Supporting Information for

Tetrabutylammonium cations for moisture-resistant and semitransparent perovskite solar cells

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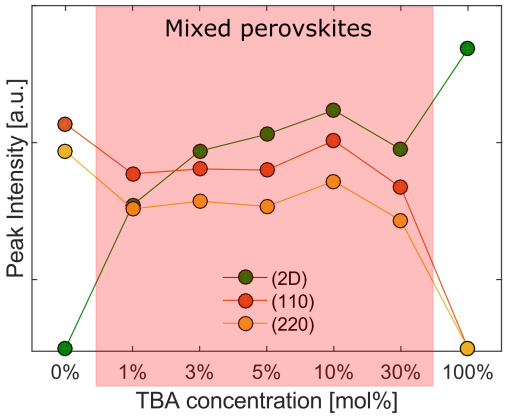

Fig. S1: Intensity of XRD peaks assigned to the 2D phase and 3D phase ([110] and [220]) of $(TBA)_n(MA)_{1-n}PbX_3$ films made from perovskite precursor solutions with n=0 (0%), n=0.01 (1%), n=0.03 (3%), n=0.5 (5%), n=0.1 (10%), n=0.3 (30%) and n=1 (100%)

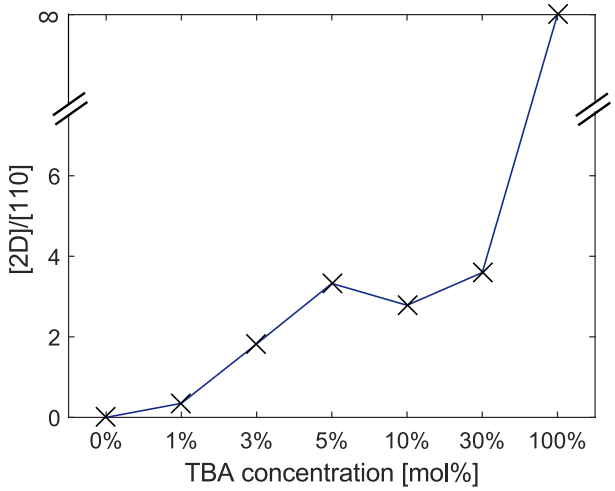

Fig. S2: Ratio between the intensity of XRD peaks assigned to the 2D phase and 3D phase (2D/[110]) of $(TBA)_n(MA)_{1-n}PbX_3$ films made from perovskite precursor solutions with n=0 (0%), n=0.01 (1%), n=0.03 (3%), n=0.5 (5%), n=0.1 (10%), n=0.3 (30%) and n=1 (100%)

Table S1: Position and integrated intensity of XRD peaks assigned to the 2D and 3D ([110] and [220]) perovskite phase. XRD patterns analysed using the MATLAB function PeakFinder

	[2D]		[110]		[220]		
N0	Pos[°]	Area	Pos[°]	Area	Pos[°]	Area	[2D]/[110]
0%	7.9	0	14.825	186.95	29.235	74.92	0
1%	7.9	12.26	14.772	35.073	29.189	10.786	0.35
3%	7.93	75.36	14.773	41.304	29.174	13.955	1.82
5%	7.912	132.16	14.758	39.738	29.152	11.7	3.33
10%	7.89	297.34	14.679	106.8	29.153	27.311	2.78
30%	7.82	79.67	14.72	22.16	29.186	7.28	3.59
100%	7.81	2337.4	14.8	0	29.2	0	∞

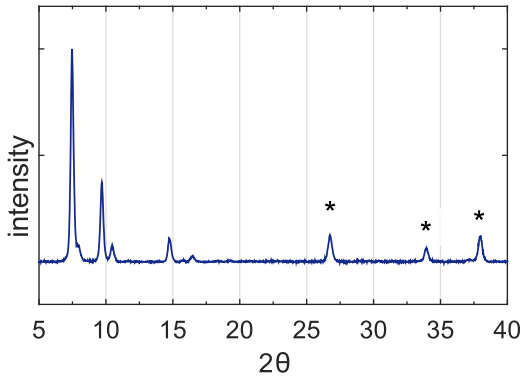

Fig. S3: XRD pattern of perovskite film with 100 % TBAI. Films have been spun onto FTO c-glass substrates. Peaks originated by SnO_2 underlayers are marked by asterisks

