

ADVANCED MATERIALS

Supporting Information

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Electrostatically Self-Assembled Nonconjugated
Polyelectrolytes as an Ideal Interfacial Layer for Inverted
Polymer Solar Cells

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Electrostatically Self-Assembled Nonconjugated Polyelectrolytes as an Ideal Interfacial Layer for Inverted Polymer Solar Cells

By Hongkyu Kang, Soonil Hong, Jongjin Lee, and Kwanghee Lee*

1. Optical and Morphological Characteristics of the ITO/NPE cathodes

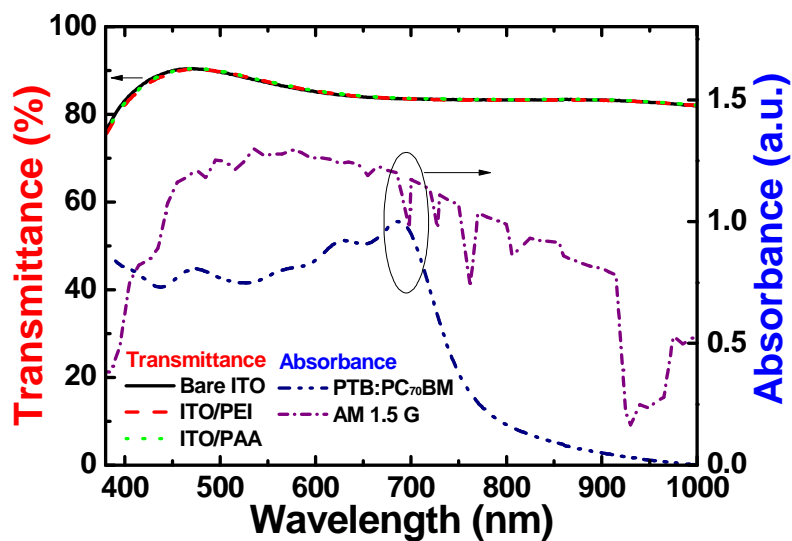


Figure S1. Optical transmittance spectra of the bare ITO, ITO/PAA, and ITO/PEI cathodes and absorption spectra of PTB:PC₇₀BM and AM 1.5 G.

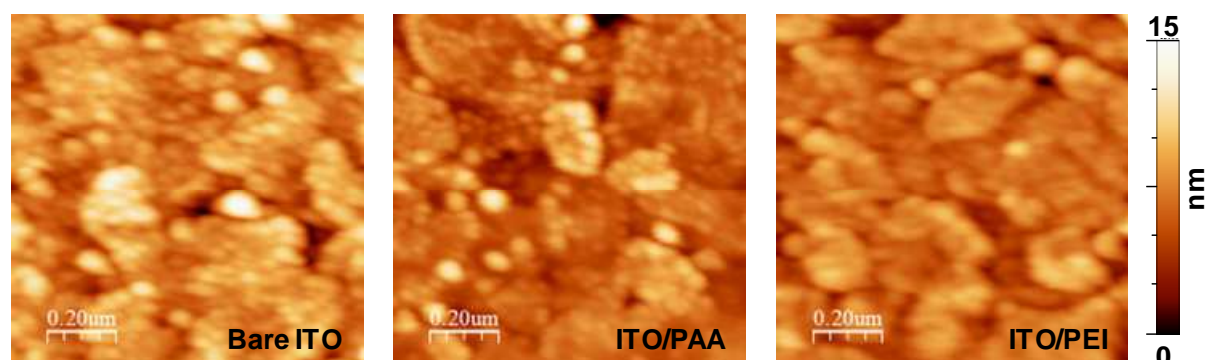


Figure S2. Topography of the bare ITO, ITO/PAA and ITO/PEI cathodes.

