Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting information

High performance as-cast semitranspant polymer solar cells

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Materials

Unless otherwise stated, all the solvents and chemicals were purchased from TCI Chemical Co, J&K and Alfa Aesar. PTB7-Th, ITVfIC and PDINO were synthesized on the basis of literatures.

Device fabrication and characterization

We fabricated the opaque polymer solar cell (PSC) with the structure of ITO/PEDOT: PSS (30 nm)/active layer(100 nm) /PDINO /Ag(100 nm). When changing the thickness of Ag to 15nm, we can get the semi-transparent polymer solar cells (ST-PSC). At first, we clean the ITO glass carefully. After that, PEDOT:PSS aqueous solution was deposited on the ITO film at 3000 rpm and then annealing 15 minutes at 150℃ for drying the water in PEDOT:PSS film. The device was then transferred to nitrogen glove box and waited for cooling. We prepared the mixed solution of PTB7-Th: ITVfIC with a concentration of 18 mg mL^{-1} (the weight ratio of PTB7-Th: ITVfIC is 1:2), where chloroform was used as solvent. The active layer was spin-coated on the cooled surface of PEDOT:PSS layer with a spin-coating rate of 3500 rpm. Then, the PDINO film of methanol as solvent with a concentration of 1.0 mg ml^{-1} was spin-coated on the surface of active layer with the thickness of 10 nm, which acts as a cathode buffer layer. The last step of evaporating Ag in vacuum is the key process to get opaque PSC or ST-PSC under a pressure of ca. 5.0×10^{-5} Pa. We evaporated Ag with different thickness in high vacuum glove box to get opaque PSCs and ST-PSCs. The Ag film thickness was detected with the thickness detector of model DEKTAK XT.

The current density – voltage (*J*–*V*) characteristics of the PSCs were measured in Glove box on a computer-controlled Keithley 2450 Source-Measure Unit. Oriel Sol3A Class AAA Solar Simulator (model, Newport 94023A) with a 450 W xenon lamp and an air mass (AM) 1.5 filter was used as the light source. The scanned scale of voltage is from -1.5 V to 1.5 V. The External Quantum Efficiency (EQE) was measured by Solar Cell Spectral Response Measurement System QE-R3-011 (Enli Technology Co., Ltd., Taiwan).

Mobility measurements

We measured the hole and electron mobilities with the device structure of ITO/PEDOT:PSS/active layer/Au and ITO/ZnO/active layer/PDINO/Al respectively. According to the space charge limited current (SCLC) method equation: $J = 9\mu\varepsilon_r\varepsilon_0 V^2/8L^3$. In the equation, J is the current density, V is the internal voltage in the device, μ is the hole or electron mobility, ε_r is the relative dielectric constant of active layer material, ε_0 is the permittivity of empty space, and L is the thickness of the active layer.

