Supporting Information

Enhancing Cycling Stability of Tungsten Oxide Supercapacitor Electrodes via a Boron Cluster-Based Molecular Cross-Linking Approach

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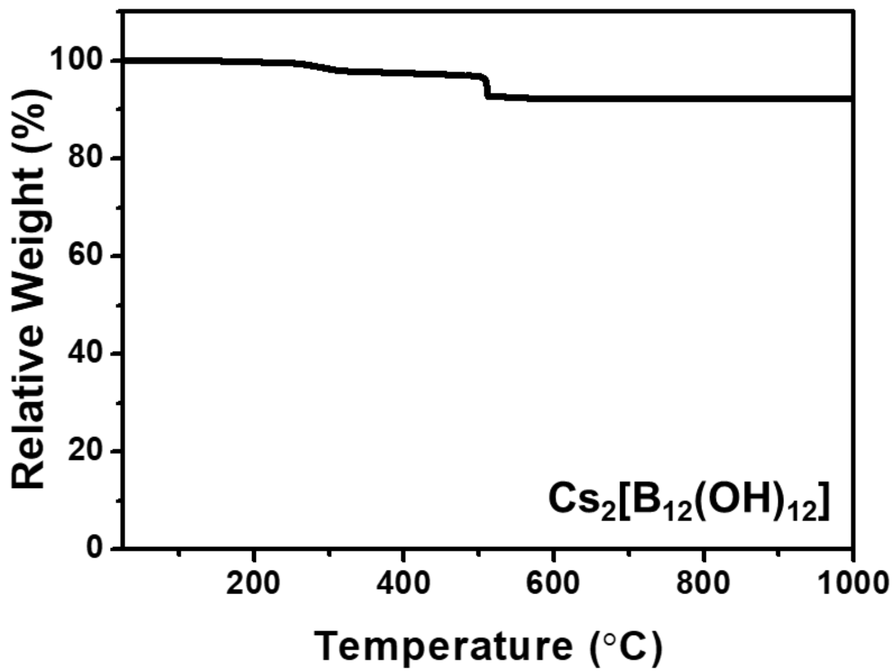


Figure S1. Thermogravimetric analysis (TGA) of $Cs_2[B_{12}(OH)_{12}]$.

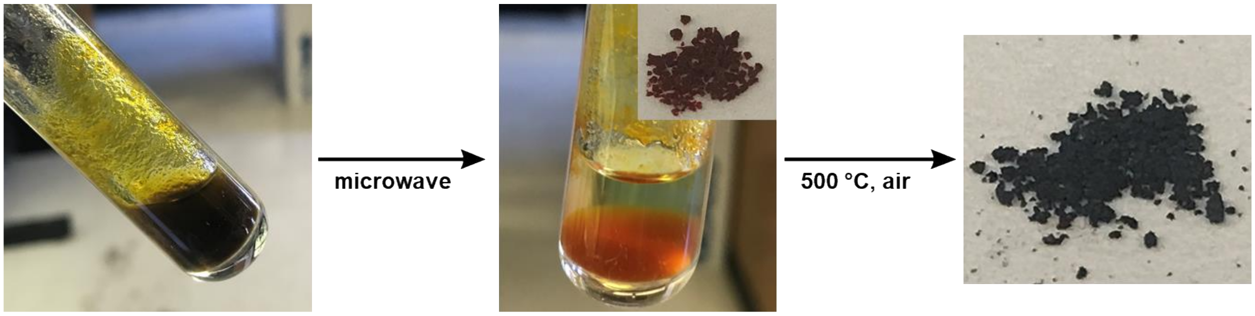


Figure S2. The optical images of synthesis of material **1**.

