

# Bridging the inter-grain charge transport via organic semiconductors for high-performance thickness-insensitive perovskite solar cells

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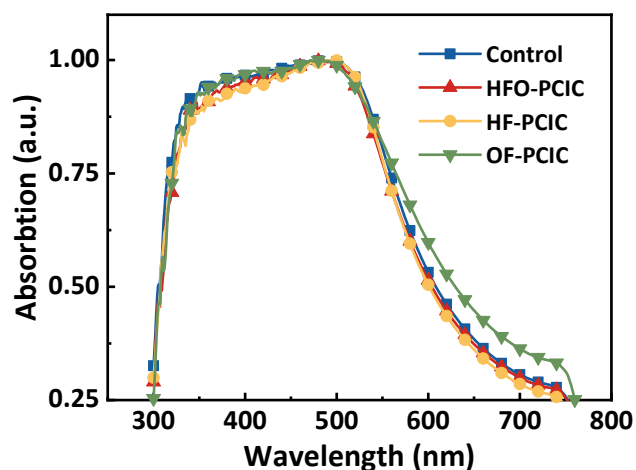


Fig. S1. UV-vis absorption spectra of the control and the NFA-mixed perovskite thin layer.

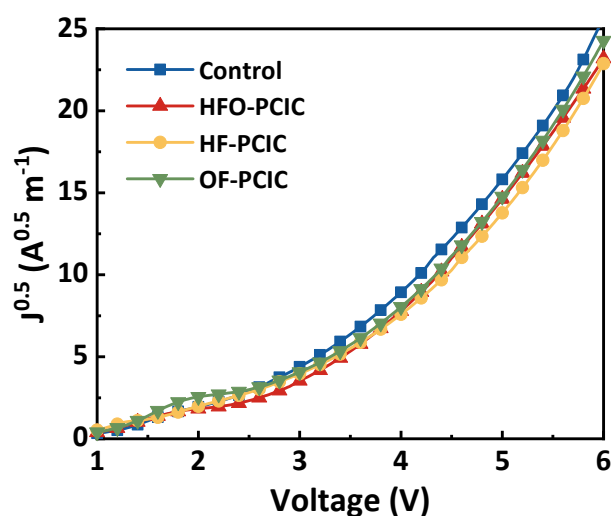
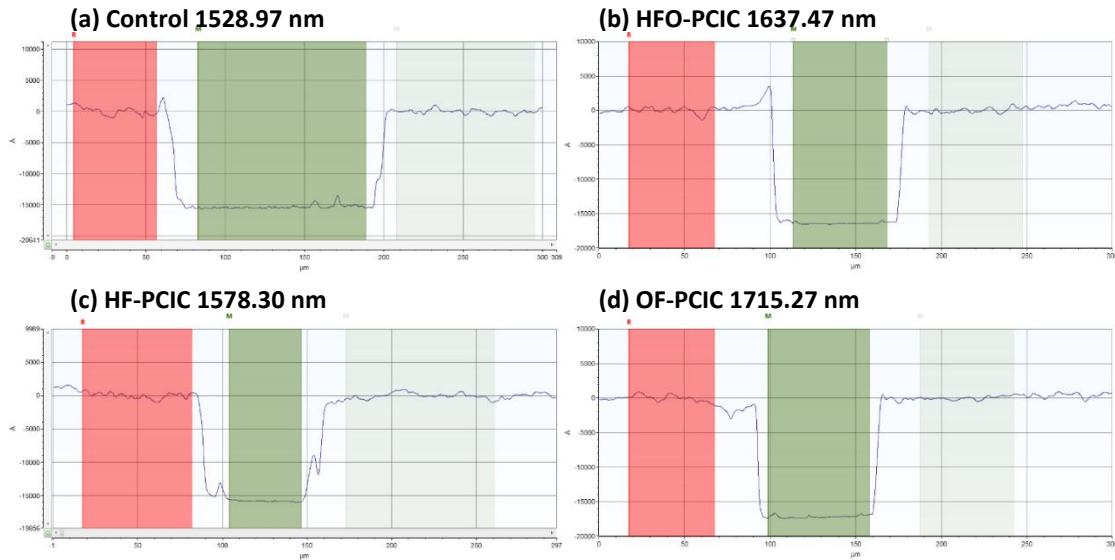


Fig. S2.  $J^{0.5}$ -V characteristics of electron-only devices.

**Table S1** The electron mobility mobilities of PVSCs.

NFA	The electron mobility ( $10^{-3} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ )
None	1.73
HFO-PCIC	1.41
HF-PCIC	1.59
OF-PCIC	1.74



**Fig. S3** The thicknesses values of the perovskite layer with/without different NFAs.

**Table S2** The real distribution and average values of the perovskite thickness.

NFAs	Thickness (nm)		
	Sample 1	Sample 2	Average
Control	1528.97	1529.53	1529.25
HFO-PCIC	1637.47	1557.62	1597.54
HF-PCIC	1578.30	1538.49	1558.40
OF-PCIC	1715.27	1534.67	1624.98

**Table S3** The detailed parameters of the performance of the PVSC with thick perovskite (>1500 nm) with/without OF-PCIC.