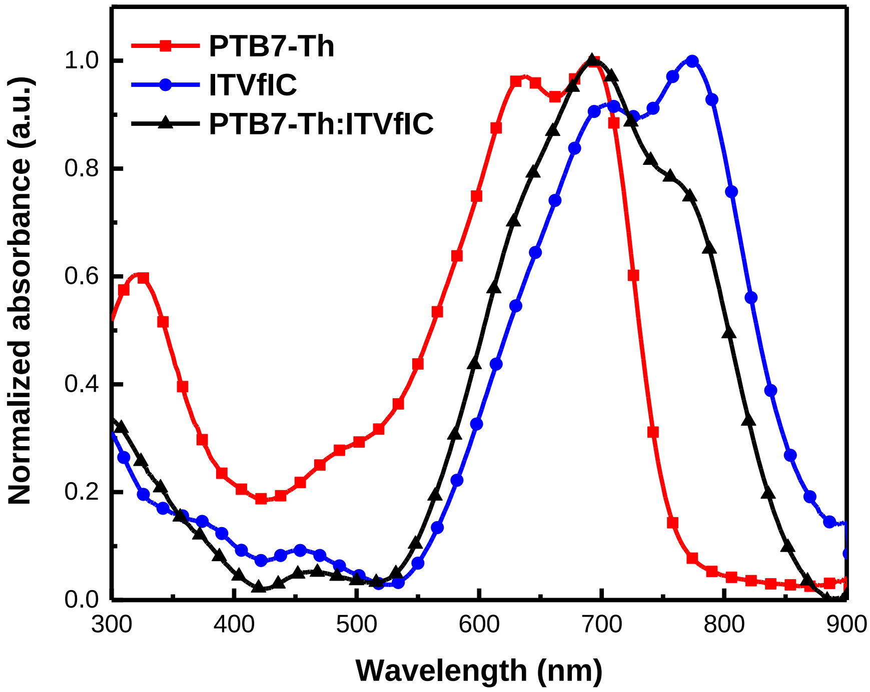

Fig. S1 The absorption spectra of PTB7-Th, ITVfIC and their blend films.

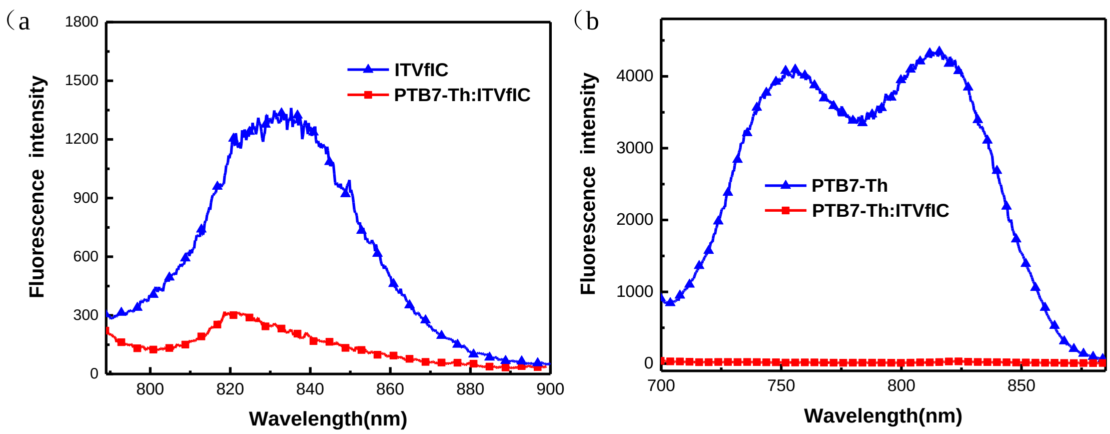

Fig. S2. Photoluminescence spectra of PTB7-Th, ITVFIC and their blend films: (a) excited at 770 nm and (b) excited at 690 nm.

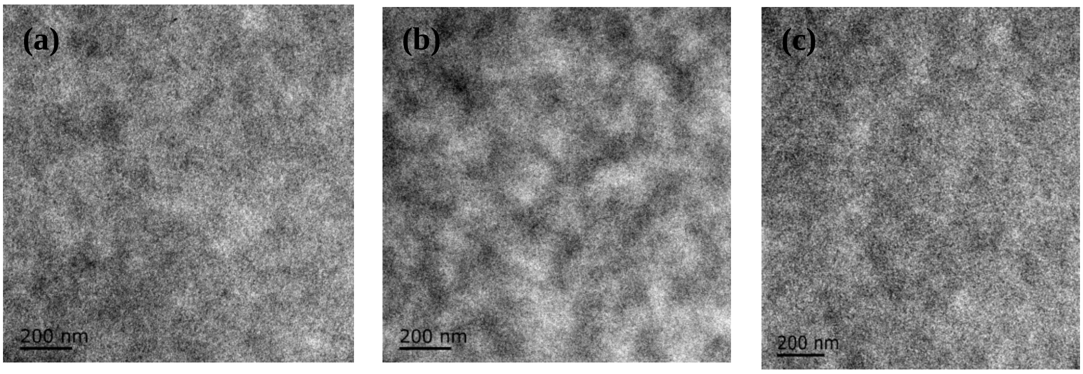

Fig. S3 TEM images of the blend films of (a) as-cast, (b) with 1% CN and (c) with thermal annealing at 160℃ for 2 min.