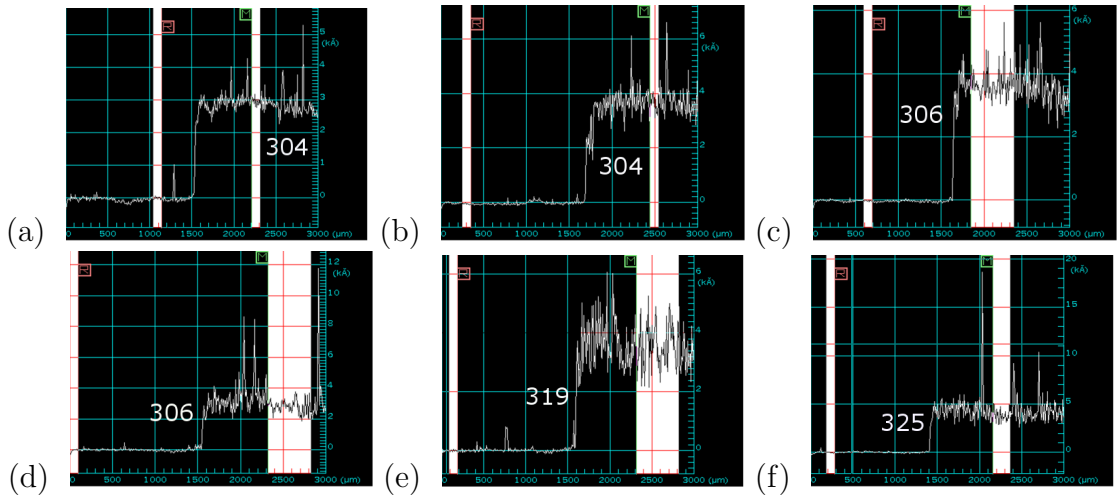

Fig. S4: Profilometry of $(TBA)_nMA_{1-n}PbX_3$ perovskite films deposited on a compact layer of TiO_2 with (a) n=0 (0%), (b) n=0.01 (1%), (c) n=0.03 (3%), (d) n=0.5 (5%), (e) n=0.1 (10%), (f) n=0.3 (30%). The values are calculated by taking the difference between the mean values of the bands R and M respectively

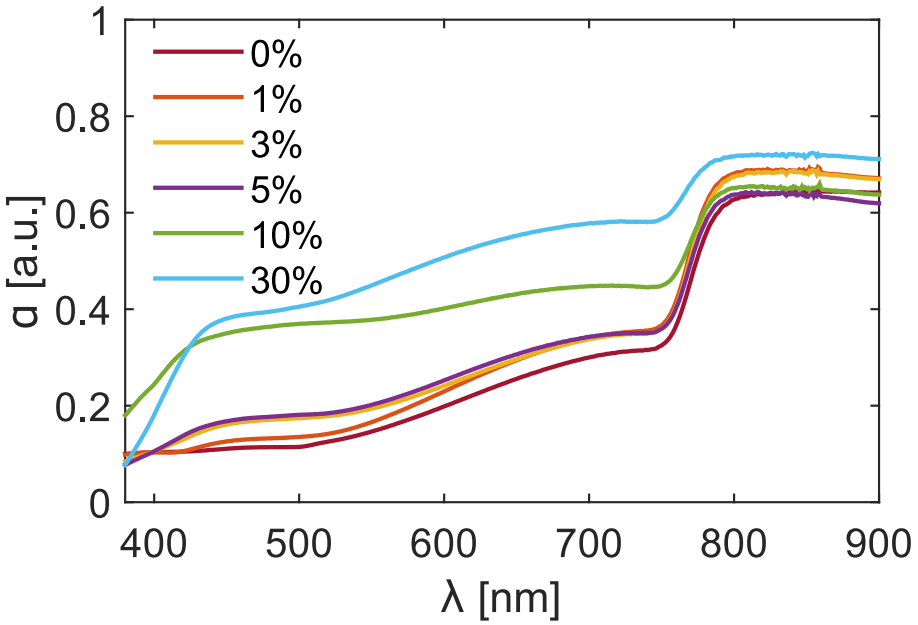

Fig. S5: Transmittance spectra of perovskite films with different concentrations of TBA in the precursor solution

