

Electronic Supplementary Material

Ethacridine lactate additive engineering for defect passivation in HTL-free carbon electrode perovskite solar cells

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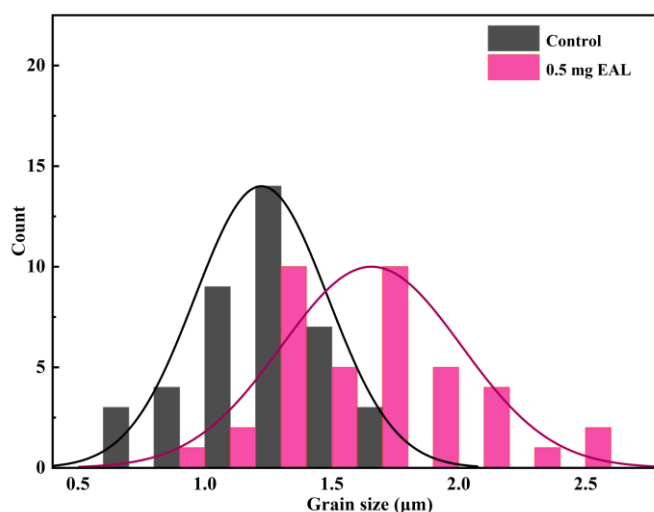


Fig. S1 Grain size distribution derived from SEM images of the control perovskite film and the perovskite film modified with 0.5 mg EAL in 1 mL of solvent.

Figure S1 shows the grain size distribution derived from SEM images of the control perovskite film and the perovskite film modified with 0.5 mg EAL in 1 mL of solvent. Upon the addition of 0.5 mg EAL, the average grain size increased from 1.2 to 1.6 μm , indicating reduced grain-boundary density, suppressed non-radiative recombination, and increased carrier lifetime.

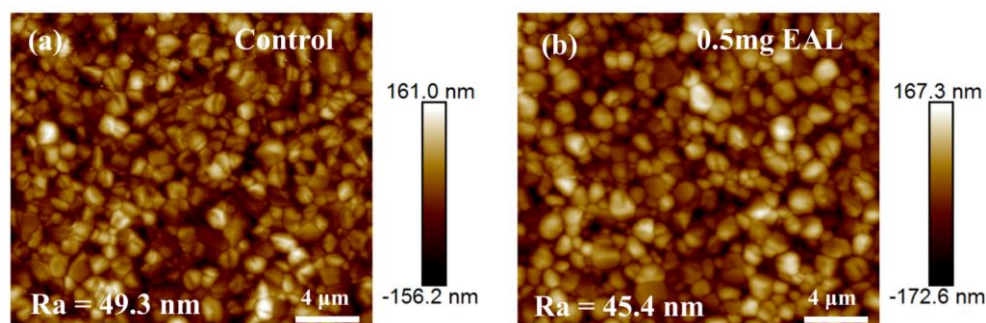


Fig. S2 AFM images and surface roughness analysis: (a) the control perovskite film; (b) the perovskite film modified with 0.5 mg EAL in 1 mL of solvent.

Figure S2(a) and S2(b) show AFM images of the control perovskite film and the perovskite film modified with 0.5 mg EAL in 1 mL of solvent. The control perovskite film exhibits a relatively rough surface, with a root-mean-square (RMS) roughness of 49.3 nm. After the incorporation of EAL, the surface roughness decreased to 45.4 nm. The smoother surface is beneficial for improving the perovskite/carbon interface in HTL-free PSC devices.