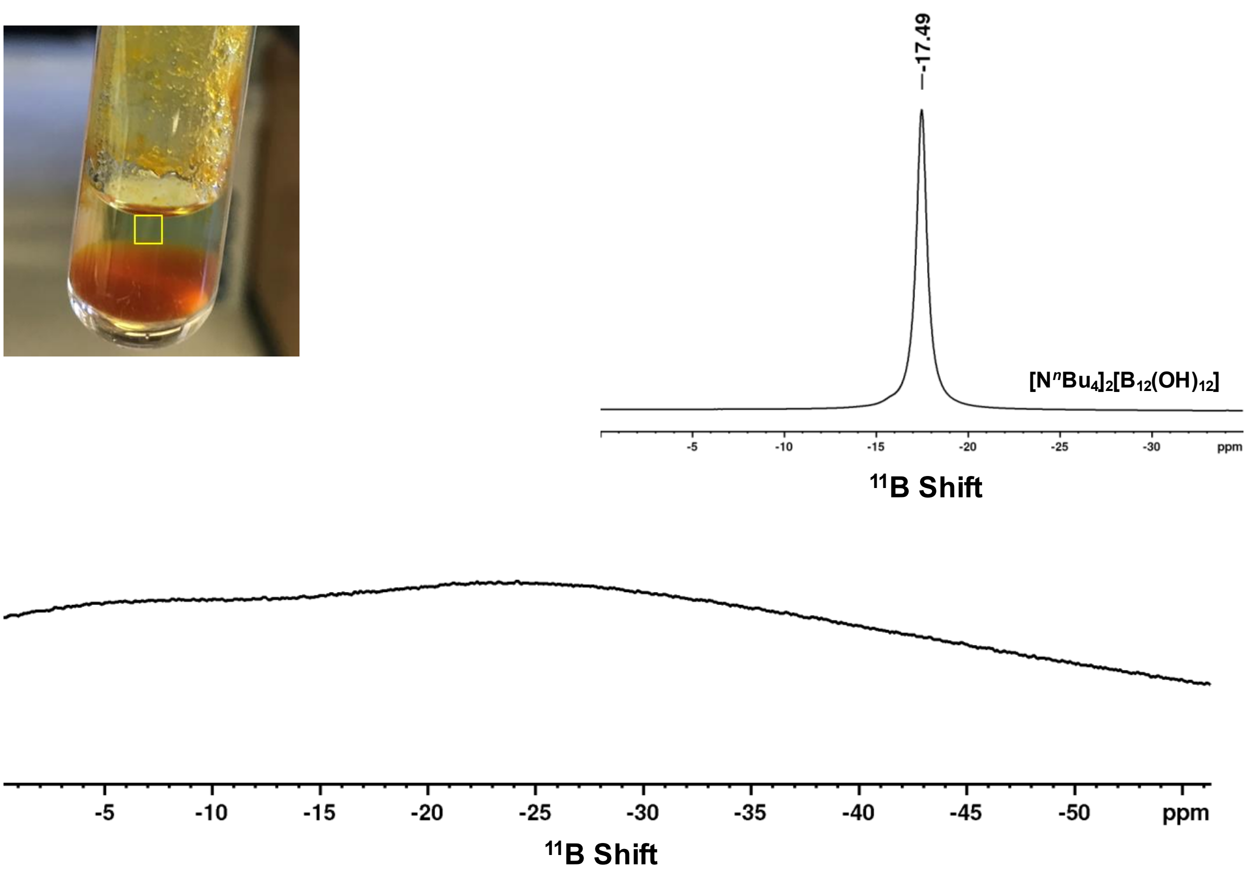


Figure S3. The ^{11}B solution NMR of the supernatant liquid after the synthesis of material **1**. (Inset) The ^{11}B NMR spectra of the $[N^{n}Bu_4]_2[B_{12}(OH)_{12}]$ in acetonitrile-d_3. The colorless solution further confirms the absence of radical $[B_{12}(OH)_{12}]^{1-}$ species.[1]

