Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

Enhanced comprehensive performance of carbon-based hole-transport-layer-free $CsPbI_2Br$ solar cells by a low-cost and stable long chain polymer

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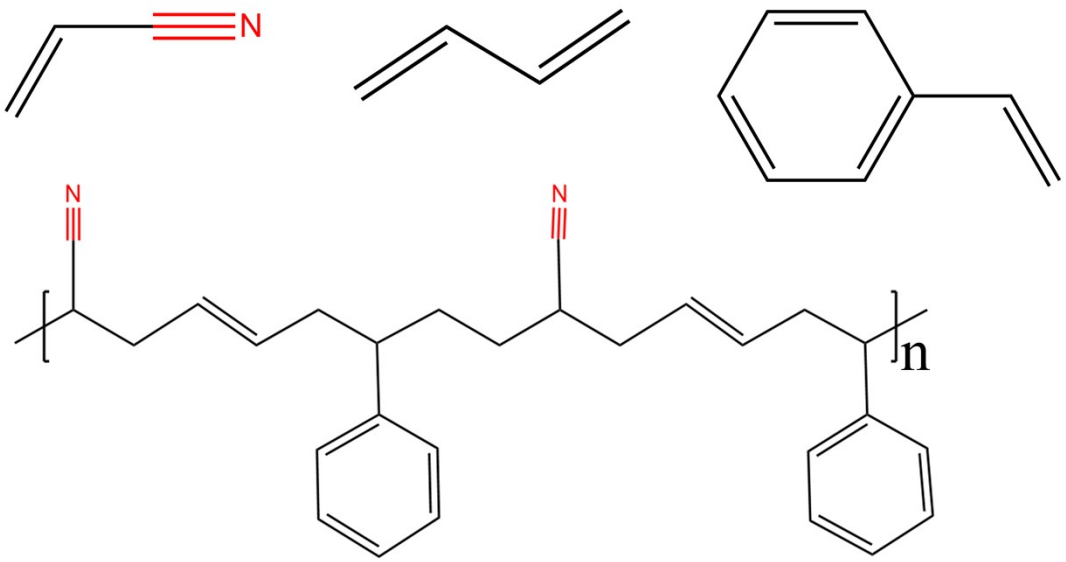

Figure S1. Molecular structures of the precursors (Top: acrylonitrile, butadiene and styrene from left to right) for synthesizing ABS (bottom).

