Electronic Supplementary Information

A Cost-effective Commercial Soluble Oxide Cluster for Highly Efficient and Stable Organic Solar Cells

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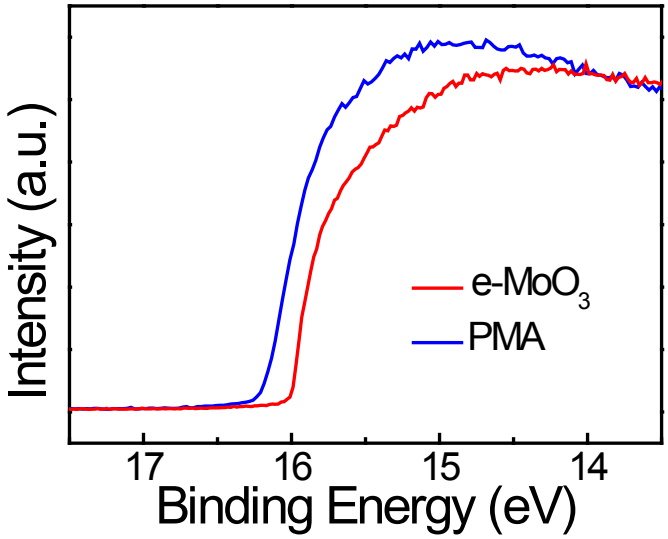

Fig. S1 The UPS spectra of e-MoO_3 and PMA film.

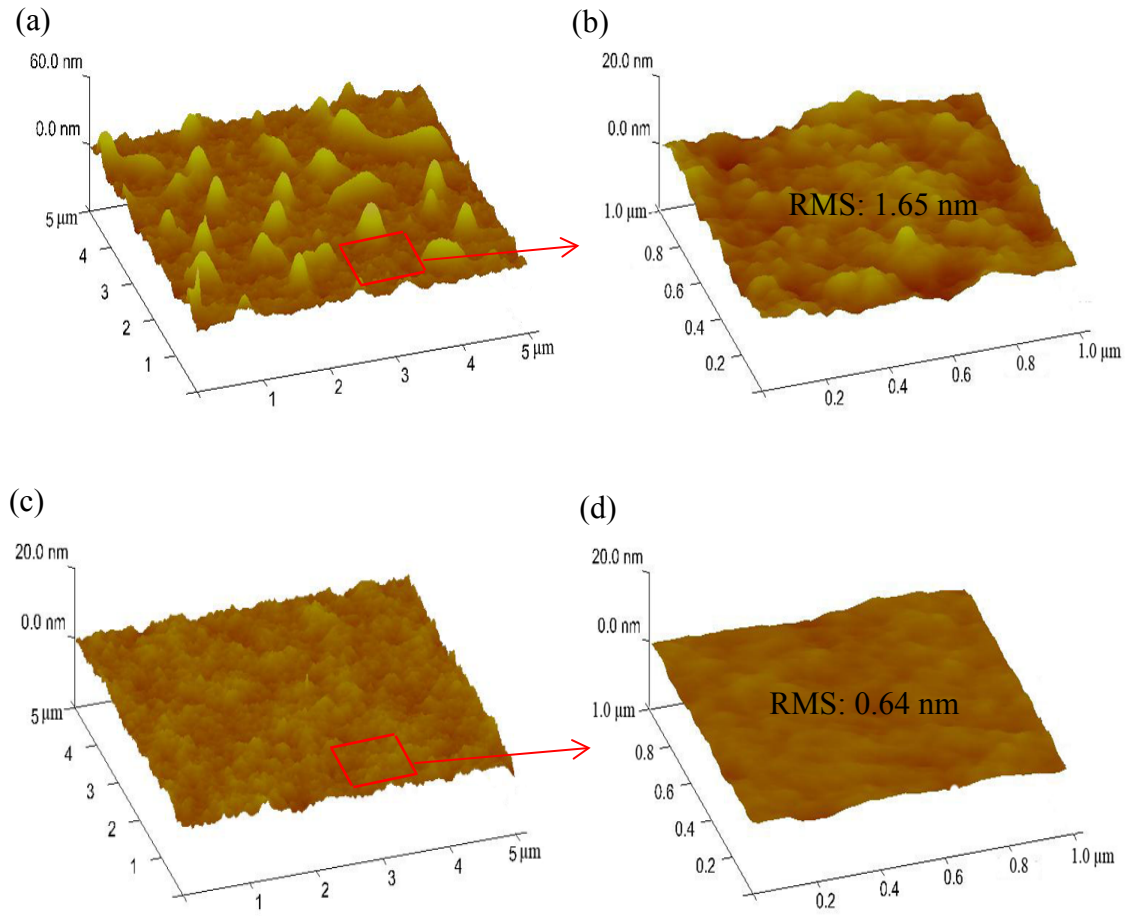

Fig. S2 Three dimensional AFM height images: (a) PTB7:$PC_{71}BM$/ZnO/ITO with spin-coating of 1 mg/ml PMA solution, (c) bare PTB7:$PC_{71}BM$/ZnO/ITO surface. (b) and (d) are images of the zoomed-in regions in (a) and (c), respectively.