2. UV dependence of I-PSCs

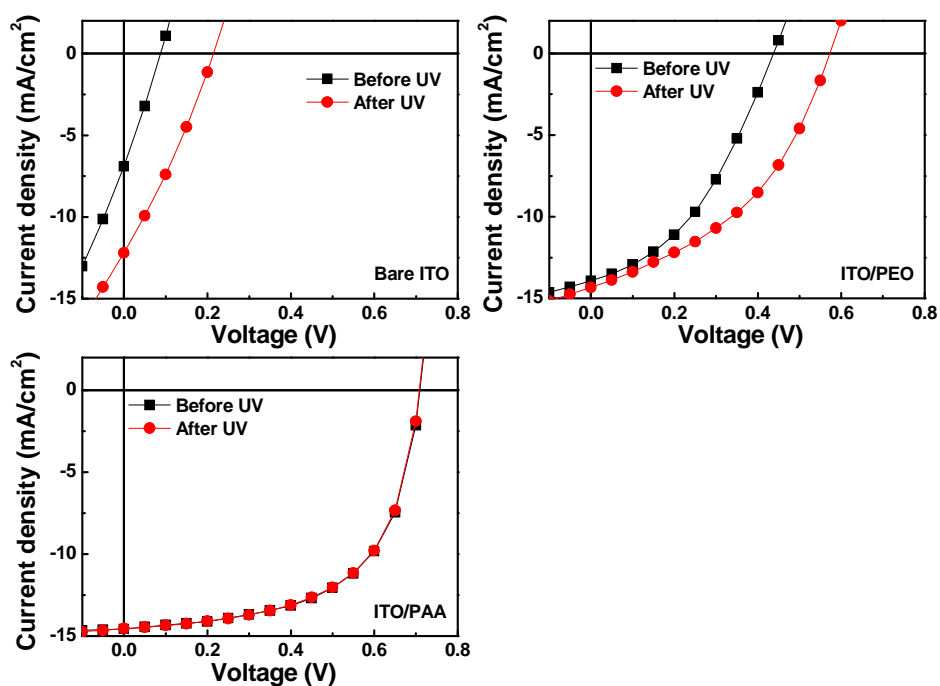


Figure S3. UV dependence of the I-PSCs with the bare ITO, ITO/PEO and ITO/PEI cathodes.

3. Thickness dependence of the NPEs in I-PSCs

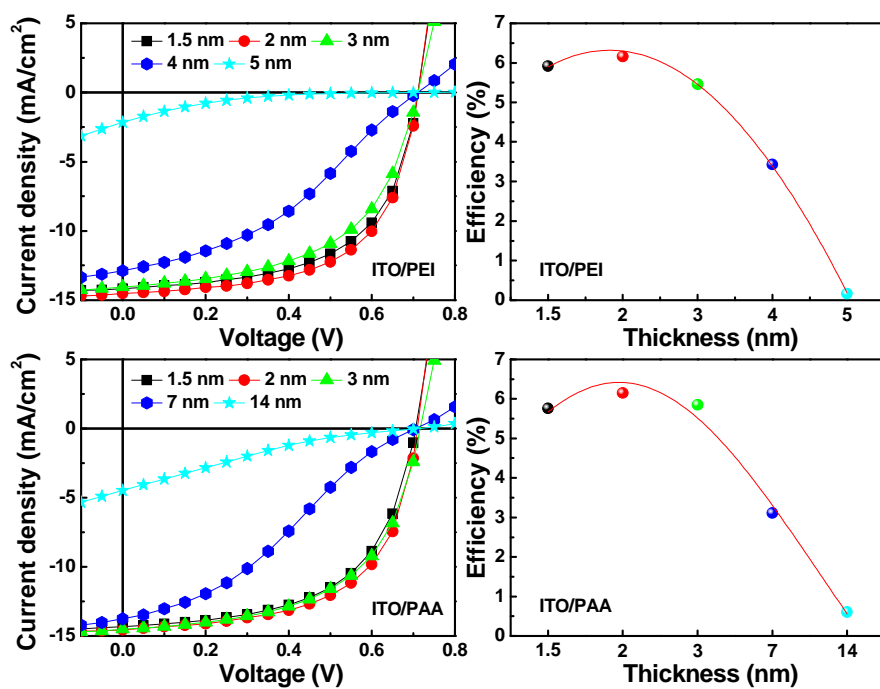


Figure S4. *J-V* characteristics and device efficiency versus thickness for the NPEs in the I-PSCs with the ITO/PEI and ITO/PAA cathodes.

