Electronic Supporting Information

Enhanced Photostability of $CsPbI_2Br$-based Perovskite Solar Cells through suppression of the phase segregation using a zwitterionic additive

Mikhail K. Kuznetsov,[a,b] Nikita A. Emelianov,[a] Denis V. Korchagin,[a] Gennady V. Shilov,[a] Sergey M. Aldoshin,[a] Pavel A. Troshin[c,a] and Lyubov A. Frolova,[a]*

[a] Institute for Problems of Chemical Physics of RAS, Chernogolovka 142432, Russia

[b] Faculty of Fundamental Physics & Chemical Engineering, Lomonosov Moscow State University, Moscow 119991, Russia

[c] Silesian University of Technology, 44-100, Gliwice, Poland

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loading in the $CsPbI_2Br$ films during 1500 h exposure under continuous light soaking (100±5 mW/cm^2, T= 35±2^{o}C).

Table S1. Overview of the relevant literature data on the perovskite solar cells based on $CsPbI_2Br$ films loaded with different additives.

Table S2. The average and the best (in brackets) values of power conversion efficiency (*PCE*), open-circuit voltage (V_{OC}), short-circuit current density (J_{SC}), and fill factor (*FF*) of the devices with different **Asn** loadings.

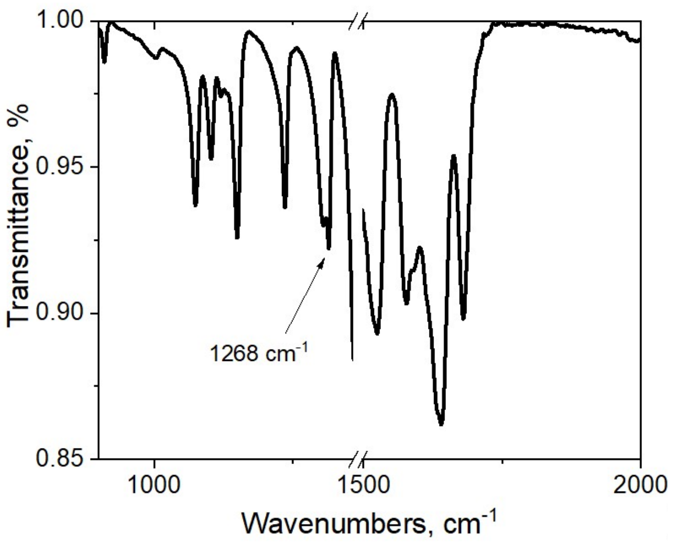

Fig. S1. ATR FTIR spectrum of the D,L-asparagine powder.

