Supporting Information

Cross-linked Perovskite/Polymer using Sodium Borate Composites for Efficient and Stable Perovskite Devices

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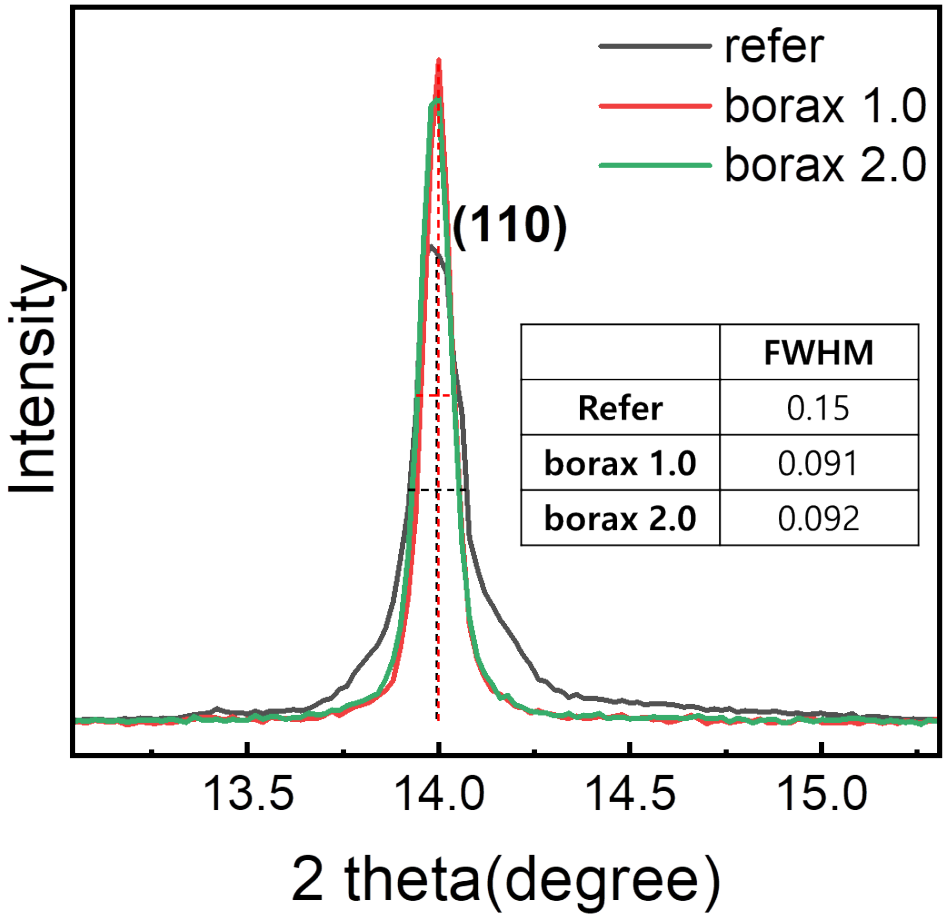


Figure S1.Comparison of FWHM values of reference, borax 1.0, and borax 2.0 samples.

