

Supplementary information for: *Systematic study of the impact of water on
the performance and stability of perovskite solar cells*

Charlotte Clegg and Ian G. Hill

Department of Physics and Atmospheric Science

Dalhousie University, 1459 Oxford St.

Halifax, NS, Canada, B3H 4R2

January 31st, 2016

1 Electronic supplementary information:

Table 1: Summary of performance metrics for devices with varying moisture contents in the PbI_2 solution. Errors represent the standard deviation of 9 - 16 devices measured with a 1.0 V/s scan rate.

$[\text{H}_2\text{O}]_{\text{PbI}_2}$ mol%	V_{oc} (V)	J_{sc} (mA/cm^2)	PCE (%)	Fill factor	R_{series} (Ω)	R_{shunt} k(Ω)
0	0.94 ± 0.05 (1.00)	15.62 ± 1.88 (19.70)	10.5 ± 1.6 (13.8)	0.72 ± 0.02 (0.74)	160 ± 20 (130)	100 ± 50 (180)
1	0.83 ± 0.03 (0.89)	14.36 ± 2.44 (18.07)	6.8 ± 2.0 (10.2)	0.55 ± 0.05 (0.63)	370 ± 120 (180)	20 ± 7 (34)
2	0.83 ± 0.01 (0.85)	13.31 ± 1.96 (18.37)	6.3 ± 0.8 (8.5)	0.58 ± 0.02 (0.61)	560 ± 140 (310)	30 ± 6 (400)
4	0.81 ± 0.02 (0.84)	15.25 ± 1.02 (16.56)	6.2 ± 0.6 (7.5)	0.51 ± 0.04 (0.57)	570 ± 140 (350)	20 ± 5 (30)
6	0.82 ± 0.03 (0.86)	14.07 ± 1.03 (15.74)	6.4 ± 0.5 (7.1)	0.56 ± 0.02 (0.60)	450 ± 120 (300)	30 ± 10 (70)

Table 2: Summary of performance metrics for devices with varying moisture contents in the PbI_2 solution. Errors represent the standard deviation of 9 - 16 devices measured with a 0.1 V/s scan rate.

$[\text{H}_2\text{O}]_{\text{PbI}_2}$ mol%	V_{oc} (V)	J_{sc} (mA/cm^2)	PCE (%)	Fill factor	R_{series} (Ω)	R_{shunt} k(Ω)
0	0.98 ± 0.04 (1.00)	14.58 ± 1.70 (18.10)	10.4 ± 1.5 (13.6)	0.73 ± 0.04 (0.76)	180 ± 50 (130)	60 ± 20 (100)
1	0.91 ± 0.02 (0.95)	13.88 ± 2.33 (17.20)	7.9 ± 1.7 (10.8)	0.62 ± 0.03 (0.66)	310 ± 90 (200)	20 ± 3 (30)
2	0.88 ± 0.02 (0.92)	10.60 ± 1.50 (14.69)	6.2 ± 0.8 (8.5)	0.67 ± 0.02 (0.70)	450 ± 100 (300)	56 ± 30 (110)
4	0.90 ± 0.01 (0.92)	13.11 ± 1.20 (14.69)	7.6 ± 0.7 (8.8)	0.65 ± 0.02 (0.68)	370 ± 90 (240)	50 ± 15 (90)
6	0.90 ± 0.01 (0.93)	11.66 ± 1.13 (13.88)	7.1 ± 0.7 (8.2)	0.68 ± 0.02 (0.70)	360 ± 100 (260)	50 ± 20 (240)

