Electronic Supplementary Information

2-Methoxyethanol as a new solvent for processing methyl ammonium lead halide perovskite solar cells

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Table S1. Physical characteristics of solvents used for perovskite deposition.

Solvent	Boiling Point (°C)	Vapour Pressure at 20 °C (Pa)
2-Methoxyethanol (2ME)	124	823
N,*N*-Dimethylformamide (DMF)	153	360
γ-Butyrolactone (GBL)	206	200
N,*N*-Dimethylacetamide (DMAc)	165	176
Dimethylsulfoxide (DMSO)	189	56
N-Methylpyrrolidone (NMP)	203	39

Table S2. Slow sweep *J*–*V* characteristics for 2ME triple anion cells annealed for various times.

Anneal Time	V_{oc} (V)	FF	J_{sc} (mA/cm^2)	$J_{sc,sr}$(mA/cm^2)	PCE (%)
5 min	0.989	0.793	17.05	16.99	13.32
10 min	0.983	0.791	18.37	18.22	14.18
15 min	0.935	0.788	17.82	18.13	13.35

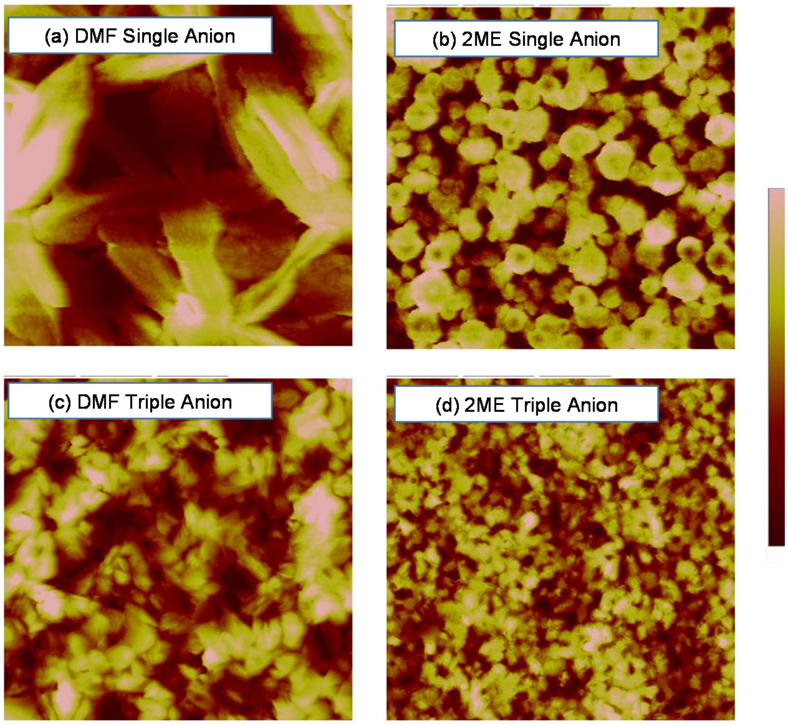

Figure S1. AFM height images of the SEM images of methyl ammonium lead triiodide perovskite layers processed on glass/ITO/PEDOT:PSS. (a) 10 µm × 10 µm, height 500 nm, R_q = 148 nm. (b) 10 µm × 10 µm, height 200 nm, R_q = 62 nm. (c) 5 µm × 5 µm, height 100 nm, R_q = 24 nm. (d) 5 µm × 5 µm, height 50 nm, R_q = 10 nm.

