

*Supporting information*

**The Mechanism of Toluene-assisted Crystallization of Organic-inorganic  
Perovskites for Highly Efficient Solar Cells**

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Table S1. Unit cell dimensions ( $a$ ,  $b$  and  $c$  axis) and unit cell volume for the different perovskite crystals. FWHM at and (110) reflections and calculated crystalline size at the same reflection

		$a=b(\text{\AA})$	$c(\text{\AA})$	Cell Volume ( $\text{\AA}^3$ )	Average crystallite size (nm)
MAI:PbI <sub>2</sub>	w/o	8.87329	12.5976	991.8	114
	with	8.86904	12.6216	992.8	95.7
3MAI:PbI <sub>2</sub>	w/o	8.81562	12.5714	977.0	67.6
	with	8.85053	12.6084	987.6	75.7
3MAI:PbCl <sub>2</sub>	w/o	8.86029	12.6052	989.6	123
	with	8.81927	12.5479	975.9	129

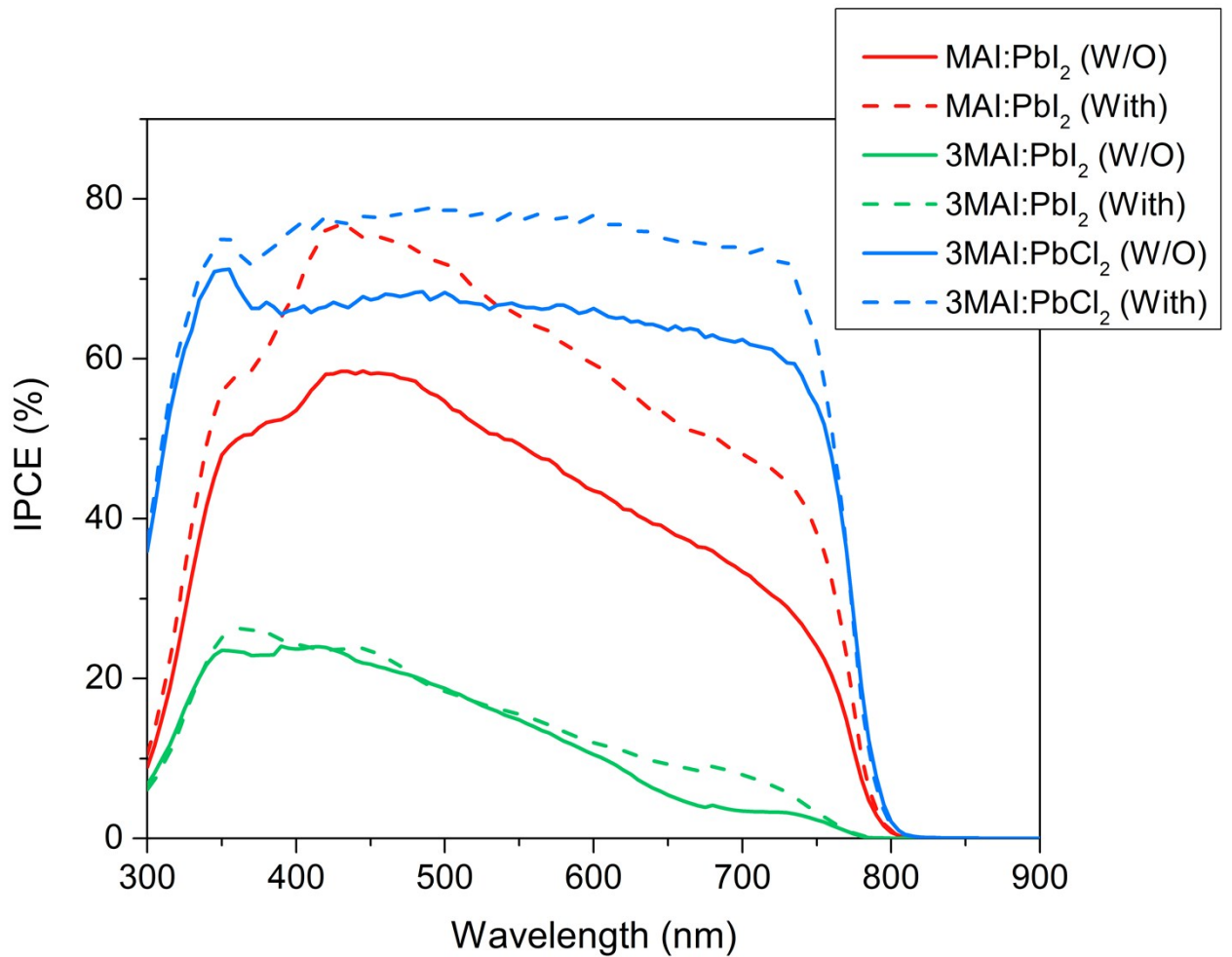


Figure S1. IPCE spectra of each perovskite solar cells without and with toluene drenching.

We observe that the perovskite solar cells fabricated from 3MAI:PbCl<sub>2</sub> shows higher IPCE value on whole wavelength as compared with MAI:PbI<sub>2</sub> and 3MAI:PbI<sub>2</sub>. Upon toluene treatment, the IPCE values of 3MAI:PbCl<sub>2</sub> and MAI:PbI<sub>2</sub> are increase by 10% and 20%, respectively. However, 3MAI:PbI<sub>2</sub> does not show a clear increase of IPCE value with toluene treatment.

Table S2. Performance parameters for perovskite solar cells with different perovskite precursor.

	<i>Scan direction</i>	$J_{sc}$ ( $mA\ cm^{-2}$ )	$V_{oc}$ (V)	<i>FF (%)</i>	<i>PCE (%)</i>	<i>SPO (%)</i>
MAI:PbI <sub>2</sub>	$V_{oc} \rightarrow J_{sc}$	16.6	0.82	54.6	7.19	2.36 ± 1.59
	$J_{sc} \rightarrow V_{oc}$	14.1	0.83	28.7	3.56	
MAI:PbI <sub>2</sub> with Toluene	$V_{oc} \rightarrow J_{sc}$	20.1	0.95	64.5	12.7	5.10 ± 0.58
	$J_{sc} \rightarrow V_{oc}$	17.3	0.84	23.5	3.78	
3MAI:PbCl <sub>2</sub>	$V_{oc} \rightarrow J_{sc}$	18.6	0.86	68.7	11.0	6.16 ± 0.71
	$J_{sc} \rightarrow V_{oc}$	17.4	0.76	56.2	7.46	
3MAI:PbCl <sub>2</sub> with Toluene	$V_{oc} \rightarrow J_{sc}$	22.7	0.97	74.1	16.3	12.7 ± 1.27
	$J_{sc} \rightarrow V_{oc}$	23.2	0.88	59.7	12.1	
3MAI:PbI <sub>2</sub>	$V_{oc} \rightarrow J_{sc}$	13.9	0.68	44.4	4.22	1.09 ± 0.31
	$J_{sc} \rightarrow V_{oc}$	12.1	0.63	21.5	1.83	
3MAI:PbI <sub>2</sub> with Toluene	$V_{oc} \rightarrow J_{sc}$	15.9	0.81	63.1	8.15	1.84 ± 0.34
	$J_{sc} \rightarrow V_{oc}$	12.0	0.67	19.2	1.84	