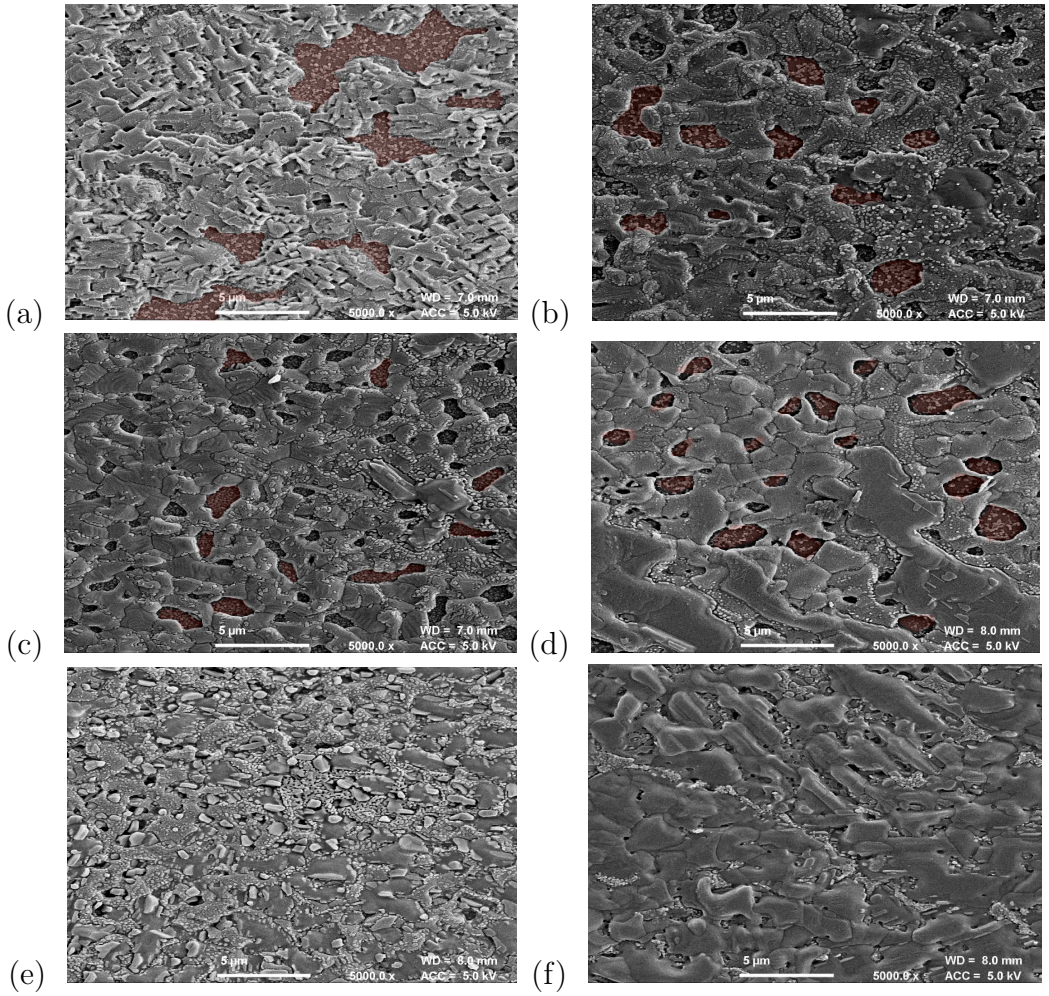

Fig. S6: Top wiew SEM images of $(TBA)_nMA_{1-n}PbX_3$ perovskite films deposited on a compact layer of TiO2. (a)0mol%; (b)1mol%; (c)3mol%; (d)5mol%; (e)10mol%; (f)30mol%. FTO areas have been marked in red using the software Inkscape 0.91 to emphasise the pinholes