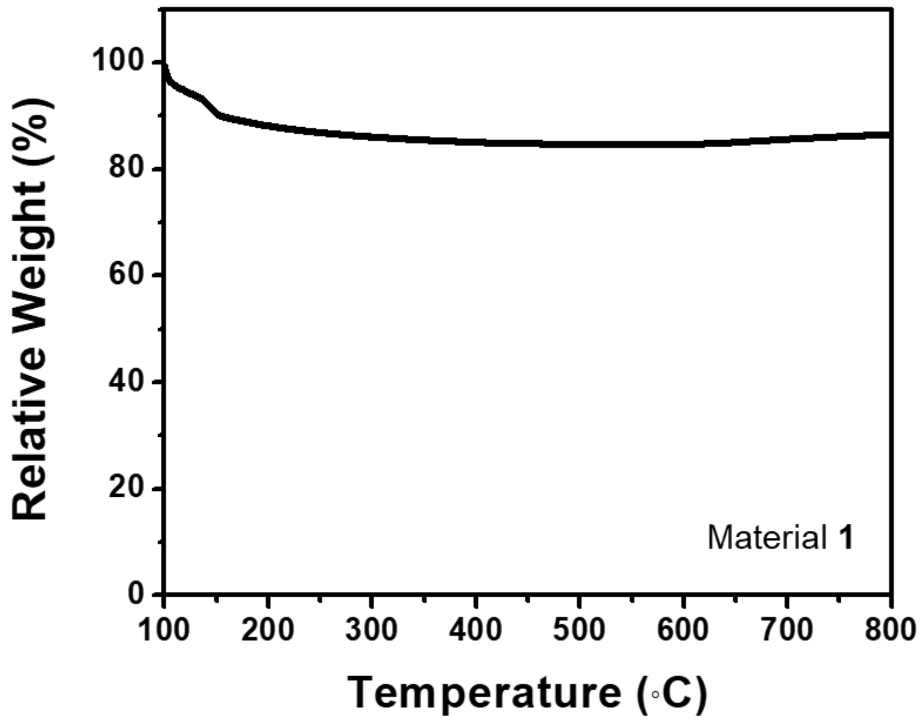
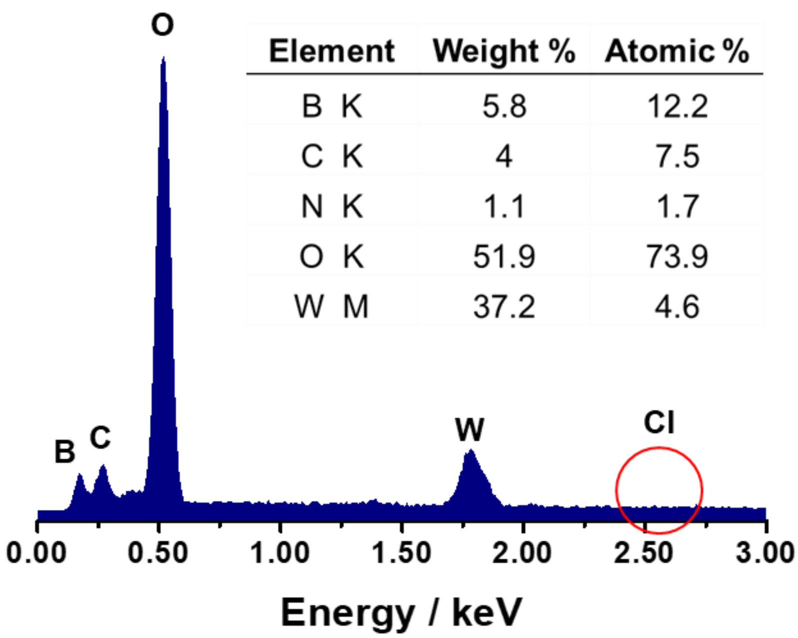


Figure S4. Thermogravimetric analysis (TGA) of material **1**.



Element	Weight %	Atomic %
B K	5.8	12.2
C K	4	7.5
N K	1.1	1.7
O K	51.9	73.9
W M	37.2	4.6

Figure S5. Energy dispersive X-ray spectroscopy (EDS) result of material **1**. (Inset) The elemental composition of material **1**. Please note that EDS is a semi-quantitative technique and these numbers do not necessarily reflect the actual elemental composition in the bulk material.