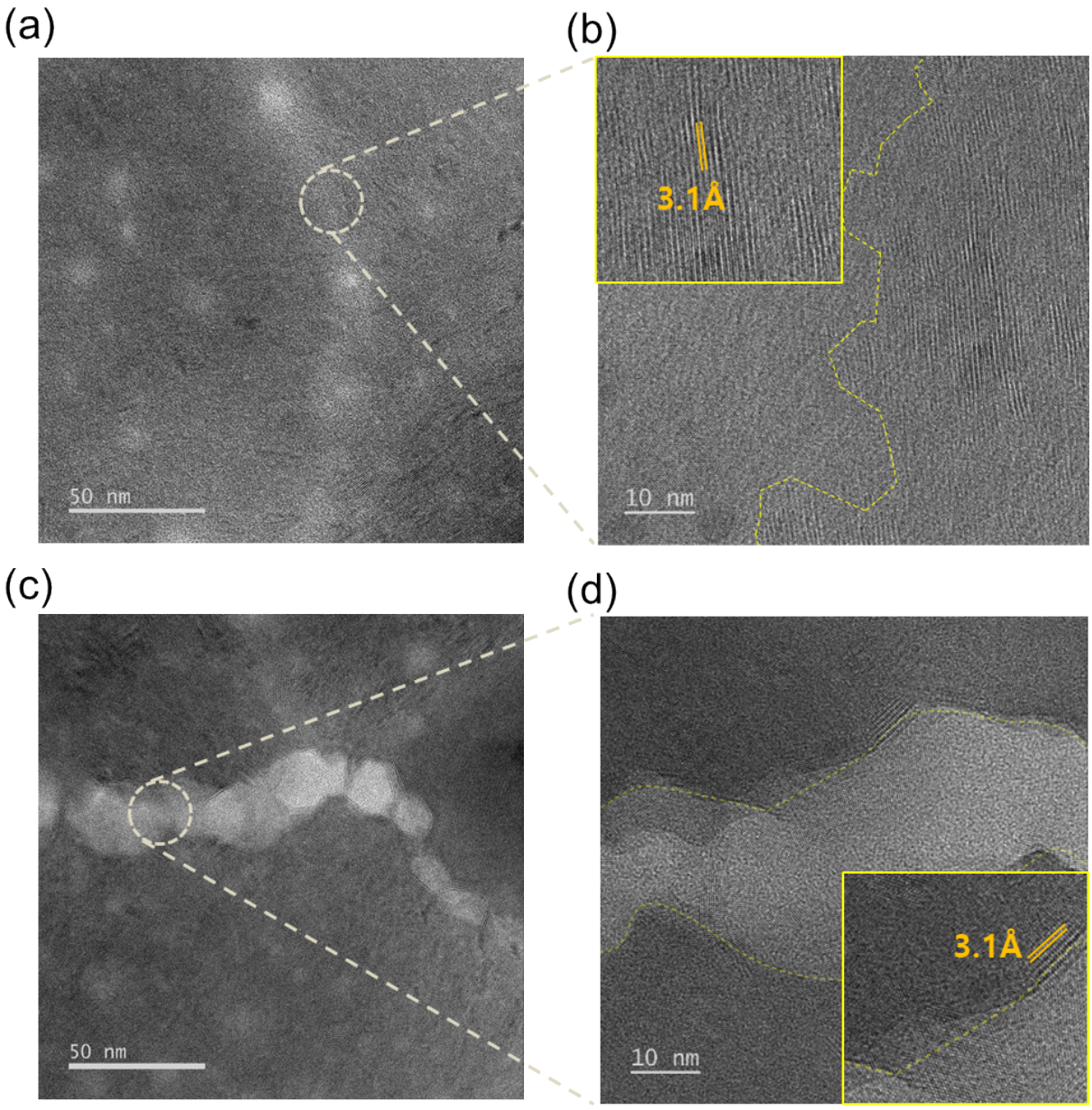


Figure S2. TEM images of the GBs of the (a, b) reference sample and (c, d) PMMA + borax (2.0 mg/mL) sample.

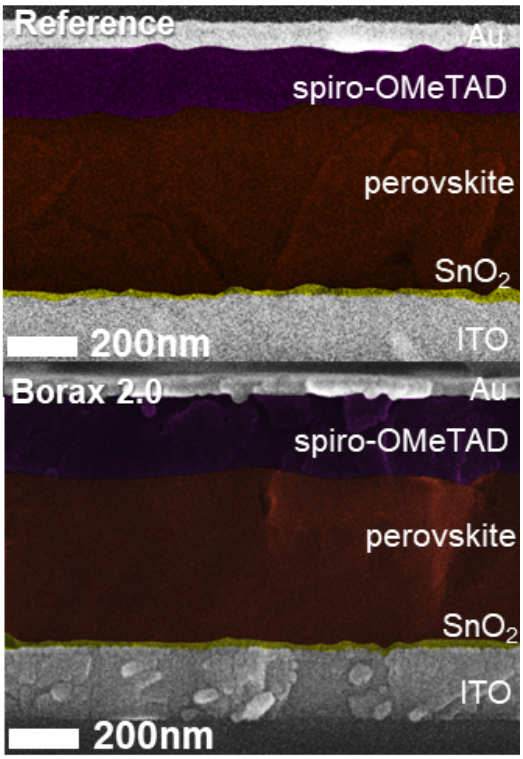
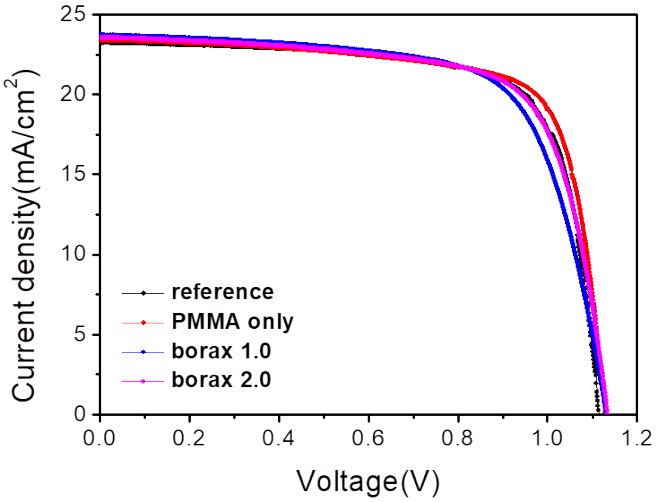