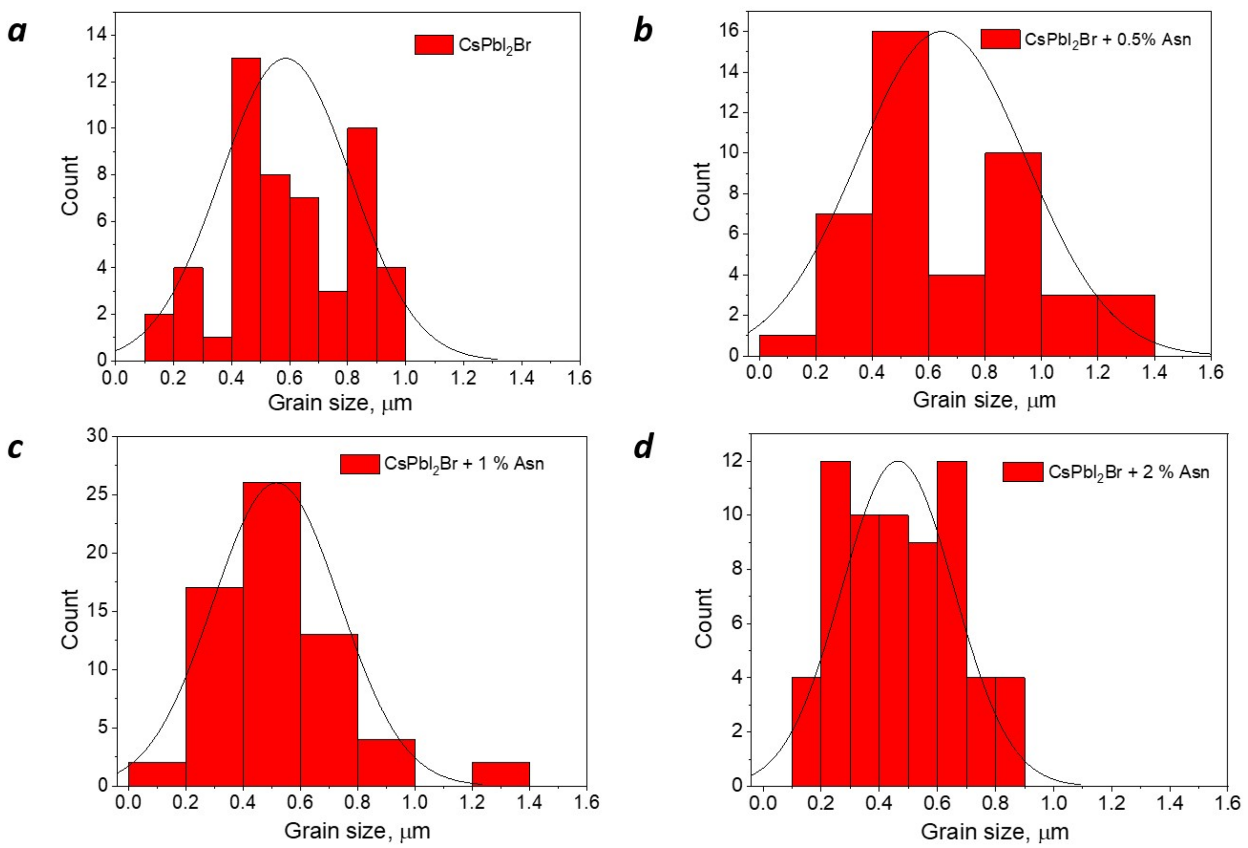

Fig. S2. Grain size distribution for the pristine and modified $CsPbI_2Br$ films with 0.5%, 1%, and 2% **Asn** loadings.

