Supporting Information

Insights into the Thermal and Chemical Stability of Multilayered V_2CT_x MXene Under Different Environments

Raj Thakur [†], Armin VahidMohammadi [‡], Jorge Moncada [†], Reid Adams [†], Mingyang Chi [†], Bruce Tatarchuk [†], Majid Beidaghi [‡]*, Carlos A. Carrero [†]*

† Department of Chemical Engineering, Auburn University, Auburn, Alabama 36830, United States

‡ Department of Material Engineering, Auburn University, Auburn, Alabama 36830, United States

Email-
* Carlos A. Carrero: cac0134@auburn.edu

* Majid Beidaghi: mzb0088@auburn.edu

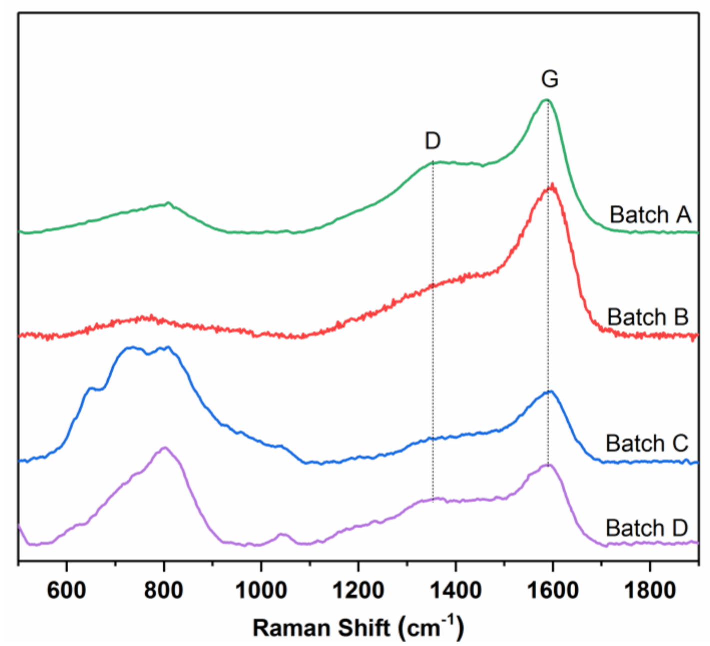

Figure S1. Raman spectra for various batches of V_2CT_X MXene showing different amount of carbon on the surface. For present study, batch D was selected.

