nanomaterials

MDPI

*Supplementary Materials*

# Effects of 5-Ammonium Valeric Acid Iodide as Additive on Methyl Ammonium Lead Iodide Perovskite Solar Cells

**Daming Zheng [1], Changheng Tong [1,2], Tao Zhu [1], Yaoguang Rong [2] and Thierry Pauporté [1,*]**

[1] Chimie ParisTech, PSL Research University, CNRS, Institut de Recherche de Chimie Paris (IRCP), UMR8247, 11 rue P. et M. Curie, F-75005 Paris, France; daming.zheng@chimieparistech.psl.eu (D.Z.); tch13986581570@gmail.com (C.T.); tao.zhu@chimieparistech.psl.eu (T.Z.)

[2] Wuhan National Laboratory for Optoelectronics, China-EU Institute for Clean and Renewable Energy, Huazhong University of Science & Technology (HUST), 430074, Hubei, China; ygrong@hust.edu.cn

* Correspondence: thierry.pauporte@chimieparistech.psl.eu

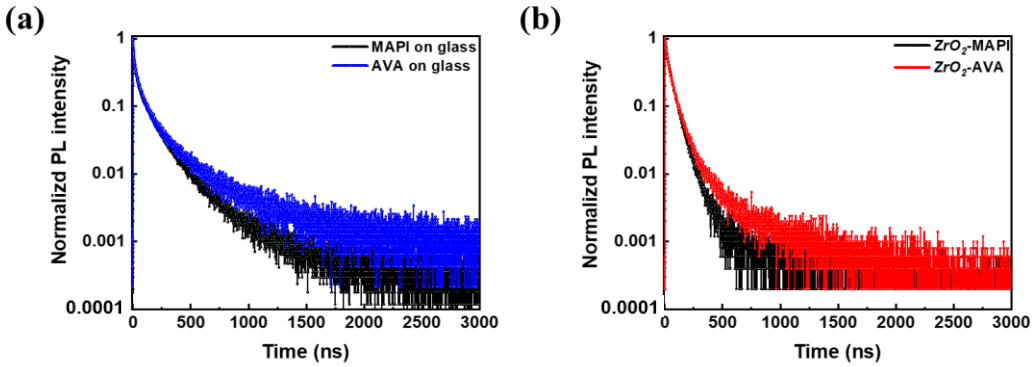


**Figure S1.** (**a**) TRPL of *1mp*-MAPI and *1mp*-AVA layers deposited on glass. (**b**) TRPL of *3mp*-MAPI and *3mp*-AVA layers deposited on mesoporous $ZrO_2$/glass.

**Table S1.** Fitting parameters by a triple exponential function of the TRPL curves of Figure S1.

| | **Fitting function:** $y = A_1\exp(-x/\tau_1) + A_2\exp(-x/\tau_2) + A_3\exp(-x/\tau_3) + y_0$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $y_0$ | $A_1$ | $\tau_{fast}$ (ns) | $RC_{fast}$ [a] | $A_2$ | $\tau_{int}$ (ns) | $RC_{int}$ [a] | $A_3$ | $\tau_{slow}$ (ns) | $RC_{slow}$ [a] |
| MAPI on glass | 7.6E-4 | 0.39 | 3.21 | 0.03 | 0.40 | 25.17 | 0.25 | 0.19 | 153.51 | 0.72 |
| AVA on glass | 1.6E-3 | 0.452 | 5.31 | 0.05 | 0.39 | 42.14 | 0.36 | 0.12 | 227.45 | 0.59 |
| MAPI on $ZrO_2$/Glass | 3.8E-4 | 0.31 | 6.93 | 0.05 | 0.58 | 39.31 | 0.49 | 0.24 | 88.01 | 0.46 |
| AVA on $ZrO_2$/Glass | 5.6E-4 | 0.41 | 9.85 | 0.09 | 0.61 | 51.47 | 0.65 | 0.07 | 181.4 | 0.26 |