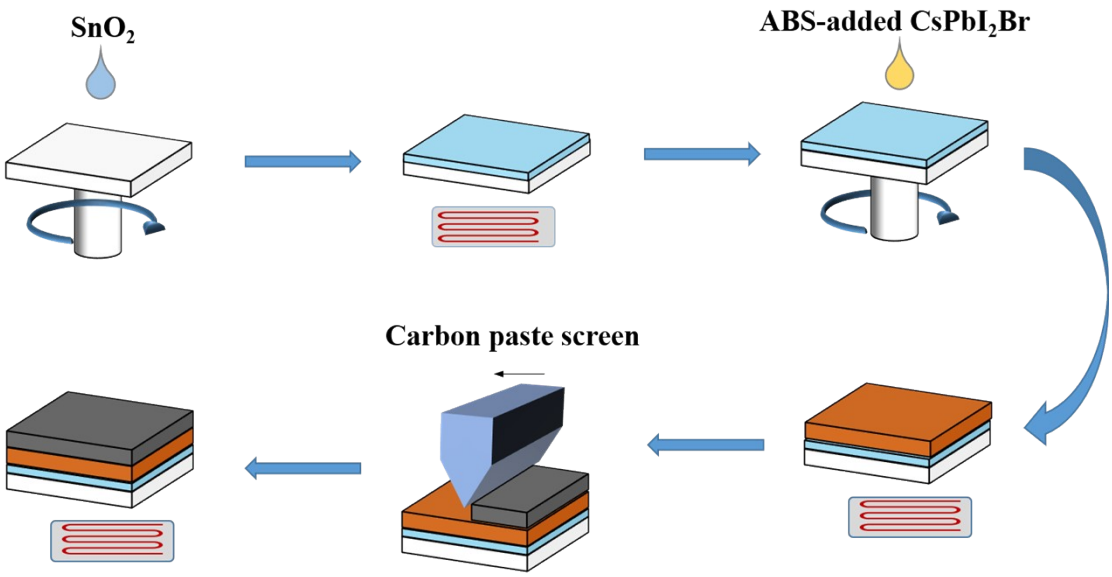

Figure S2. Main procedures of fabricating an HTL-free $CsPbI_2Br$ solar cell with a carbon electrode.

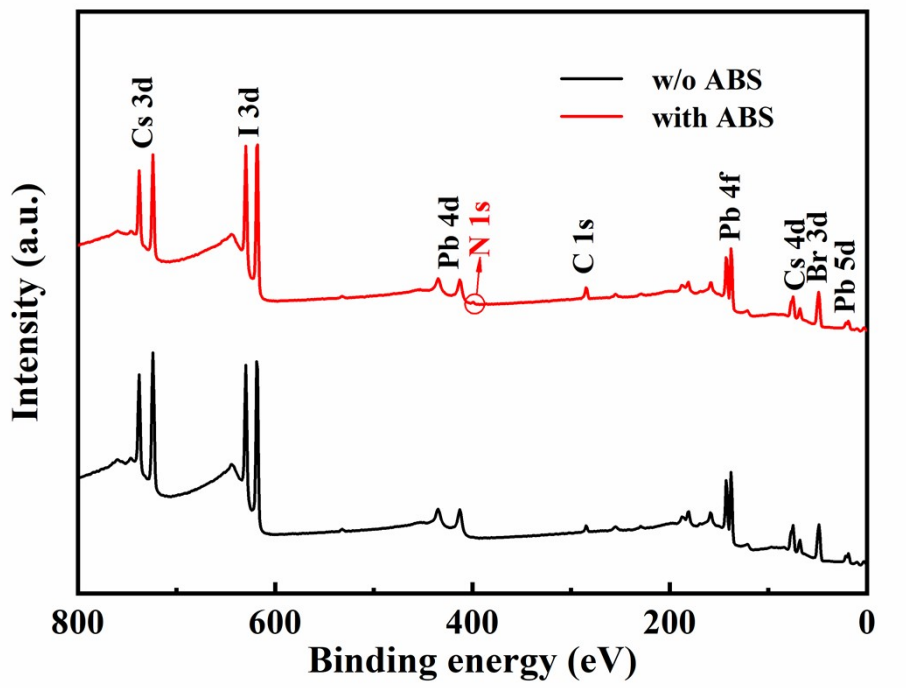

Figure S3. XPS full spectra of the pristine and ABS-added $CsPbI_2Br$ layers.