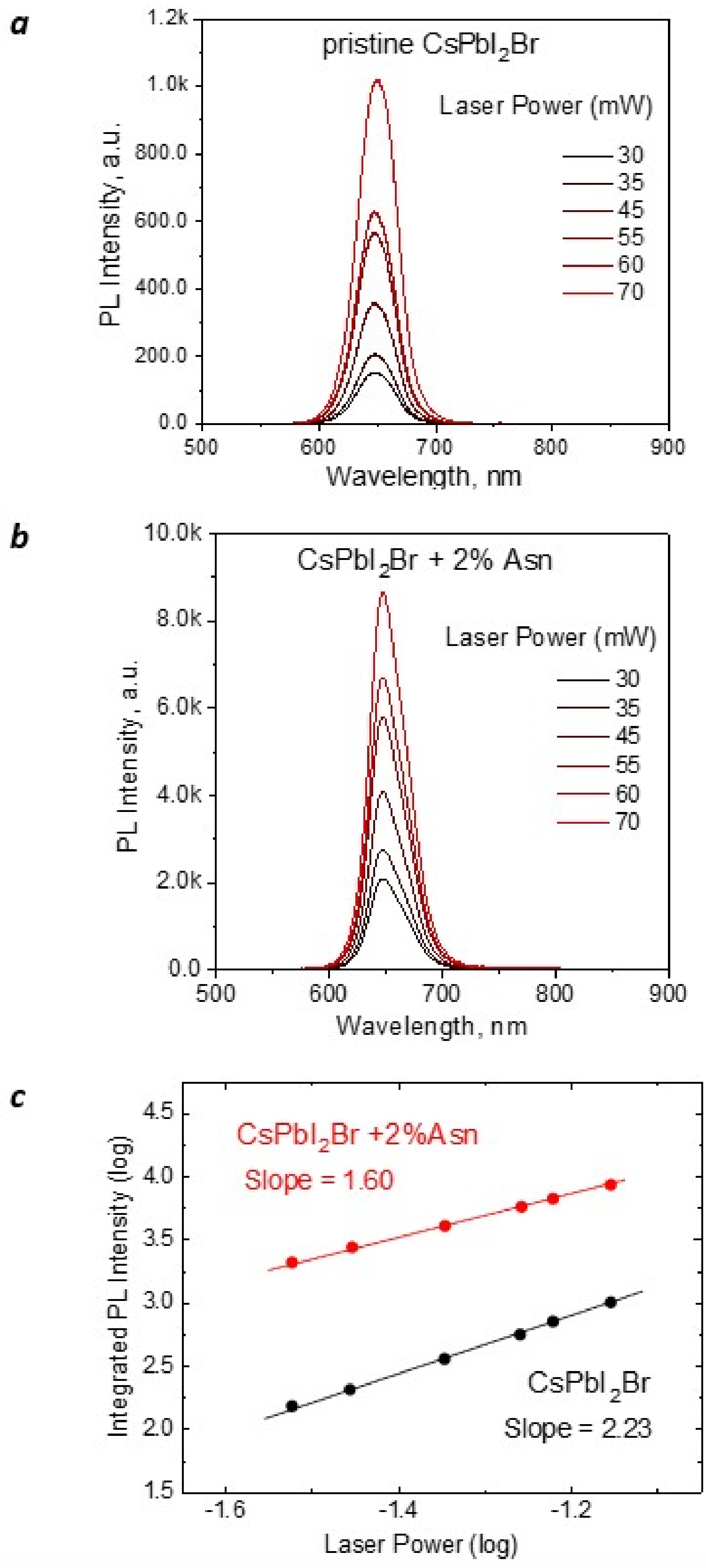

Figure S3. The evolution of the PL spectra of $CsPbI_2Br$ (a) and $CsPbI_2Br$ + 2% **Asn** (b) with increase in the laser power (λ = 450 nm) and a double logarithmic plot of the integrated PL intensity as a function of the excitation power (c).