4. Comparison of conventional PSC and I-PSCs

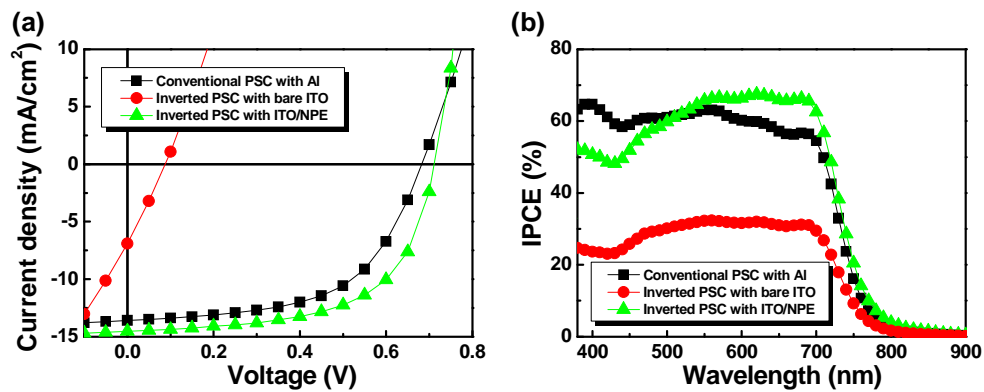


Figure S5. (a) *J-V* characteristics and (b) IPCE spectra of the conventional PSC with Al and the I-PSCs with and without NPE.

5. UV dependence of the ITO/Interfacial Materials cathodes

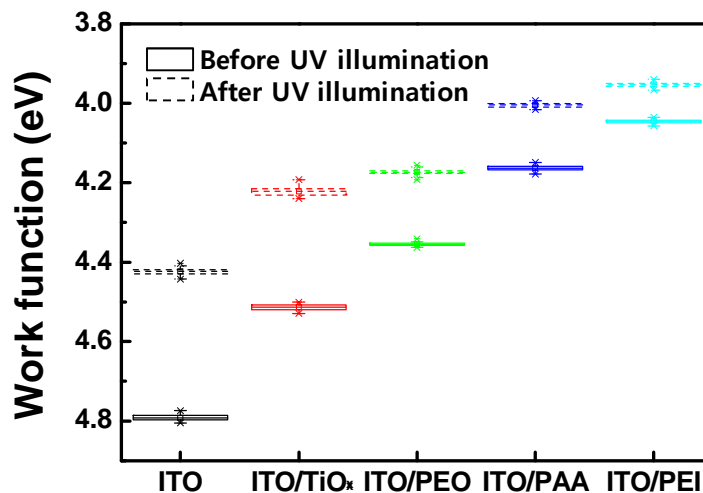


Figure S6. UV-induced WF reductions of the ITO cathodes coated with interfacial materials.

6. Thermogravimetric analysis of the NPEs

Because our I-PSCs were post-annealed at 150 °C, we performed thermogravimetric analysis (TGA) using TA Instrument (TA 2950) to verify that the PAA and PEI are thermally stable under the post-annealed condition. Figure S7 exhibits the TGA data for both NPEs. The TGA data of both NPEs exhibit no significant decomposition up to ~ 300 °C for PEI and ~ 450 °C for PAA, indicating that both NPEs are thermally stable at the post-annealing

temperature (150 °C) of the I-PSCs. The slight weight loss between the room temperature to near 100 °C for PAA is well known to be originated because of the desorption of water and CO₂.