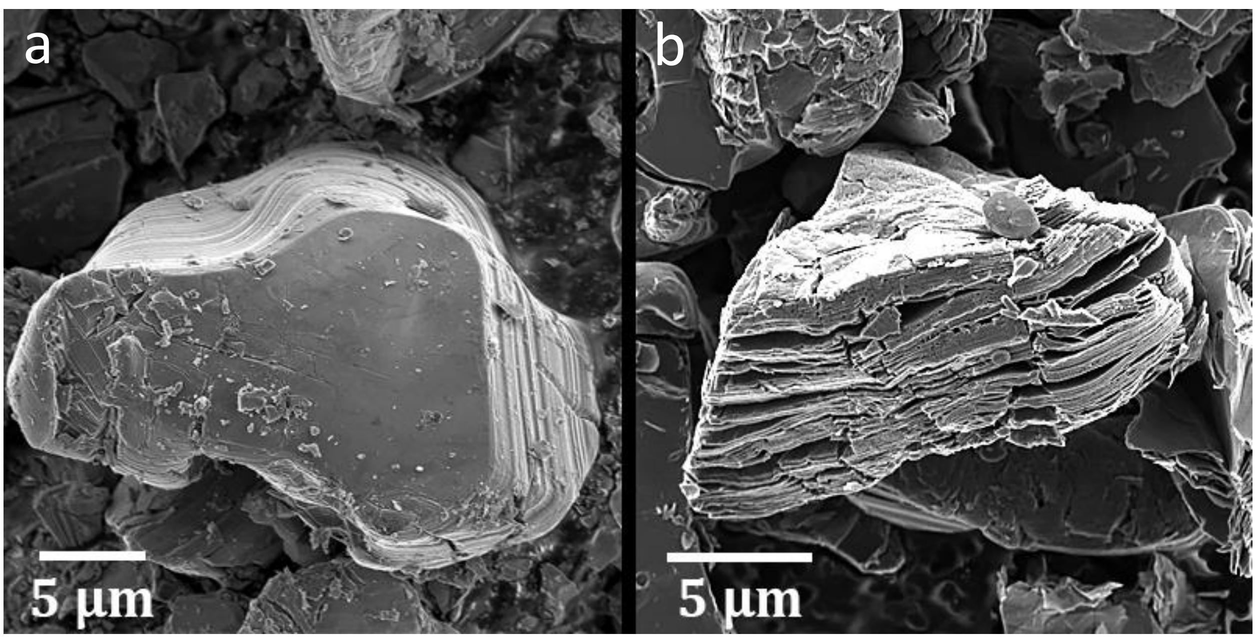

Figure S2. SEM image of (a) V_2AlC MAX phase and (b) V_2CT_x MXene phase.

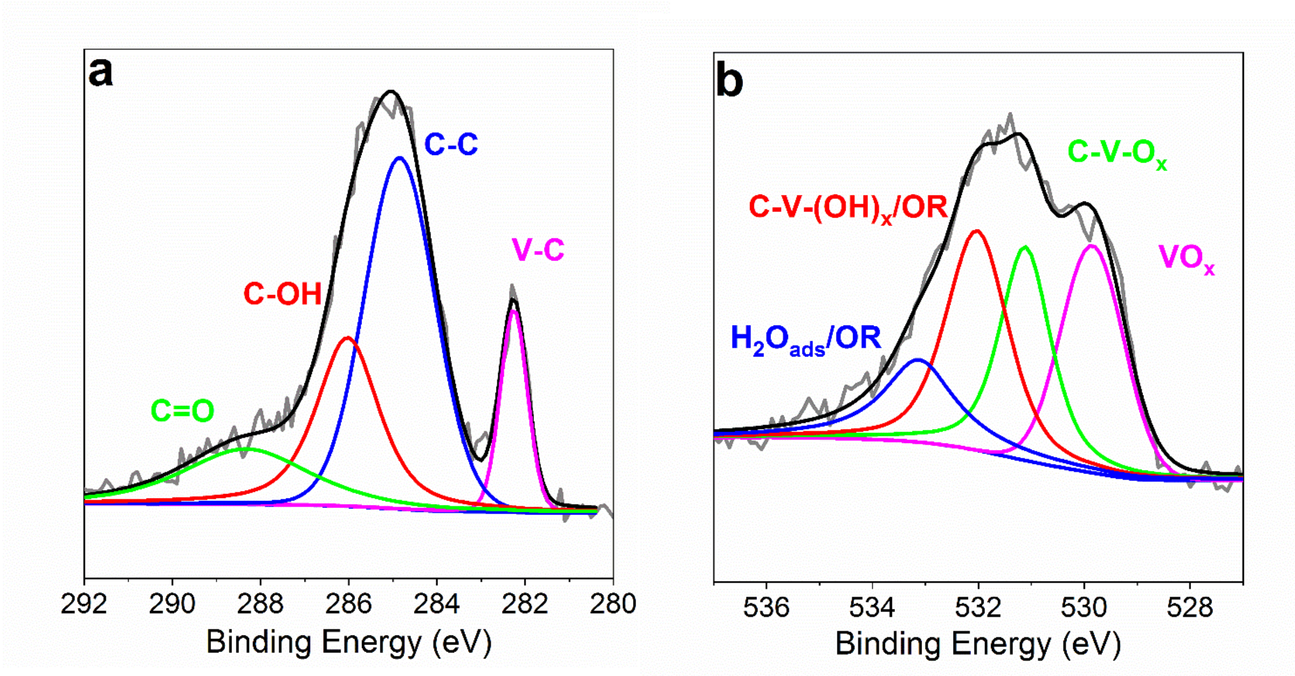

Figure S3. XPS spectra of (a) C1s region and (b) O1s region for the bare V_2CT_x MXene. Surface charging were corrected using the C1s level at 284.8 eV. OR stands for organic compounds due to atmospheric surface contaminations.[1-4]

