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


# Supporting Information

# An Effective Encapsulation for Perovskite Solar Cells Based on Its Building Integration Photovoltaics

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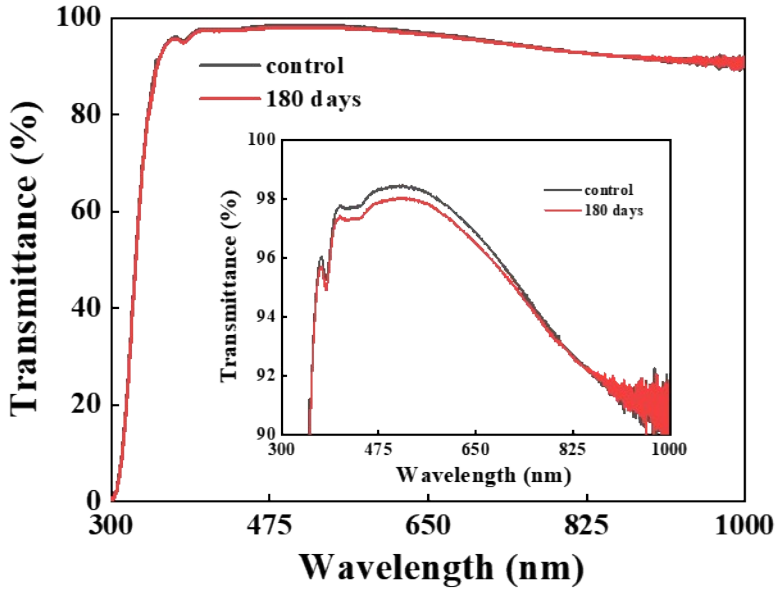


**Fig. S1** 95.1% of the transmittance is for the AHMA/Glass (control), and 94.9% after 180 days under light illumination.