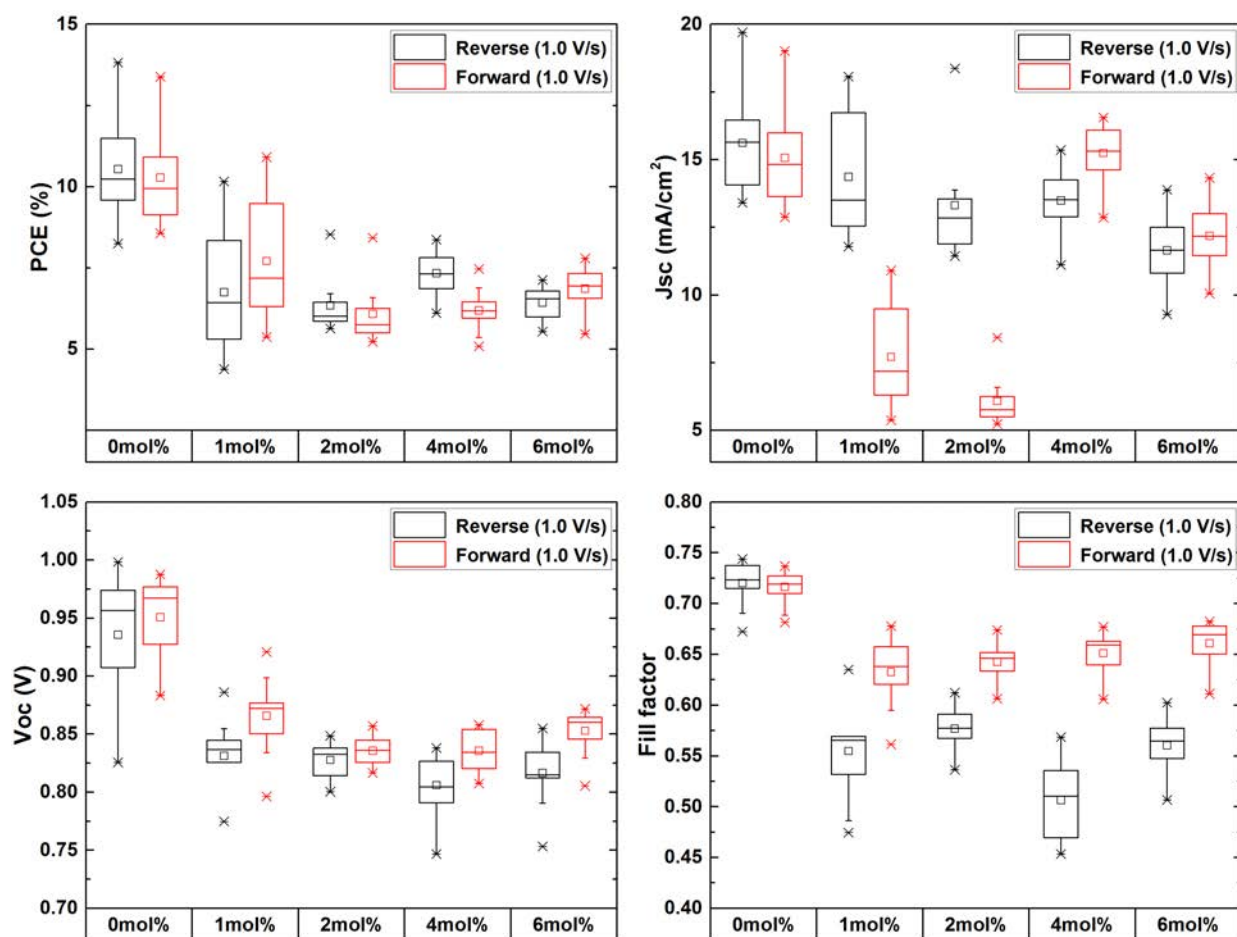


Figure 1: Summary of performance metrics for devices made using varying concentrations of H₂O in the PbI₂ solution. Data are representative of 9 - 16 devices tested by sweeping at 1.0 V/s in the reverse direction (black) and forward direction (red). The spread of the data, mean, median and outliers are represented by the vertical bars, small square, horizontal line and crosses, respectively.

