# **Electronic Supplementary Information (ESI)**

## Large grain size perovskite thin film with dense structure for planar heterojunction solar cells *via* spray deposition under ambient condition

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### **ESI 1:**

Contact angles of perovskite precursor solution with a concentration of 11.3 wt% on the surfaces of different substrates: (a) FTO, (b) cp-TiO<sub>2</sub> (compact TiO<sub>2</sub>)/FTO, (c) ms-TiO<sub>2</sub> (mesoporous TiO<sub>2</sub>) /cp-TiO<sub>2</sub>/FTO, and (d) PEDOT:PSS/FTO; contact angles of perovskite precursor solution with different concentration on the surfaces of cp-TiO<sub>2</sub>: (e) 5.6 wt%, (f) 9.0 wt%, (g) 11.3 wt%, and (h) 15.0 wt%.



## **ESI 2:**

Surface SEM images of the perovskite thin films prepared using a precursor solution concentration of 11.3 wt% by spray deposition on compact  $TiO_2$  (a), and spin-coating on compact  $TiO_2$  (b) and mesoporous  $TiO_2$  (c).



### **ESI 3:**

Photocurrent density-voltage (J-V) at forward scan (from short-circuit to open-circuit under the forward bias voltage) and reverse scan (from open-circuit to short-circuit under the forward bias voltage) for planar solar cells using perovskite films with varied precursor concentration *via* spray deposition.



### **ESI 4:**

Photocurrent density-voltage (J-V) at forward scan and reverse scan for mesoporous solar cells using perovskite films with varied precursor concentration *via* spray deposition.



**Table.** Device parameters (at reverse scan) for mesoporous solar cells using perovskite films prepared using a precursor solution with a concentration of 11.3 wt% *via* spray deposition.

Precursor solution	J <sub>sc</sub>	V <sub>oc</sub>	FF	PCE
concentration	$(mA/cm^2)$	(V)		(%)
11.3 wt%	19.0	0.69	0.53	7.01

#### **ESI 5:**

Photocurrent density-voltage (J-V) curves for solar cells employed perovskite films prepared using a precursor solution concentration of 11.3 wt% by spray deposition, and spin-coating. The corresponding photovoltaic parameters of which are summarized in the table below the figure.



**Table.** Device parameters (at reverse scan) for solar cells employed perovskite films prepared using a precursor solution with a concentration of 11.3 wt% *via* spray deposition and spin-coating.

	J <sub>sc</sub>	$V_{oc}$	FF	PCE
	$(mA/cm^2)$	(V)	ГГ	(%)
Spray deposition	18.81	0.81	0.48	7.89
Spin-coating	14.33	0.70	0.42	4.23