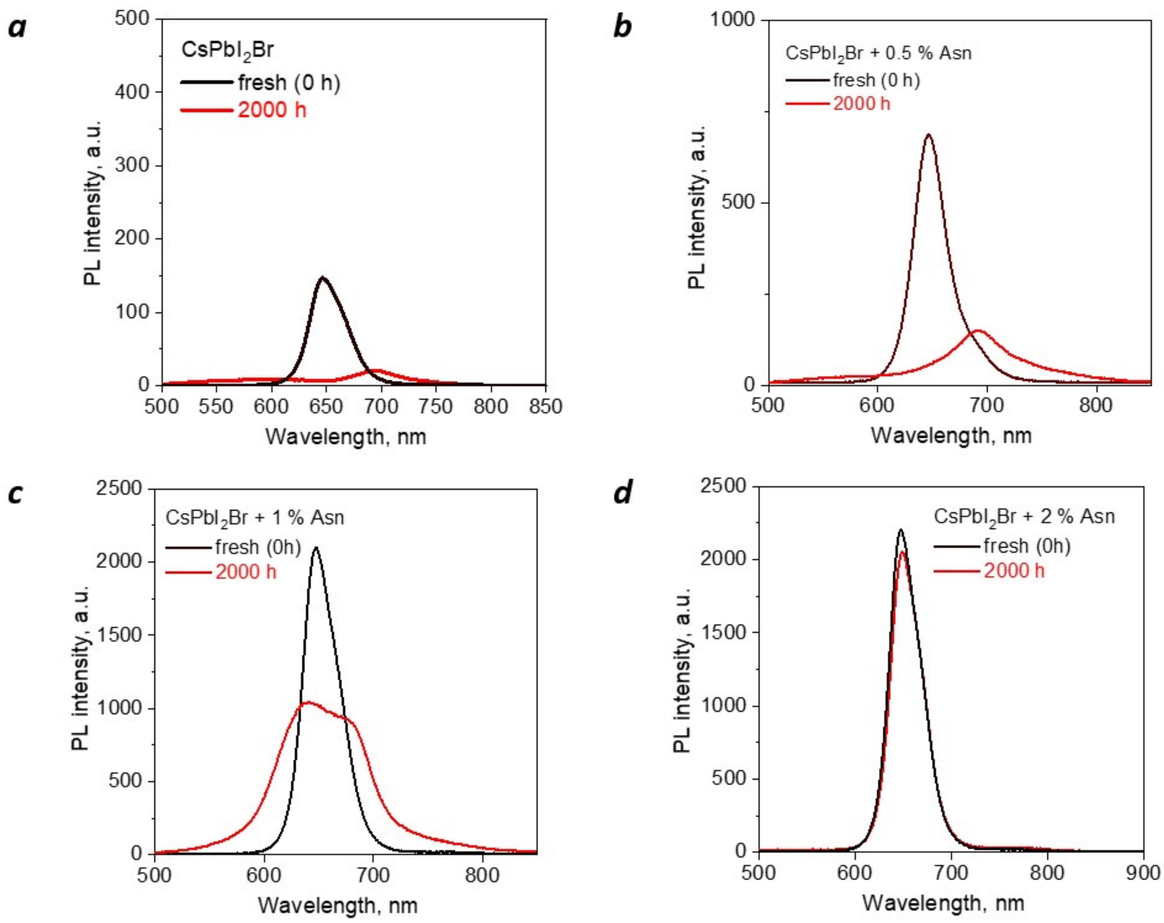

Figure S4. A comparison of the PL-spectra of the perovskite films before and after light soaking at 100 ± 5 mW/cm^2 and 35 ± 2 °C for 2000 h for the samples with different **Asn** loadings: (a) pristine - 0%, (b) 0.5%, (c) 1%, and (d) 2%.

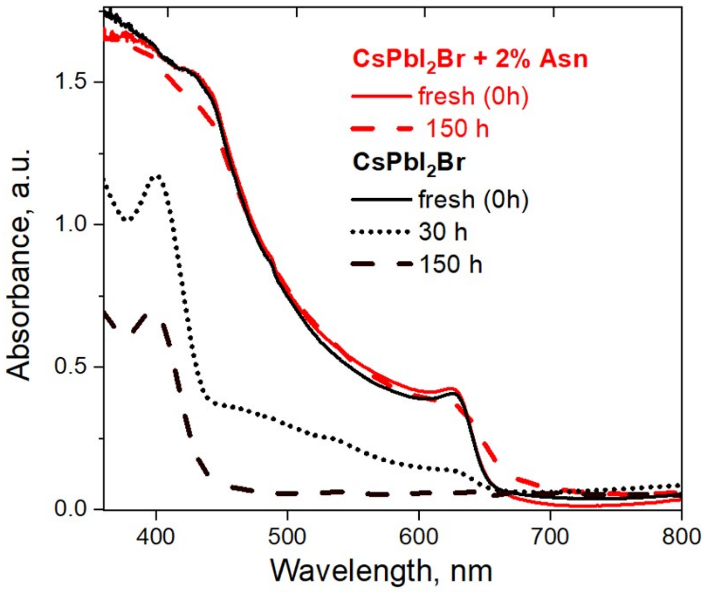

Figure S5. A comparison of the absorption spectra of the pristine $CsPbI_2Br$ films (a) and the films with 2% **Asn** loading (b) before and after annealing at 85 ± 3 °C for 150 h.