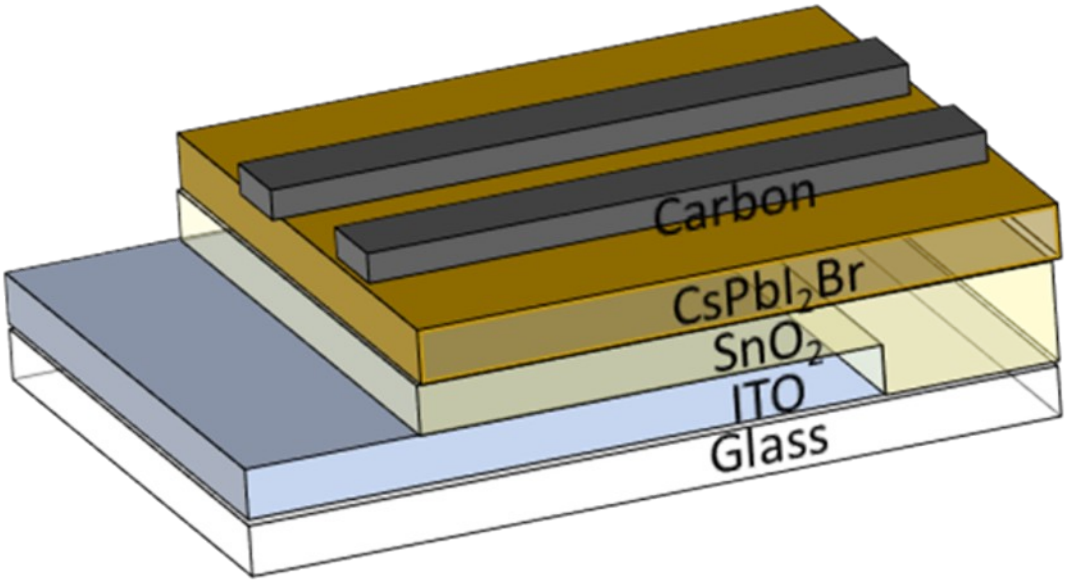

Figure S4. Device configuration of the HTM-free carbon-based $CsPbI_2Br$ solar cells.

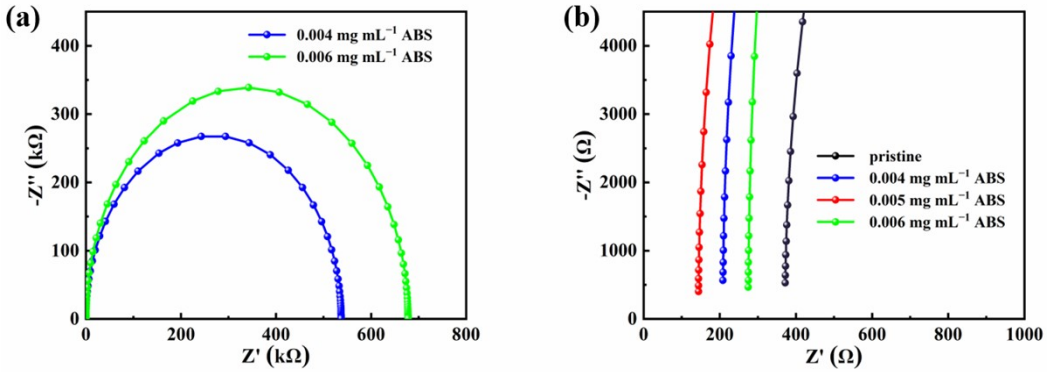

Figure S5. (a) Nyquist plots of the EIS curves for the devices prepared with the ABS addition of 0.004 and 0.006 mg mL^{-1}. (b) Enlarged plots of the EIS curves at high frequency for the devices prepared with different ABS additions.