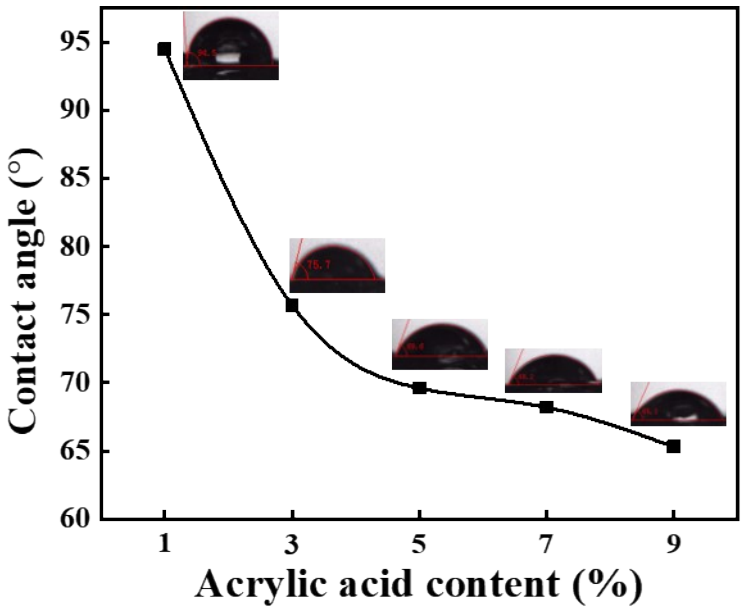


**Fig. S2** The water contact angle of AHMA with different acrylic acid content.

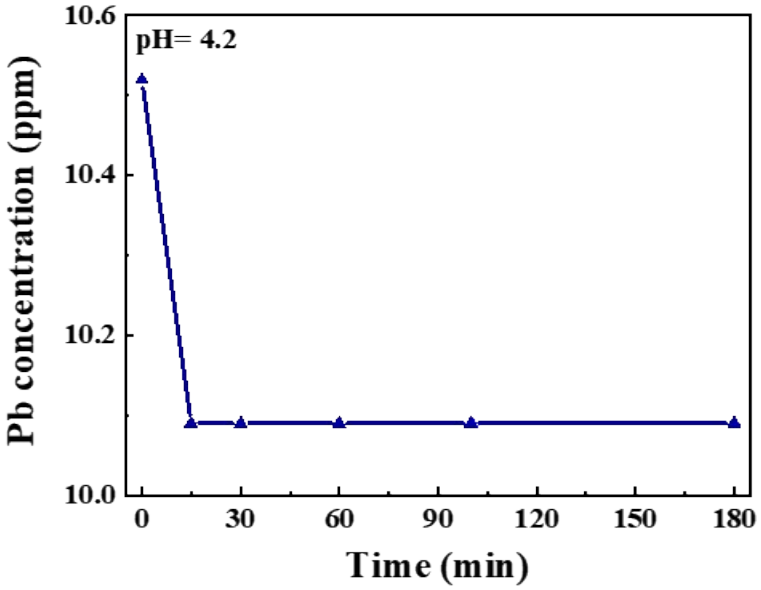


**Fig. S3** Lead ion concentration tracking of $PbNO_3$ solution (pH= 4.2) soaked with AHMA film at 40 ℃ (140 mg of AHMA coated on 25*25mm of glass).

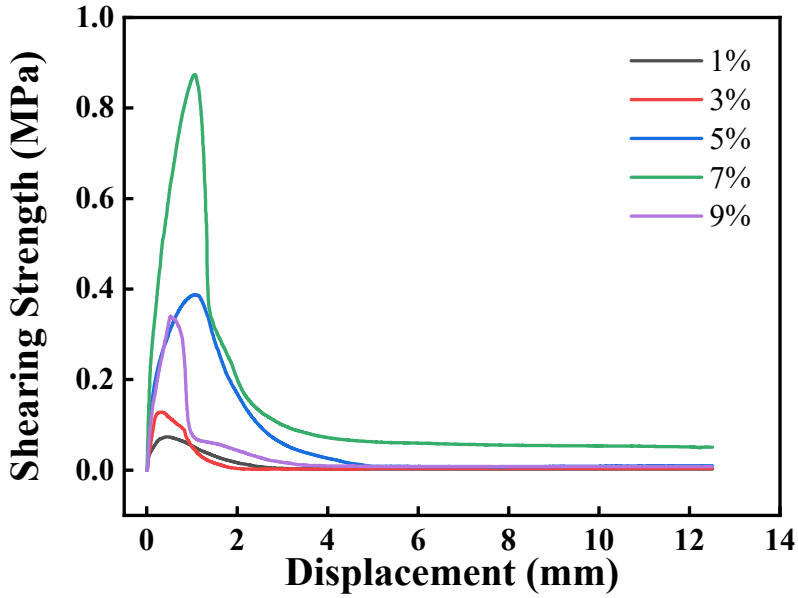


**Fig. S4** Shear strength between glass and AHMA with different content of acrylic acid. Two glasses sheets bonded by a AHMA film (12.5 mm * 25 mm). It was measured on an electronic universal testing machine at a deflection rate of 5 mm/min.