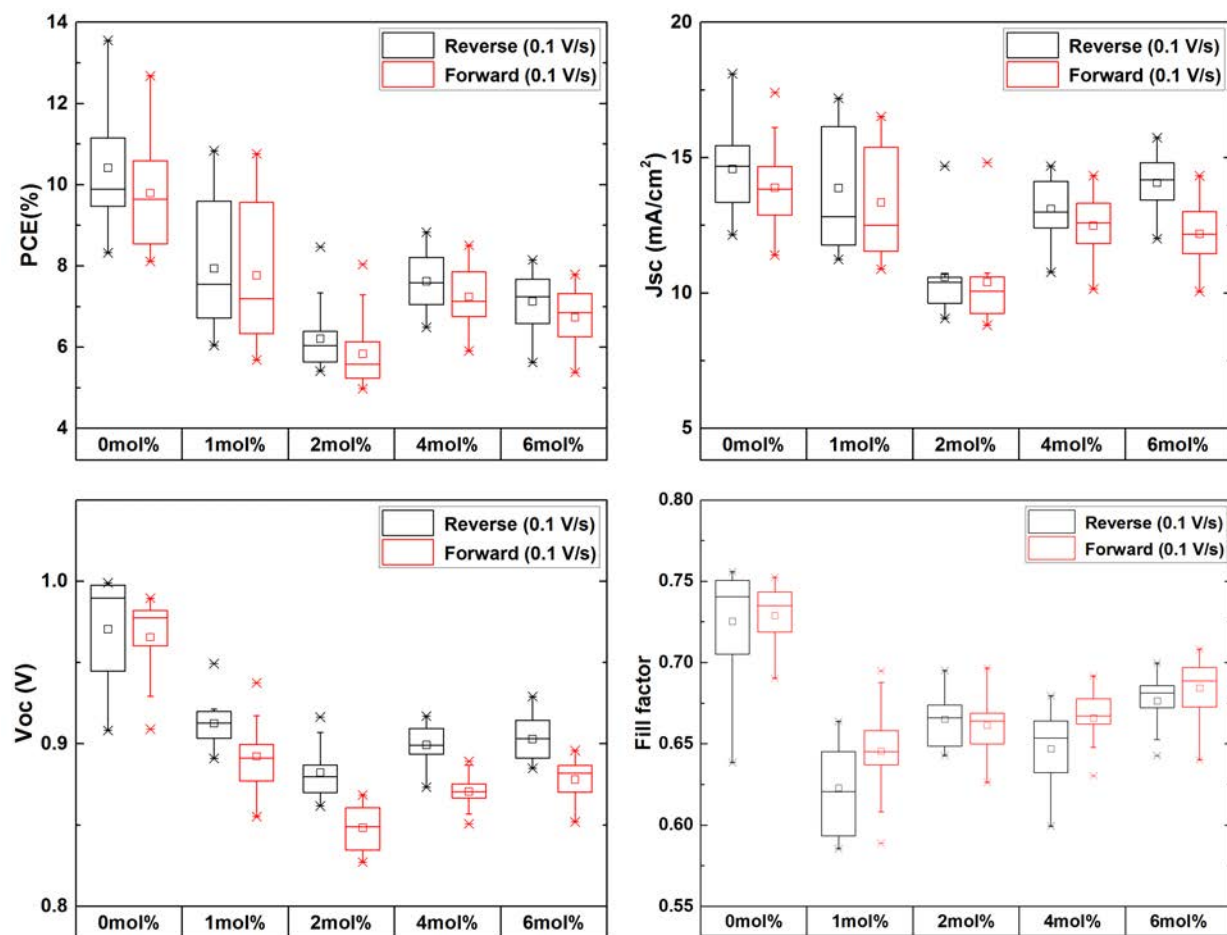


Figure 2: Summary of performance metrics for devices made using varying concentrations of H₂O in the PbI₂ solution. Data are representative of 9 - 16 devices tested by sweeping at 0.1 V/s in the reverse direction (black) and forward direction (red). The spread of the data, mean, median and outliers are represented by the vertical bars, small square, horizontal line and crosses, respectively.

