

## **Two-Step Thermal Annealing Improves the Morphology of Spin-Coated Films for Highly Efficient Perovskite Hybrid Photovoltaics**

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Table S1. PV parameters of perovskite devices prepared using various fabrication

devices	$J_{sc}$ (mA cm <sup>-2</sup> )	$V_{oc}$ (V)	FF(%)	PCE (%)
70°C (30min)	N.A.	N.A.	N.A.	N.A.
70°C (30min) <sup>a</sup>	9.0	0.96	72.1	6.2 (5.9)
80°C (30min)	15.7	0.67	48.4	5.1(4.7)
80°C (30min) <sup>b</sup>	14.6	0.84	54.2	6.7(6.3)

<sup>a</sup> Devices annealed at 70 °C for 30 min and then at 100 °C for 2 min. <sup>b</sup> annealed at 80 °C for 30 min and then at 100 °C for 2 min.

Table S2 Photovoltaic parameters of perovskite devices (20 wt%–derived device that had been subjected to a two-step annealing process) after storage for various periods of time in a N<sub>2</sub>-filled glove box

devices	$J_{sc}$ (mA cm <sup>-2</sup> )	$V_{oc}$ (V)	FF(%)	PCE (%)
pristine	14.3	0.86	60.9	7.5(7.3)
168 h	14.1	0.85	61.2	7.3(7.2)
336 h	14.7	0.87	61.4	7.9(7.5)
504h	14.5	0.88	62.1	7.9(7.8)
672h	14.5	0.87	65.4	8.3(7.7)
840h	14.6	0.90	63.9	8.4(8.2)
1008h	14.7	0.90	64.9	8.6(8.2)
1176h	14.3	0.90	68.0	8.8(8.5)
1344h	14.7	0.91	67.9	9.1(8.6)

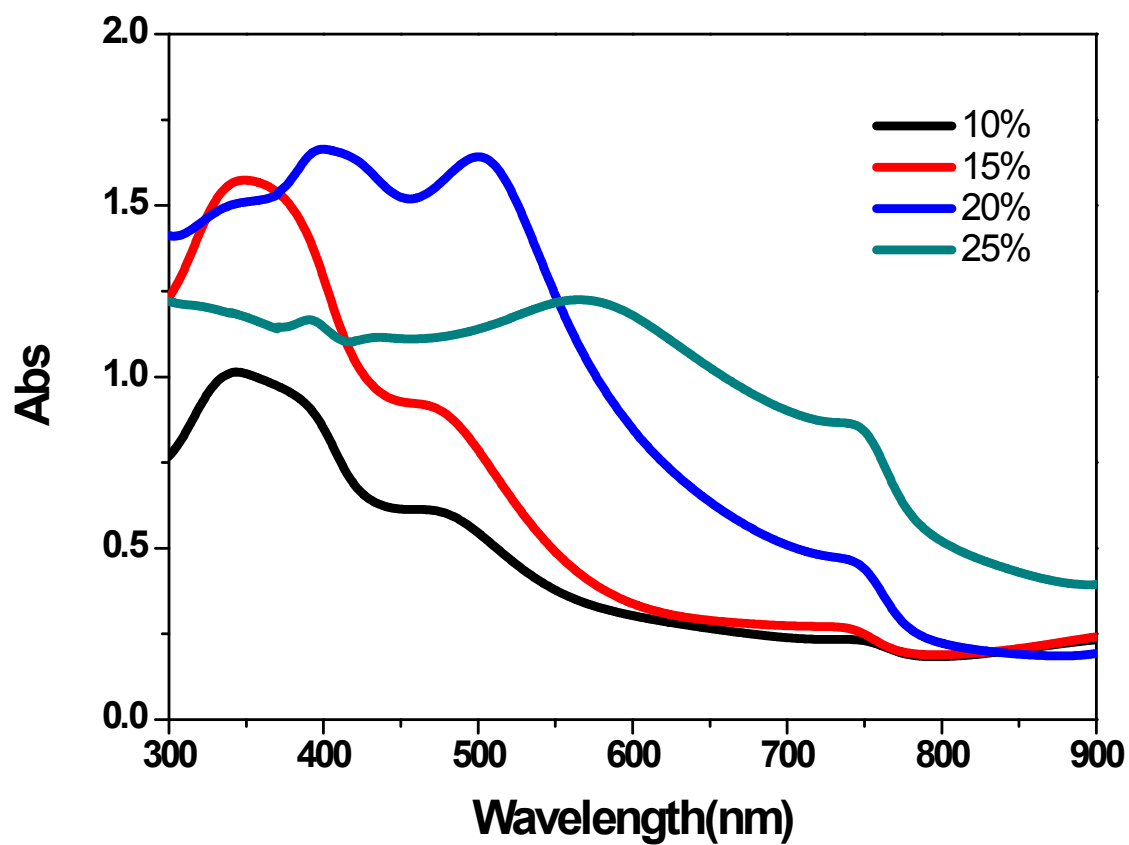


Figure S1. UV-Vis spectra of perovskite films obtained from various precursor concentrations, after annealing at 100 °C for 5 min.

