## Supplementary information

## Tuning $CH_3NH_3Pb(I_{1-x}Br_x)_3$ Perovskite Oxygen Stability in Thin Films and Solar Cells

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Figure S1: UV visible absorbance spectra of mixed halide,  $CH_3NH_3Pb(I_{1-x}Br_x)_3$ , perovskite thin film samples. Increasing bromide ratio results in blue shift absorbance edge.

Table S1: Example images used in Fig 1b, during a relative humidity change from 85% to 90% whereupon the  $CH_3NH_3Pb(I_{0.9}Br_{0.1})_3$  degrades from the perovskite phase to the hydrate phase (note  $CH_3NH_3PbI_3$  is already fully degraded at 85% RH). Optical image data is obtained by analysing the RGB signal of a set 15x15 pixel area of images taken every 15 min.

Time (hr)	CH <sub>3</sub> NH <sub>3</sub> Pb(I <sub>1-x</sub> Br <sub>x</sub> ) <sub>3</sub> , x=					
	0.00	0.10	0.50	0.75	1.00	
13.0	A.	1. A.				
14.7		and the second sec				
16.3						
18.0						



Figure S2: a) Optical tracking of thin film CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> samples after exposure to 1 sun equv LED light and dry air. The effect of air diffusion time on the degradation mechanism was investigated to elucidate the limiting steps of the reaction sequence in air and light. Before exposure to light and dry air, films were kept in the dark in ambient air. Optical tracking from the point of light exposure shows the air diffusion is not a limiting step in orating conditions of the material degradation of thin film samples. b) Optical tracking of [CH<sub>2</sub>(NH<sub>2</sub>)<sub>2</sub>]<sub>0.85</sub>[CH<sub>3</sub>NH<sub>3</sub>]<sub>0.15</sub>Pb(I<sub>0.85</sub>Br<sub>0.15</sub>)<sub>3</sub>, CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> and CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> thin films showing significant degradation in light and oxygen is seen in the mixed organic cation perovskite material. The films were exposed to 1 sun equv LED light and dry air.



Figure S3: The current voltage characteristics of initial performances of  $FTO/TiO_{2}$ bl/TiO<sub>2</sub>-mp/CH<sub>3</sub>NH<sub>3</sub>Pb(I<sub>1-x</sub>Br<sub>x</sub>)<sub>3</sub>/undoped-P3HT/Au devices measured with xenon lamp AM1.5 simulated solar spectrum at a scan rate of 0.125 V/s. A sweep scan was performed to measure the hysteresis of the device. Initially the device is held at open circuit conditions for 15 s to stabilise and then scanned from -0.5 V to 1.5 V and back to 0V.

	$CH_3NH_3Pb(I_{1-x}Br_x)_3, x =$				
	0.00	0.25	0.50	0.75	1.00
J <sub>sc</sub> (mA cm <sup>-2</sup> )	19.04	9.01	7.23	4.50	5.65
V <sub>oc</sub> (V)	0.87	0.85	0.97	0.94	1.33
FF	0.63	0.54	0.57	0.45	0.49
PCE (%)	10.36	4.11	4.02	1.89	3.72

Table S2: Device performance characteristics of initial performance for devices in Fig S3 with AM1.5 solar spectrum.



Figure S4: Power conversion data of  $CH_3NH_3Pb(I_{(1-x)}Br_x)_3$  (x=0, 0.1, 0.75, 1) solar cell devices exposed to 1 sun eqv. LED light and dry air with a device structure of TiO<sub>2</sub>-bl/TiO<sub>2</sub>-mp/CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub>/Spiro-OMeTAD/Au. Devices were held at open circuit between measurements.

Table S3: Device performance characteristics of initial performance for devices in Fig S3 with AM1.5 solar spectrum.

	$CH_3NH_3Pb(I_{1-x}Br_x)_3$ , x =				
	0.00	0.25	0.75	1.00	
J <sub>sc</sub> (mA cm <sup>-2</sup> )	20.98	12.87	6.11	2.88	
V <sub>oc</sub> (V)	0.96	0.88	0.74	1.10	
FF	0.50	0.50	0.32	0.43	
PCE (%)	9.92	5.73	1.46	2.02	



Wavelength (nm)

Figure S5: Normalised photoluminescence spectra of mixed halide,  $CH_3NH_3Pb(I_{1-x}Br_x)_3$ , perovskite thin films showing the emission from the lower energy iodide rich domains.



Figure S6: Transient absorption measurements of CH<sub>3</sub>NH<sub>3</sub>PbBr<sub>3</sub> films probing at 530 nm and exciting at 420 nm. a) A sample with scans immediately preceding each other showing no light induced change of signal. b) A trace of a sample before and after being exposed to 3 hr dry air followed by 12 hr nitrogen purging.

		$CH_3NH_3Pb(I_{1-x}Br_x)_3$ , x =				
	0.00	0.10	0.20	0.50	0.75	1.00
Correction factor ( $\beta$ )	1.00	0.85	0.84	0.52	0.44	0.35

Table S4: Absorption correction factors of mixed halide films using the absorptions shown in Figure S1 and tungsten-halide light spectrum, relative to  $CH_3NH_3PbI_3$ .