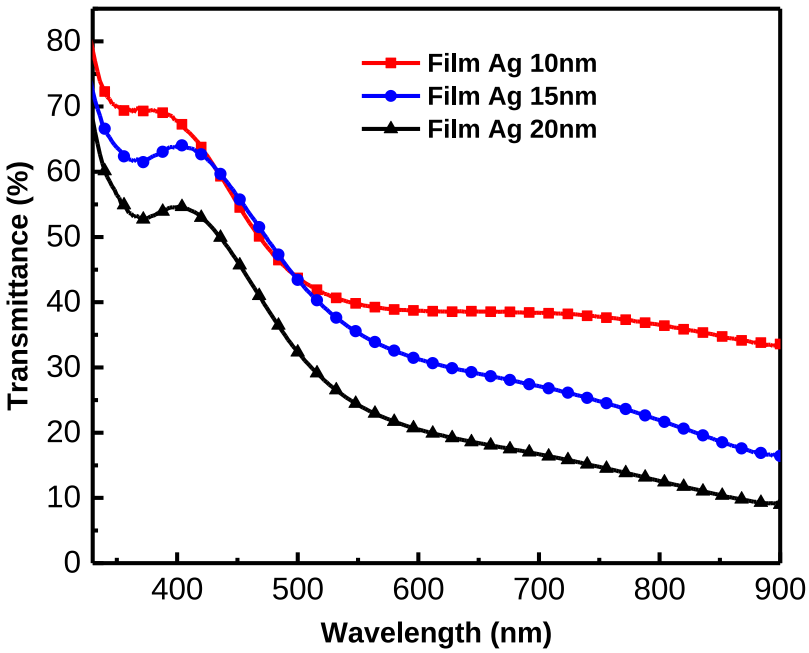

Fig. S4 The transmittance spectra of Ag film electrode with the thickness of 10, 15 and 20 nm.

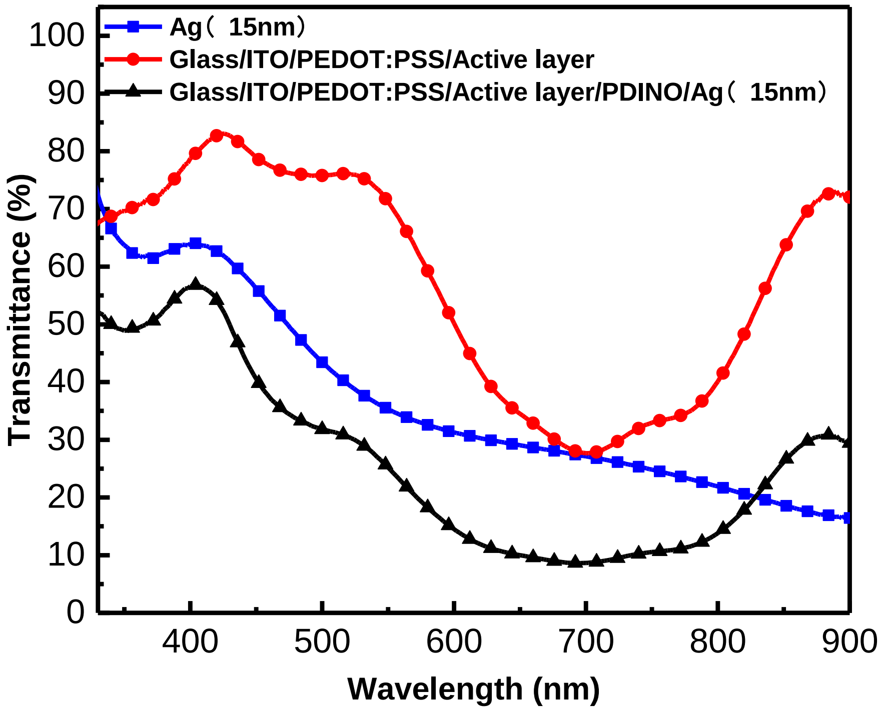

Fig. S5 Visible transmission spectra of ITO/PEDOT:PSS/Active layer , PDINO/Ag and integrated device.