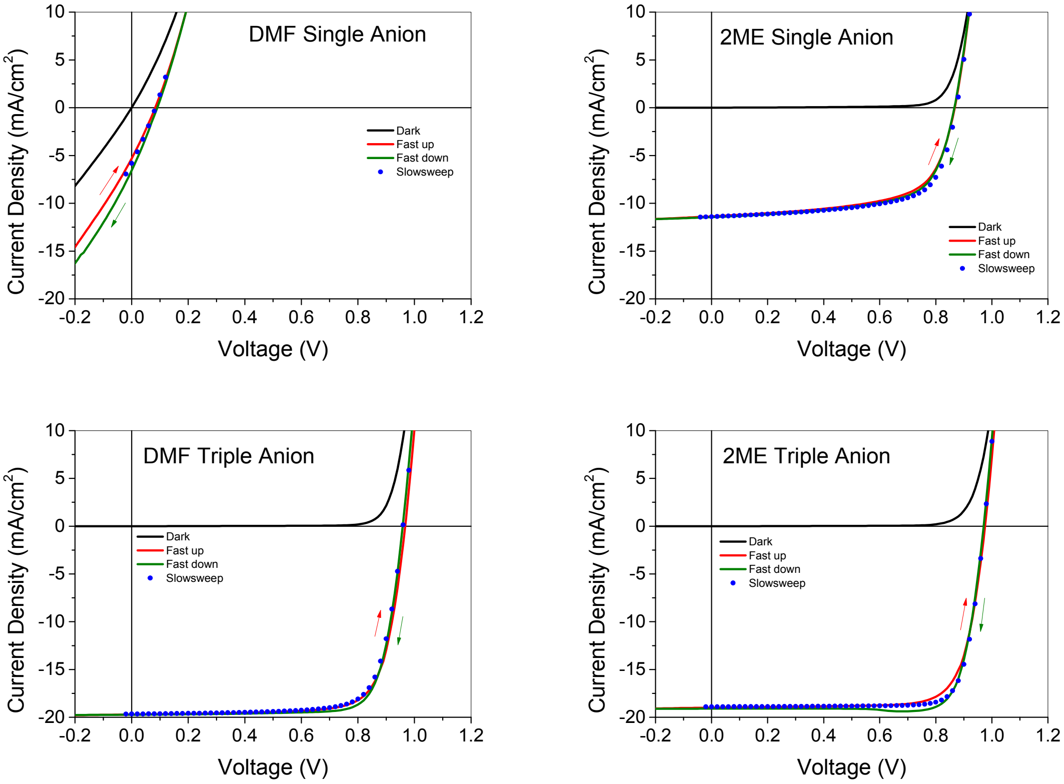

Figure S2. Upwards and downwards fast measurements (0.25 V/s), and slow sweep *J–V* curves of the best perovskite cells made from single and triple anion precursors.

