Supporting Information for

Facile Approach to Preparing a Vanadium Oxide Hydrate Layer as a Hole-Transport Layer for High-Performance Polymer Solar Cells

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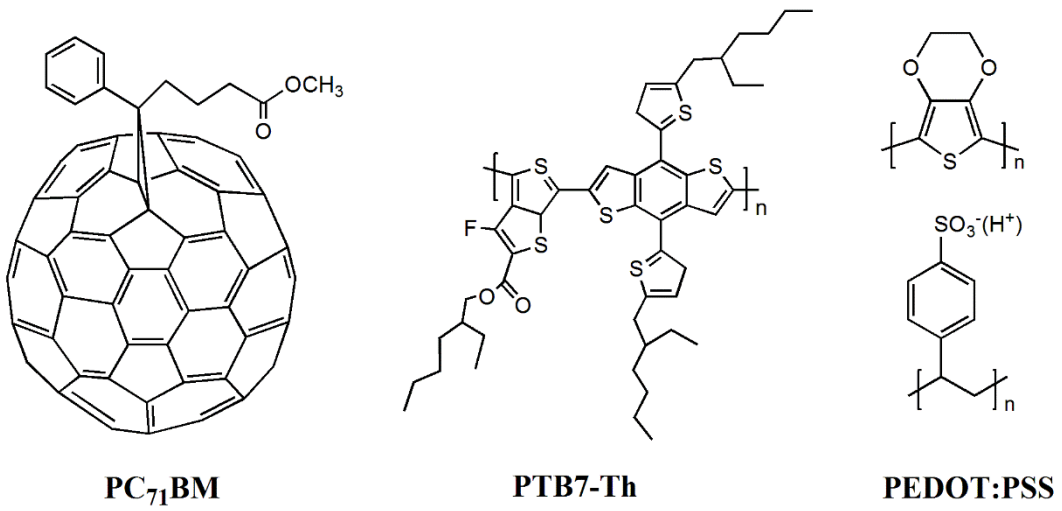

Figure S1. Schematic molecule structures of $PC_{71}BM$, PTB7-Th, PEDOT:PSS.

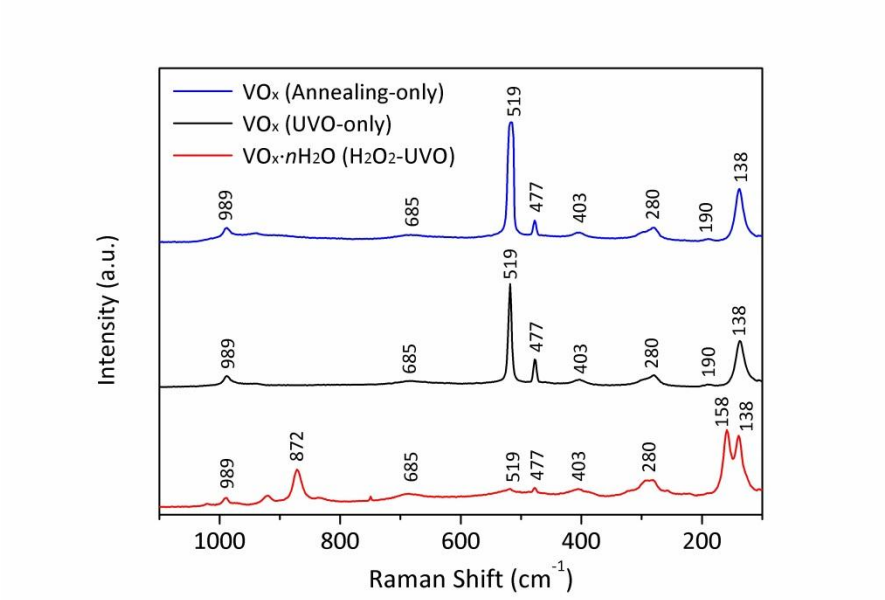

Figure S2. Micro-Raman spectra of the as-prepared VO_x nH_2O (H_2O_2-UVO) and VO_x layers.

