Supporting Information

Oxygen- and Water-induced Energetics Degradation in Organometal Halide Perovskites

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Keywords: organometal halide perovskites; energetics; oxygen/water; degradation; perovskite solar cell

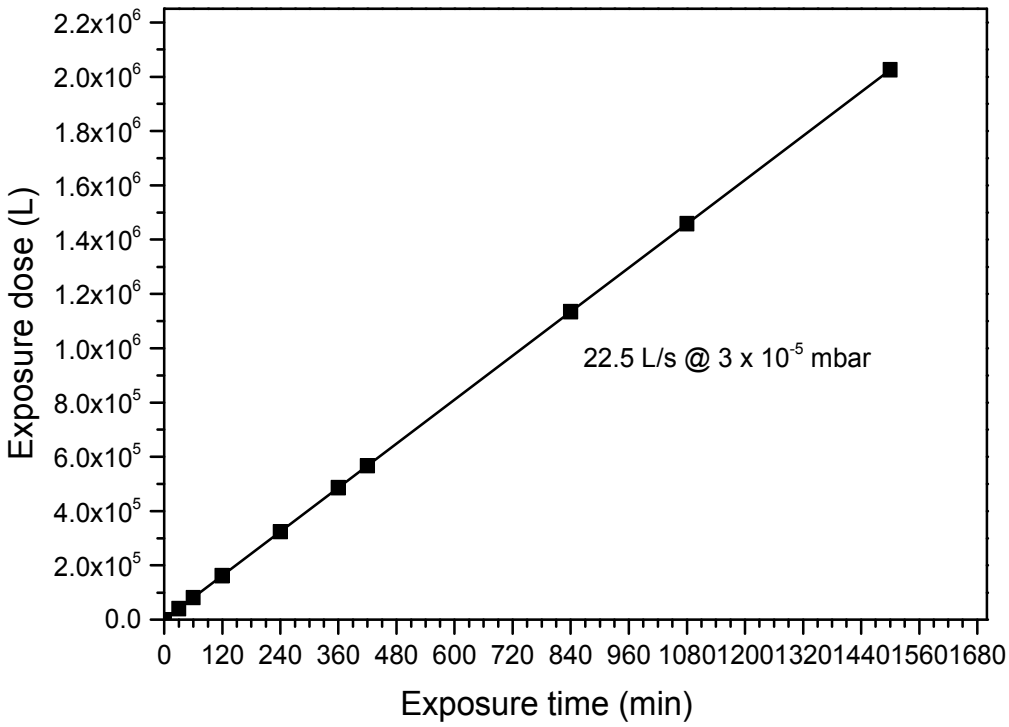

Figure S1. Relationship between exposure dose and exposure time at a pressure of 3 x 10^{-5} mbar. Langmuir (L) is a unit of gas adsorption to a surface in ultrahigh vacuum (UHV), which is defined by multiplying the pressure of the gas by the time of gas exposure. 1 L corresponds to an exposure of 10^{-6} Torr (T) during one second (s)[1]. In the experiment, the exposure pressure is 2.25 x 10^{-5} T (3 x 10^{-5} mbar), which means 22.5 L/s during exposure.