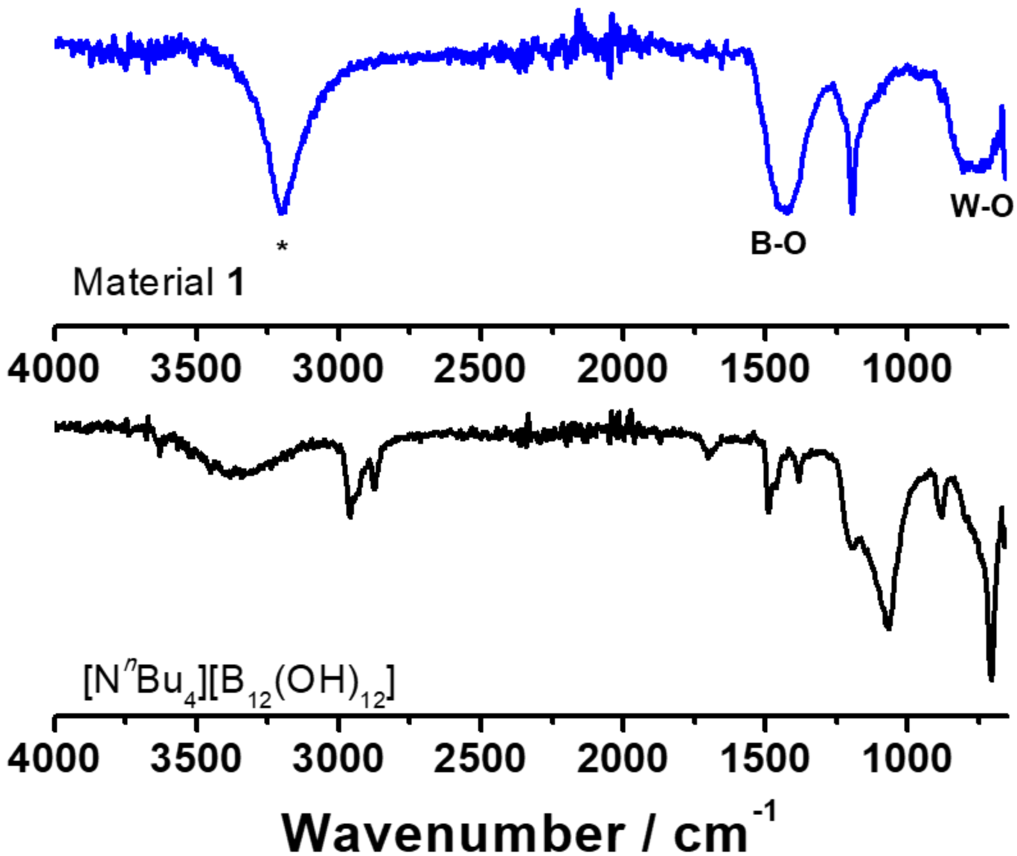


Figure S6. FT-IR spectra of material **1** (top) and $[N^nBu_4]_2[B_{12}(OH)_{12}]$ (bottom). *The peak at ~3250 cm^{-1} can likely arise from the surface bound water or hydroxyl groups.[2,3]