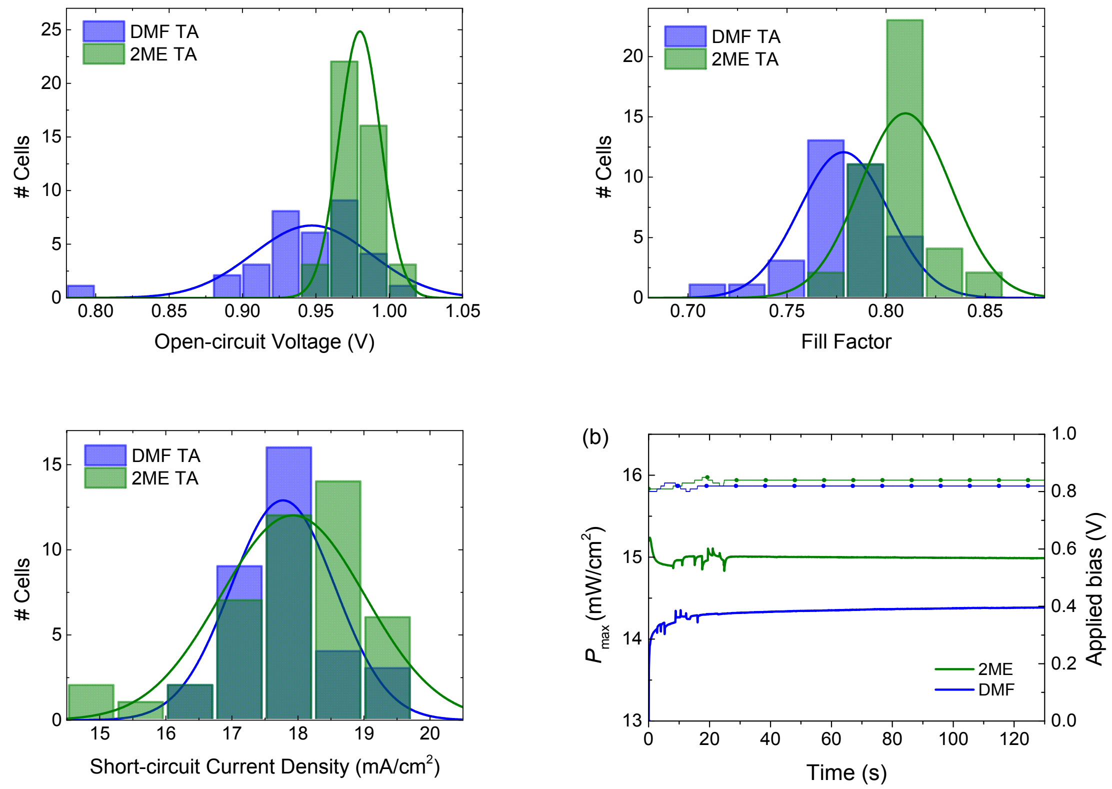

Figure S3. Histograms and normal curves of all fabricated devices using 2ME or DMF triple anion precursor solutions, determined by a fast downward *J–V* sweep in the solar simulator, (a) V_{oc}, (b) FF, and (c) J_{sc}. (d) Maximum power point tracking curves for the best solar cells, showing the applied bias (dotted line) and P_{max} (thick line) measured by the solar simulator.