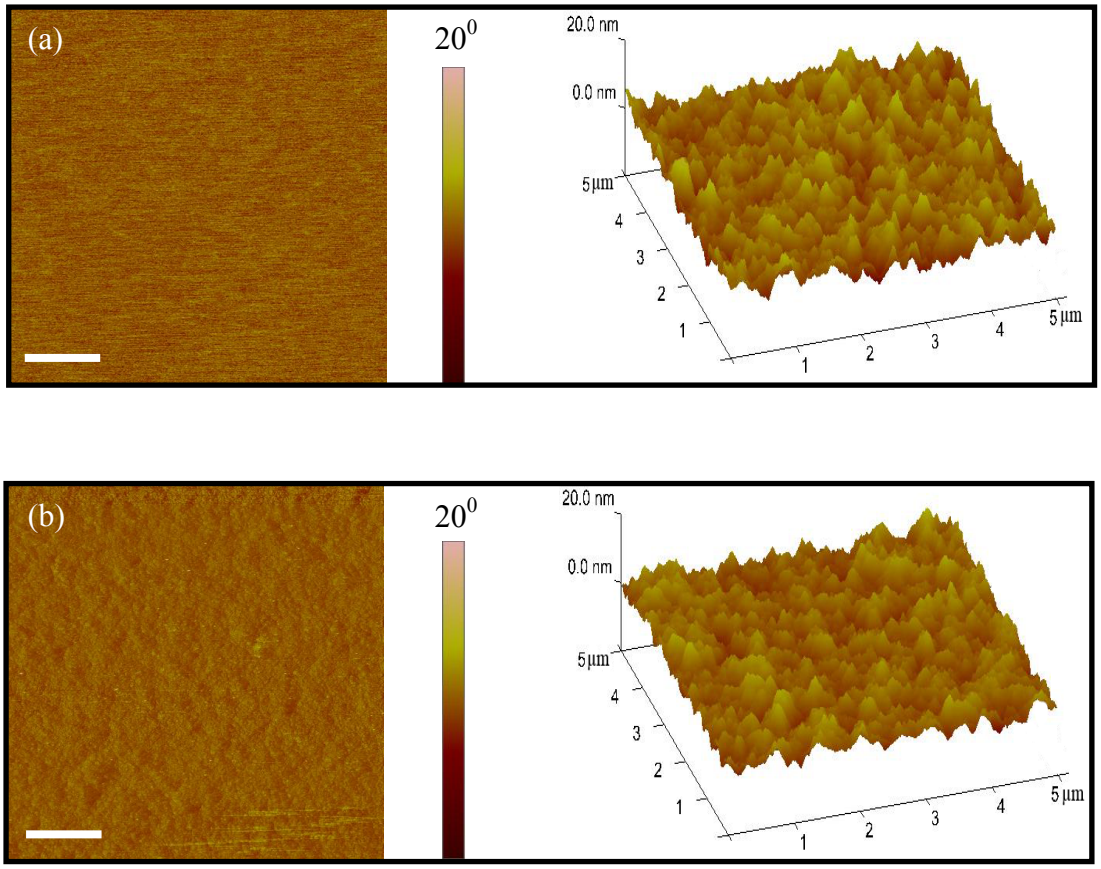

Fig. S3 AFM images: (a) PTB7:$PC_{71}BM$ film, (b) PTB7:$PC_{71}BM$ film treated with pristine isopropanol spin-coated washing. The left half in each template shows the phase image while the right half shows the three dimensional height one. Both the scale bars are 1 µm.