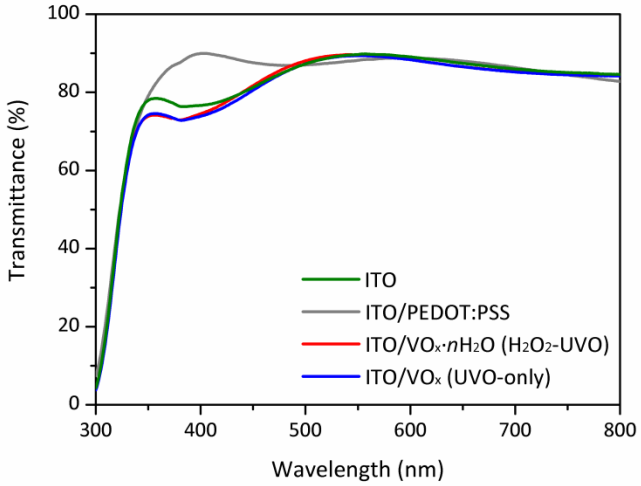

Figure S3. Optical transmittance spectra of the bare ITO, PEDOT:PSS and $VO_x \cdot nH_2O$ (H_2O_2-UVO) and VO_x (UVO-only) layers.

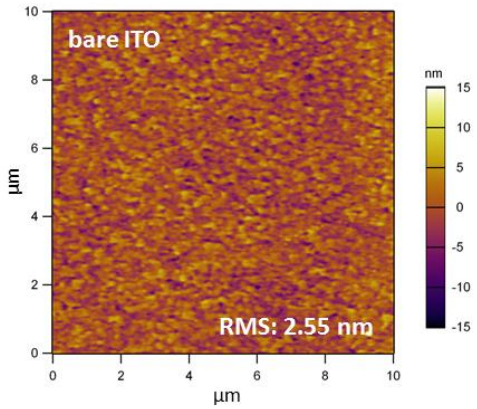

Figure S4. AFM height image of the bare ITO. The scan size is 10 µm × 10 µm.

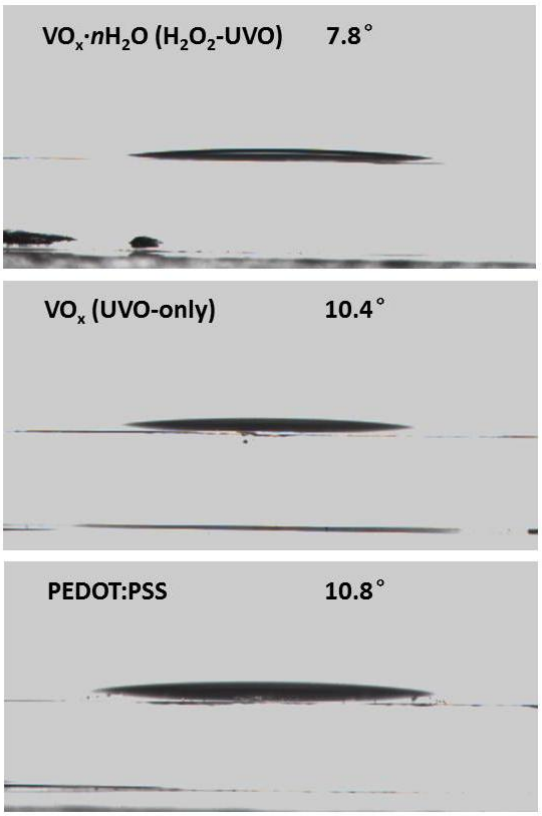

Figure S5 Measured contact angle between a drop of 1,2-dichlorobenzene and the HTL. $VO_x \cdot nH_2O$ (H_2O_2-UVO), VO_x (UVO-only), and PEDOT:PSS layers from top to bottom, respectively.

Table S1. Device performance of the PSCs (based on PTB7-th:$PC_{71}BM$) with $VO_x \cdot nH_2O$ (H_2O_2-UVO) layer with varied concentration.

precursor	V_{oc} (V)	J_{sc} (mA/cm^2)	*FF* (%)	PCE (%)
1.0 mg/mL	0.796	16.49	68.2	8.11
1.5 mg/mL	0.790	14.69	63.6	7.38
2.0 mg/mL	0.772	15.15	61.4	7.18