[a] Relative contribution

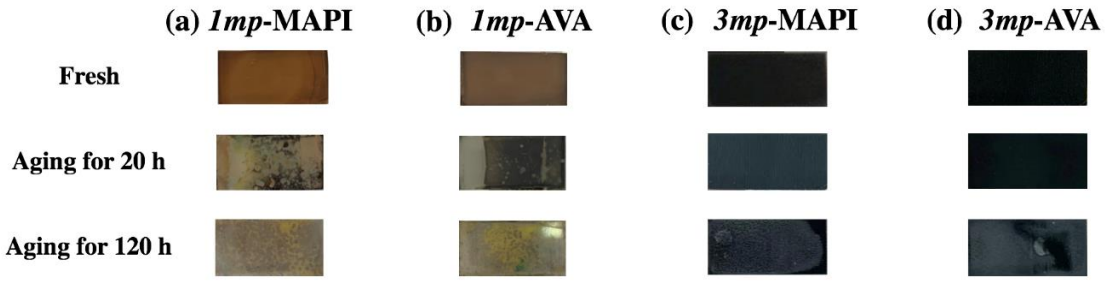


**Figure S2.** Pictures of PVK layers: fresh and after 20 h and 120 h aging at ≥90% RH/RT. The black/grey aspect of the *3mp* samples is due to the carbon back electrode. (**a**) *1mp*-MAPI, (**b**) *1mp*-AVA, (**c**) *3mp*-MAPI and (**d**) *3mp*-AVA.

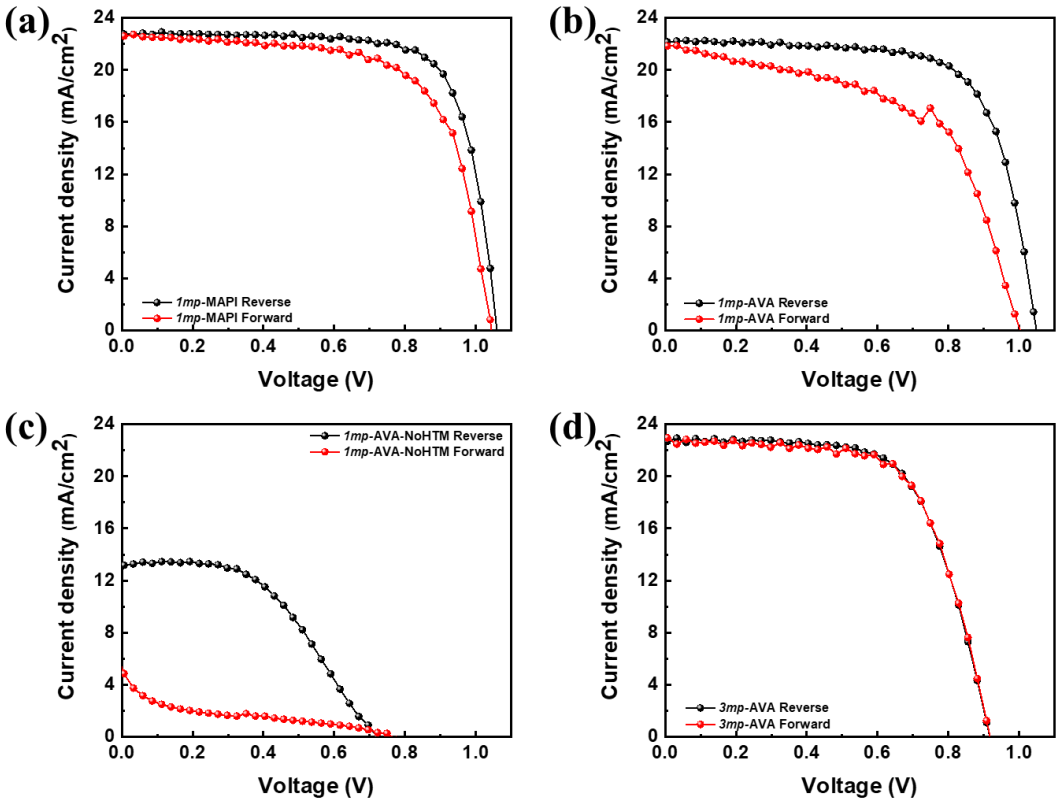


**Figure S3.** Forward and reverse *J-V* curves of (**a**) *1mp*-MAPI, (**b**) *1mp*-AVA, (**c**) *1mp*-MAPI-NoHTM and (**d**) *3mp*-AVA best cells.