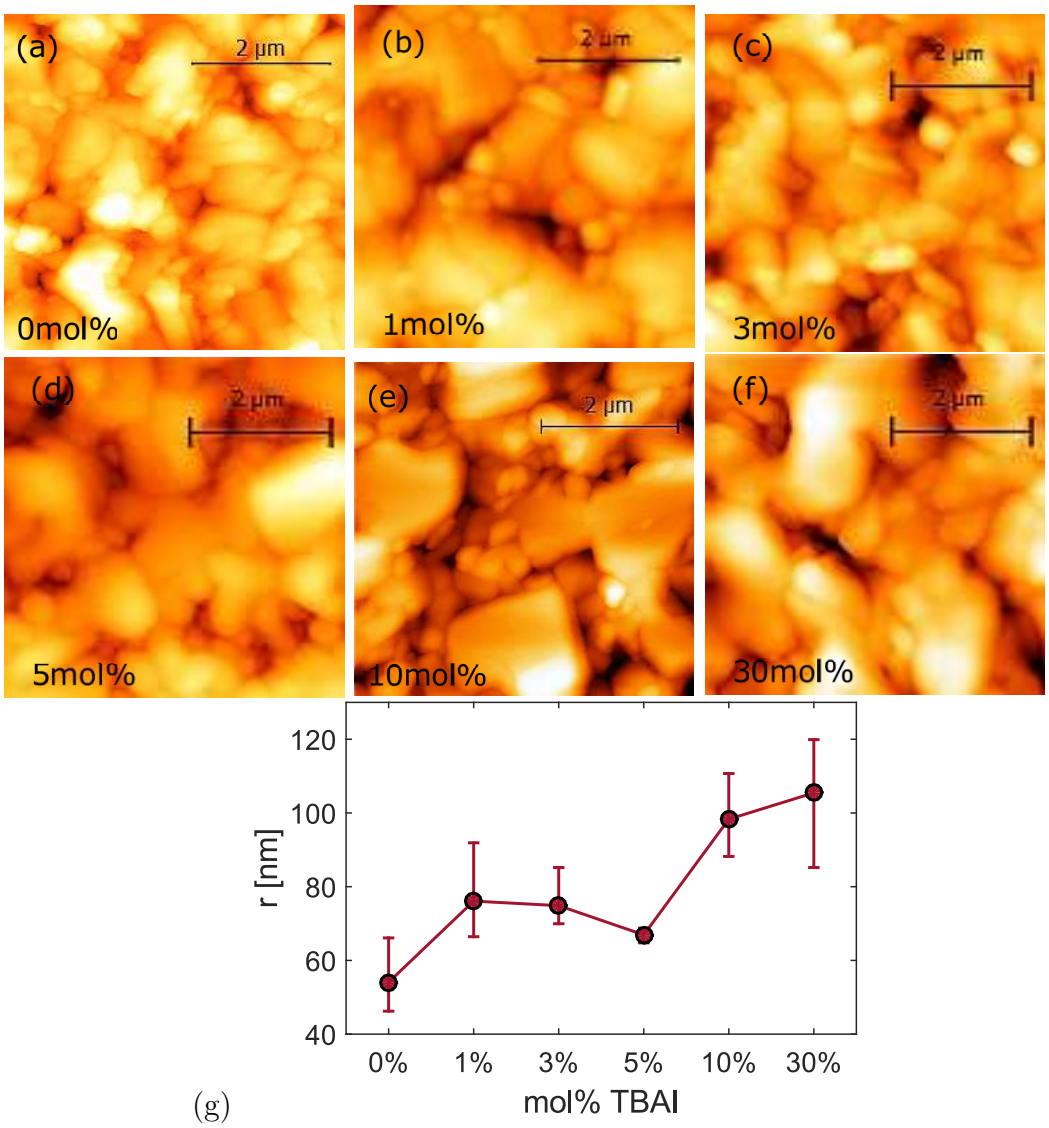

Fig. S7: (a)-(f) AFM images of $(TBA)_n(MA)_{1-n}PbX_3$ perovskite films deposited on a compact layer of TiO_2 with different TBA concentration; (g) Average roughness values extracted using Atomic Force Microscope as a function of TBA concentration in the perovskite precursor solution. Values were measured and averaged over 50*50 μm areas.