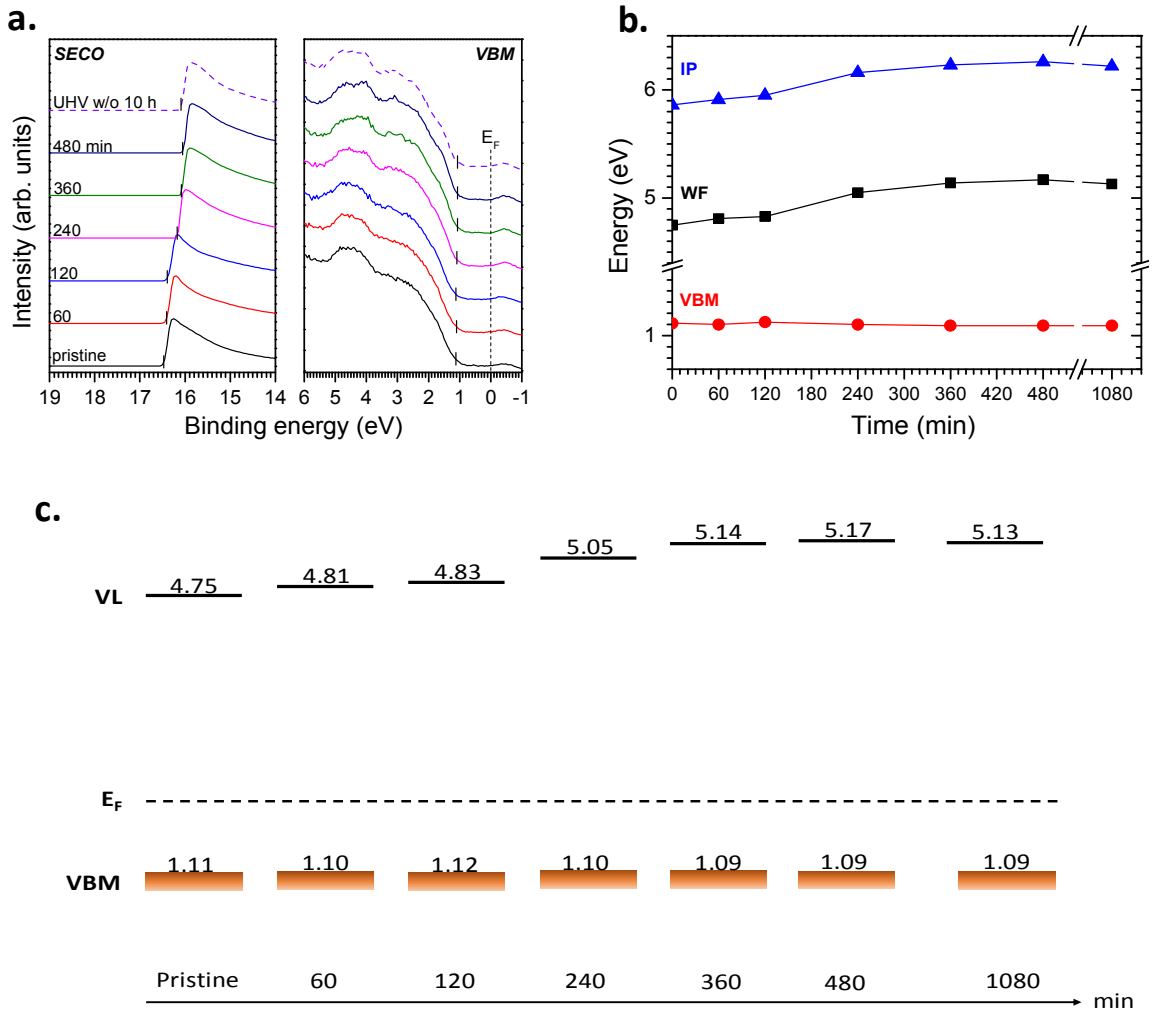

Figure S2. (a) UPS spectra in the secondary electron region and the frontier electronic structure region of the film as function of in suit oxygen exposure time under the pressure of 3 x 10^{-5} mbar; (b) Summary of WF, VBM energy and IP. (c) Energy level diagrams of the oxygen-exposed $CH_3NH_3PbI_{3-x}Cl_x$ films.