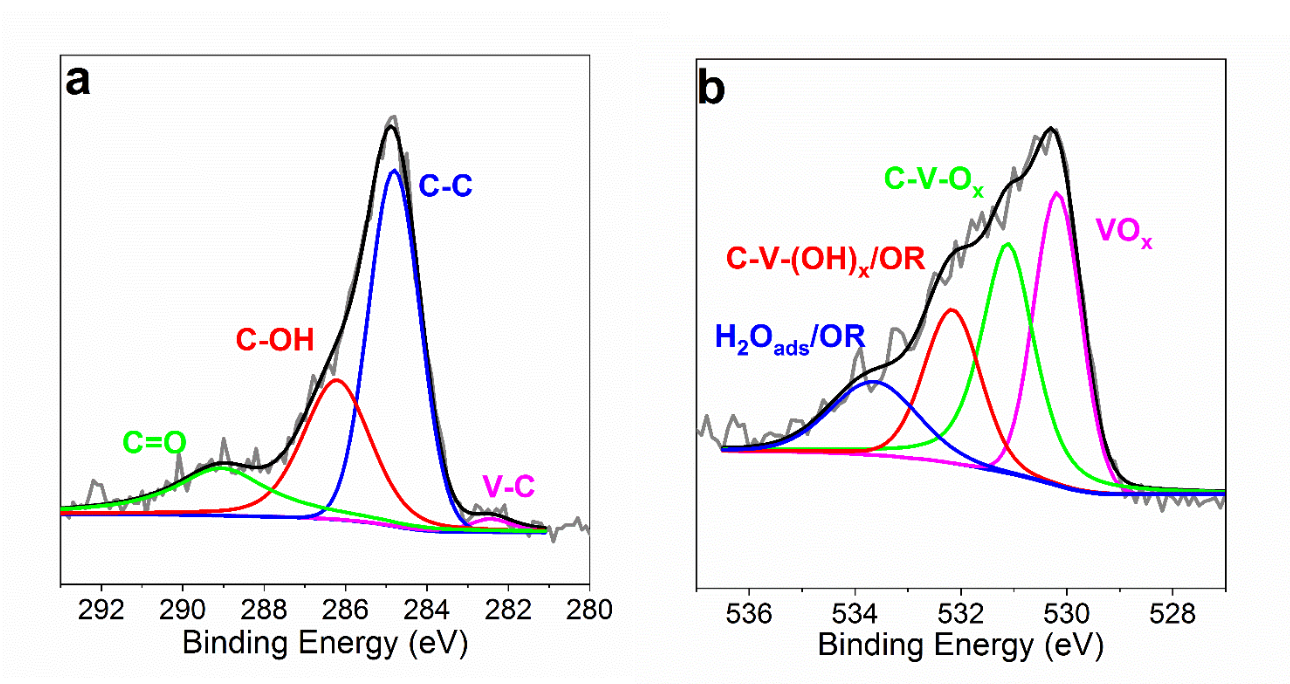

Figure S4. XPS spectra of (a) C1s region and (b) O1s region for the V_2CT_x MXene treated under nitrogen at 600ºC Surface charging were corrected using the C1s level at 284.8 eV. OR stands for organic compounds due to atmospheric surface contaminations. [1-4]

