Sequential Solid-State Multiligand Exchange of $FAPbI_3$ Quantum Dots for More Efficient and Stable Photovoltaic Devices

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Table S1. Diffraction angles of alpha-phase of $FAPbI_3$ with their Miler plane index.

Diffraction angle (2θ°)	Miller index
13.92	(100)
28.22	(200)
31.28	(012)
40.22	(220)
42.25	(221)

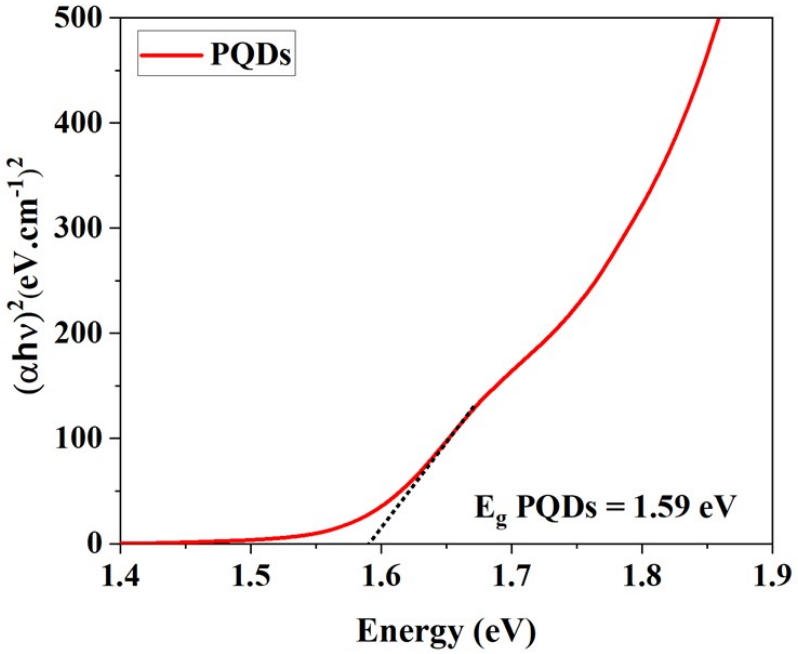

Figure S1. Tauc plot of UP $FAPbI_3$ CQDs.

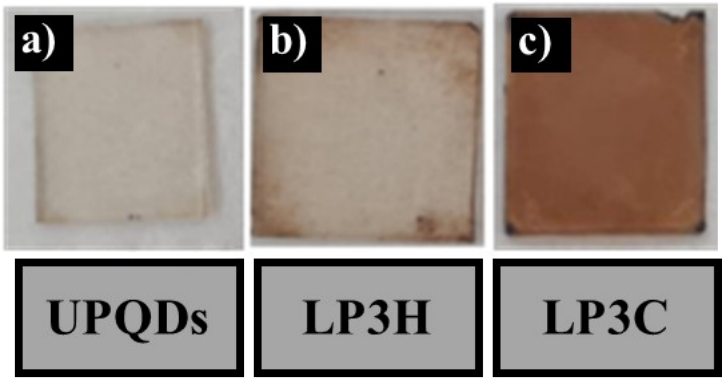

Figure S2. Photographs taken from spin-coated films of **(a)** UP, **(b)** LP3H, and **(c)** LP3C QDs on FTO.

Table S2. All FTIR peaks and corresponding bonds of precursors.