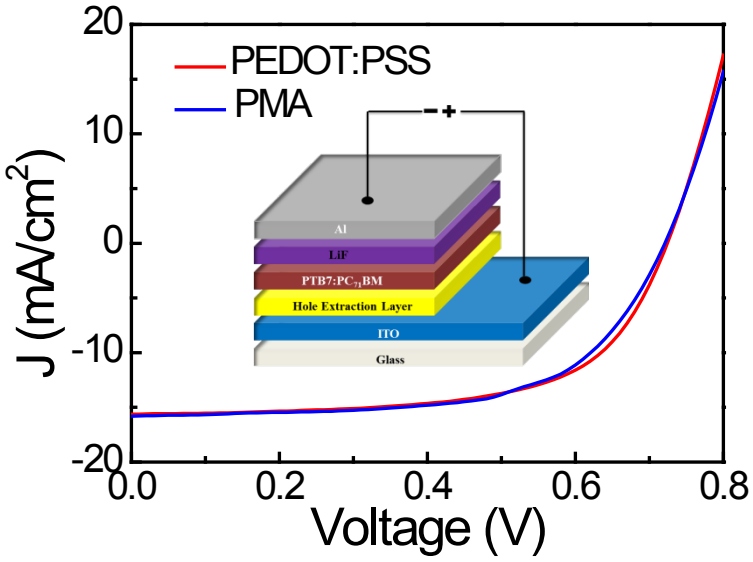

Fig. S4 J-V characteristics for PTB7:$PC_{71}BM$ based normal organic solar cells with different hole extraction layers under AM 1.5G solar illumination at 100 mW/cm^2. (Insert) Schematic illustration of the device structure.

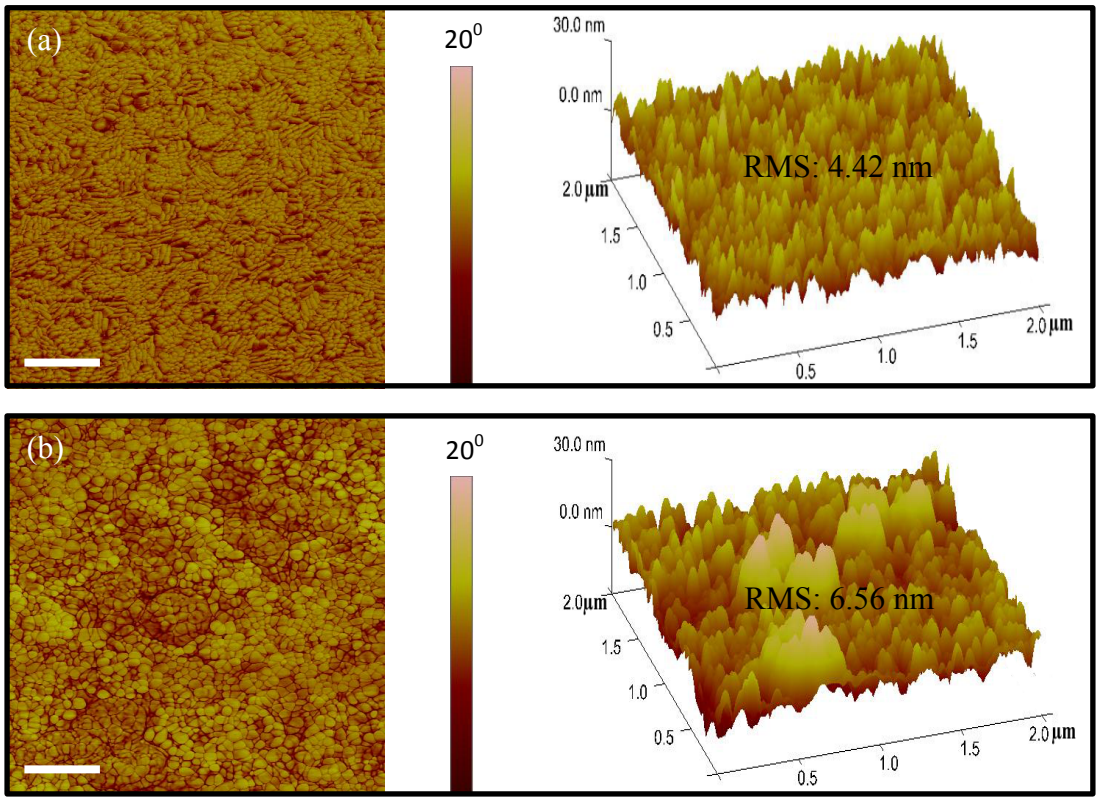

Fig. S5 AFM images of (a) pristine ITO surface and (b) PMA film on top of ITO. The left part shows the phase image while the right one shows the height image. Both scale bars are 400 nm.