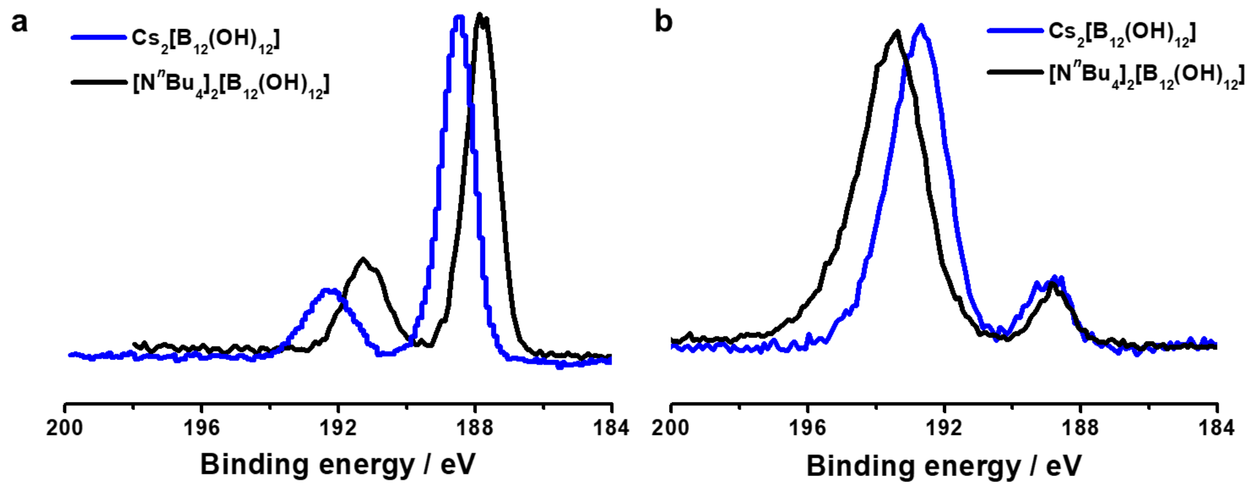


Figure S7. X-ray photoelectron spectroscopy (XPS) of (a) the pristine cross-linking agent, $[N^nBu_4]_2[B_{12}(OH)_{12}]$ and the salt $Cs_2[B_{12}(OH)_{12}]$ and (b) the annealed $[N^nBu_4]_2[B_{12}(OH)_{12}]$ and the salt $Cs_2[B_{12}(OH)_{12}]$ clusters at 500 °C.

	C 1*s*	**O 1*s***	**W 4*f***	**B 1*s***
At %	23 %	51 %	5 %	21 %

Table S1. The elemental composition of material **1** at the surface from X-ray photoelectron spectroscopy (XPS) results.

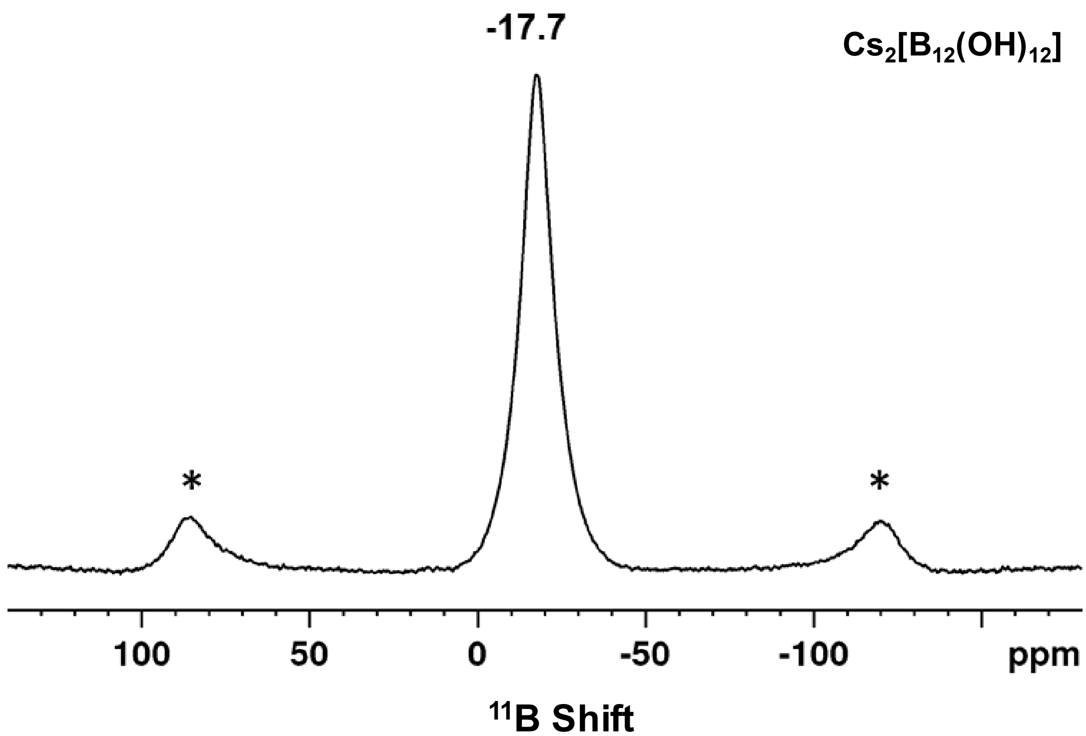


Figure S8. Solid-state 1D ^{11}B MAS NMR of $Cs_2[B_{12}(OH)_{12}]$. *spinning side bands