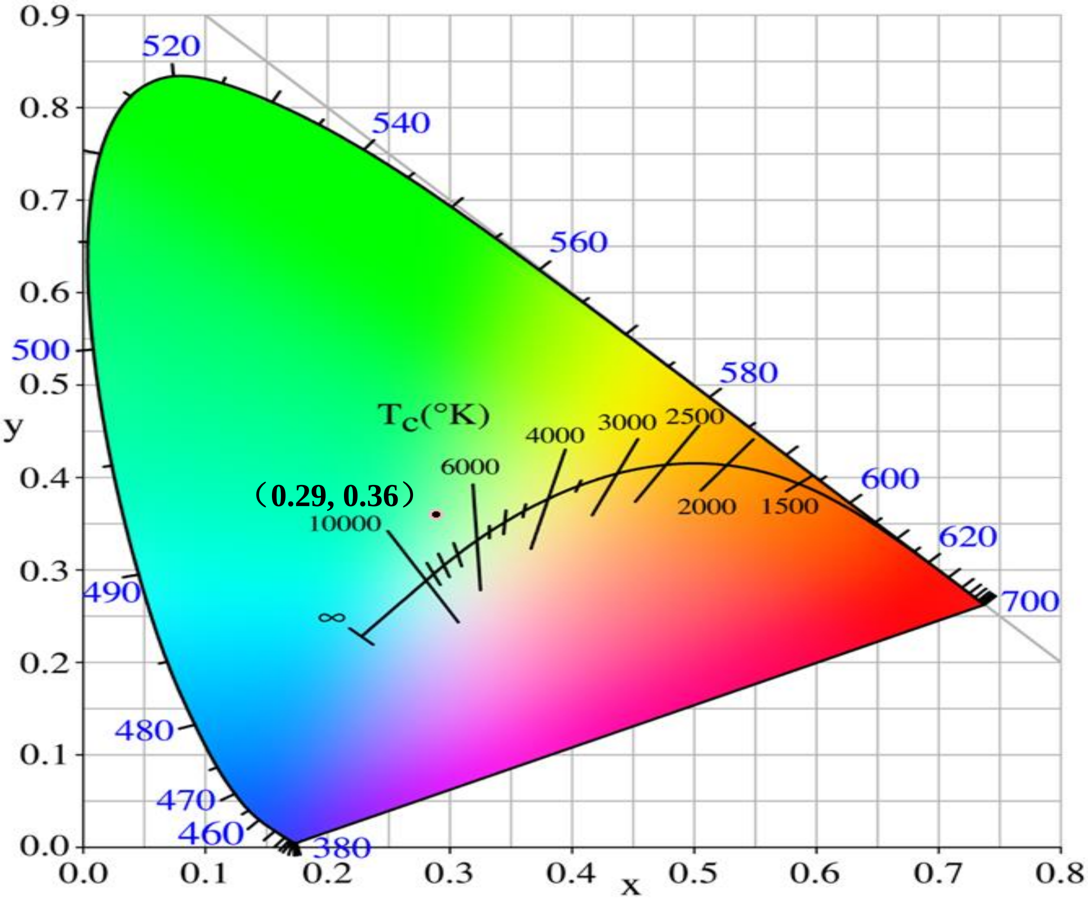

Fig. S6 The representation of color coordinate of the semitransparent device on CIE 1931 xyY chromaticity diagram.