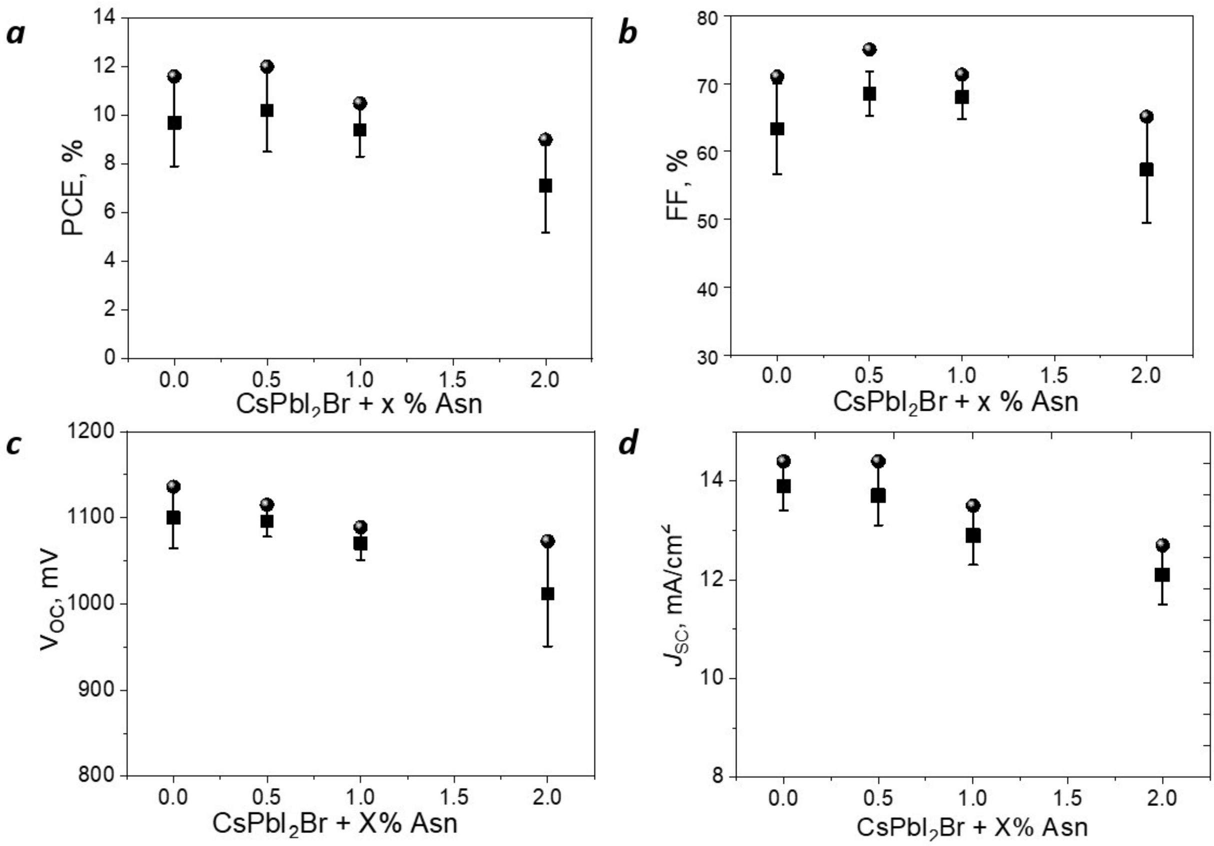

Figure S6. The evolution of the power conversion efficiency (PCE) (a), open circuit voltage (V_{OC}) (b), short circuit current density (J_{SC}) (c), and fill factor (FF) (d) values of the devices depending on the **Asn** loading in the $CsPbI_2Br$ films.