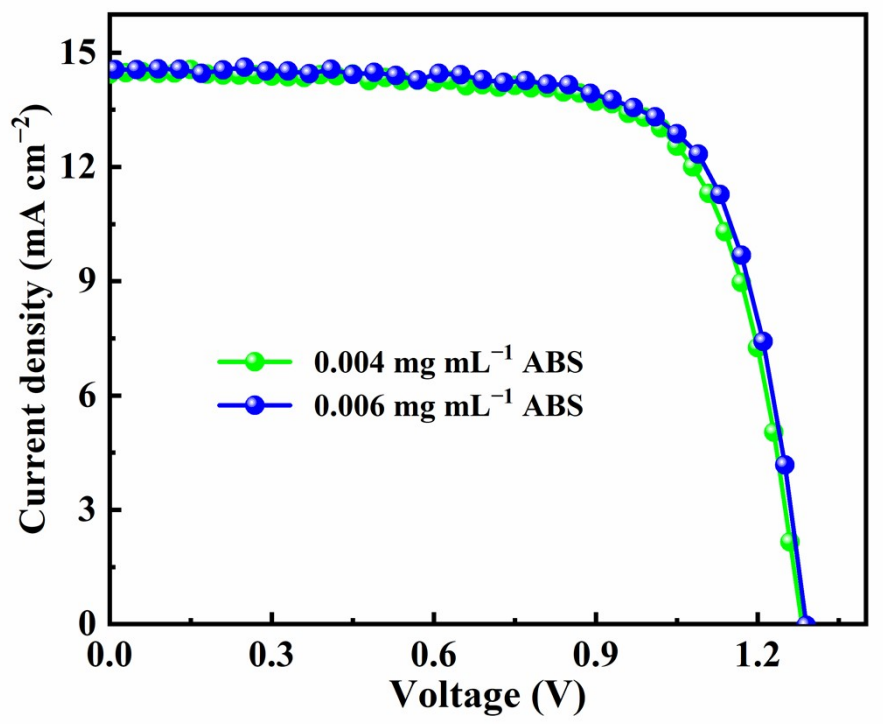

Figure S6. Illuminated *J-V* curves at AM 1.5G for the devices prepared with the ABS addition of 0.004 and 0.006 mg mL^{-1}

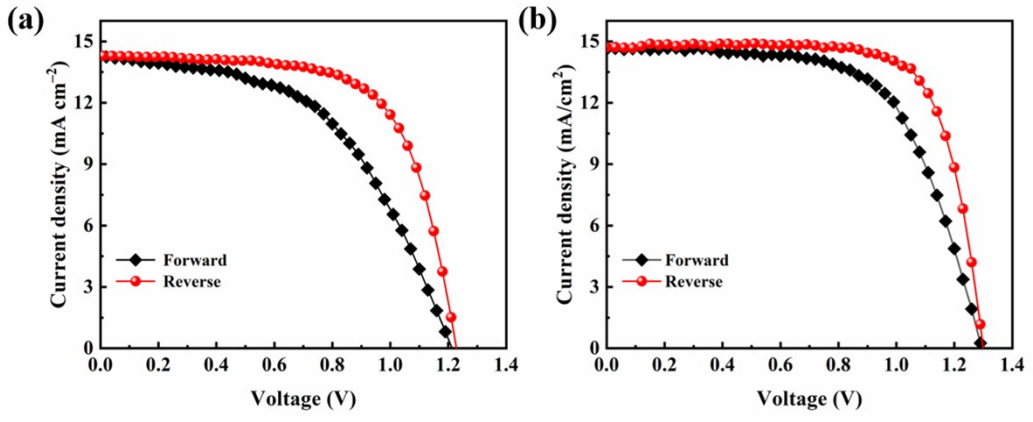

Figure S7. *J-V* curves of the (a) pristine and (b) 0.005 mg mL^{-1} ABS-added champion $CsPbI_2Br$ PSCs at the forward and reverse scans.