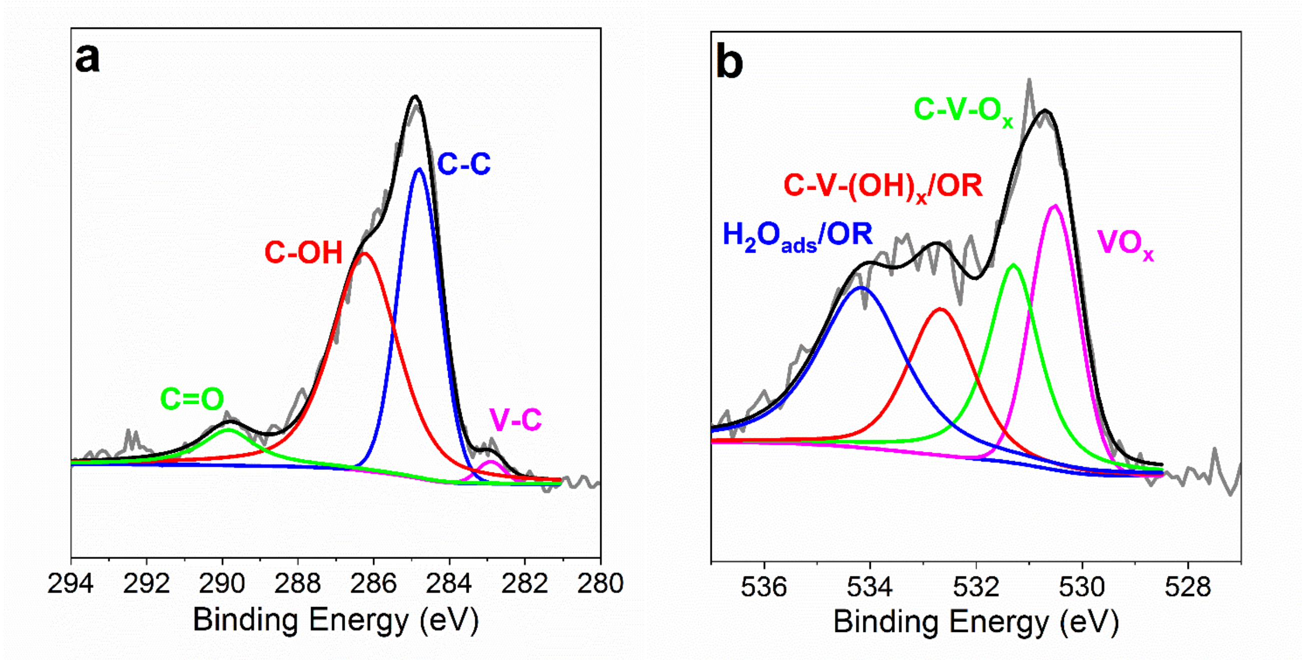

Figure S5. XPS spectra of (a) C1s region and (b) O1s region for the V_2CT_x MXene treated under Carbon dioxide at 600ºC. Surface charging were corrected using the C1s level at 284.8 eV. OR stands for organic compounds due to atmospheric surface contaminations. [1-4]

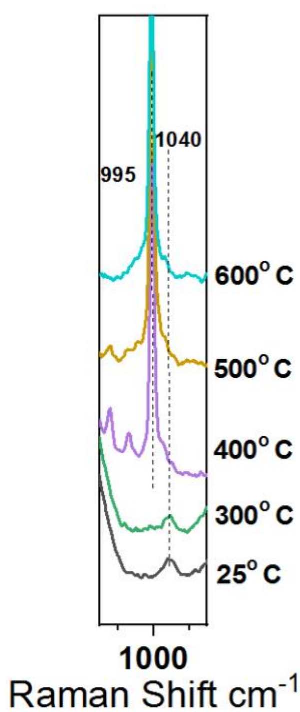

Figure S6. In situ Raman spectra of air treated V_2CT_x MXene. Surface V=O (vanadyl) shift to 995 cm^{-1} from 1040 cm^{-1} as a function of temperature.