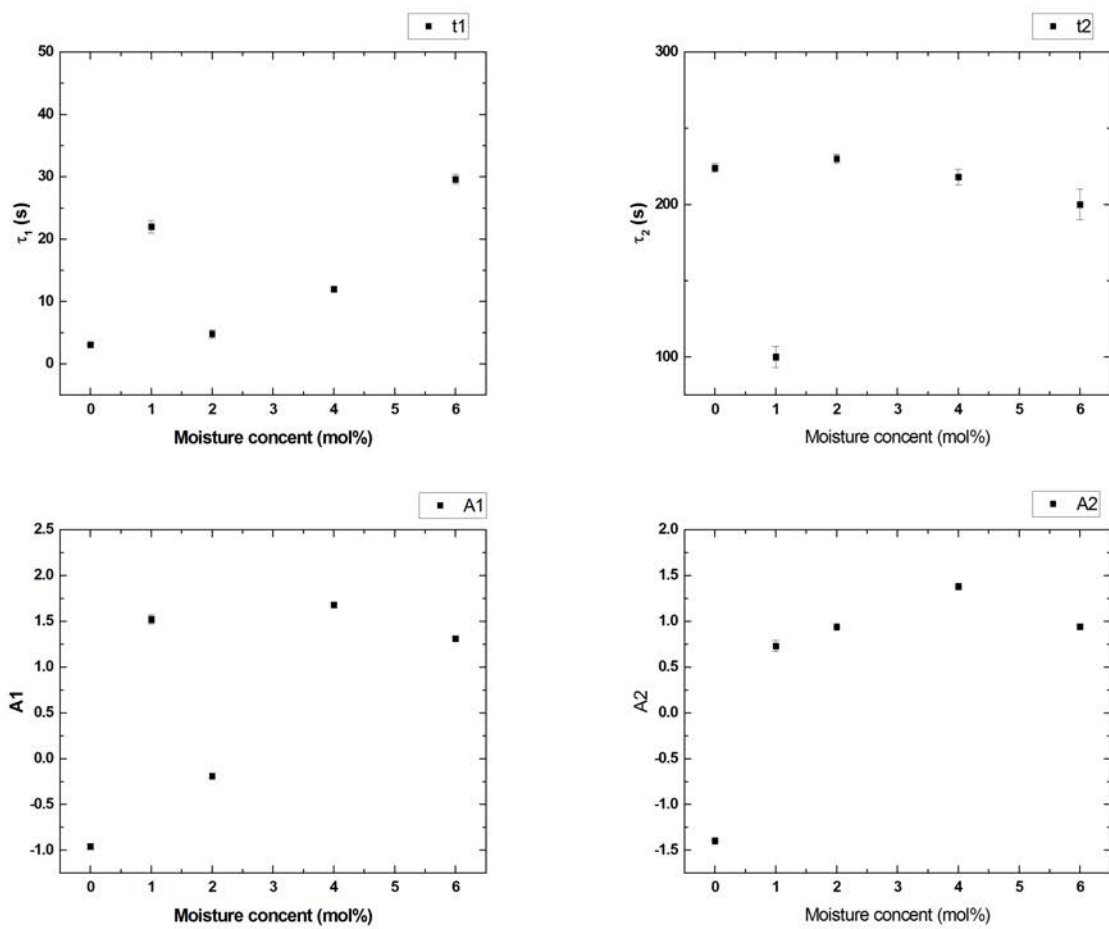


Figure 3: Derived parameters from a biexponential fit applied to transient photocurrent behaviours measured over 500 seconds.