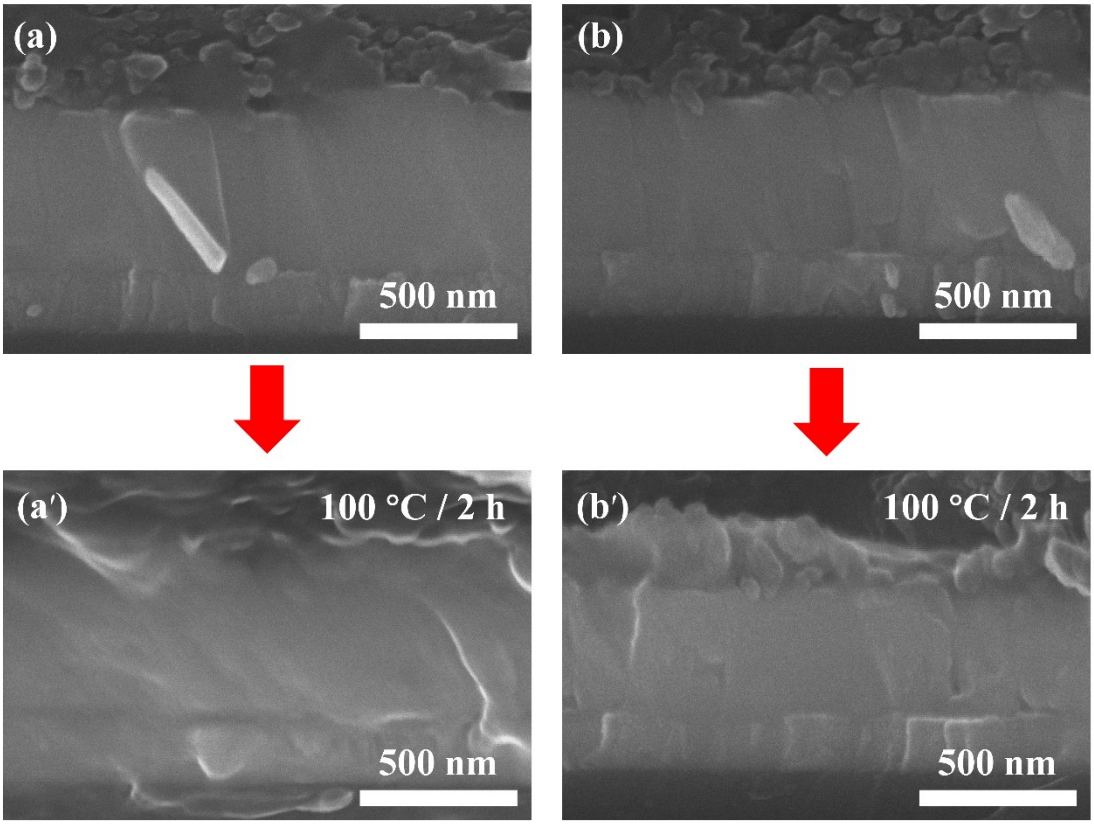

Figure S8. Cross-sectional SEM images of the (a, a′) pristine device and (b, b′) 0.005 mg mL^{-1} ABS-added device before and after annealing at 100 °C for 2 h in air.

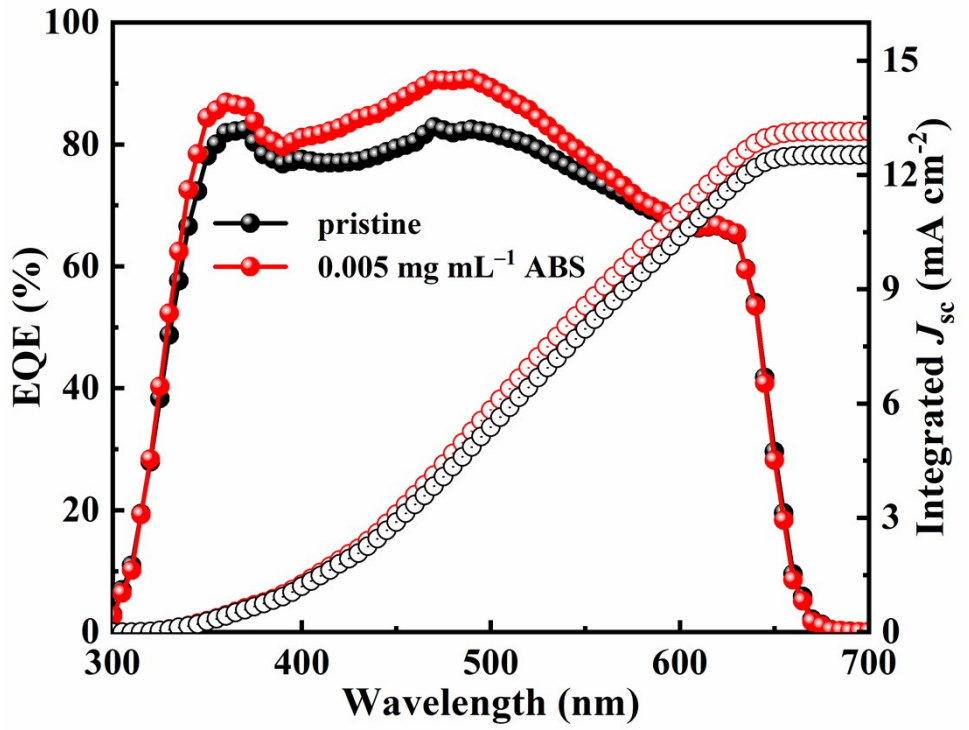

Figure S9. EQE spectra and the integrated Jsc of the devices prepared with the ABS addition of 0 and 0.005 mg mL^{-1}.