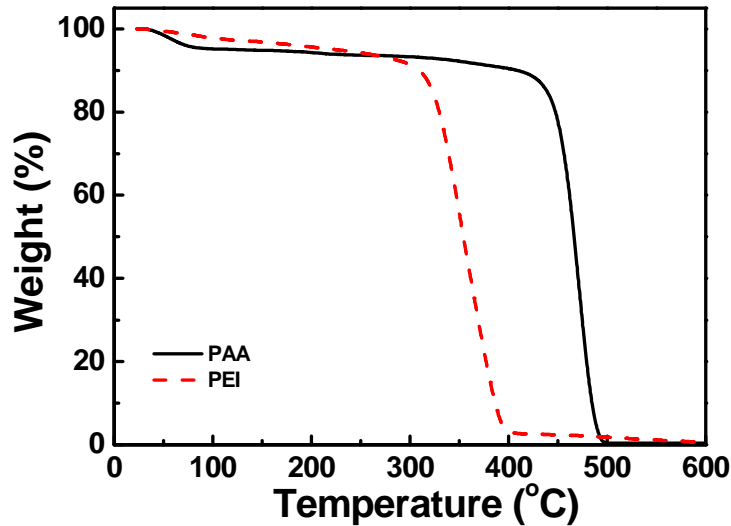


Figure S7. TGA of PAA and PEI.

7. Effects of UV/ozone treatment on ITOs

UV/ozone treatment on ITO could induce not only a positive effect that makes more hydroxyl terminal groups for enhancing self-assembly of the NPEs but also a negative effect that raises the WF of the ITO cathode. Therefore, to investigate whether the UV/ozone treatment of ITO (before coating the NPE layer) affects the performance of the I-PSCs, we fabricated two I-PSCs using a UV/ozone-treated ITO/NPE (u-ITO/NPE) cathode and a b-ITO/NPE (b-ITO/NPE) cathode with a structure of u-ITO or b-ITO/NPE/PTB:PC₇₀B-M/PEDOT:PSS/Ag and compared the device performance. As shown in Figure S8a and S8b, the *J-V* characteristics of the I-PSCs show that the UV/ozone treatment has almost no effect on the performance of the devices using the PEI and PAA. We attribute these results to the solvent (DI-water) of the NPE solutions. Regardless of the UV/ozone treatment, the solvent (DI-water) of the NPE solutions eventually lead to the similar surface states for the u-ITO and the bare ITO, resulting in comparable WF changes for the u-ITO (1→2) and the bare ITO (1')

as shown in Figure S8c. Therefore, there is no significant difference between the WFs of the u-ITO/NPE and the b-ITO/NPE (Figure S8d), resulting in almost identical performance for both I-PSCs.