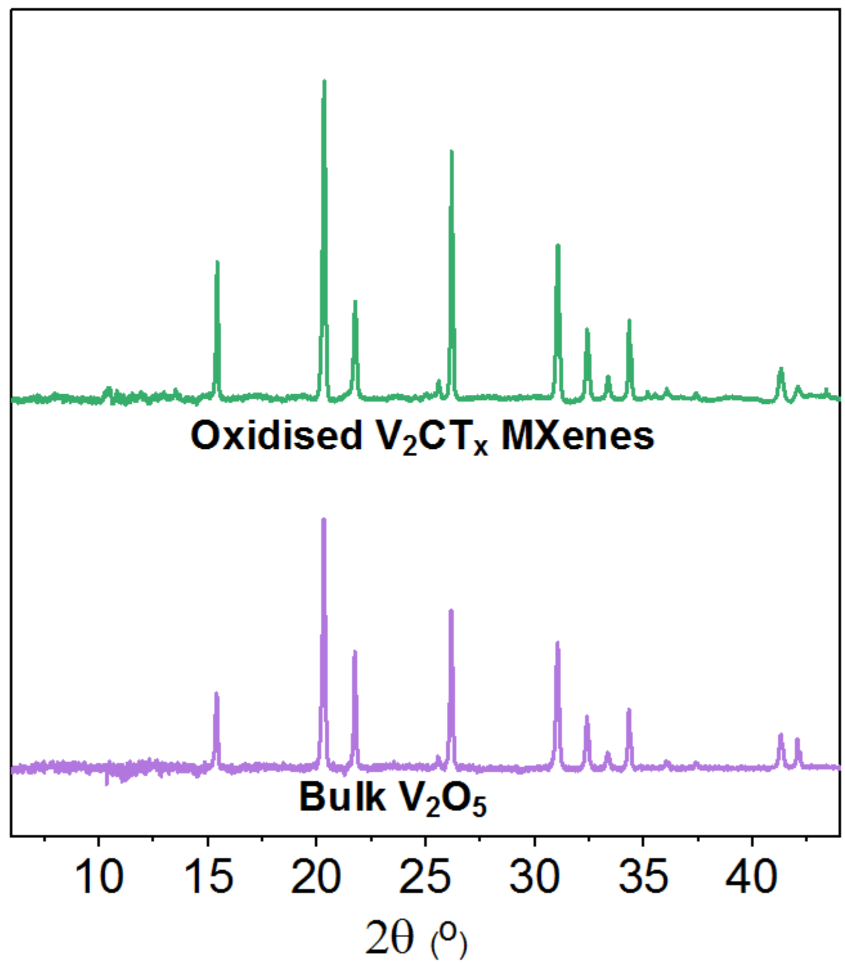

Figure S7. XRD diffractogram of commercial bulk V_2O_5 [5] and V_2CT_x MXene after treating under air.[6] (JCPDS No. 41-1426).

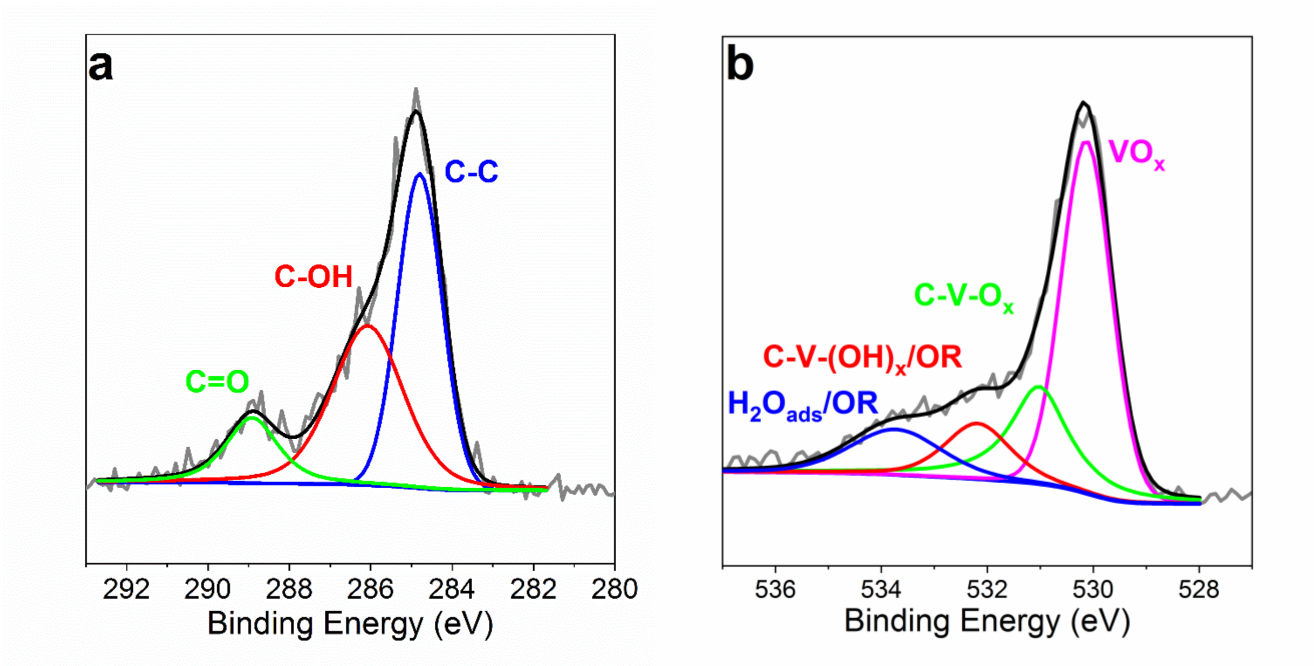

Figure S8. XPS spectra of (a) C1s region and (b) O1s region for the V_2CT_x MXene treated under air at 600ºC. Surface charging were corrected using the C1s level at 284.8 eV. OR stands for organic compounds due to atmospheric surface contaminations. [1-4]