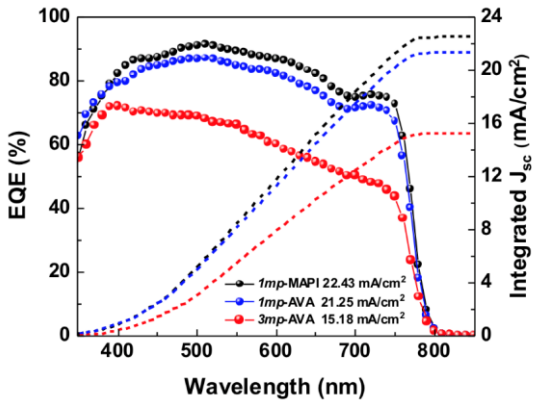


**Figure S4.** External quantum efficiency, EQE, spectra and $J_{sc}$ integration curves of the various cells.

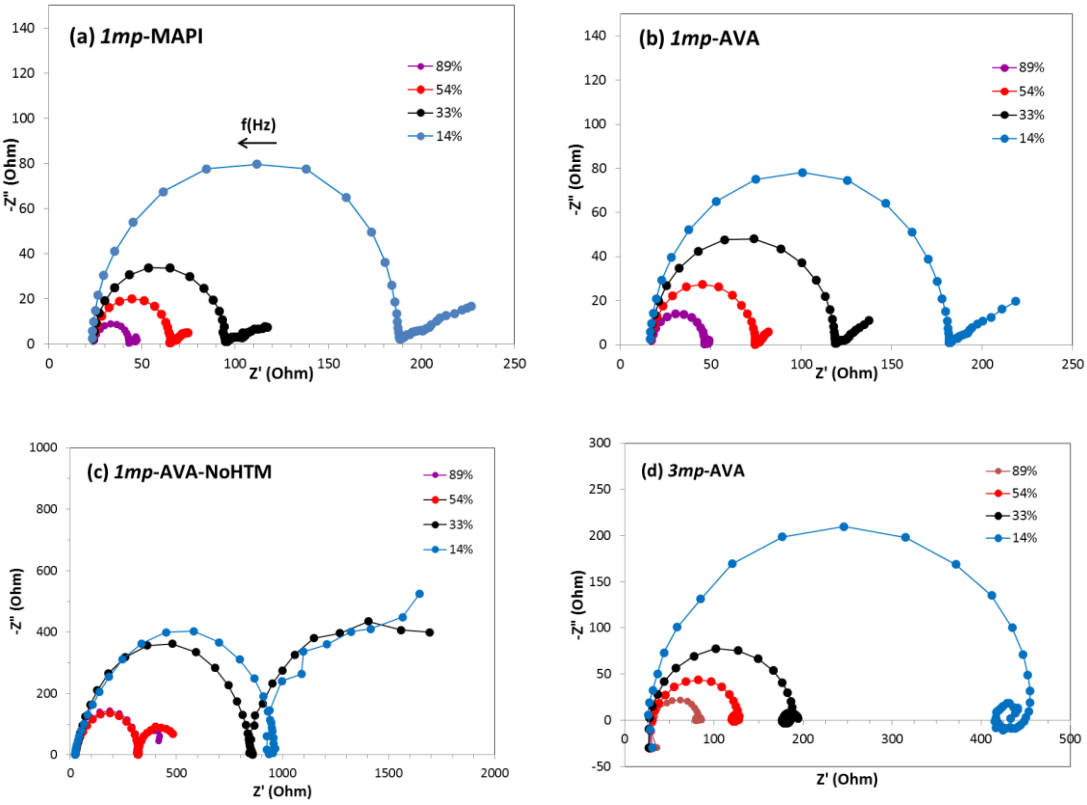


**Figure S5.** Effect of the light intensity in sun% on the impedance spectra measured at the $V_{oc}$. (**a**) *1mp*-MAPI, (**b**) *1mp*-AVA, (**c**) *1mp*-AVA-NoHTM and (**d**) *3mp*-AVA.