	$V_{oc}$ (V)	$J_{sc}$ (mA/cm <sup>2</sup> )	Fill Factor (%)	Efficiency (%)	$R_s$ (ohm)	
Control	Sample 1	1.09	22.09	80.59	19.34	90.78
	Sample 2	1.08	22.01	77.95	18.50	112.59
	Sample 3	1.07	22.33	77.27	18.53	107.33
OF-PCIC	Sample 1	1.06	17.73	77.59	14.62	125.58
	Sample 2	1.06	17.21	75.37	13.69	142.62
	Sample 3	1.06	17.35	77.13	14.21	126.06

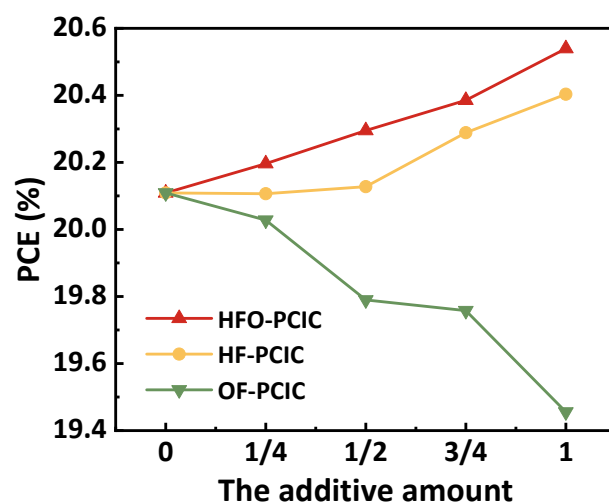


Fig. S4 The relation between the additive amount and the PCE.

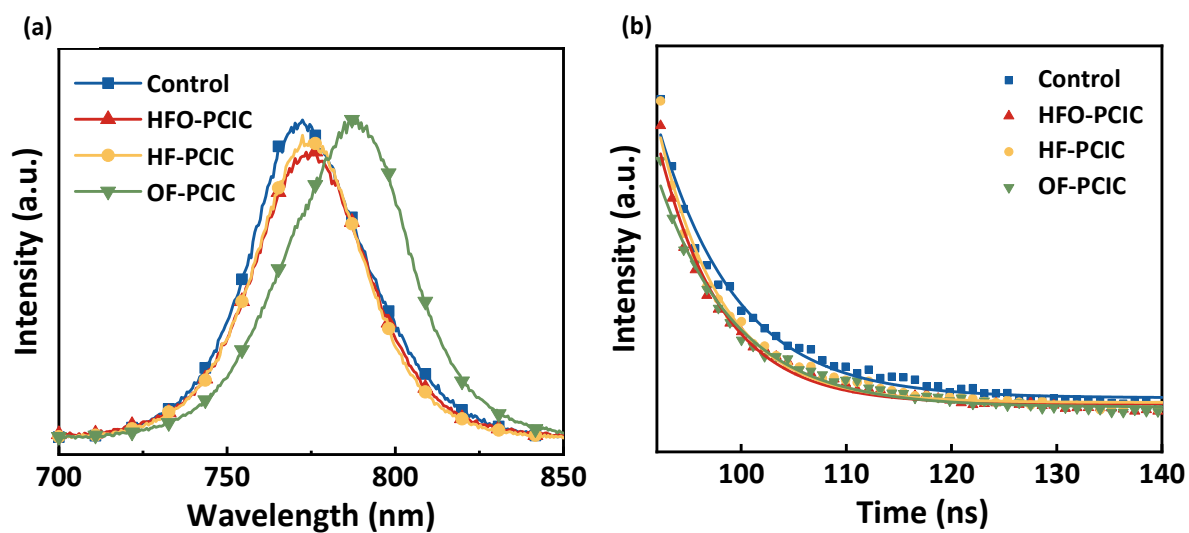


Fig. S5 (a) steady-state photoluminescence (PL) spectroscopy and (b) time-resolved photoluminescence (TRPL).

Table S4 The fitting date of TRPL.

	$\tau$ (ns)
Control	7.42
HFO-PCIC	6.02
HF-PCIC	6.05
OF-PCIC	7.28

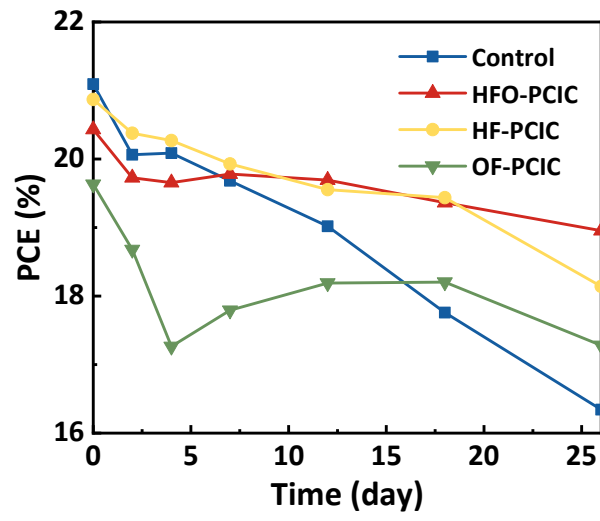


Fig. S6 The stability of the device with/without NFAs in 26 days.