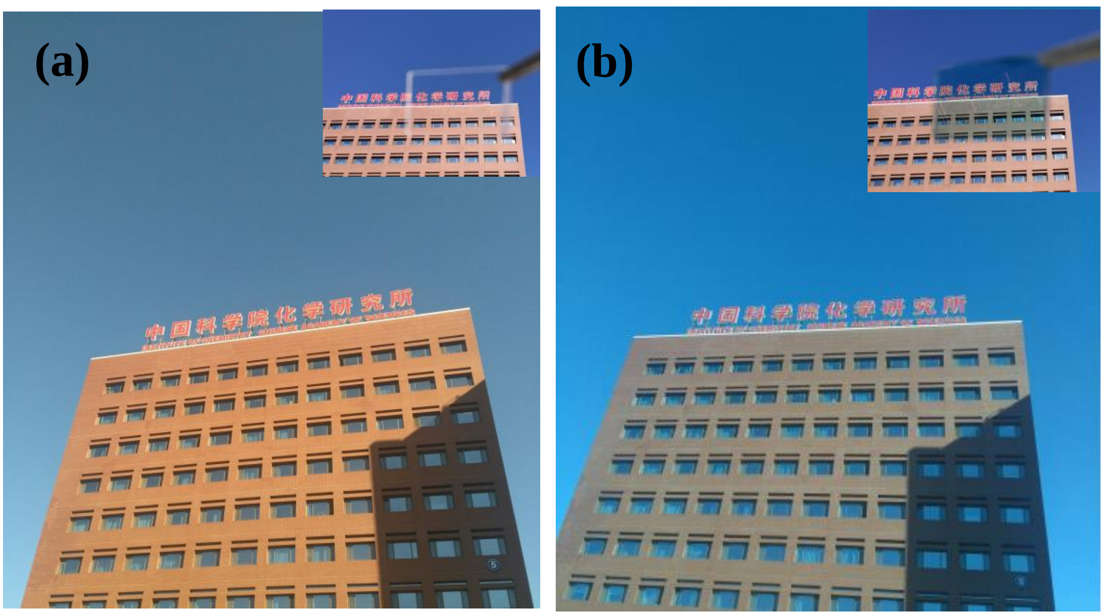

Fig. S7 The picture of ICCAS building (a) without or (b) with ST-PSC on glass.

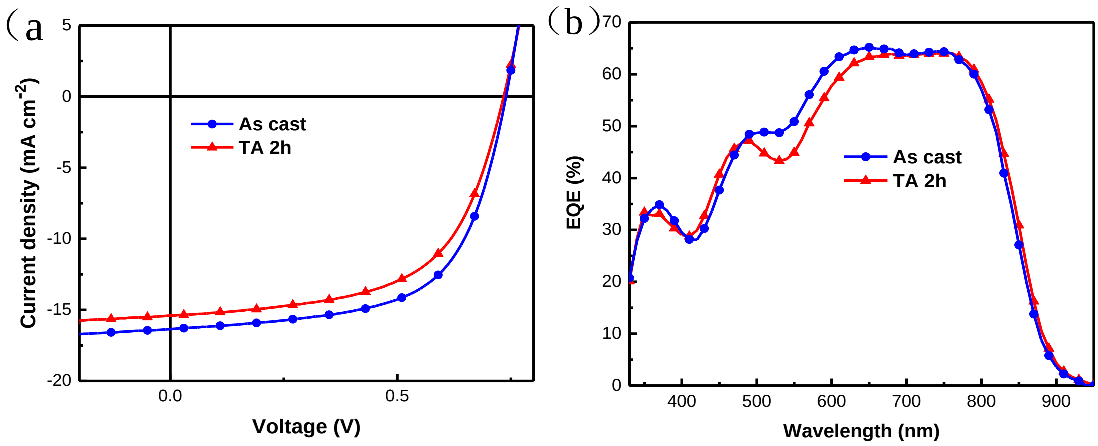

Fig. S8 Typical *J*-*V* curves (a)and External quantum efficiency (EQE) spectra (b)of the ST-PSC as cast and after thermal treatment at 200 ^{o}C for 2h.