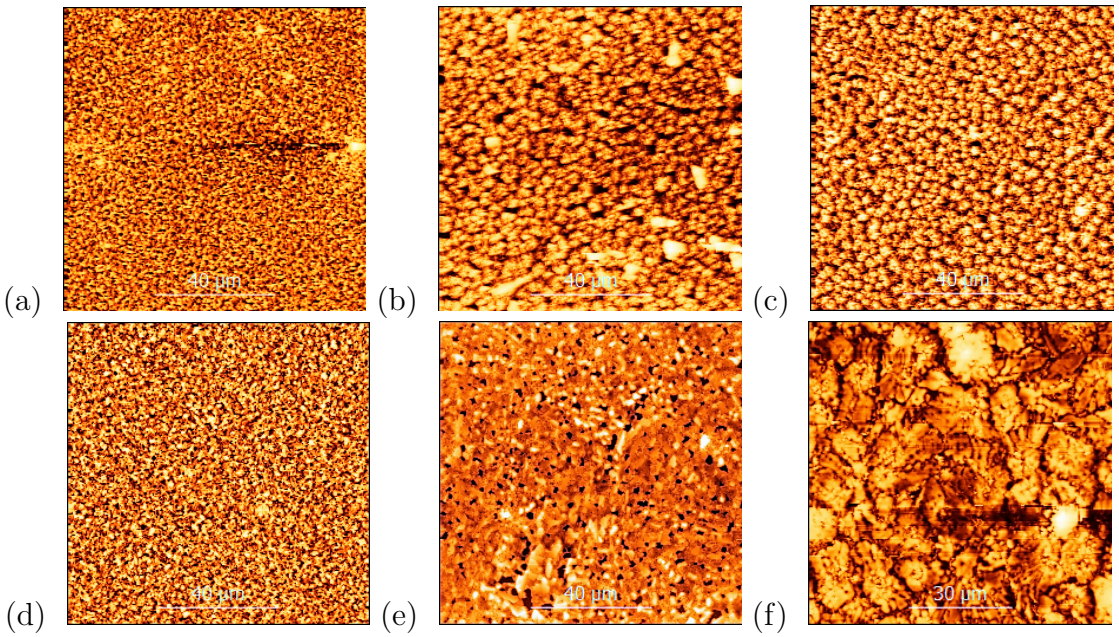

Fig. S8: AFM images of $(TBA)_nMA_{1-n}PbX_3$ perovskite films deposited on a compact layer of TiO2; (a)0mol%; (b)1mol%; (c)3mol%; (d)5mol%; (e)10mol%; (f)30mol%