Figure S3. Cross sectional FE-SEM image of the full structure of reference and PMMA/borax mixture ([PMMA] = 0.3 mg/mL, [borax] = 3 mg/mL) PSCs.



(mg/ml)	J_{sc} (mA cm^{-2})	V_{oc} (V)	FF	PCE (%)
Reference	22.65 (22.75)	1.12 (1.12)	0.73 (0.74)	18.52 (18.69)
PMMA only	23.24 (23.39)	1.12 (1.132)	0.73 (0.73)	19.01 (19.33)
borax 1.0	23.44 (23.56)	1.13 (1.134)	0.72 (0.73)	19.07 (19.34)
borax 2.0	23.57 (23.71)	1.13 (1.135)	0.73 (0.73)	19.44 (19.64)

Figure S4.Comparison of J-V results of post-treated PMMA only, borax 1.0, and borax 2.0 devices compared to reference.

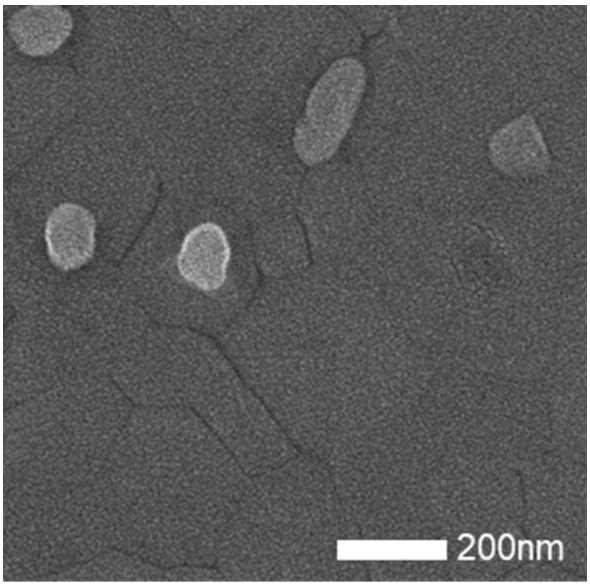


Figure S5. Top FE-SEM image of the PMMA/borax mixture ([PMMA] = 0.3 mg/mL, [borax] = 3 mg/mL).

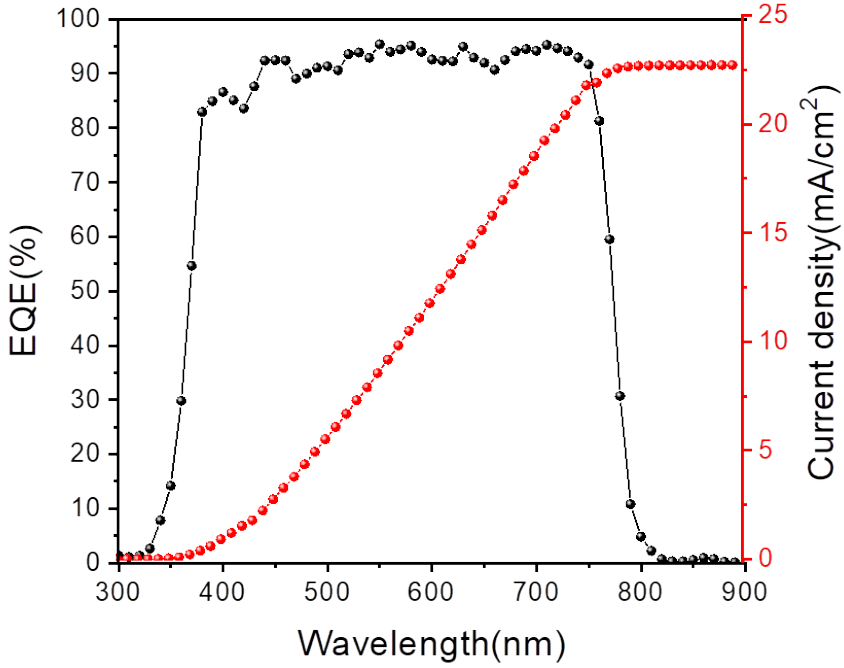


Figure S6. Measured EQE of the PSCs with PMMA/borax mixture ([PMMA] = 0.3 mg/mL, [borax] = 3 mg/mL).