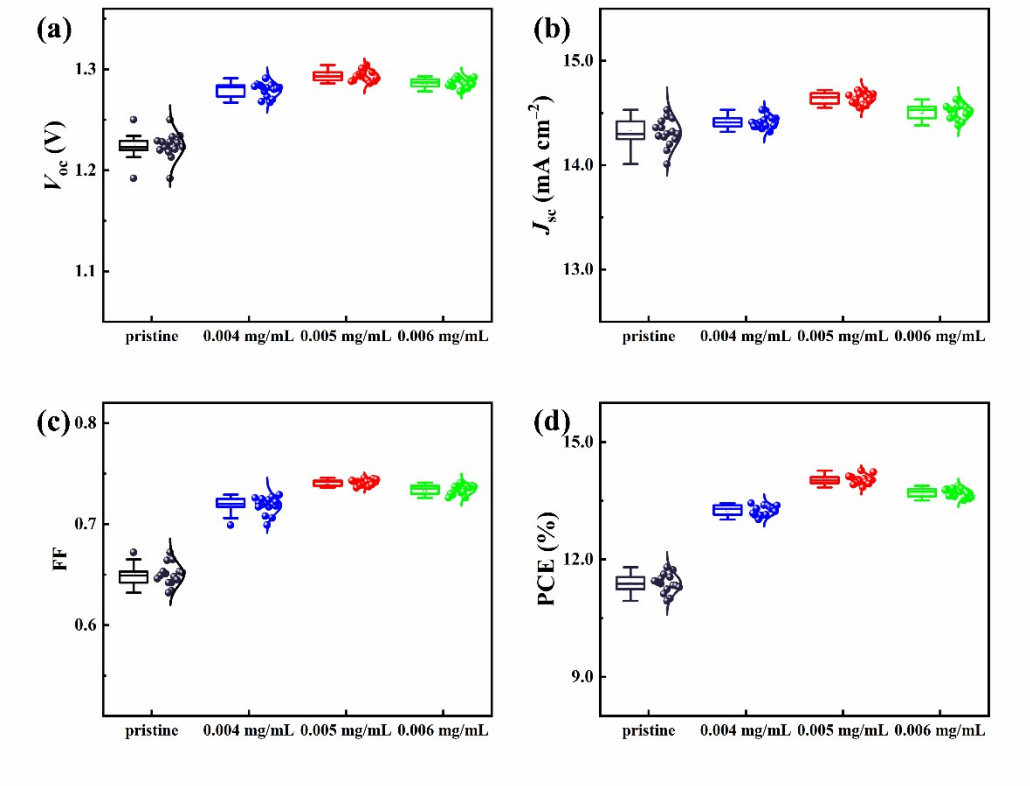

Figure S10. Statistical charts of (a) V_{oc}, (b) J_{sc}, (c)FF and (d) PCE of the 15 independent devices for each ABS addition.