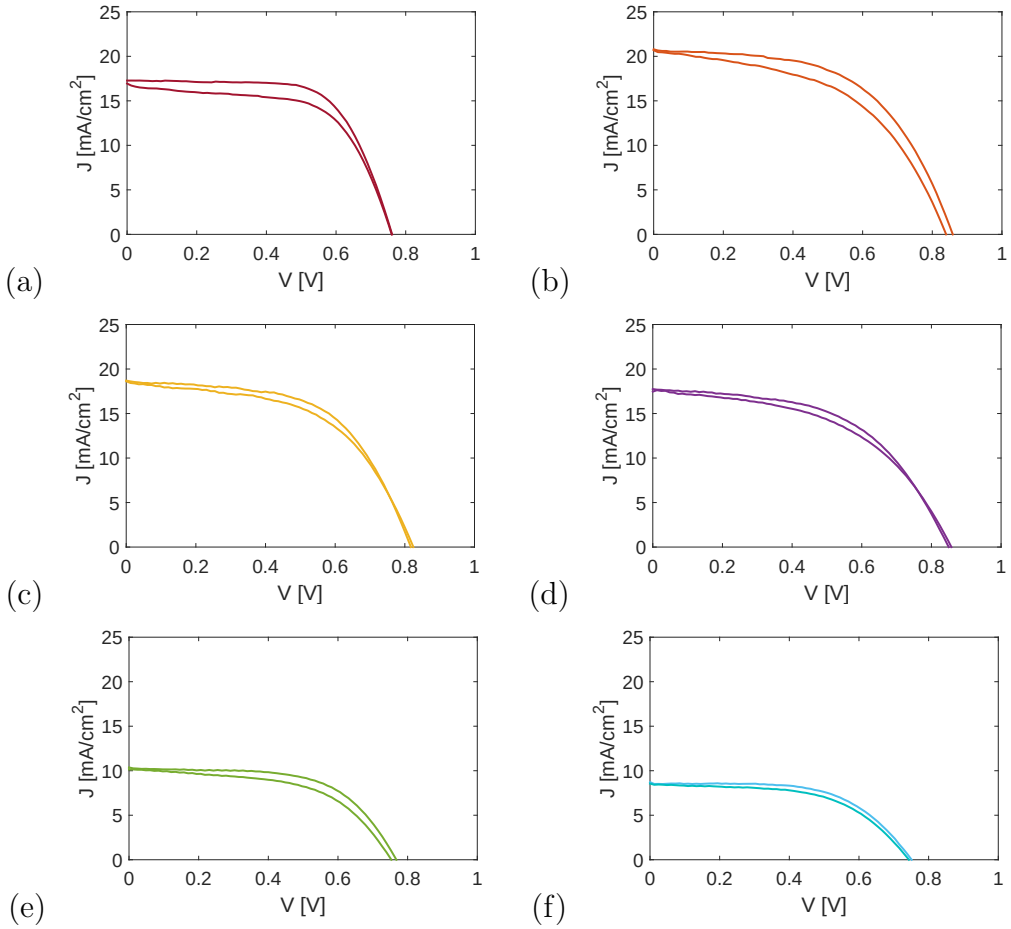

Fig. S9: JV curves in forward and reverse scan of perovskite solar cells made of $(TBA)_nMA_{1-n}PbX_3$ with (a)n=0; (b)n=0.01; (c)n=0.03; (d)n=0.05; (e)n=0.1; (f)n=0.3

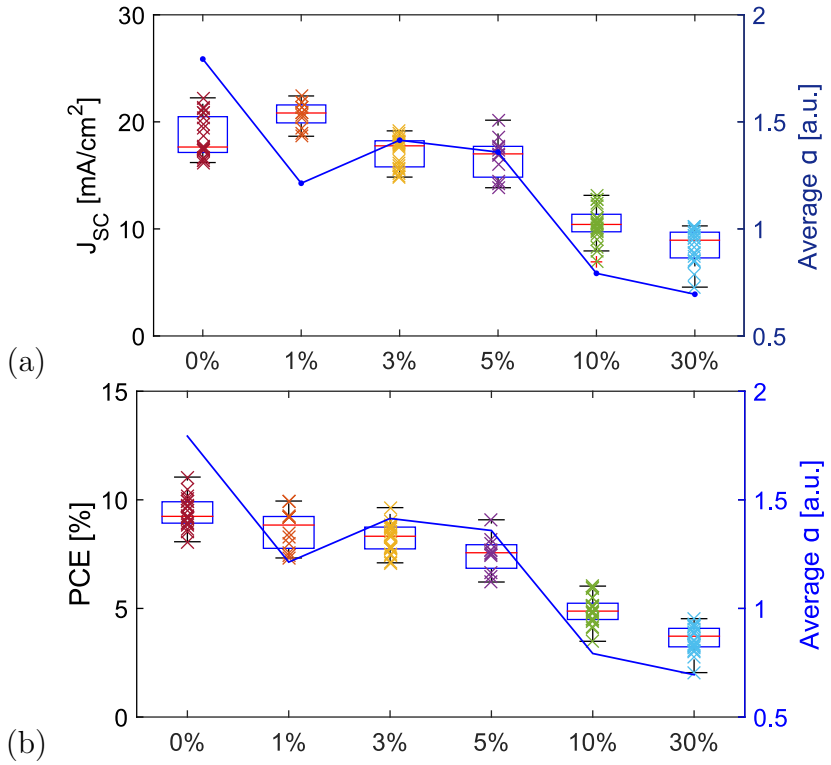

Fig. S10: Trend of photocurrent and PCEs of devices as a function of TBA concentration in the solution precursor. Data are compared to the reduction of absorption measured with UV-Vis. The absorption coefficient has been averaged between 450 and 750 nm.