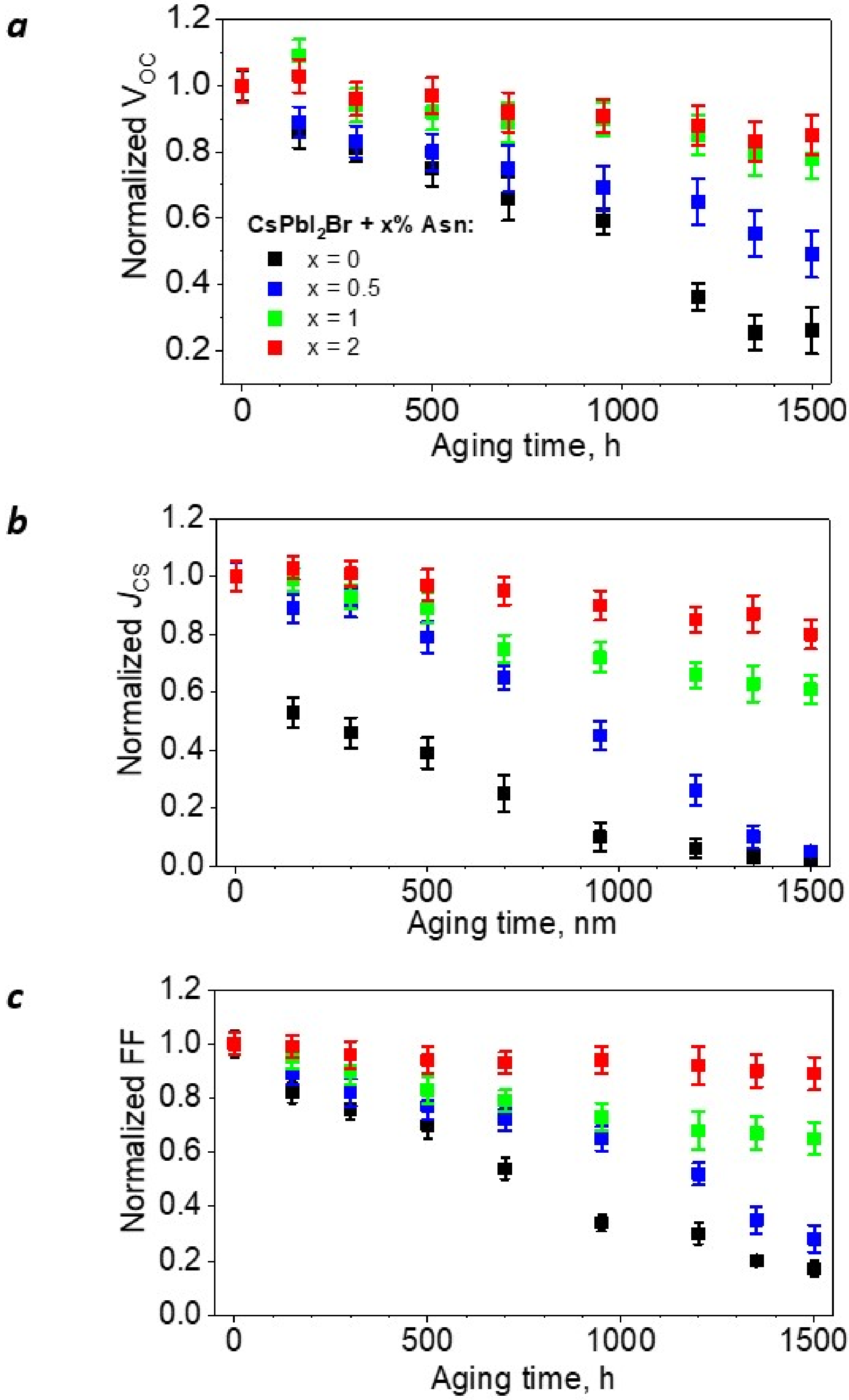

Figure S7. The evolution of the normalized open circuit voltage (V_{OC}) (a), short circuit current (J_{SC}) (b), and fill factor values (FF) (c) of the devices depending on the **Asn** loading in the $CsPbI_2Br$ films during 1500 h exposure under continuous light soaking (100±5 mW/cm^2, T= 35±2^{o}C).

Table S1. Overview of the relevant literature data on the perovskite solar cells based on $CsPbI_2Br$ films loaded with different additives.

Additive	**PCE, %**	**Aging conditions**	**Aging time / Retained fraction (%) of the initial efficiency of PSCs**	**Aging time during which the films remain stable**	**Ref.**
1-butyl-3-methylimidazolium tetrafluoroborate ($BMIMBF_4$)	13.21%	Dark, N_2 atmosphere Dark, T=30°C, RH =35 %	1080 h / 86.9% 500 h / ~80%		S1
Methylamine acetate (MAAC)	8.7%	Dark, RT, ambient air	168 h / 68%		S2
Phenylethylammonium bromide	16.70%	Dark, RT, inert atmosphere	1000 h/ 92%		S3
CH_3NH_3Cl	12.9%	Light (100 mW/cm²), RT, RH ~30 %	10 h / ~75%		S4
2-hydroxyethyl methacrylate (HEMA)	16.13%	Dark, RT, RH=30%	1000 h / 78%		S5
Tetrabutylammonium (TBA) iodide	11.05%	Dark, RT, ambient air	1080 h /60 %		S6
$HPbI_{3+x}$ (DMA=dimethylamine)	10.56%	Dark, RT, RH <20 %	-	168 h	S7
$HC(NH_2)_2I$	12.28%	Dark, RT, RH ~25-80 %	1440 h / ~100%		S8
$HC(NH_2)_2I$ (QD)	14.12%	Dark, RT, RH ~20-30 %	720 h / ~85%		S9
Tetramethylammonium chloride	14.12%	Dark, RT, ambient air Dark, T=85°C, N_2 atmosphere	720 h / ~60% 168 h /~80%		S10
Cs_4PbBr_6 nanocrystals	15.52%	Dark, RT, RH ~40 %	500 h /~90%		S11