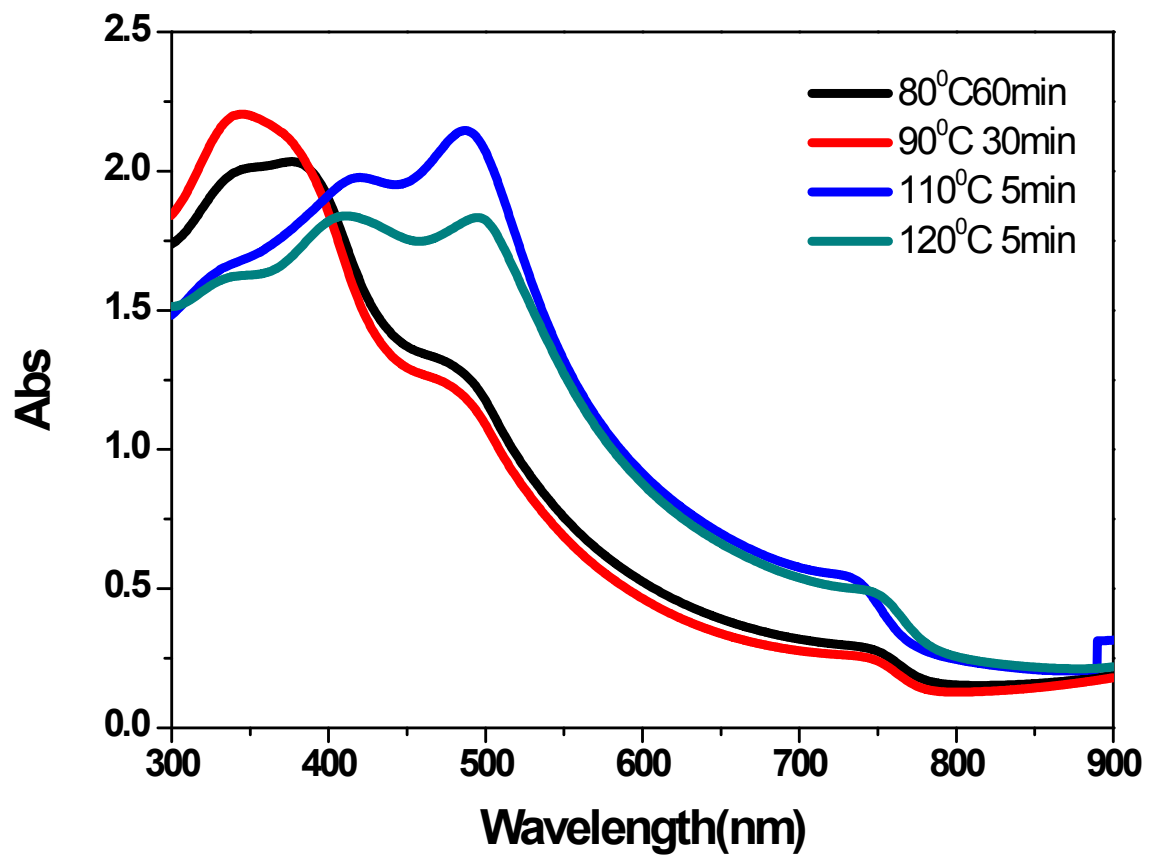


Figure S2. UV-Vis spectra of perovskite films obtained from the 20 wt% precursor concentration, after at annealing under various conditions.