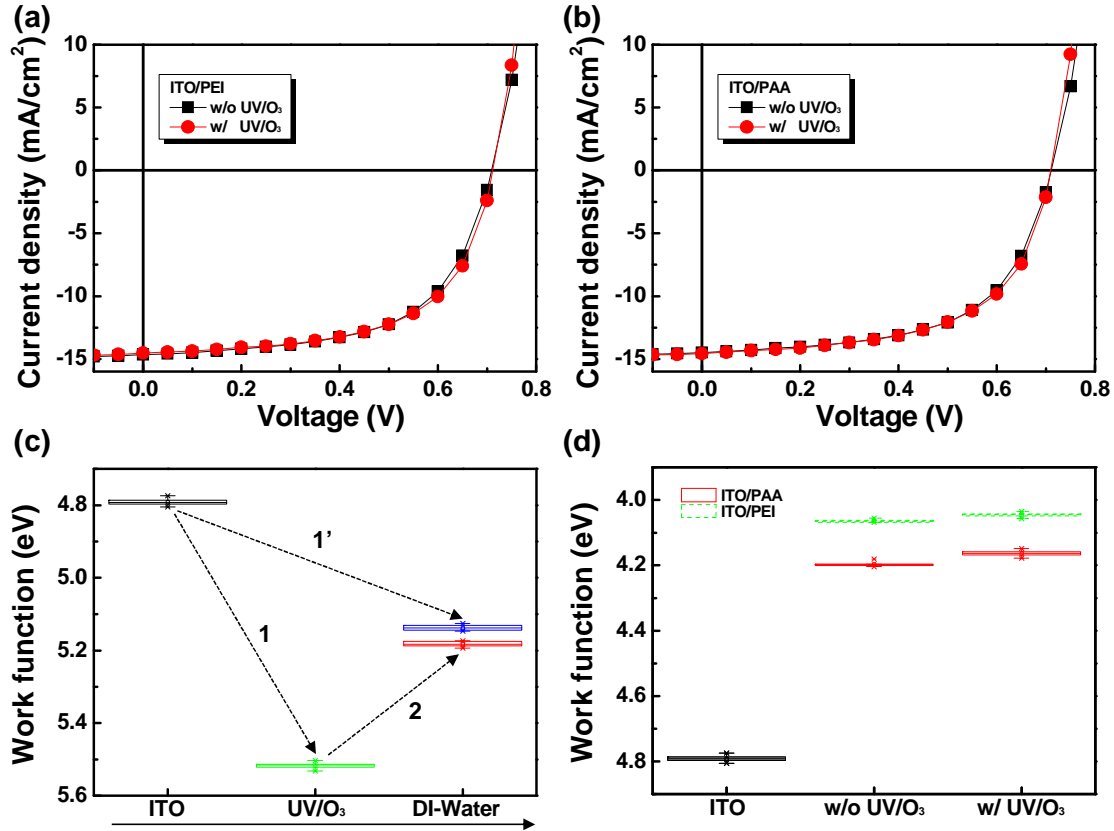


Figure S8. *J-V* characteristics of the I-PSCs using (a) b-ITO/PEI and u-ITO/PEI cathodes, and using (b) b-ITO/PAA and u-ITO/PAA cathodes. (c) WF changes of ITO by UV/ozone treatment and DI-water. (d) WFs of the b-ITO/NPE and u-ITO/NPE cathodes.

8. Solvent effect (DI-water) of I-PSCs

To sort out the effect by the solvent (DI-water) of the NPE solutions on the performance of I-PSCs, two I-PSCs using a DI-water coated ITO (d-ITO) and bare ITO without coating DI-water were fabricated and compared with a device structure of d-ITO or b-ITO/PTB:PC₇₀-BM/PEDOT:PSS/Ag. As shown in Figure S9a, both devices show almost comparable performance. Because we used thermal pre-annealing, ultrahigh vacuum process, and post-annealing to complete our I-PSCs, we consider that there would be no residual water within

the I-PSCs. Figure S9b also exhibits that the initial WF of ITO is very similar to its final WF after three processes (1→2→3). Therefore, we conclude that the solvent (DI-water) of the NPE solutions has no significant effect on the performance of the I-PSCs and the high performance of the I-PSCs using the NPEs originates solely from the NPEs themselves.

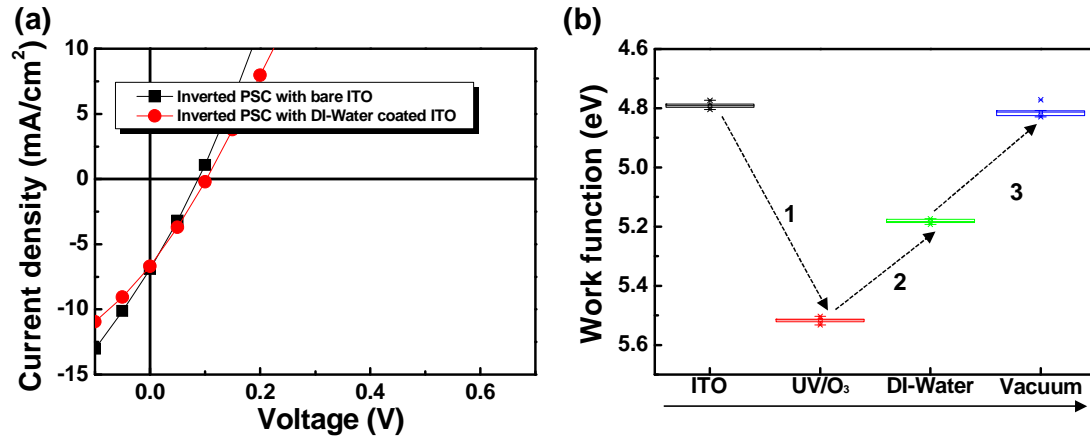


Figure S9. (a) J - V characteristics of I-PSCs using the b-ITO/NPE and d-ITO/NPE cathodes.

(b) WF changes of ITO with various treatments.