Supporting information

**Bottom-up Fabrication of Graphene-based Conductive Polymer Carpets for Optoelectronics**

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Figure S1. $^1$H NMR (500 MHz, CDCl$_3$) spectrum of P3HT collected from solution. (a) Whole spectrum. (b) A close-up of aromatic proton region. The d1 - d3 represent the defects in the P3HT structure. (c) A close-up of α-methylene β-methylene proton regions. All regions indicate that the P3HT has high percentage of regioregular head-to-tail (HT) linkage (> 95%).
**Figure S2.** Gel permeation chromatography traces for P3HT polymer collected from solution. $M_n = 12000 \text{ g/mol}, D = 1.5$. 
Figure S3. Monolayer layer graphene. (a) AFM topography and (b) height profile of single layer graphene on 300 nm SiO$_2$/Si.
**Figure S4.** Development of PSBr and P3HT thickness with reaction time. (a) PSBr thickness vs. SIPGP reaction time. (b) P3HT thickness vs. SI-KCTP reaction time.
**Figure S5.** XPS survey spectrum and high resolution element scan of Br3d, S2s and C1s of the (a) PSBr modified graphene and the same sample after grafting of (b) P3HT by SI-KCTP.
Figure S6. GI-XRD of G-PS-P3HT on 300 nm SiO$_2$/Si wafer. The two sets of curves (black and red) are belong to two identical samples.
Figure S7. Representative I-V characteristics collected by conductive mode atomic force microscopy for (a) single layer graphene and (b) 200 nm thick G-PS-P3HT carpets on Au coated Si wafer substrate.
Figure S8. Raman spectra of the 2D band region for graphene and graphene/PSBr.

The invariability of the 2D peak width reflects the preservation of crystallinity of graphene after functionalization. The doping/charge effect of PSBr is reflected as the shift in peak position.
Figure S9. Micropatterned G-PS-P3HT. (a) Schematic illustrations showing the fabrication processes by SIPGP of 4-bromostyrene using a mask, followed by SI-KCTP of 3-hexylthiophene. (b) Topography image obtained by AFM and (c) the height profile corresponding to the dashed line in the AFM image, inset: optical micrograph of microstructured G-PS-P3HT. (d) Mapping of integrated Raman intensity of P3HT shows only minor amounts of polymer traces appeared in the non-irradiated parts (branches) probably due to physical adsorption.
**Figure S10.** Height and conductive AFM imaging. (a) AFM topography and (b) conductive image of p-n heterostructure of MoS$_2$ flakes deposited on G-PS-P3HT surface. A significantly high photocurrent was observed on the P3HT region where MoS$_2$ introduced.