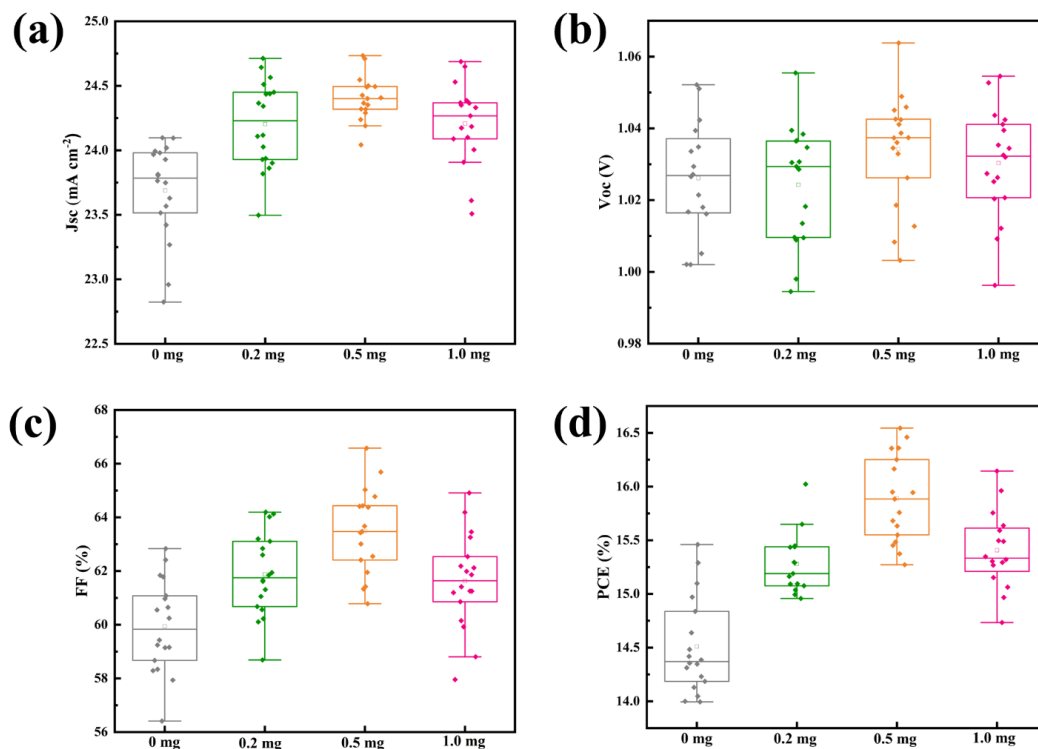


Fig. S3 Box plots of photovoltaic parameters of devices prepared with different amounts of EAL (0, 0.2, 0.5, and 1.0 mg) added to 1 mL of precursor solution: (a) J_{sc} ; (b) V_{oc} ; (c) FF; (d) PCE.

The photovoltaic parameters of 60 devices (15 devices per condition: 0, 0.2, 0.5, and 1.0 mg of EAL) are shown in Fig. S3. Devices containing EAL exhibited significant improvements in J_{sc} , V_{oc} , and FF. Among all conditions, the devices modified with 0.5 mg EAL achieved the best overall performance. However, further increasing the EAL amount to 1.0 mg led to a decline in device performance. Compared with the control devices, the 0.5 mg EAL-modified devices showed an increase in J_{sc} from 24.11 to 24.74 mA cm^{-2} , V_{oc} from 1.05 to 1.06 V, FF from 62.41% to 66.57%, and PCE from 15.46% to 16.54%.

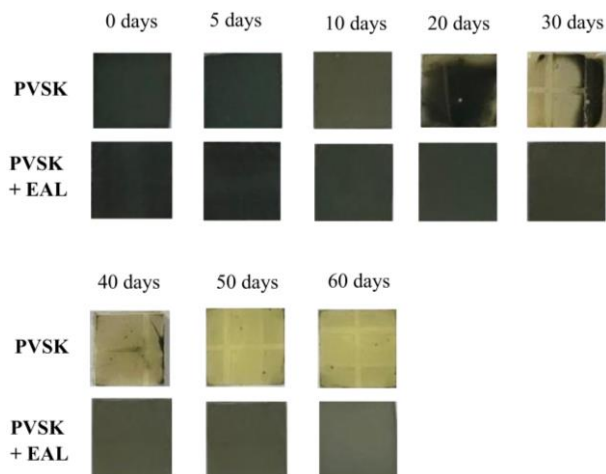


Fig. S4 The impact of environmental conditions on the control perovskite film and the perovskite modified with 0.5 mg EAL in 1 mL of solvent.

Figure S4 presents the visual changes in the control perovskite film and the perovskite film modified with 0.5 mg EAL in 1 mL of solvent under ambient conditions. The control film began to deteriorate after 20 d and became severely degraded by day 60, whereas the film modified with 0.5 mg EAL in 1 mL of solvent maintained much better environmental stability and remained relatively intact even after 60 d.