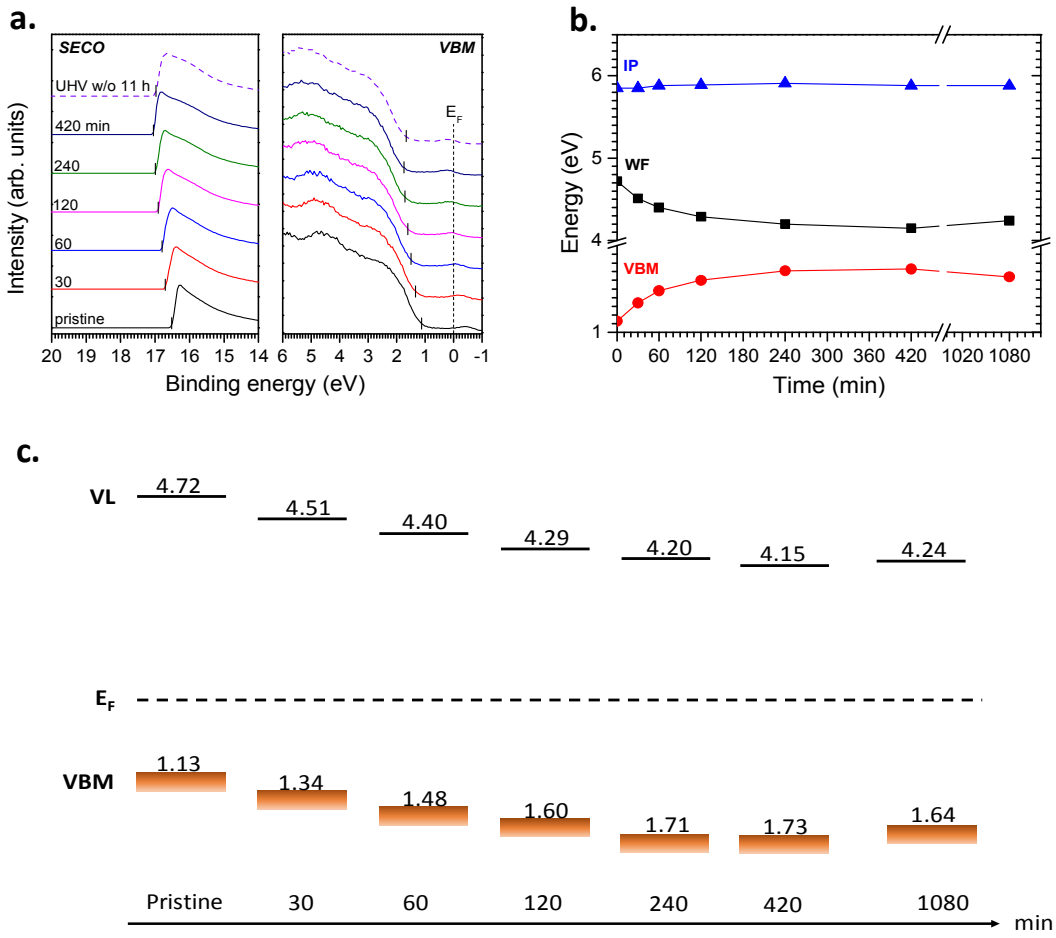

Figure S3. (a) UPS spectra in the secondary electron region and the frontier electronic structure region of the $CH_3NH_3PbI_{3-x}Cl_x$ film as function of in suit water exposure time under the pressure of 3 x 10^{-5} mbar; (b) Summary of WF, VBM energy and IP. (c) Energy level diagrams of the water-exposed $CH_3NH_3PbI_{3-x}Cl_x$ films.

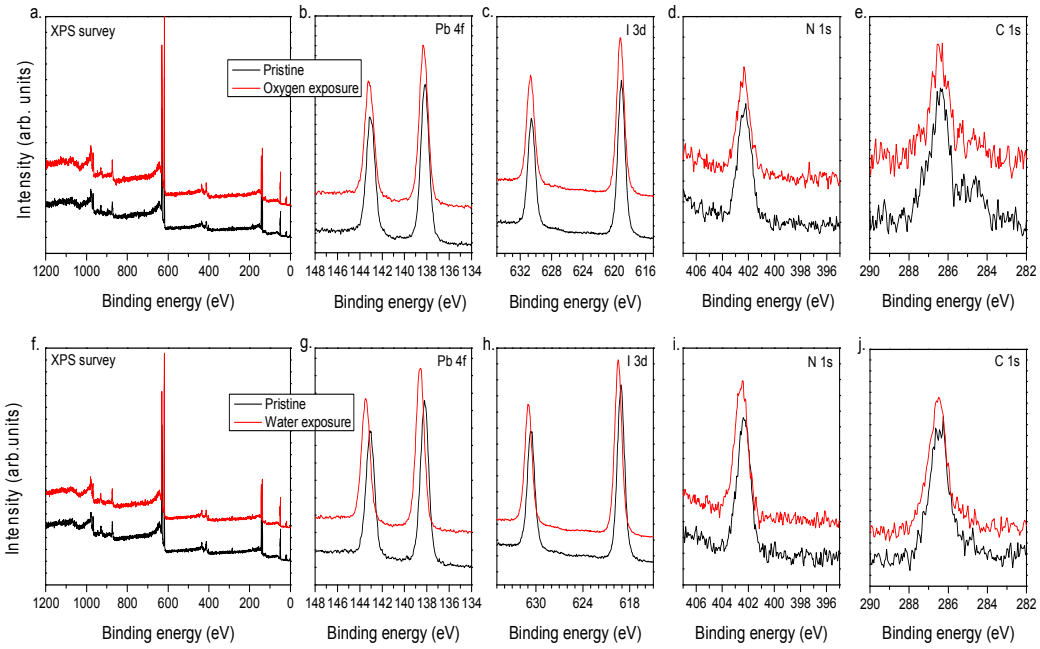

Figure S4. XPS survey spectra and Pb4f, I3d, N1s and C1s core level spectra of the $CH_3NH_3PbI_3$ films before and after (a-e) oxygen and (f-j) water exposure