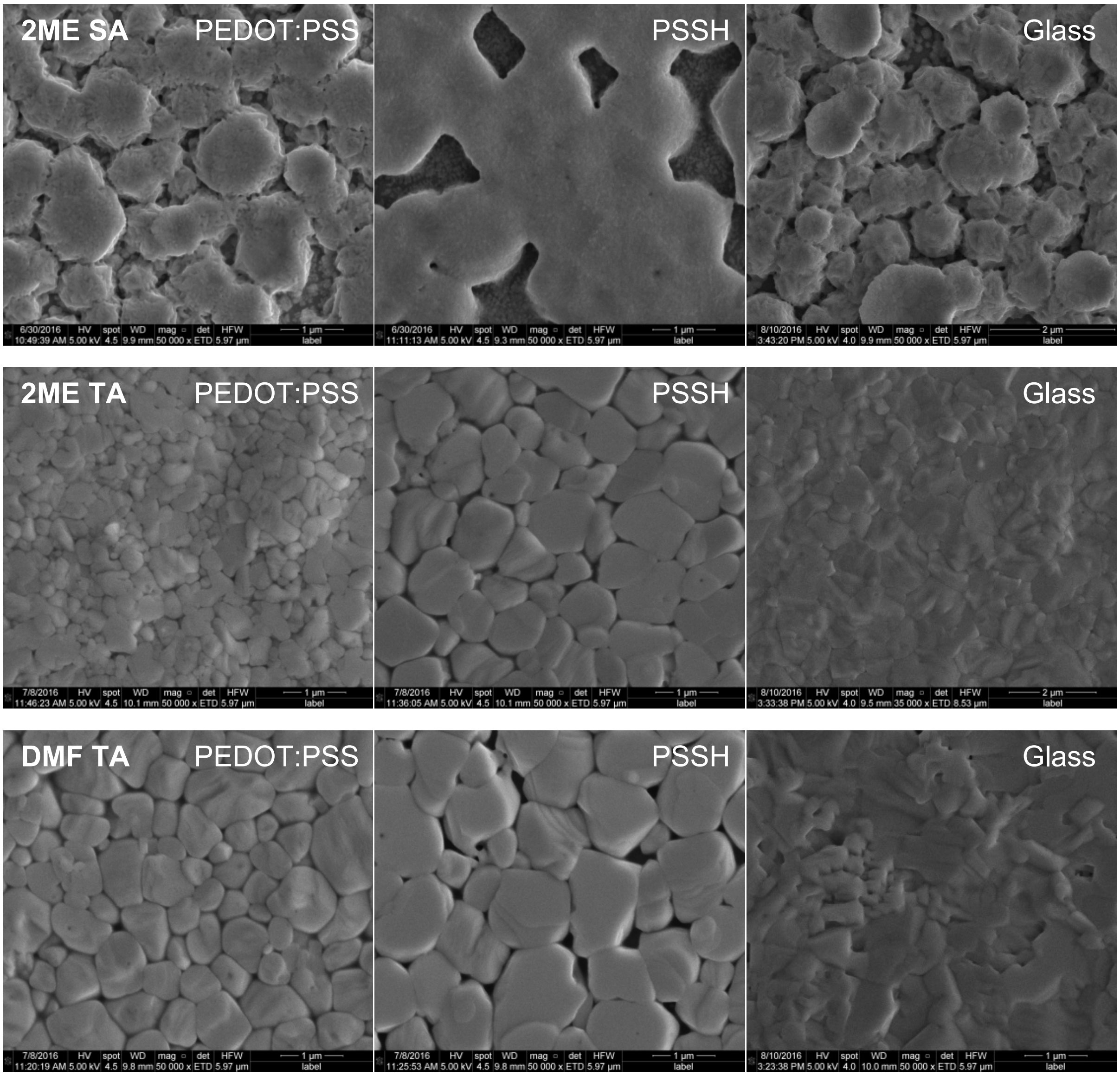

Figure S4. SEM images of perovskite layers processed on glass/PEDOT:PSS (left), glass/PSSH (middle), and glass (right) for photoluminescence lifetime measurements. From top to bottom: 2ME single anion, 2ME triple anion and DMF triple anion.

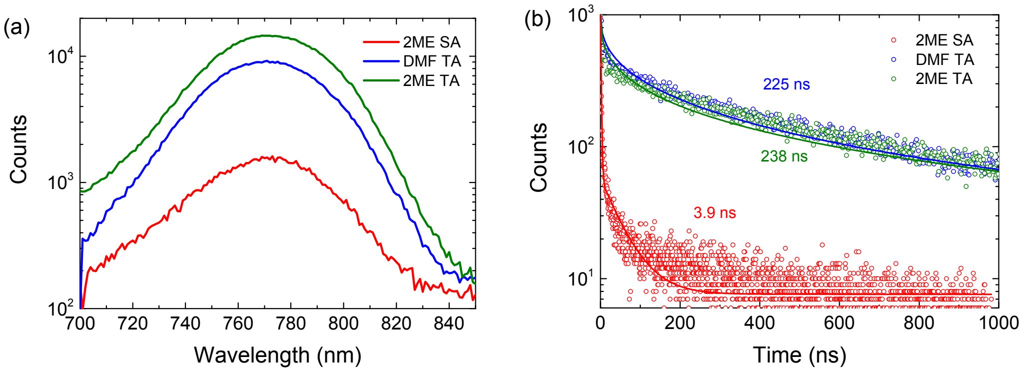

Figure S5. (a) Photoluminescence emission spectra and (b) photoluminescence decay traces of perovskite layers on glass processed from 2ME or DMF. The solid lines are the stretched exponential fits. The lifetimes depicted in the graph are the average lifetimes for the respective curves. For the single-anion precursor a stretched exponential does not fit that data correctly and an amplitude average lifetime was determined from a tri-exponential fit.

Table S3. Time resolved fluorescence data fit to a stretched exponential decay[a]

Precursor	Solvent	Substrate	τ_c (ns)	β	$<\tau>$ (ns)	τ_{ave} (ns) [b]
Triple-anion	DMF	PSSH	618	0.66	828	855
		Glass	68	0.40	225	195
	2ME	PSSH	125	0.57	202	219
		Glass	49	0.35	238	183
Single-anion	2ME	PSSH	2	0.64	3	3.8
		Glass	2	0.93	2	3.9

[a] $I(t)=I(0)e^{-(t/\tau_c)^\beta}$ where τ_c is the lifetime, β the distribution coefficient, and $<\tau>=(\tau_c/\beta)\Gamma(\beta^{-1})$ the average lifetime. [b] Amplitude average lifetime determined from a bi-exponential (for triple-anion) and tri-exponential (for sing-anion) fits.