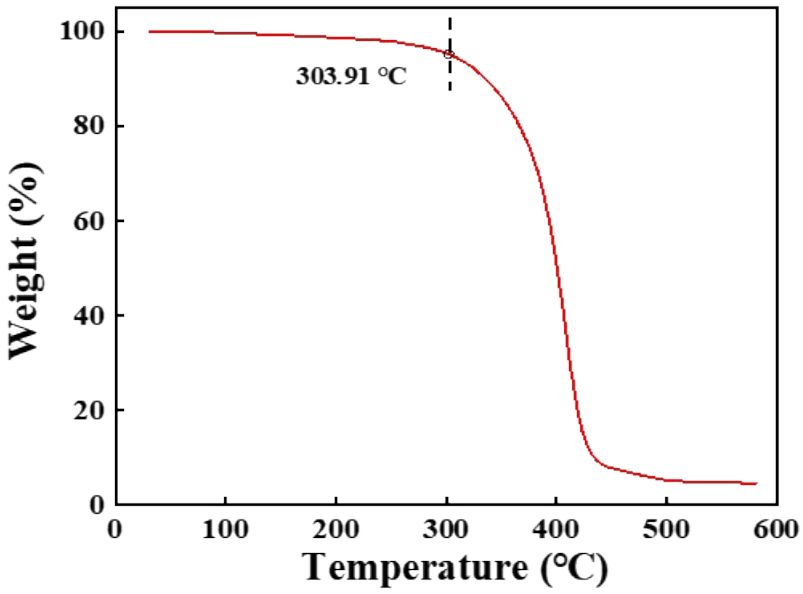


**Fig. S5** TG curves of AHMA with 7% of acrylic acid.

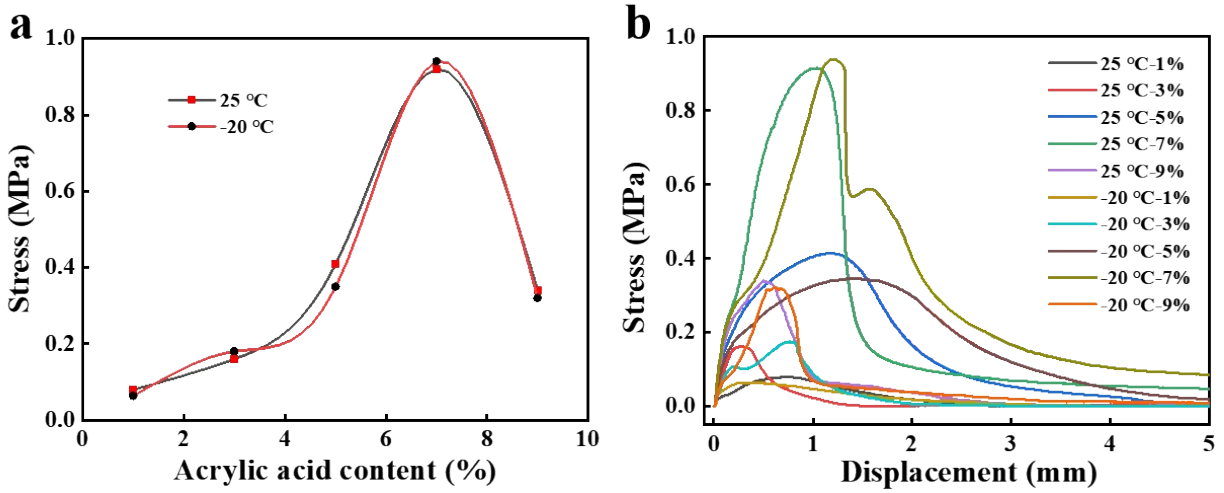


**Fig. S6** Good cold resistance of the AHMA materials has been confirmed, the bond shear strength of which at -20 °C is consistent with that at room temperature.

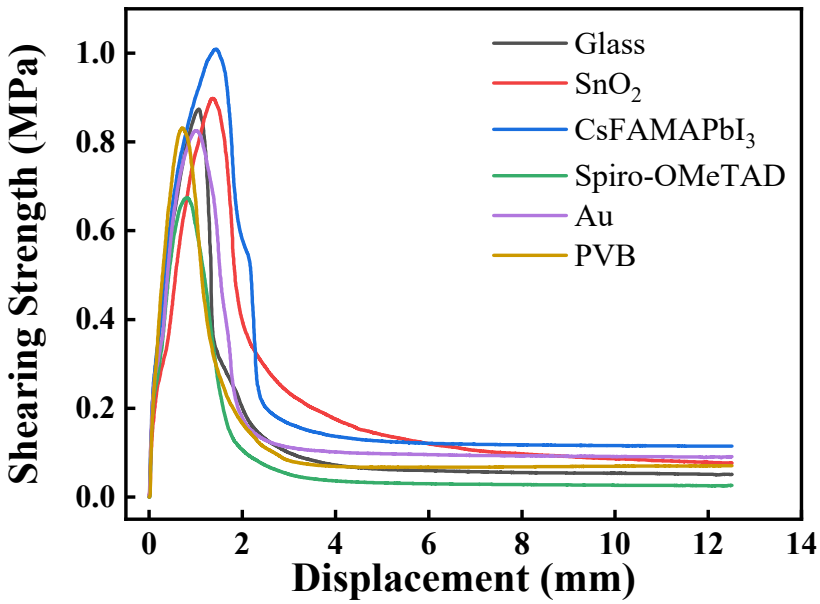


**Fig. S7** The shear strengths among AHMA with different materials of each layer in photovoltaic building integrated module.