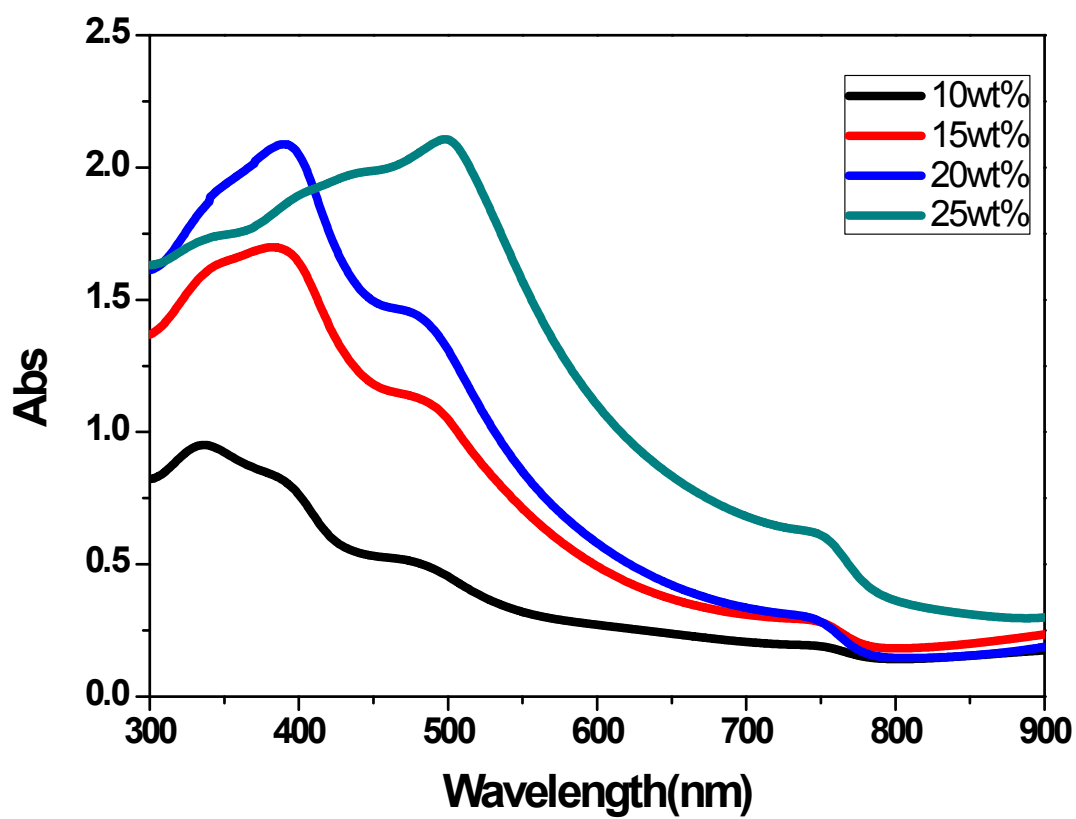


Figure S3. UV-Vis spectra of perovskite films obtained from various precursor concentrations, after two-step annealing.

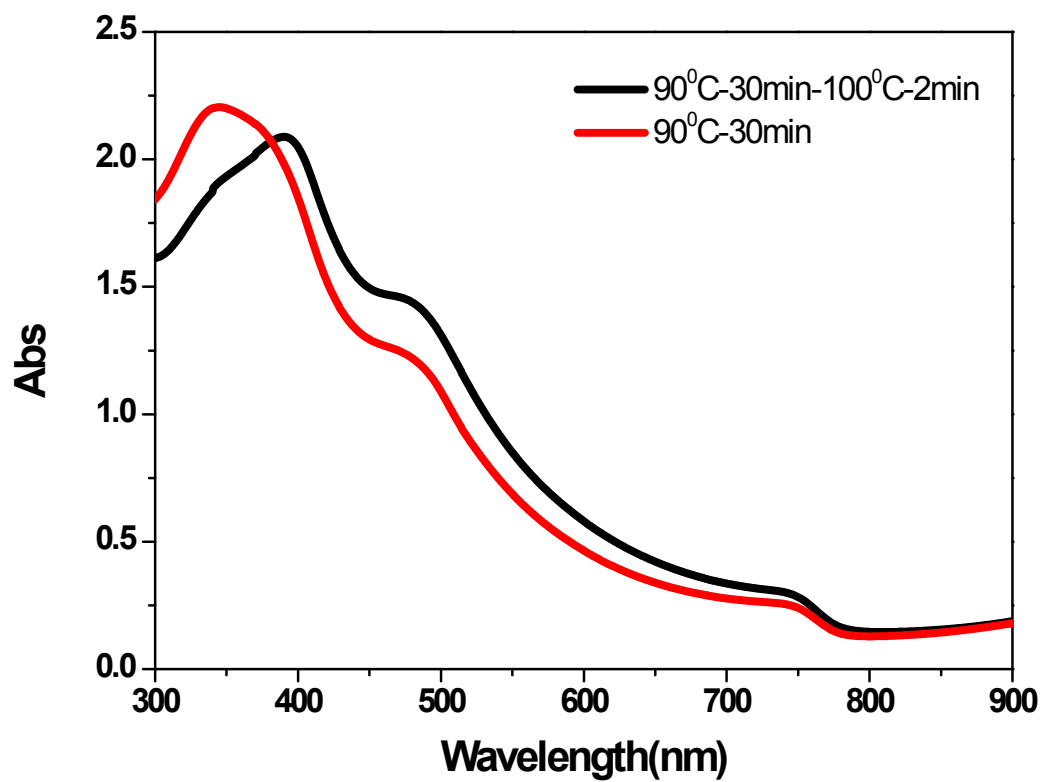


Figure S4. UV-Vis spectra of the perovskite films of 90 °C for 30 min and the film that had been subjected to a two-step annealing process.