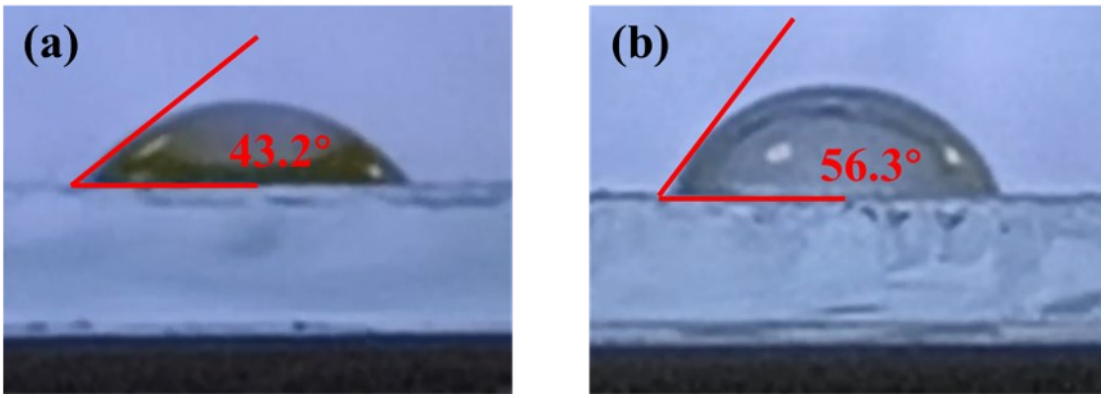

Figure S11. Water contact angle of the (a) pristine and (b) 0.005 mg mL^{-1} ABS-added $CsPbI_2Br$ layers.

Table S1. Molecular mass and density of ABS.

Sample	Mw (g/mol)	ρ (g/ml)
ABS	633.91	1.05

Table S2. XRD data of the $CsPbI_2Br$ layers with different ABS additions.

Sample	(100)		(200)	
	2θ°	**FWHM**	**2θ°**	**FWHM**
pristine	14.63°	1.11	29.55°	0.58
0.004 mg ml^{-1} ABS	14.62°	0.99	29.53°	0.47
0.005 mg ml^{-1} ABS	14.62°	0.90	29.54°	0.46
0.006 mg ml^{-1} ABS	14.63°	0.89	29.56°	0.48

Table S3. Carrier lifetimes estimated from the TRPL spectra of Figure 4d.

Sample	τ_1 **(ns)**	τ_2 **(ns)**	A_1	A_2	τ_{ave} **(ns)**
Pristine	1.11	8.86	227.25	2.18	1.66
0.005 mg mL^{-1} ABS	0.92	12.47	292.37	2.41	2.08

Table S4. Summary of the reported photovoltaic parameters of the HTM-free carbon-based $CsPbI_2Br$ PSCs.

Strategy	J_{sc} (mA cm^{-2})	V_{oc} (V)	FF (%)	PCE (%)	Ref
ABS additive	14.69	1.30	74.7	14.27	This work
Cs_2PtI_6 surface modification	14.85	1.28	72.0	13.69	[44]
PTU and PU interface modification	14.83	1.22	72.0	13.01	[45]
ATHPBr additive	14.28	1.30	78.1	14.50	[46]
non-hydrophilic Cl-containing SnO_2 ETL	14.70	1.26	76.2	14.11	[47]
$CsPbI_2Br/CsPb_2I_4Br$ heterostructure	14.60	1.32	79.1	15.25	[48]
HTAB surface modification	14.10	1.26	80.6	14.31	[49]
KTFA and CF_3PMABr additive	14.98	1.27	73.7	14.05	[23]
P-F-PEAI/Br passivation layer	14.91	1.27	73.8	13.97	[50]
Ionic modified ZnO layer	14.95	1.27	75.1	14.25	[51]
EDTA interface modification	14.95	1.26	74.3	13.94	[52]

Table S5. Photovoltaic parameters of the champion devices fabricated with the pristine and 0.005 mg mL^{-1} ABS-added $CsPbI_2Br$ layers at the forward and reverse scans.

Devices		V_{oc} (V)	J_{sc} (mA cm^{-2})	FF	PCE (%)	HI (%)
pristine	Forward	14.28	1.213	0.522	9.04	23.4%
	Reverse	14.30	1.228	0.672	11.80	
0.005 mg mL^{-1} ABS	Forward	14.62	1.294	0.632	11.96	16.2%
	Reverse	14.69	1.300	0.747	14.27	