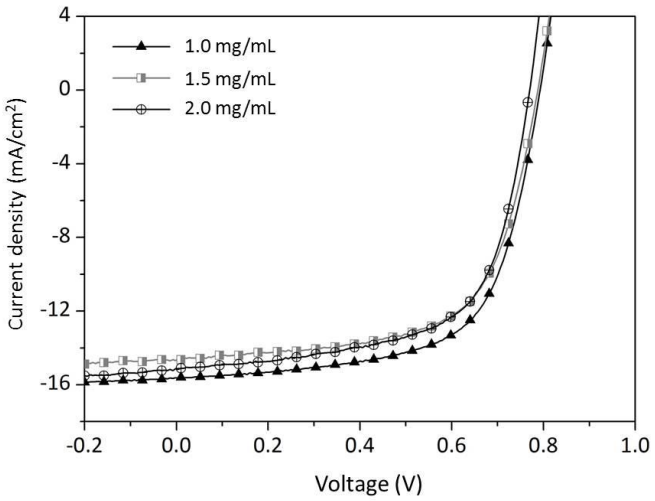

Figure S6. *J–V* curves of the PSCs (based on PTB7-th:$PC_{71}BM$) with $VO_x \cdot nH_2O$ (H_2O_2-UVO) layer with varied concentration under 1 sun illumination condition.

Table S2. Device performance of the PSCs based on P3HT:$PC_{61}BM$ with different HTLs.[a]

device	hole transport layer	V_{oc} (V)	J_{sc} (mA/cm^2)	*FF* (%)	PCE (%)[b]
A′	PEDOT:PSS	0.647	7.90	62.26	3.18(3.32)
B′	VO_x·nH_2O (H_2O_2-UVO)	0.638	8.12	62.24	3.24(3.32)
C′	VO_x (UVO-only)	0.630	7.75	60.98	2.98(3.04)
D′	VO_x (annealing-only)	0.637	8.14	52.38	2.72(2.90)

[a]Statistical data achieved from 10 independent devices. [b]The maxima PCEs are in the brackets.

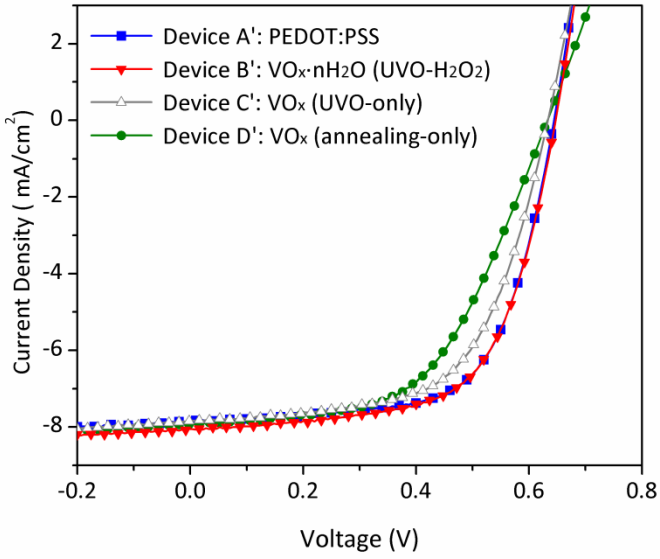

Figure S7. *J*–*V* curves of best performing devices based on P3HT:$PC_{71}BM$ with different HTLs under 1 sun illumination condition.

Space charge limited current (SCLC) measurements

The SCLC devices or hole-only devices were fabricated with a configuration of ITO/HTL/PTB7-th:$PC_{71}BM$/MoO_3/Ag. The SCLC can be written as $J_{SCLC}=9\varepsilon_0\varepsilon_r\mu_h(V-V_{BI})^2/(8L^3)$: where J is current density, ε_r is dielectric constant of the fullerene derivatives (normally a value of 3 is used), ε_0 ($8.8541878176\times10^{-12}$ F/m) is the permittivity of vacuum, μ_h is hole carrier mobility, L is film thickness, $V=V_{appl}-V_{bi}$, V_{appl} is the applied potential, and V_{bi} is the built-in potential resulting from work function difference between two electrodes (in this device, V_{bi}=0.6 V)[1]. To evaluate the μ_h value, the log J-V line obtained in dark was fitted using a function of $y=a+2x$ and electron mobility (μ_h) was calculated from the y-intercept of the fitting line.

Reference.

1. Morsli1, M.; Cattin, L.; Bernède, J. C.; Kumar, P.; Chand, S. *J–V* Characteristics of Dark and Illuminated Classical and Inverted Organic Solar Cells Based on the CuPc/C_{60} Heterojunction. *J. Phys. D: Appl. Phys.* **2010**, *4*3, 335103.