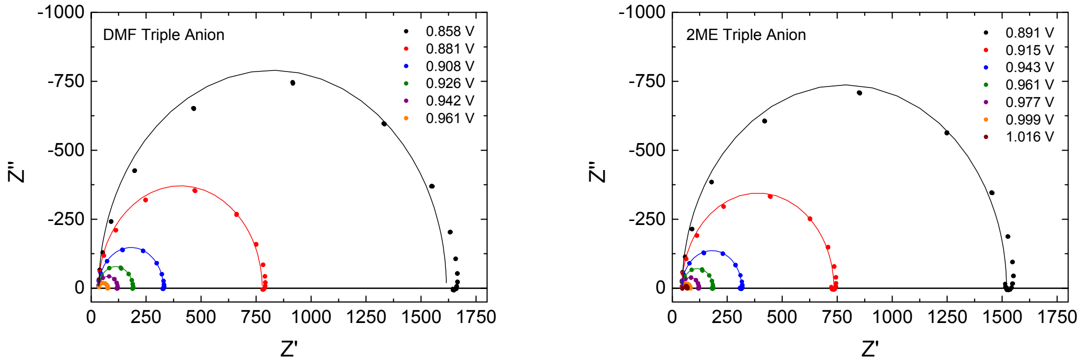

Figure S6. Nyquist plots of impedance data measured at open-circuit conditions at various light intensities of perovskite solar cells processed from triple anion precursors of (a) DMF and (b) 2ME. The solid dots are the measured data points, the lines are fits of the medium-frequency arc to an -$R_s(R_{rec}C)$- equivalent circuit.

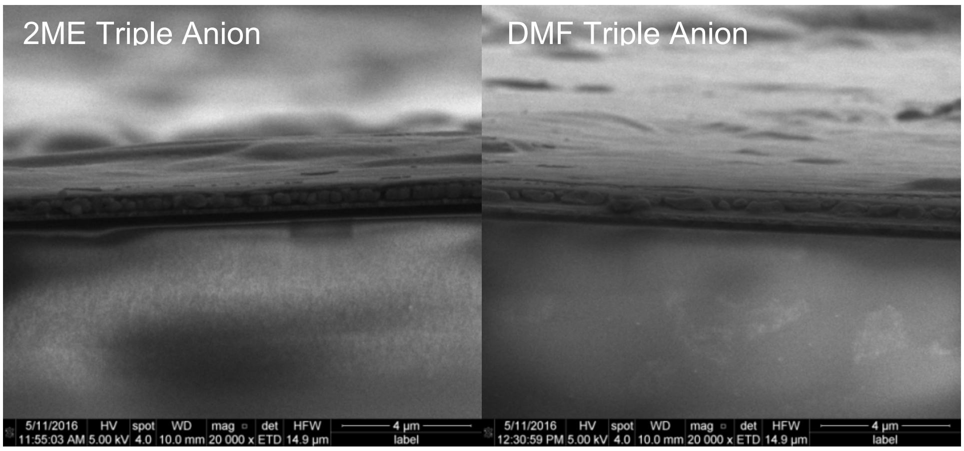

Figure S7. Low magnification cross-section SEM images of perovskite solar cells processed from 2ME and DMF triple anion precursors.

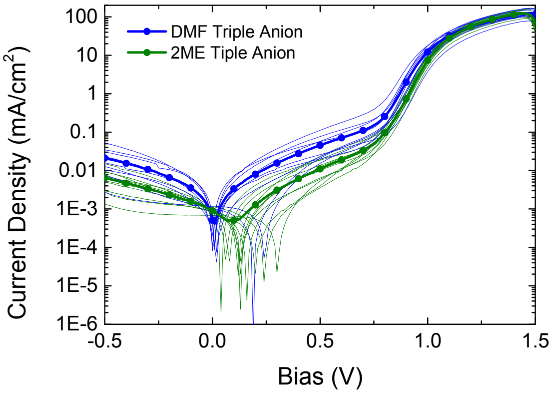

Figure S8. Fast downward *J-V* sweeps in the dark of the DMF and 2ME triple anion processed cells shown in Table 1 and Figure 2 (thin lines) showing that the 2ME cells have a lower dark current. The thick lines with symbols are the average dark curves. The fact that not all curves have a minimum current density at 0 V is likely due to the fast measurement protocol, inducing a displacement current or it is related to the little hysteresis that is present.