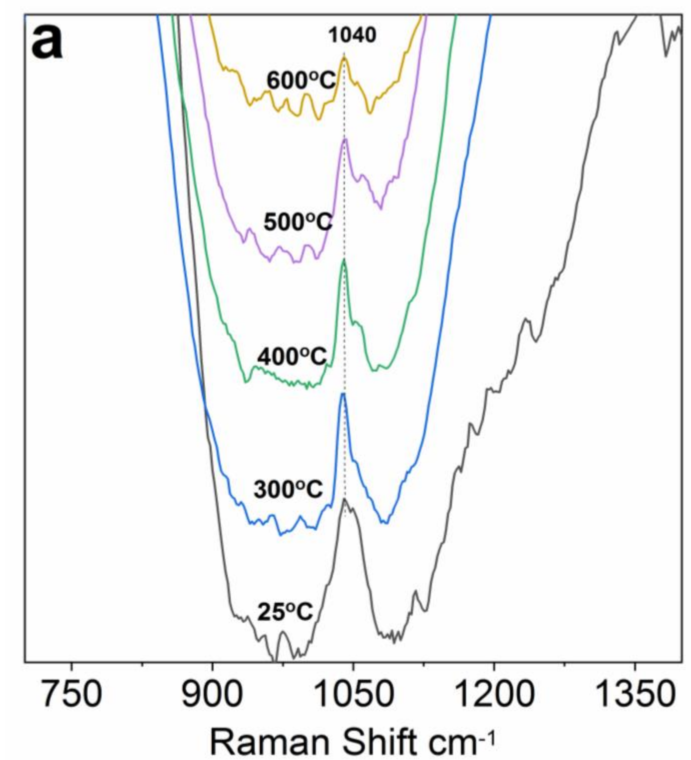

Figure S9. In situ Raman spectra of hydrogen treated V_2CT_x MXene. Surface V=O (vanadyl) as a function of temperature under H_2 environment.

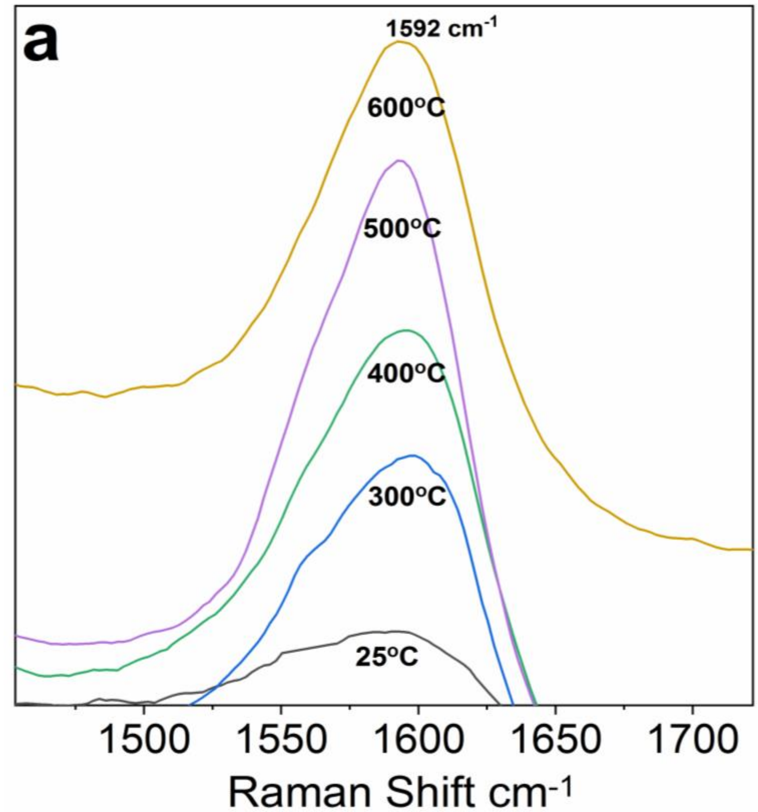

Figure S10. In situ Raman spectra of hydrogen treated V_2CT_x MXene. G carbon signals increase as a function of temperature under H_2 environment.