Wavenumber (cm^{-1})	Bonds	Belongs to
1717	υ(C=N)	FA^+ in $FAPbI_3$
3300 and 3500	−N−H	OAm and FAI
2919	CH_2 Asymmetric	OA, OAm
2885	CH_2 symmetric	OA, OAm
2984	CH_3 symmetric	OA, OAm
1409	COO^- symmetric	Oleate
1530	COO^- Asymmetric	Oleate
2382 and 2412	S-H	MPA
3170	$N\text{-}H_3^+$	FA^+
3357	$C{=}N\text{-}H_2^+$	FAI

Table S3. Integrated peak area (IPA) of ligands and FA^+ deduced from ^1H NMR spectra

Sample	IPA of Ligands ($\times 10^9$)	Ligand Removal	IPA of FA^+ ($\times 10^7$)
UP	2.27	0% (100% coverage)	1.67
LP3	1.089	52.02	1.09
SLP	0.352	84.49	0.67
SLP-MF	0.059	97.4	1.23

IPA: Integrated Peak Area

Table S4. The average characteristics of SLP and SLP-MF solar cells (n=10).

Cells	V_{OC} (V)	J_{SC} (mA/cm^2)	FF (%)	PCE (%)
R-SLP	1.038±0.03	10.91±0.8	65.75±2.3	7.48±1.0
R-SLP-MF	1.068±0.01	13.49±0.5	71.94±1.18	10.38±0.7

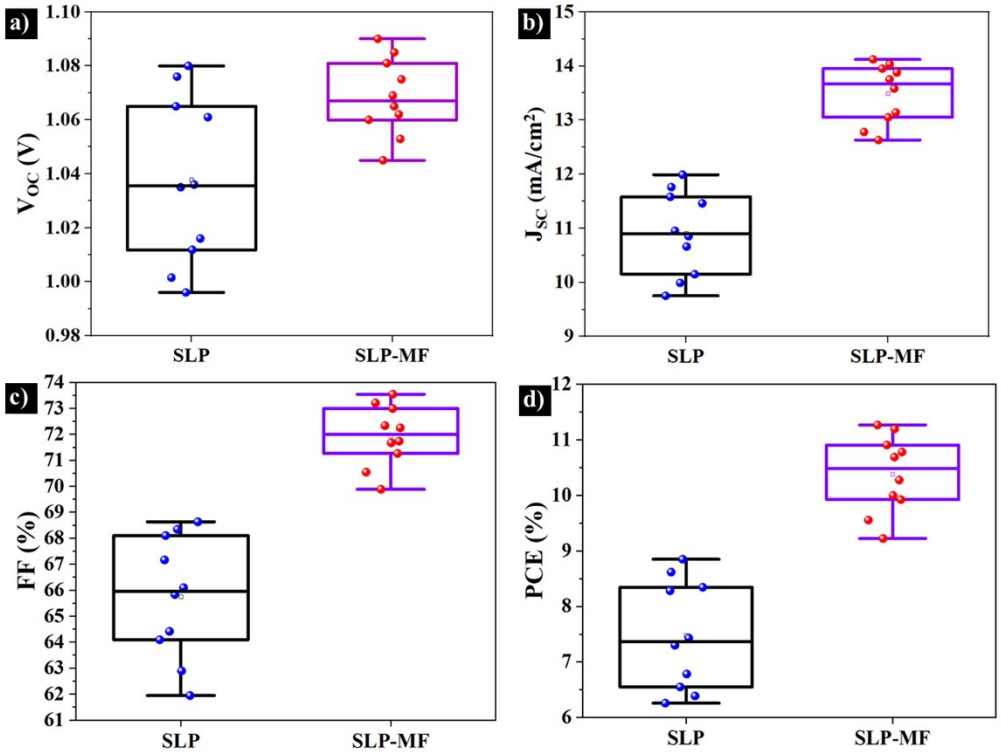

Figure S3. The statistical distribution of photovoltaic parameters: **(a)** V_{OC}; **(b)** J_{SC}; **(c)** FF; **(d)** PCE