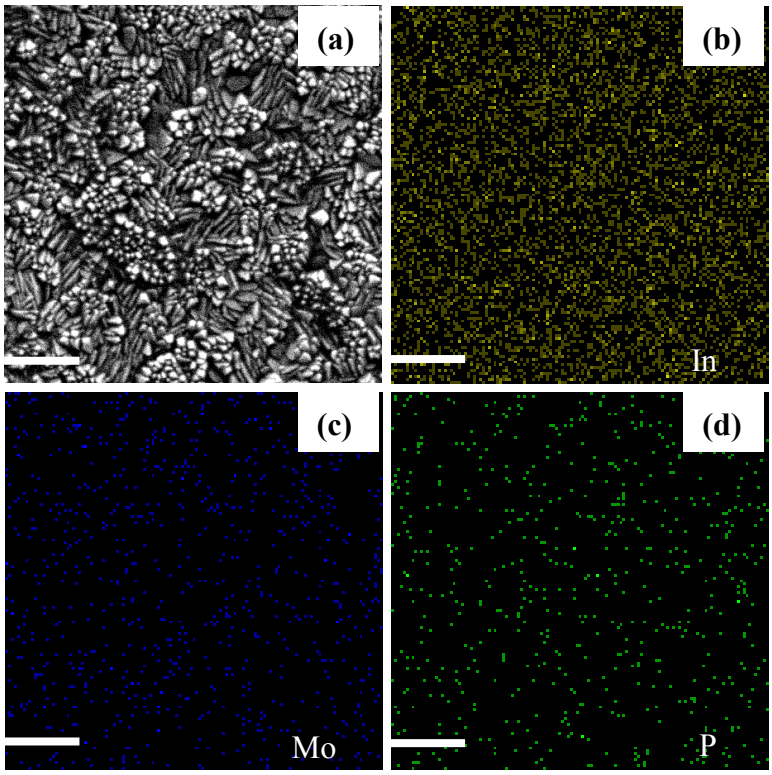

Fig. S6 (a) SEM image of 1 mg/mL PMA film coated on ITO, and corresponding element mapping images by energy-dispersive X-ray spectroscopy of (b) Indium, (c) Molybdenum and (d) Phosphorus elements. All scale bars are 500 nm.

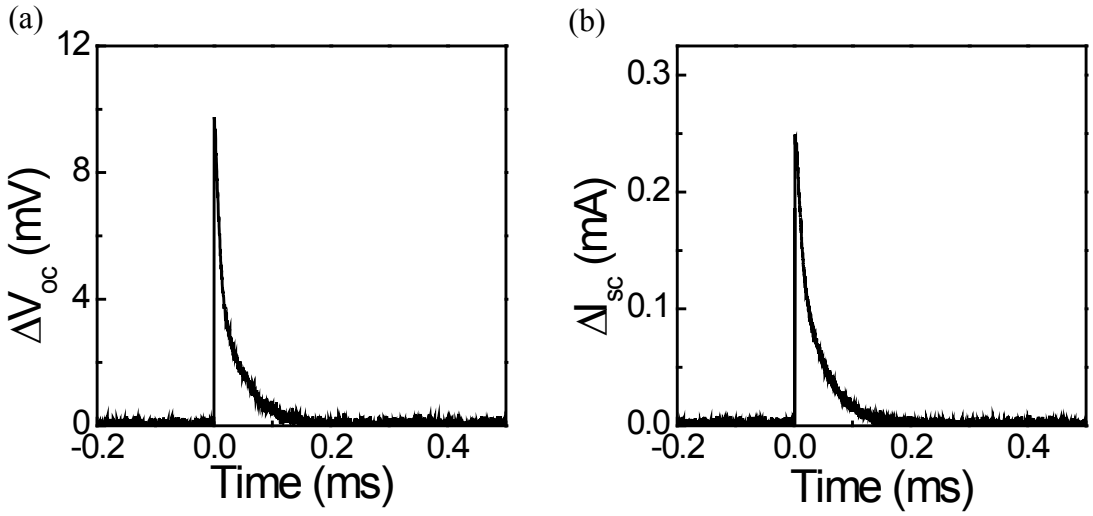

Fig. S7 V_{oc} (a) and J_{sc} (b) transients induced from the perturbation light pulse.

Table S1 Summary of electric output characteristics of PTB7:$PC_{71}BM$ based inverted organic solar cells with different thicknesses of e-MoO_3 hole extraction layers.[a,b]

Hole extraction layer	V_{oc} (V)	J_{sc} (mA/cm^2)	FF	PCE (%)
3 nm e-MoO_3	**0.71**	**15.2**	**0.68**	**7.34**
	0.71(±0.003)	15.2(±0.024)	0.67(±0.005)	7.23(±0.015)
6 nm e-MoO_3	**0.72**	**15.7**	**0.66**	**7.46**
	0.72(±0.003)	15.5 (±0.105)	0.66(±0.003)	7.30(±0.083)
10 nm e-MoO_3	**0.71**	**14.5**	**0.70**	**7.24**
	0.72(±0.003)	14.5(±0.042)	0.69(±0.003)	7.20(±0.019)

[a] Data and statistics based on 20 cells of each type. [b] Numbers in bold are the maximum recorded values.

Table S2 Summary of electric output characteristics of PTB7:$PC_{71}BM$ based normal organic solar cells with different hole extraction layers.

Hole Extraction layer	V_{oc} (V)	J_{sc} (mA/cm^2)	FF	PCE (%)
PEDOT:PSS	0.72	15.61	0.63	7.12
PMA	0.72	15.79	0.62	7.01