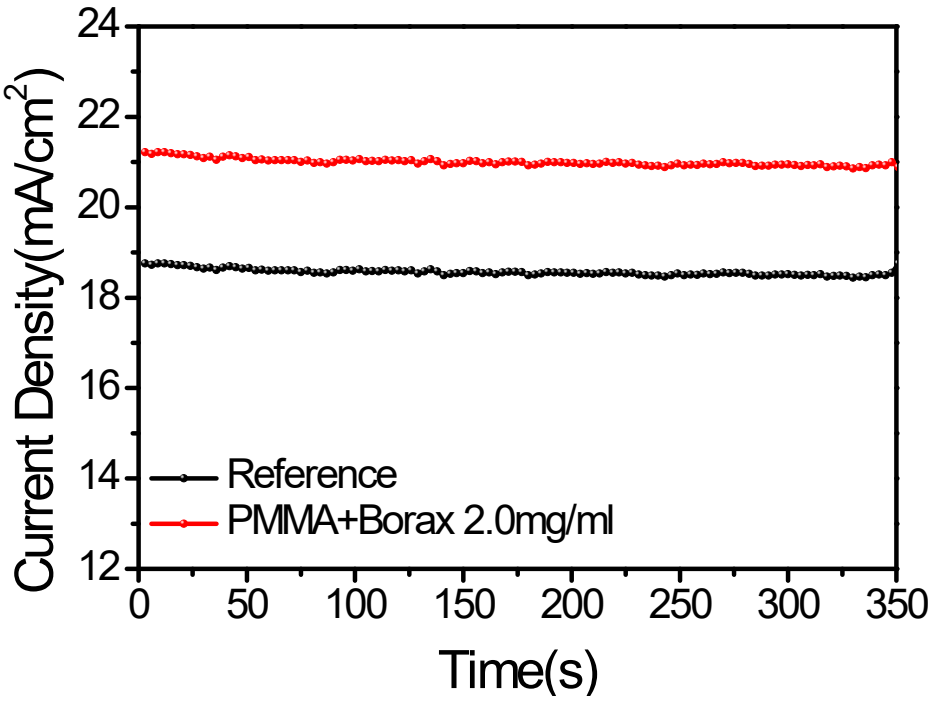


Figure S7. PCEs measured at the maximum power point of the PSCs with and without PMMA/borax additives.