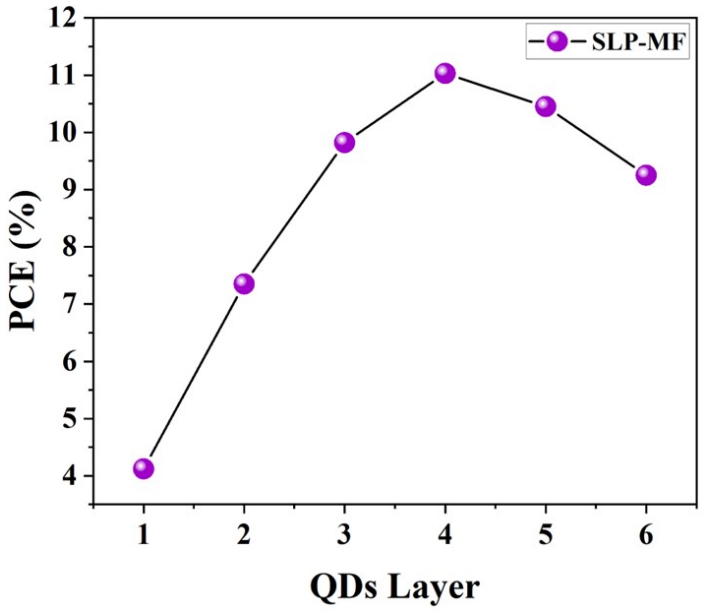

Figure S4. The effect of the SLP-MF QD film thickness on PCE.

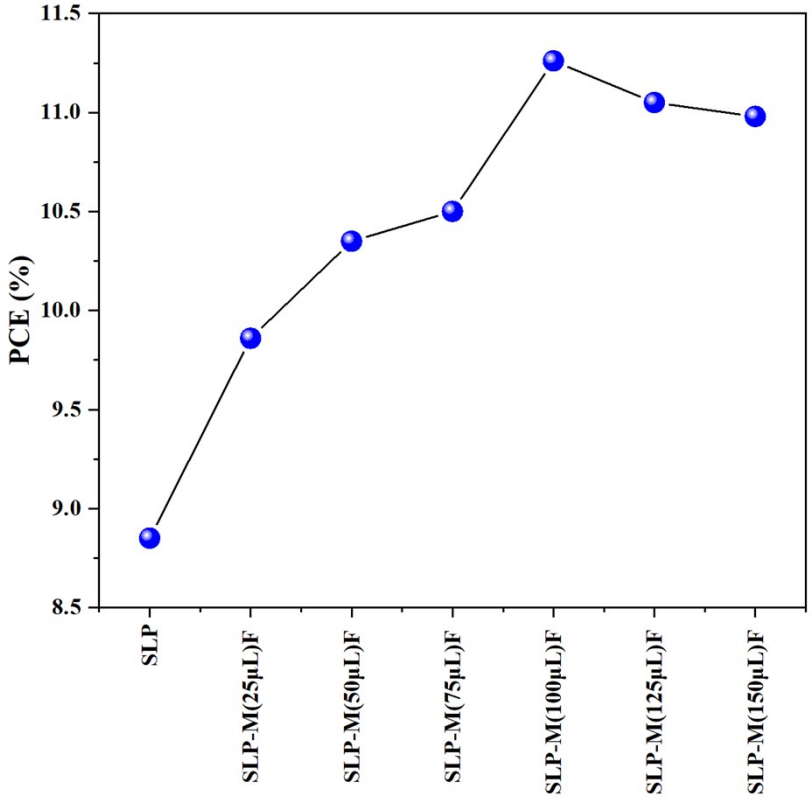

Figure S5. The effect of MPA concentration on the PCE of cells at one mg FAI concentyration.