Additive	PCE, %	Aging conditions	Aging time / Retained fraction (%) of the initial efficiency of PSCs	Aging time during which the films remain stable	Ref.
5-aminovaleric acid hydrobromide (5-AVABr)	16.58%	Dark, RT, ambient air Dark, T=85^{o}C, inert atmosphere	1560 h / 93% 288 h / 80%		S12
Levulinic acid (LA)	11.68%	Dark, RT, RH ~35 %	240 h / 50%		S13
(P3CT) carboxylated conjugated polymer	12.25%	-	-	-	S14
Sulfur-contained aminothiazolium iodide (ATI)	13.91%	Dark, RT, RH ~60 % Dark, T=80^{o}C, RH=60%	12 h / 90% 200 h / ~90%		S15
4-chlorobenzoic acid (CBA)	14.3%	Dark, RT, RH ~20 %	500 h / 95%		S16
4-bromobenzylamine (BrBeAI)	14.63%	Dark, RT, RH=60%		20 min	S17
$Pb(Ac)_2$	12%	Dark, RT, inert atmosphere	~750 h / 90%		S18
Pb(II) propionate	14.58%	-	-	-	S19
1-butyl-3-methylimidazolium hexafluorophosphate ($BMIMPF_6$),	16.2%	Dark, RT, inert atmosphere Dark, RT, RH=30% 200 thermal cycles (25–100oC)	1200 h / 98.9% 1000 h / 88.6% 99.5%		S20
Guanidinium bromine (GABr)	16.97%	Dark, T=85oC, inert	120 h / 85%		S21

Additive	**PCE, %**	**Aging conditions**	**Aging time / Retained fraction (%) of the initial efficiency of PSCs**	**Aging time during which the films remain stable**	**Ref.**
		atmosphere Dark, RT, RH<20%	 1000 h / 85%		
4-guanidinobenzoic-acid hydrochloride (4-GBACl)	15.59%	Dark, RT, RH<20%	1200 h / 88%		S22
Phenethylammonium chlorine (PEACl) 4-fluoro-phenethylammonium chlorine (F-PEACl)	15.64% 16.29%	Dark, RT, RH=20%	1000 h / 87.2%		S23
p-type molecule (BTEC-2F)	16.25%	Dark, RT, RH=25%	500 h / 80%		S24
4-Aminobenzoic acid (ABA)	8.44%				S25
Butylamine iodine (BAI)	12%	Dark, RT, RH=35%		48 h	S26
Biuret additive consisting of functional amino and carbonyl groups	13.3%	Dark, RT, RH=20%	1000 h / ~80%		S27
Polymethylmethacrylate (PMMA)	11.18%	Dark, RT, inert atmosphere	~500 h / 80%		S28
Polyethylene glycol (PEG)	12.92%	Dark, RT, ambient air	2880 h / 90%		S29
Polyethylene glycol (PEG)	13.59%	Dark, RT, inert atmosphere	500 h / 85%		S30
Polyvinylpyrrolidone (PVP)	10.47%	Dark, RT, RH=50-60%		96 h	S31
Poly(N-alkyldiketopyrrolo-pyrrole dithienylthieno[3,2-b]thio-phene) (DPP-DTT)	15.14%	Dark, T=85^{o}C, inert atmosphere Dark, RT,	600 h / 90% ~530 h / ~96%		S32