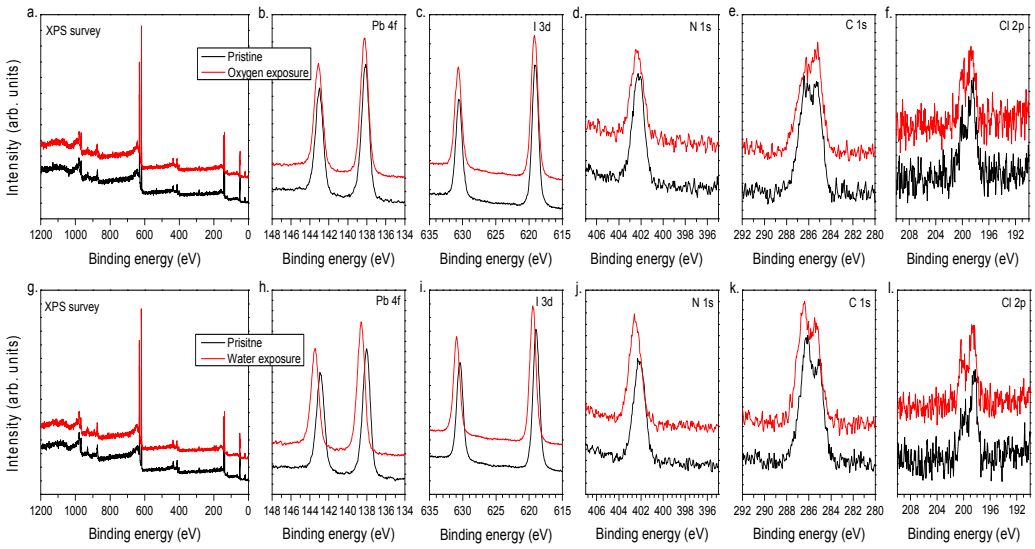

Figure S5. XPS survey spectra and Pb4f, I3d, N1s, C1s and Cl2p core level spectra of the $CH_3NH_3PbI_{3-x}Cl_x$ films before and after (a-f) oxygen and (g-l) water exposure.

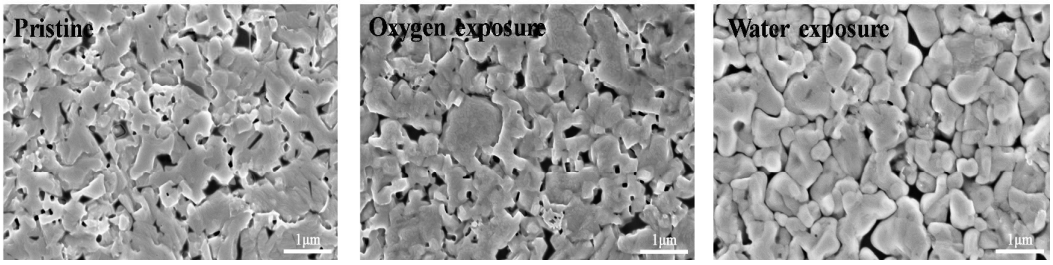

Figure S6. Surface morphologies of the pristine, oxygen exposed and water exposed $CH_3NH_3PbI_{3-x}Cl_x$ films.