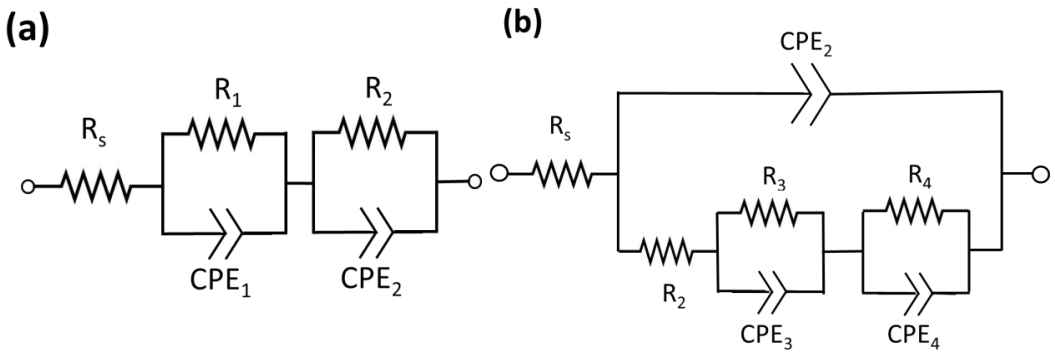


**Figure S6**. (**a**,**b**) Equivalent electrical circuits employed to fit impedance spectra of PSCs. See the core text for explanation. $R_S$, $R_1$, $R_2$, $R_3$ and $R_4$ are resistances. $CPE_1$, $CPE_2$, $CPE_3$ and $CPE_4$ are constant phase elements.