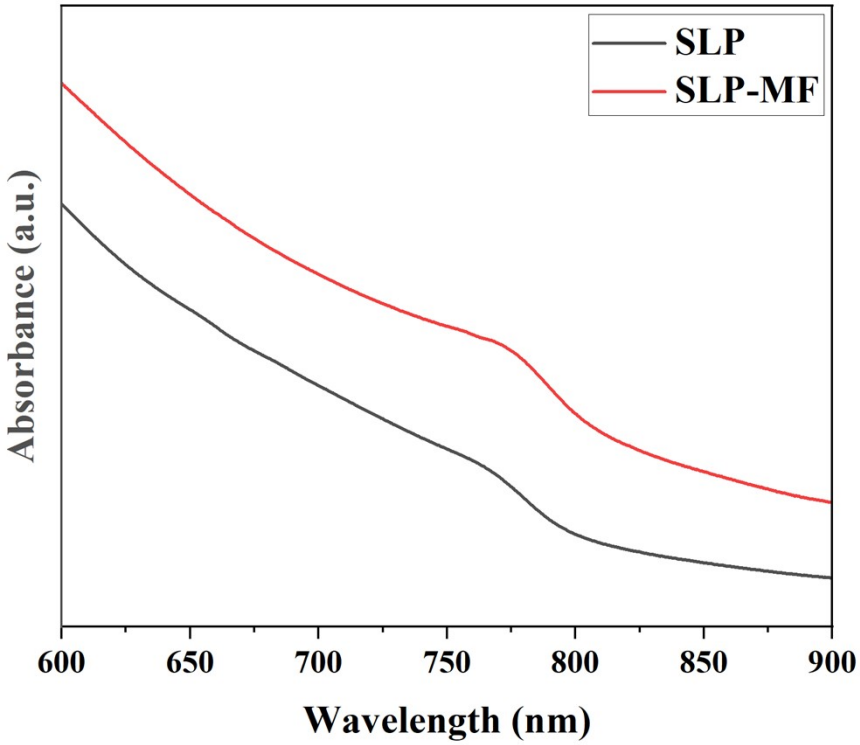

Figure S6. Absorbance spectrum of SLP and SLP-MF thin-films.

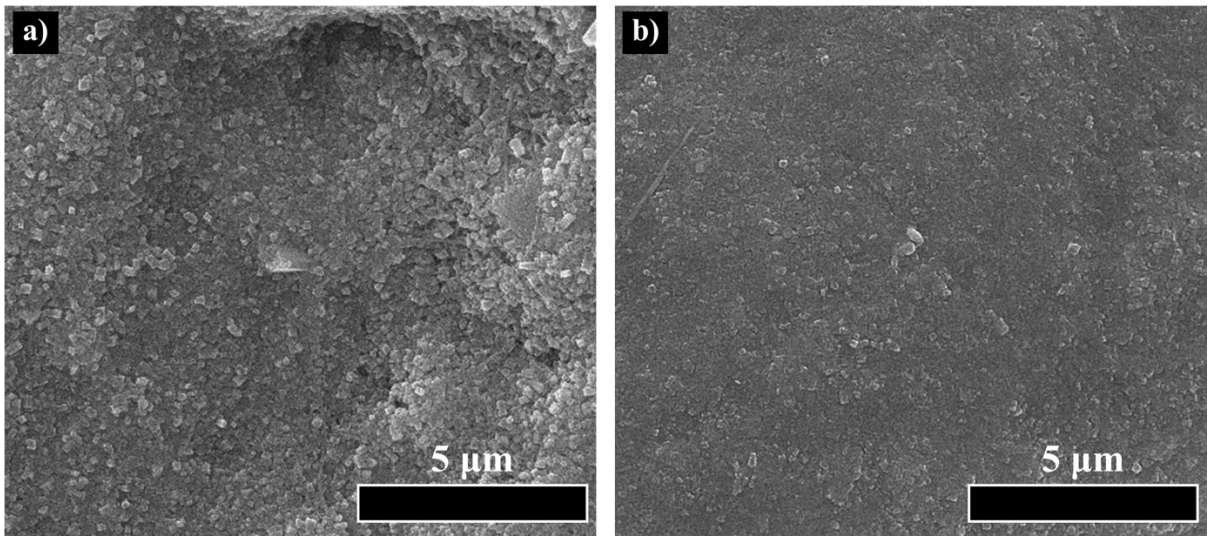

Figure S7. Representative top -view FESEM images of (a) SLP and (b) SLP-MF PQD layers.