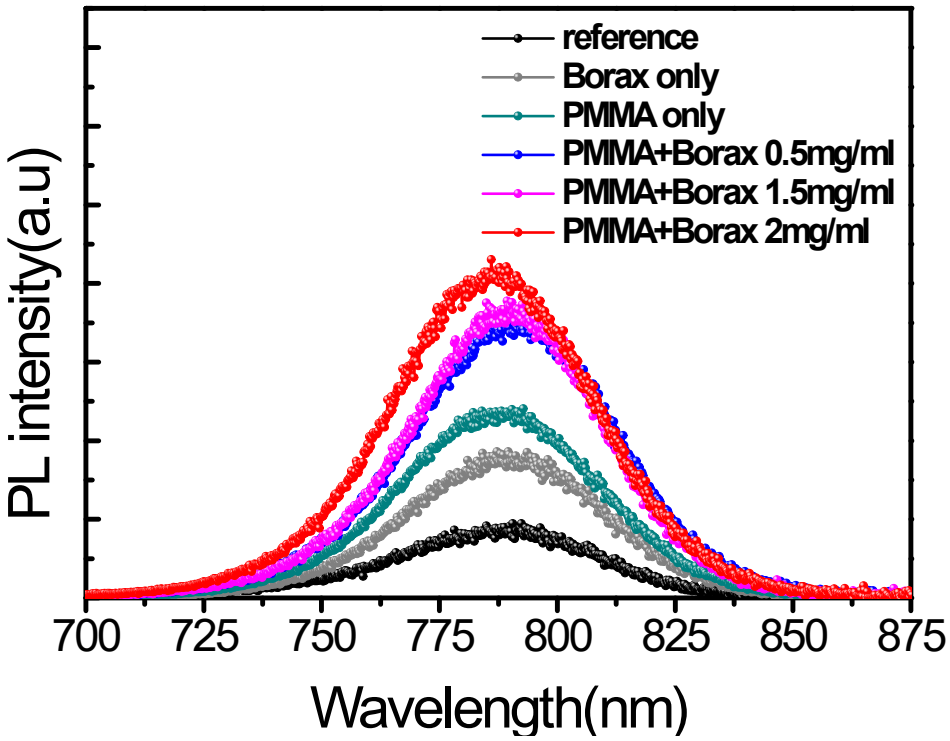


Figure S8. Steady-state PL spectra of the PSCs with various concentrations of additives (reference, borax-only, PMMA-only, PMMA (0.3 mg/mL)/borax (0.5, 1.5, 2.0 mg/mL) samples).

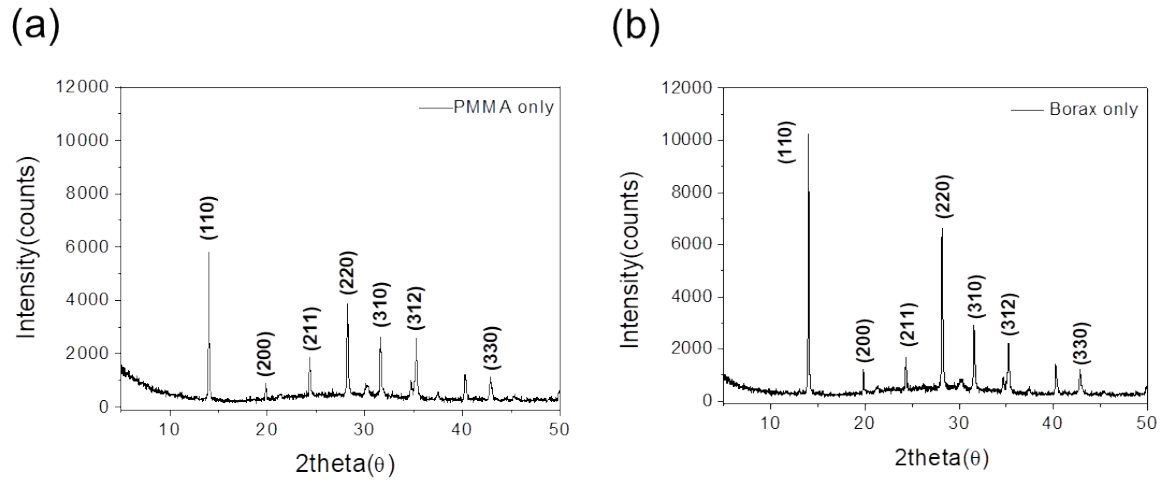


Figure S9. XRD spectra of the (a) PMMA-only and (b) borax-only perovskite films.