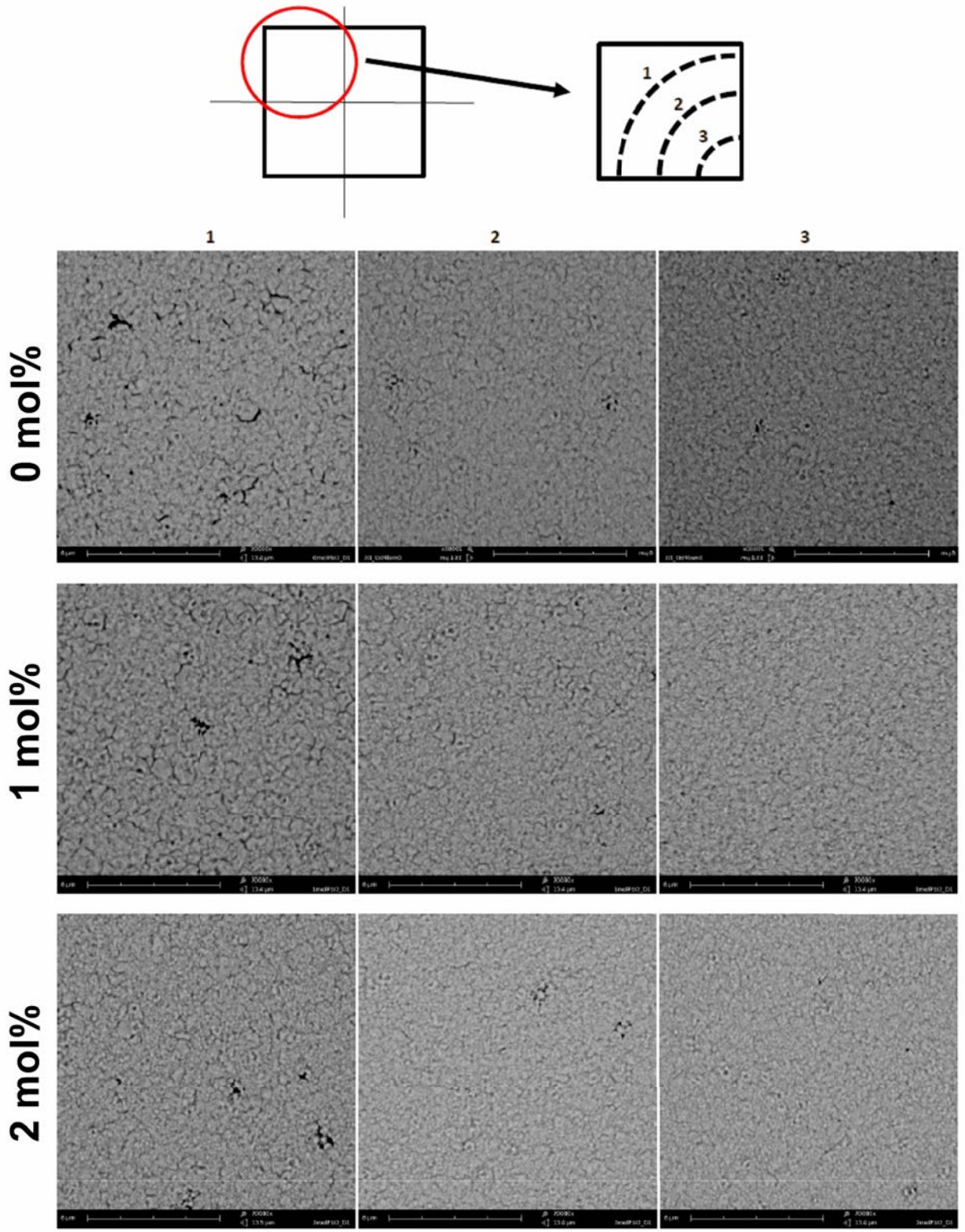


Figure 4:

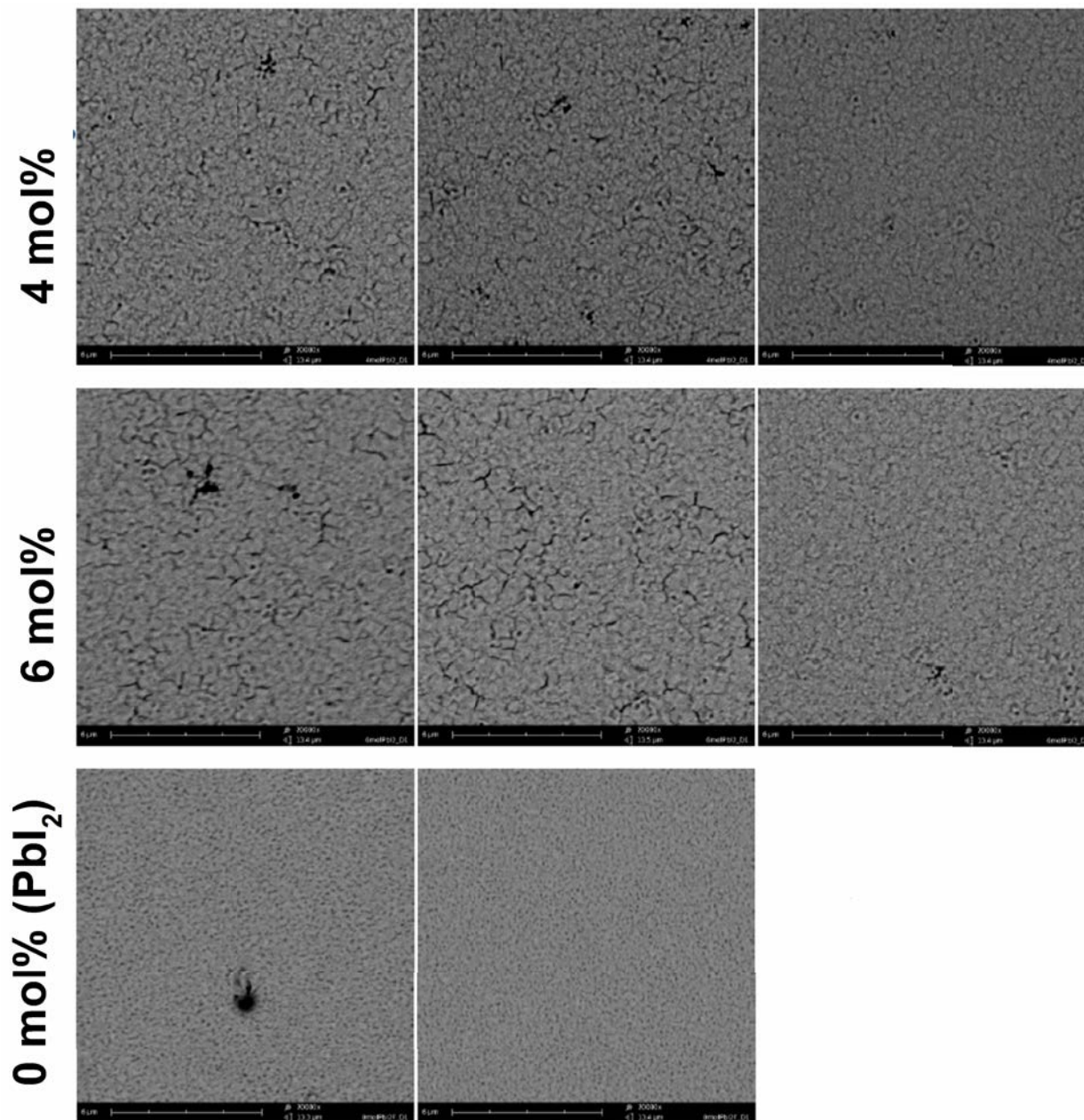


Figure 5: Top view SEM images of films made with varying concentrations of H_2O in the PbI_2 solution. Due to size restrictions associated with the SEM sample stage, films were cut into quarters as indicated. Images were taken at three different locations on the film as indicated. Images collected at position 2 are most representative of the perovskite surface where devices would be made on a similarly sized substrate