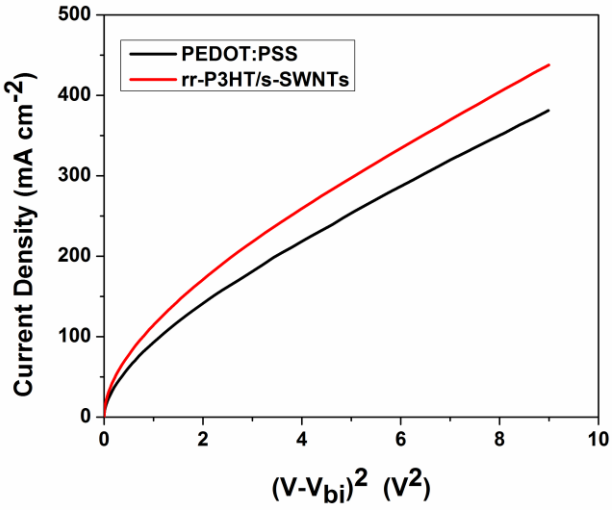

Figure S3. J – $(V\text{-}V_{bi})$ characteristics of nanohybrids and PEDOT:PSS incorporated hole only devices for SCLC analysis.

References

1. Blom, P. W. M.; de Jong, M. J. M.; Vleggaar, J. J. M. Electron and hole transport in poly(p-phenylene vinylene) devices. *Appl Phys Lett* **1996,** *68,* 3308-3310.