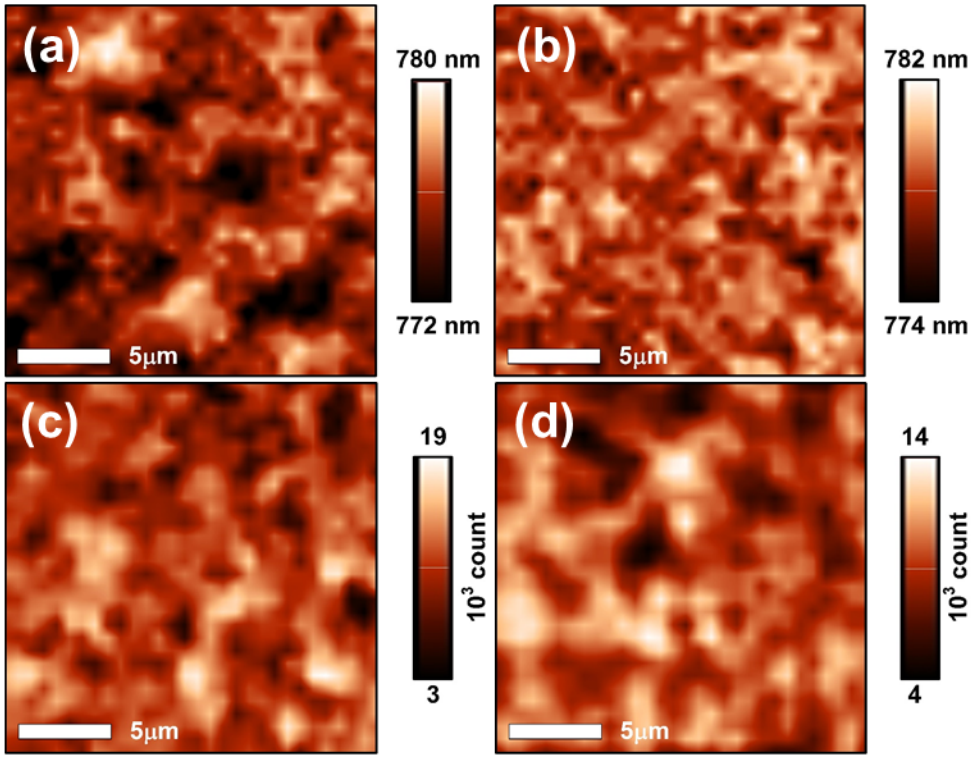


Figure S10. PL mapping data of the (a, c) PMMA-only and (b, d) borax-only samples.