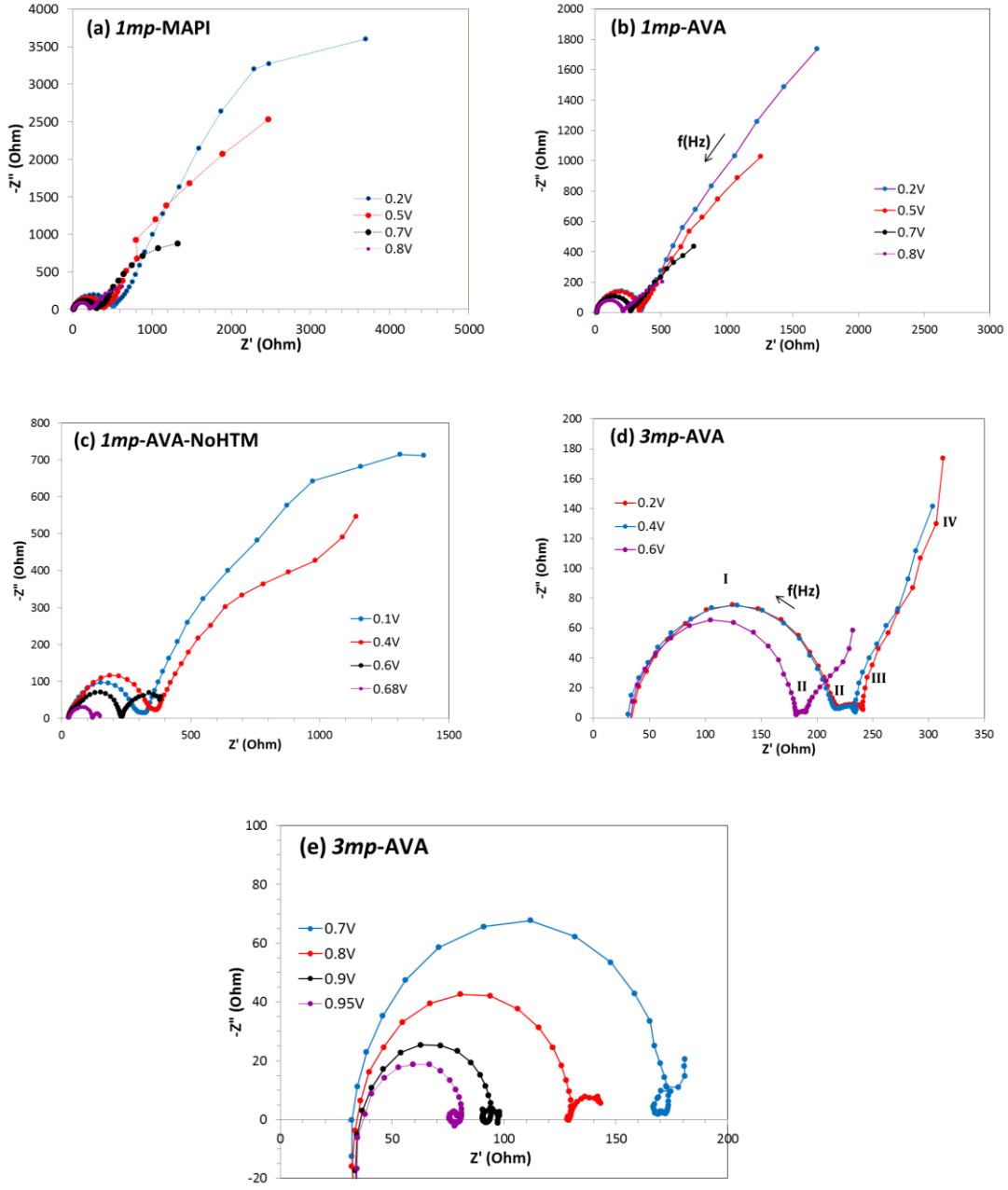


**Figure S7.** Effect of the applied voltage on the impedance spectra of the investigated cells. (a) *1mp*-MAPI, (b) *1mp*-AVA (c) *1mp*-AVA-NoHTM, (d) *3mp*-AVA low voltage and (e) *3mp*-AVA high voltage.

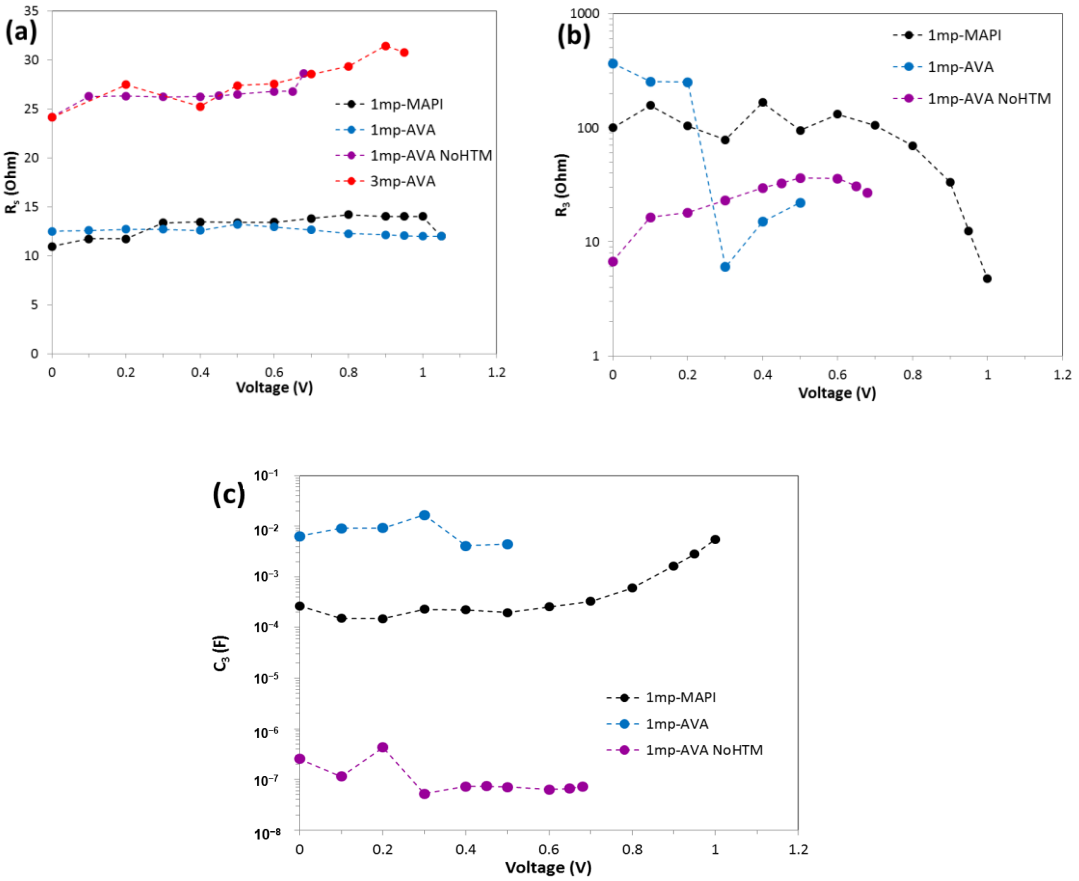


**Figure S8.** Effect of $V_{appl}$ on (**a**) $R_s$, (**b**) $R_3$ and (**c**) $C_3$ parameters.