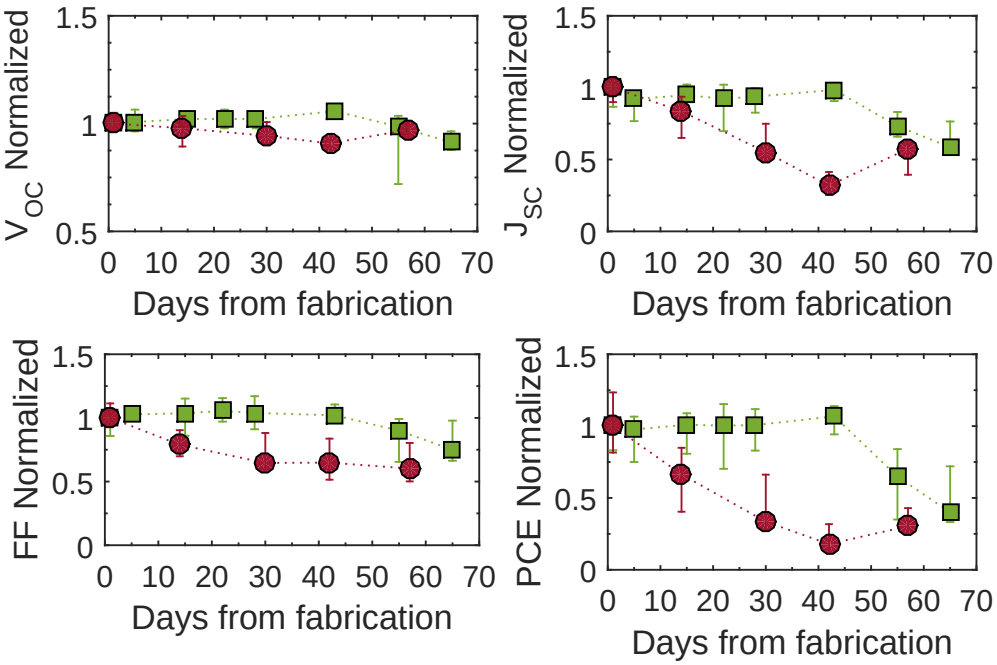

Fig. S11: Evolution of the main photovoltaic parameters over time. All the values have been normalised with respect to the median value obtained after deposition. Square green markers indicate the film with 1mol% of TBA, while red markers indicate the reference solar cell without TBA added. Cells with similar initial PCE have been considered (7.13% and 7.36% for MAPI and MAI/TBAI based cells respectively)

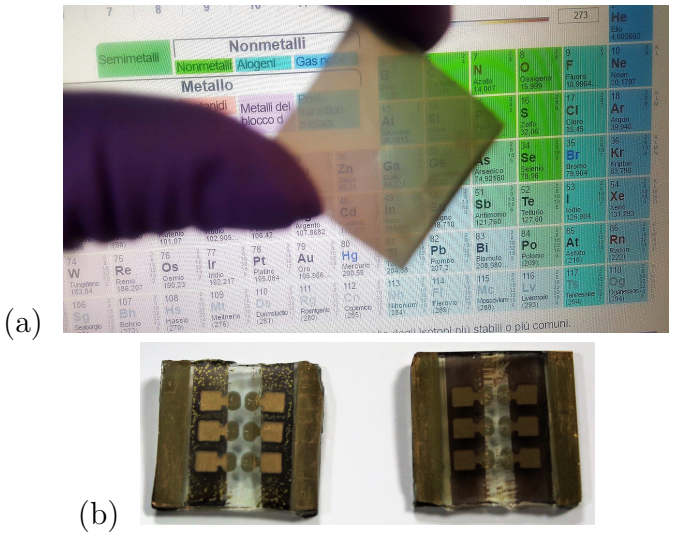

Fig. S12: (a) Image to show the semitransparent film with 30% TBA added into the solution (b) Image to show the degradation in air after over 100 days in ambient condition of films without (left) and with(right) TBA