Additive	PCE, %	Aging conditions	Aging time / Retained fraction (%) of the initial efficiency of PSCs	Aging time during which the films remain stable	Ref.
		RH<30%			
Polyethyleneimine (PEI) with multiple amino-groups	15.48%.	Dark, RT, RH<20±5%	500 h / 81.9%		S33
Phenylethylammonium chlorine (PEACl)	14.05%	Dark, RT, RH<60%	12 h / 80%		S34
CH3COOCs	10.53%	Dark, T=20 °C, RH ≈ 30%	~475 h / ~60%		S35
$Sm(AcAc)_3$	12.85%	Dark, T= 85 °C	200 h / 85%		S36
$FeCl_2$	17.1%	Light (100 mW/cm^2), RT, inert atmosphere	420 h / 76%		S37
$Eu(Ac)_3$	15.25%	Dark, room temperature, RH =35-40 %	720 h / 80%		S38
$Eu(Ac)_3$	12.1%	Dark, T=85^{o}C, inert atmosphere Dark, RT, RH=40%	200 h / 80% 500 h / 80%		S39
SrI_2	16.61%	Dark, RT, ambient air	100 h / 85%		S40
BaI_2	14.85 %	Dark, T=85^{o}C, ambient air	450 h / ~80%		S41
$LaCl_3$	8.03%	Dark, T=85^{o}C, RT, ambient air	450 h / ~80%		S42
Nb^{5+}	10.42%	-	-	-	S43
$InCl_3$	13.74%	-	-	-	S44
NiI_2	15.88%	Dark, RT, RH	550 h /		S45

Additive	PCE, %	Aging conditions	Aging time / Retained fraction (%) of the initial efficiency of PSCs	Aging time during which the films remain stable	Ref.
		~35 %	70%		
GeI_2	10.8 %	Dark, RT, RH ~30 %	7 h / ~100%		S46
YbI_2	14.04%	Dark, T=85^{o}C, RH ~30 %	280 h / 85%		S47
$CuBr_2$	16.15%	-	-		S48
$MgCl_2$	13.47%	Dark, T=25^{o}C, RH ~25 %	840 h / ~95%		S49
$CaCl_2$	16.79%	Dark, T=85^{o}C, room temperature, ambient air	1000 h / 90%		S50
CsBr	10.7%	Light (100 mW/cm^2), T=60^{o}C, inert atmosphere	500 h / ~70%	1000 h	S51
CsBr	6.7%	Dark, T=85^{o}C, RH ~85 %	240 h / 90%		S53
Lewis base adducts PbI_2(DMSO) and $PbBr_2$(DMSO)	14.78%	Dark, RT, RH ~20 %	500 h / ~95%		S54
Organic ligands armored ZnO		Light (100 mW/cm^2), RT, ambient atmosphere Dark, T=85^{o}C, inert atmosphere	200 h / ~90% 400 h / ~85%		S55

Table S2. The average and the best (in brackets) values of power conversion efficiency (*PCE*), open-circuit voltage (V_{OC}), short-circuit current density (J_{SC}), and fill factor (*FF*) of the devices with different **Asn** loadings.*

Asn loading, %	**V_{OC}, V**	**J_{SC}, mA cm^{-2}**	***FF*, %**	**PCE, %**
0	(1.136) 1.100 ± 0.036	(14.4) 13.9± 0.5	(71.0) 63.3 ± 6.7	(11.6) 9.7 ± 1.8
0.5	(1.115) 1.096 ± 0.018	(14.4) 13.7± 0.6	(75.2) 68.1± 6.9	(12.1) 10.2 ± 1.7
1.0	(1.089) 1.070 ± 0.019	(13.5) 12.9 ± 0.6	(71.3) 68.0 ± 3.3	(10.5) 9.4 ± 1.1
2.0	(1.074) 1.012 ± 0.061	(12.8) 12.1 ± 0.8	(66.3) 58.3 ± 7.8	(9.1) 7.1 ± 2.0

Notes: * *J*–*V* curves were measured in forward directions with a scan rate of 0.01 V/s

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