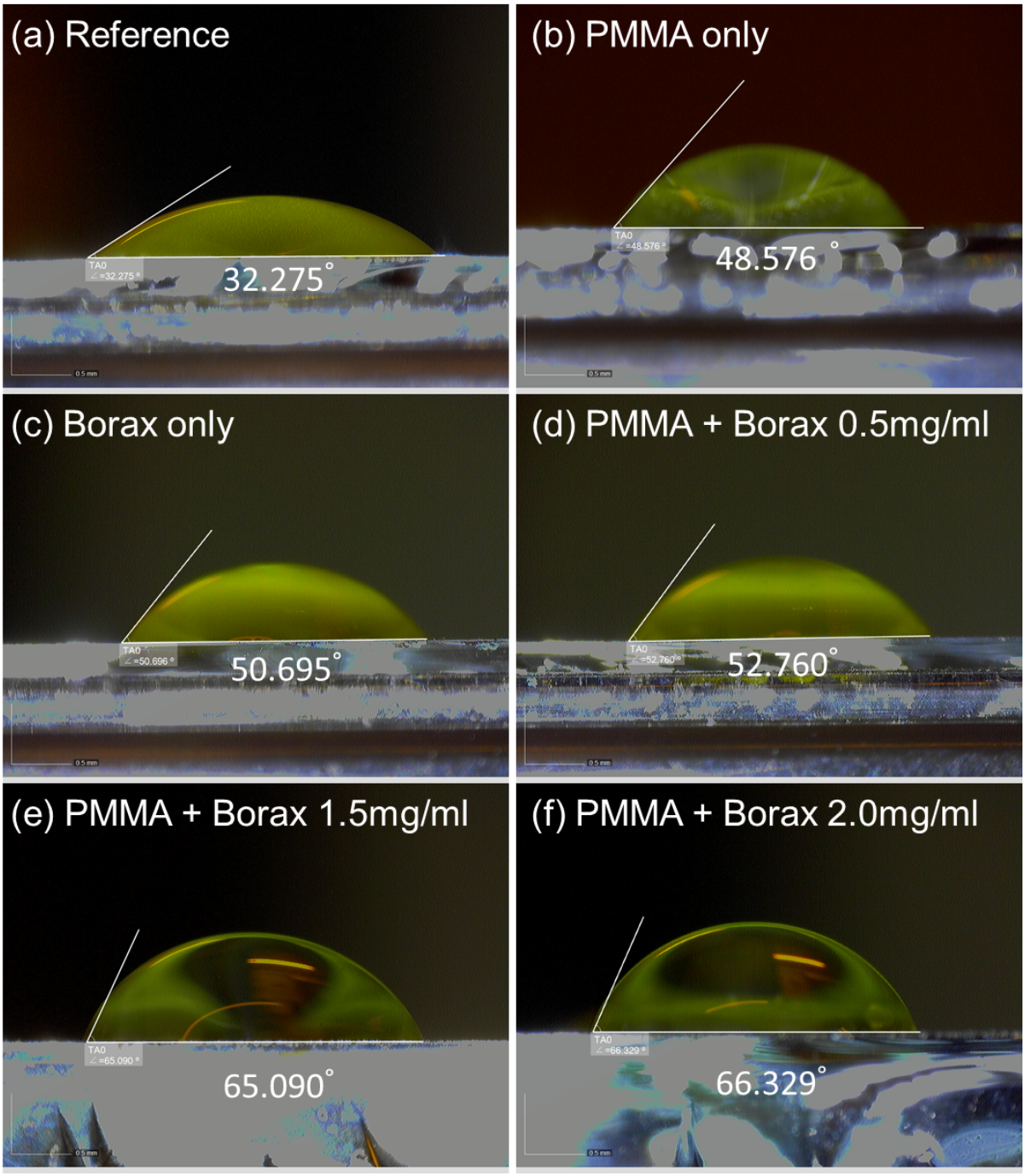


Figure S11. Contact angles of deionized water droplets on the (a) reference sample, (b) PMMA-only sample, (c) borax-only sample, (d) PMMA (0.3 mg/mL)/borax (0.5 mg/mL) sample, (e) PMMA (0.3 mg/mL)/borax (1.5 mg/mL) sample, and (f) PMMA (0.3 mg/mL)/borax (2.0 mg/mL) sample.

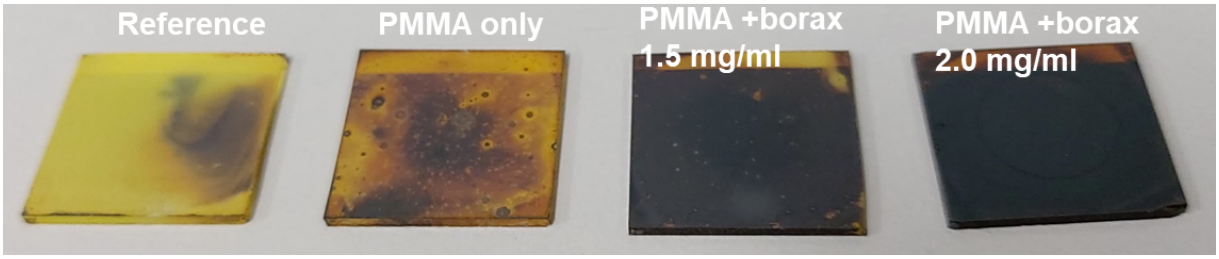


Figure S12. Images of the degraded as-prepared perovskite samples at 25 °C, 20 ± 10% humidity, obtained after 30 d (reference, PMMA-only, PMMA + borax (1.5 mg/mL), PMMA + borax (2.0 mg/mL) samples).

Table S1. TEM-EDS results of boron ions, obtained from the a) reference and b) PMMA/borax perovskite films.

a)

Element	K factor	Absorption Correction	Wt(%)
B	11.294	0.00	0.00
O	1.455	1.16	1.44
Br	2.454	0.93	1.65
I	1.951	0.95	50.56
Cs	2.005	0.95	1.62
Pb	3.107	0.93	44.74
Total:	-	-	100.00

b)

Element	K factor	Absorption Correction	Wt(%)
B	11.294	1.09	3.04
O	1.455	1.16	3.61
Br	2.454	0.94	0.76
I	1.951	0.95	48.28
Cs	2.005	0.95	2.43
Pb	3.107	0.94	41.87
Total:	-	-	100.00

Table S2. Fitted parameters of the PL decay curves of the perovskite samples with various concentrations of additives, excited by a 670-nm laser (the values of the goodness-of-fit parameter (χ^2) are all close to 1.0).

	A_1[%]	T_1[ns]	A_2[%]	T_2[ns]	A_3[%]	T_3[ns]	A_4[%]	T_4[ns]	$T_{average}$[ns]
Reference	5.9	3.7	0.166	63	3.1	13	0.0101	325	31
Borax only	1.41	63	4	2	4.89	20	0.0575	267	56
PMMA only	1.54	85	4.55	19	4.4	2	0.094	296	83
PMMA+Borax 0.5	1.91	67	0.084	250	4	1.9	4.3	21	64
PMMA+Borax 1.5	0.1335	274	4.15	21	2.18	78	3.6	1.9	84
PMMA+Borax 2.0	0.1414	364	3.19	19	2.13	97	4.3	1.68	122

where, $Counts(t) = A_1\exp(-t/\tau_1) + A_2\exp(-t/\tau_2) + A_3\exp(-t/\tau_3)$
τ_{avg}: amplitude weighted average lifetime