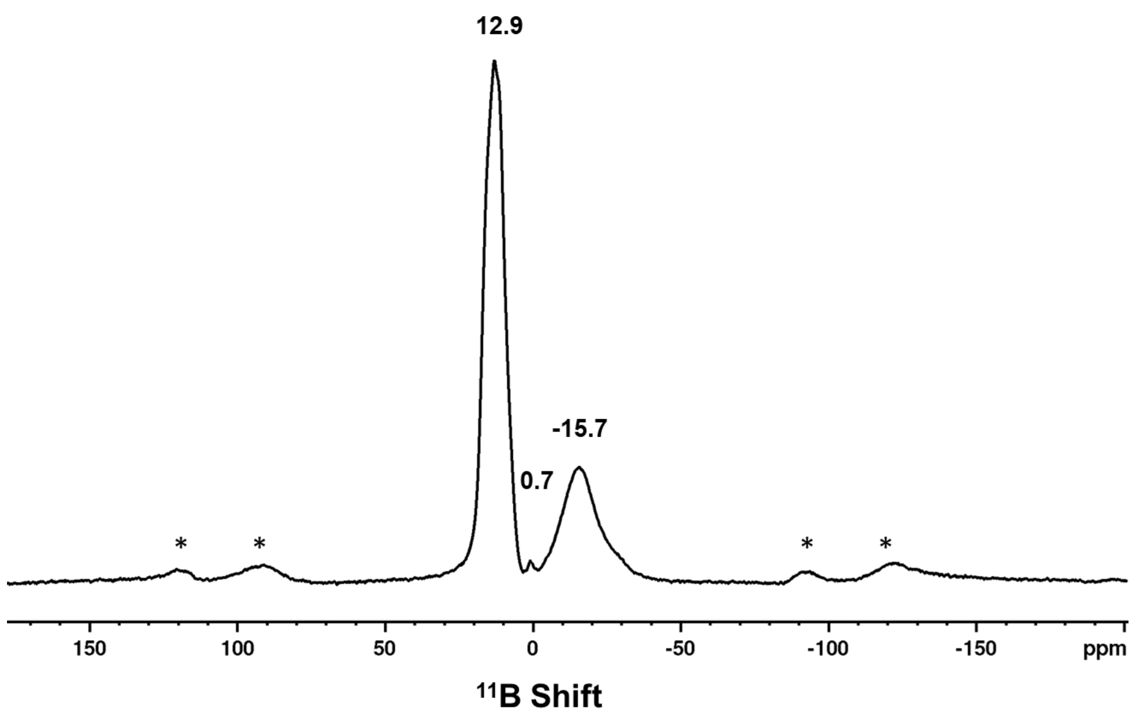


Figure S9. Solid-state 1D ^{11}B MAS NMR of material **1**. *spinning side bands

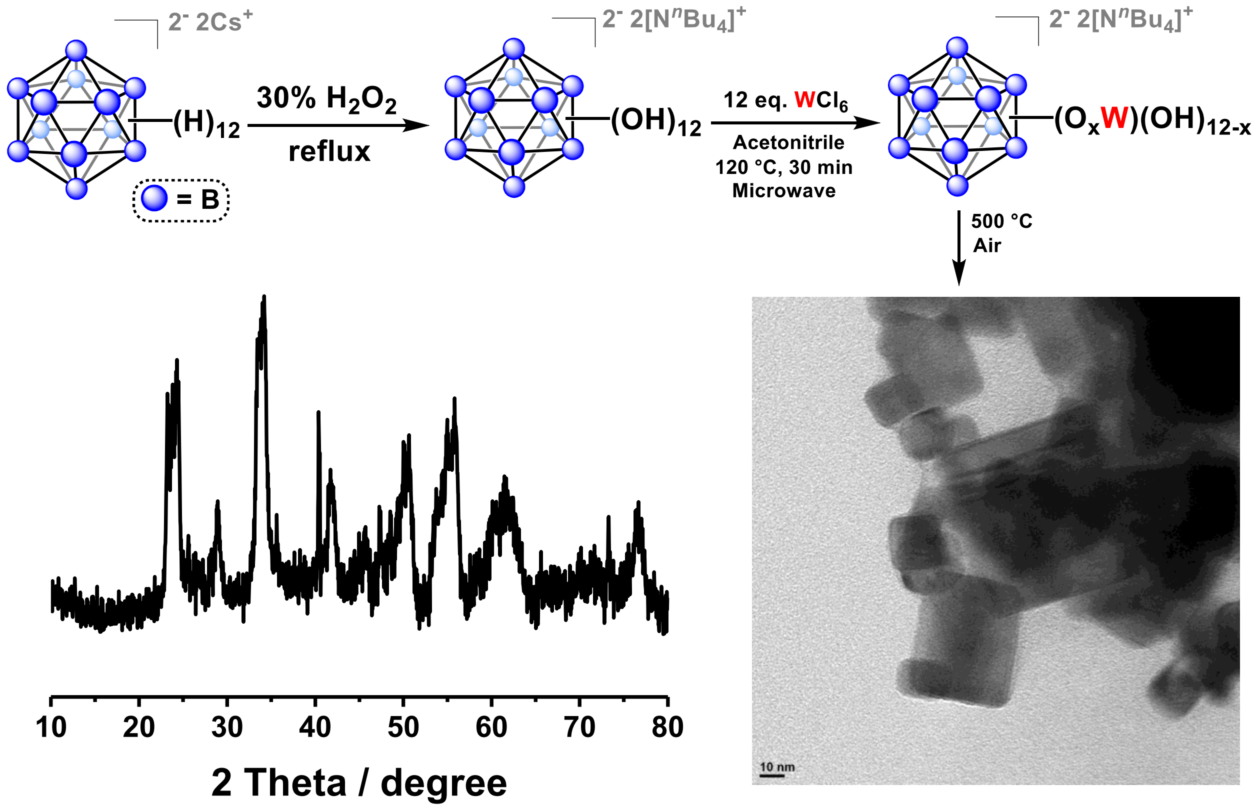


Figure S10. The synthetic route to produce material **2**. $[N^nBu_4]^+$ represents a tetrabutylammonium ion. (b) PXRD and (c) TEM image of material **2**.

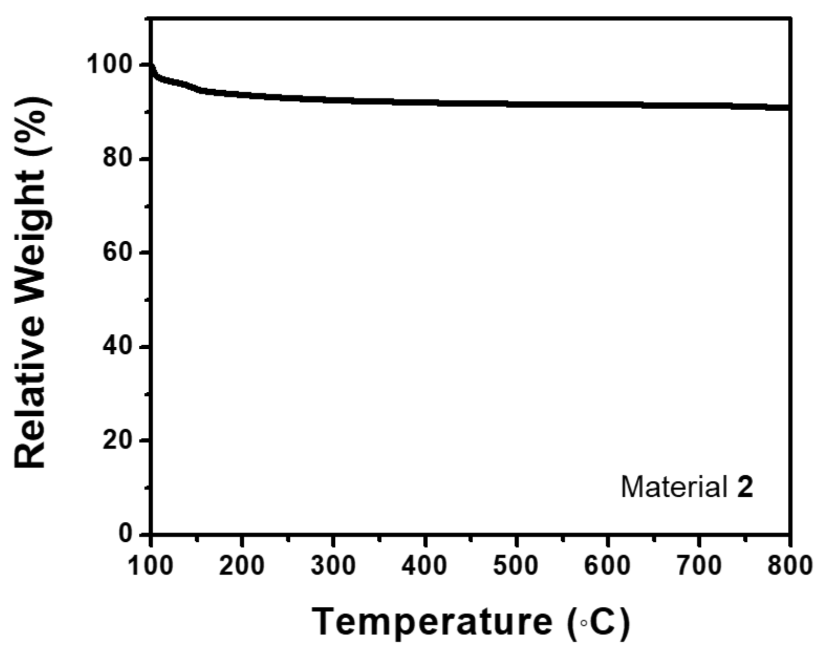


Figure S11. Thermogravimetric analysis (TGA) of material **2**.