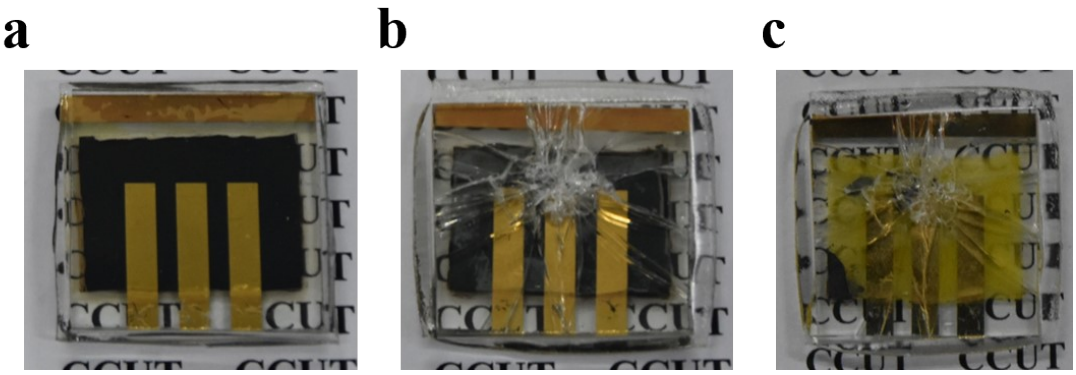


**Fig. S8** Lead leakage on perovskite modules. (a) Image of the PSCs encapsulated with PVB-glass. (b) Images of the damaged PSCs encapsulated with PVB-glass by falling ball impact with a 100 g of steel ball at 50.8 cm of high. (c) Images of the damaged PSCs after dripping by heavy rainfall (pH=4.2) at 5 mL $h^{-1}$ for 6 h.


**Fig. S9** Images of the damaged PSCs soaking in 40 mL of water (pH=4.2 and 6.8).

**Fig. S10** Setup of water-dripping tests. Photograph of the setup for water-dripping tests.

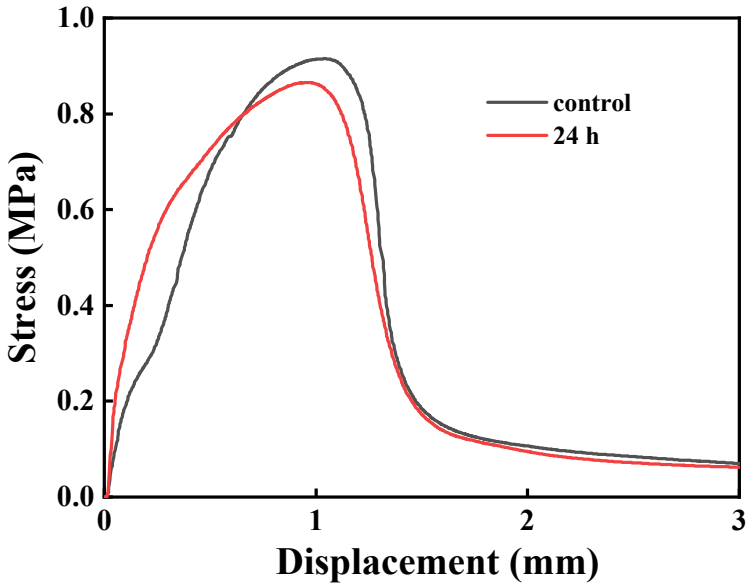


**Fig. S11** After soaking in water for 24 hours, the bonding shear strength between AHMA with 7% of acrylic acid and glass decreased by less than 0.05 MPa.