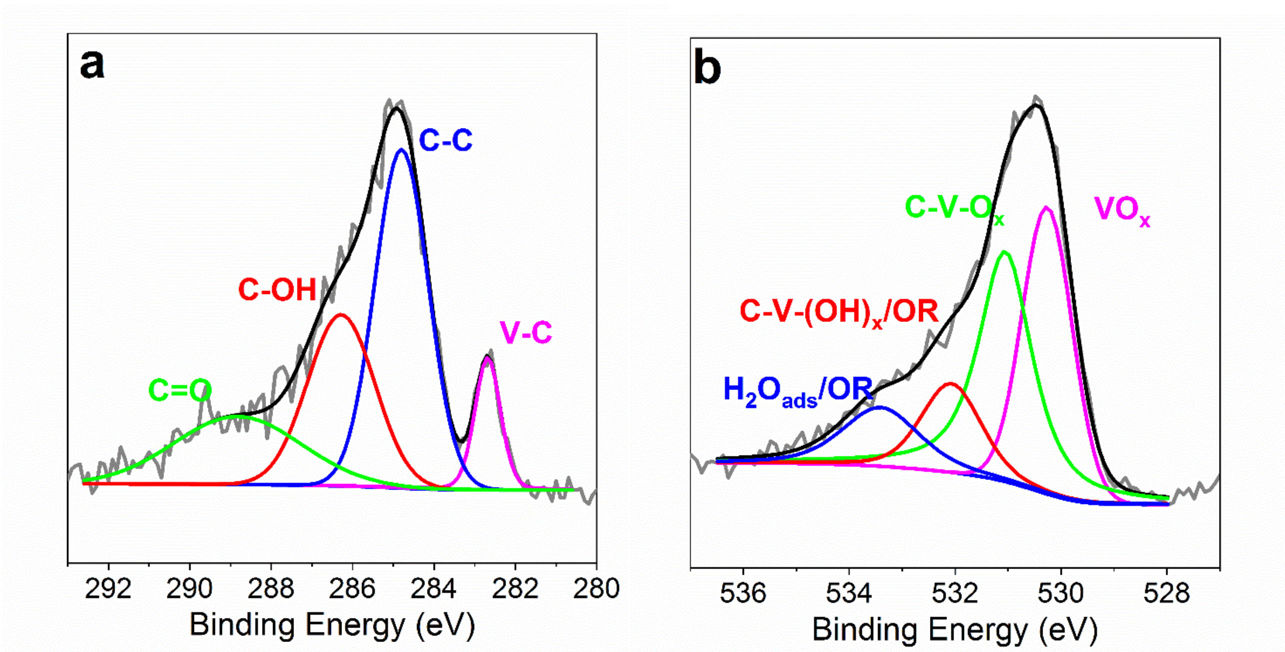

Figure S11. XPS spectra of (a) C1s region and (b) O1s region for the V_2CT_x MXene treated under hydrogen at 600ºC. Surface charging were corrected using the C1s level at 284.8 eV. OR stands for organic compounds due to atmospheric surface contaminations. [1-4]

References:

1. Didziulis, S. V.; Frantz, P.; Perry, S. S.; El-bjeirami, O.; Imaduddin, S.; Merrill, P. B., Substrate-dependent reactivity of water on metal carbide surfaces. *The Journal of Physical Chemistry B* **1999,** *103* (50), 11129-11140.
2. Jayaweera, P.; Quah, E.; Idriss, H., Photoreaction of ethanol on TiO2 (110) single-crystal surface. *The Journal of Physical Chemistry C* **2007,** *111* (4), 1764-1769.
3. Beamson, G.; Briggs, D., High resolution monochromated X-ray photoelectron spectroscopy of organic polymers: A comparison between solid state data for organic polymers and gas phase data for small molecules. *Molecular Physics* **1992,** *76* (4), 919-936.
4. Choi, J.-G., The surface properties of vanadium compounds by X-ray photoelectron spectroscopy. *Applied surface science* **1999,** *148* (1-2), 64-72.
5. Fu, H.; Yang, X.; An, X.; Fan, W.; Jiang, X.; Yu, A., Experimental and theoretical studies of V2O5@ TiO2 core-shell hybrid composites with high gas sensing performance towards ammonia. *Sensors and Actuators B: Chemical* **2017,** *252*, 103-115.
6. Wu, M.; Wang, B.; Hu, Q.; Wang, L.; Zhou, A., The Synthesis Process and Thermal Stability of V2C MXene. *Materials* **2018,** *11* (11), 2112.