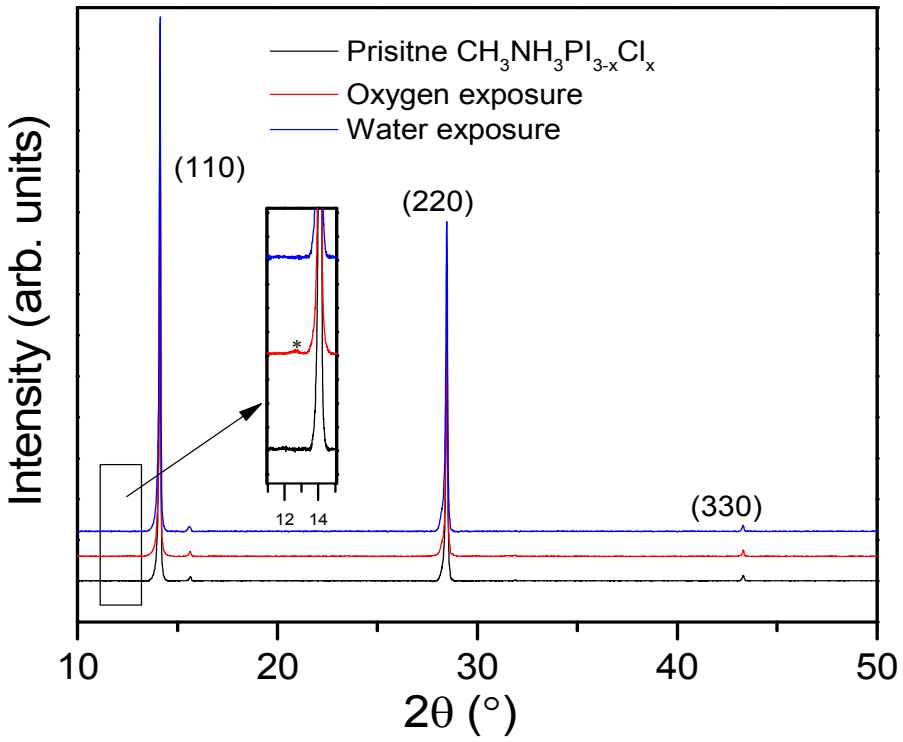

Figure S7. X-ray diffractograms of the pristine, oxygen exposed and water exposed-CH3NH3PbI$_{3-X}$Clx films.

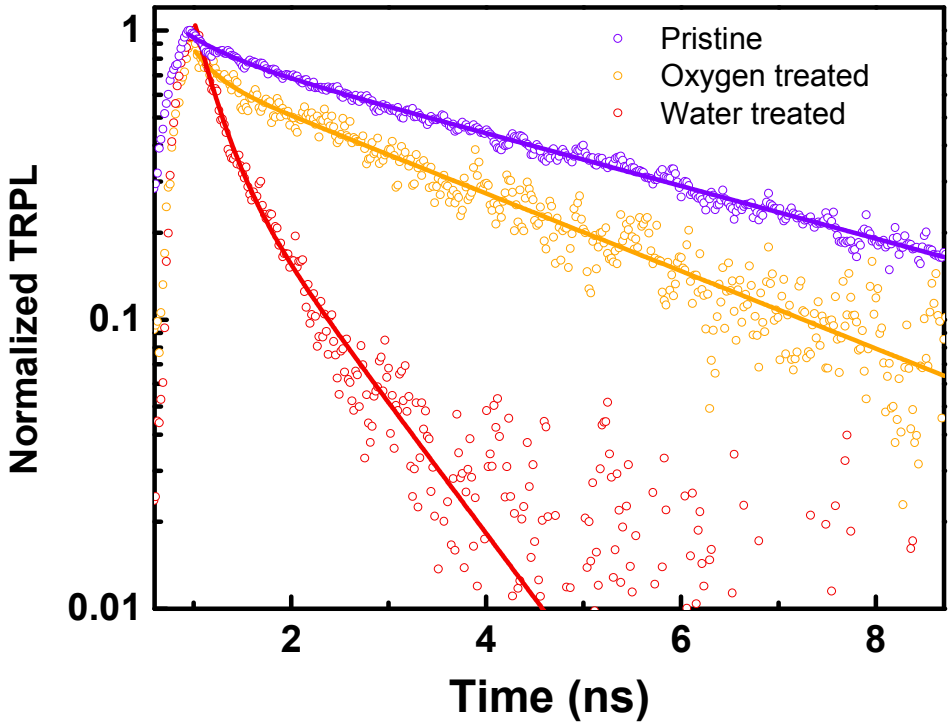

Figure S8. Photoluminescence decay kinetics of the $CH_3NH_3PbI_{3-X}Clx$ film before (violet symbols) and after oxygen (yellow symbols) and water (red symbols) exposure.

References

1. D. Alpert, New Developments in the Production and Measurement of Ultra High Vacuum, *J. Appl. Phys.* 24, 7 (1953), 860–876