**Table S1.** Lead ion concentration tracking of $PbNO_3$ solution (pH= 4.2) soaked with AHMA film at 40 ℃ (140 mg of AHMA coated on 25*25mm of glass).

| Time (min) | Pb concentration (ppm) |
|---|---|
| 0 | 10.52 |
| 15 | 10.09 |
| 30 | 10.09 |
| 60 | 10.09 |
| 100 | 10.09 |
| 180 | 10.09 |

**Table S2.** The water contact angle of AHMA film with different acrylic acid content; Shear strength between glass and AHMA with different content of acrylic acid; Adhesion holding force between glass and AHMA with different acrylic acid content at 70 ℃, based on 12*25 mm of the adhesive area and 500 g of the weight.

| Acrylic acid content (%) | Water contact angle (°) | Shearing strength (MPa) | Time(s) |
|---|---|---|---|
| 1 | 94.5 | 0.08 | 45 |
| 3 | 75.7 | 0.15 | 62 |
| 5 | 69.6 | 0.40 | 91 |
| 7 | 68.2 | 0.91 | 103 |
| 9 | 65.3 | 0.34 | 98 |

**Table S3.** The shear strengths among AHMA with different materials of each layer in photovoltaic building integrated module.

| Material | Shearing strength (MPa) |
|---|---|
| Glass | 0.89 |
| $SnO_2$ | 0.89 |
| $FAMAPbI_3$ | 1.04 |
| Spiro-OMeTAD | 0.69 |
| AU | 0.84 |
| PVB | 0.84 |

**Table S4.** Lead leakage on perovskite modules. Non-encapsulated (Control) and AHMA-PVB-Glass encapsulated (Encapsulation) PSCs, impact resistance of which was detected by free fall impact with a 100 g of steel ball at 50.8 cm of high. Images of the damaged PSCs after soaking in 40 mL of water (pH=4.2 and 6.8) for different time. Detection of $Pb^{2+}$ concentration in water after soaking with damaged PSC modules with and without encapsulation.

| **Time (min)** | **Control pH=4.2** | **Encapsulation pH=4.2** | **Encapsulation pH=6.8** |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 30 | 2.868 | 1.138 | 0.1106 |
| 60 | 3.807 | 1.104 | 0.1705 |
| 90 | 4.100 | 0.8094 | 0.0637 |
| 120 | 4.317 | 0.8090 | 0.4262 |
| 150 | 4.500 | 1.079 | 0.1476 |
| 180 | 4.607 | 0.8244 | 0.4045 |

**Table S5.** Detection of $Pb^{2+}$ concentration in solution from the damaged PSC modules with and without encapsulation by dripping with heavy rainfall for different time.

| Time (h) | AHMA-PVB | PVB | Control |
|---|---|---|---|
| 1.5 | 0.0010 | 0.1039 | 2.384 |
| 3 | 0.3915 | 0.5479 | 3.524 |
| 6 | 0.7029 | 1.992 | 17.32 |

**Table S6.** Summary of the photovoltaic parameters obtained from the champion devices for pre- and post-encapsulation. Measurements were performed with 0.0625 $cm^2$ active area and under AM 1.5G solar illumination.

| Sample | $V_{oc}$ (V) | $J_{sc}$ (mA $cm^{-2}$) | FF | PCE (%) |
|---|---|---|---|---|
| Control (reverse) | 1.14 | 24.13 | 0.79 | 21.78 |
| Control (forward) | 1.13 | 24.24 | 0.80 | 21.96 |
| Encapsulation (reverse) | 1.12 | 24.20 | 0.76 | 20.59 |
| Encapsulation (forward) | 1.12 | 24.21 | 0.77 | 20.88 |

**Movie S1.**

Falling ball impact (100 g of steel balls, 50.8 cm) video of unencapsulated devices.

**Movie S2.**

Falling ball impact (100 g of steel balls, 50.8 cm) video of encapsulated devices.