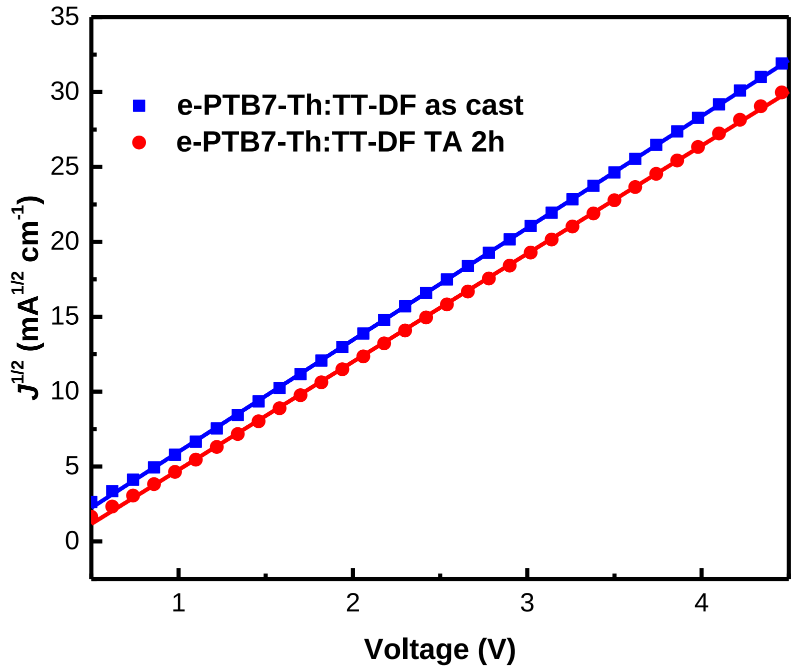

Fig. S9 $J^{1/2}$~(V_{appl}-V_{bi}) characteristics of the electron-only devices based on the blend films as-cast and with high temperature treatment at 200℃ for 2h .

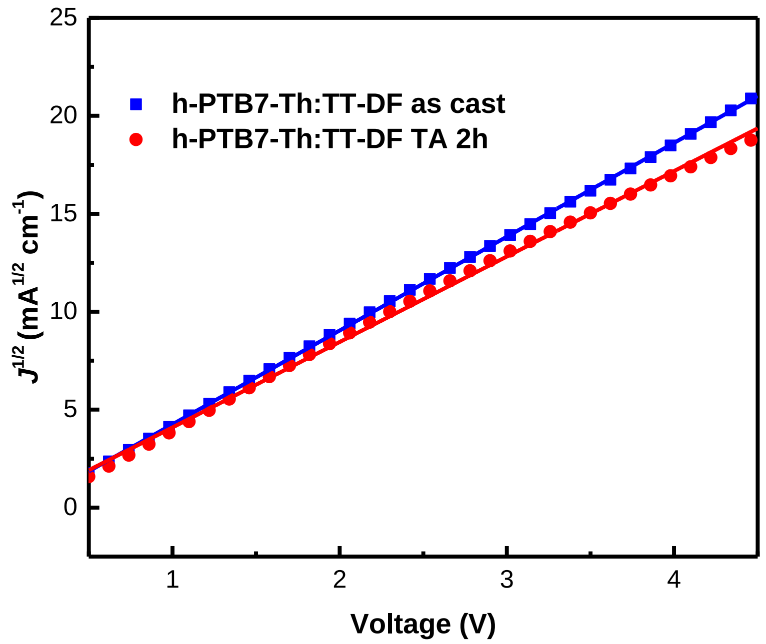

Fig. S10 $J^{1/2}$~(V_{appl}-V_{bi}) characteristics of the hole-only devices based on the blend films as-cast and with high temperature treatment at 200℃ for 2h.

Table S1 Device performance of the ST-PSCs based on PTB7-Th:ITVfIC with different cathode and additive

cathode	Process	V_{oc} (V)	J_{sc} (mA cm^{-2})	FF (%)	PCE (%)	AVT (%)	AT (%)
Al (100 nm)	-	0.742	20.05	61.93	9.21	-	-
Ag (100 nm)	-	0.741	18.88	64.94	9.09	-	-
Ag (20 nm)	-	0.740	17.94	64.39	8.55	18.2	22.74
Ag (15 nm)	-	0.742	17.54	63.11	8.21	26.40	33.71
Ag (10 nm)	-	0.732	15.56	61.86	7.05	34.98	44.98
Ag (15 nm)	CN (1%)	0.694	17.23	56.46	6.75	-	-
Ag (15 nm)	160 ºC/2 min	0.737	17.77	61.65	8.07	-	-

Table S2 The AVT and AT of active layer and Ag film with different thickness

	Active layer (100 nm)	Ag (10 nm)	Ag (15 nm)	Ag (20 nm)
AVT (%)	58.61	46.03	40.54	30.10
AT (%)	73.46	47.87	45.76	35.19