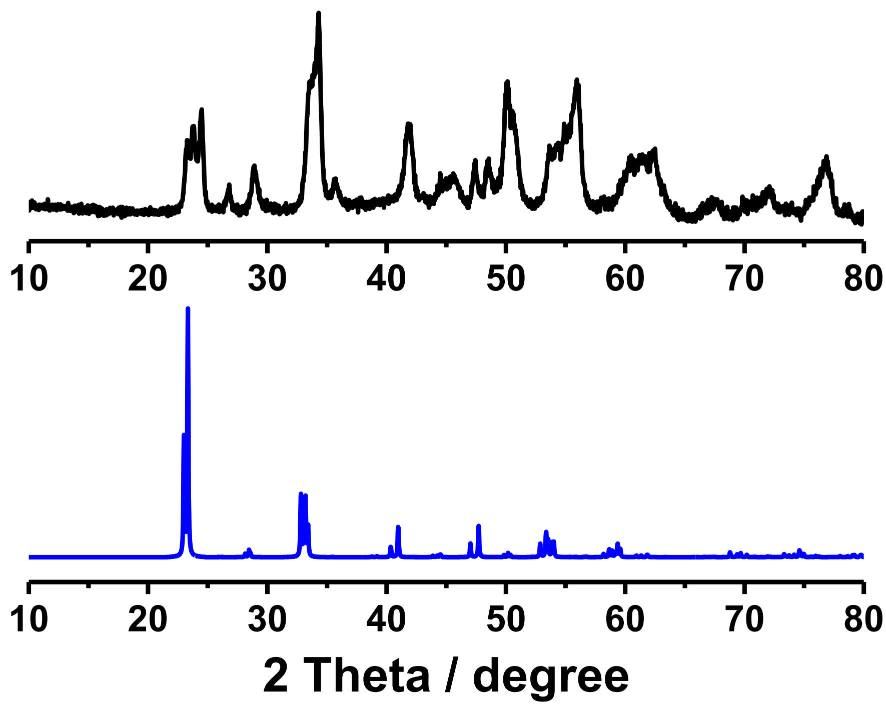


Figure S12. PXRD results of monoclinic WO_3 (top) and simulated monoclinic WO_3.[4]

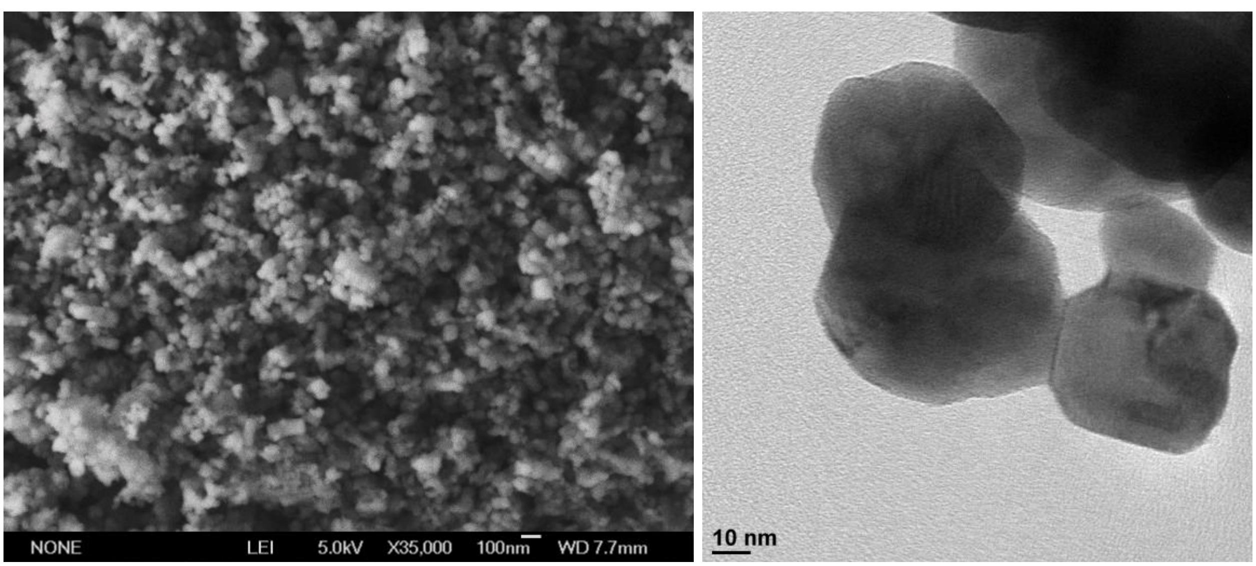


Figure S13. SEM and TEM images of monoclinic WO_3.

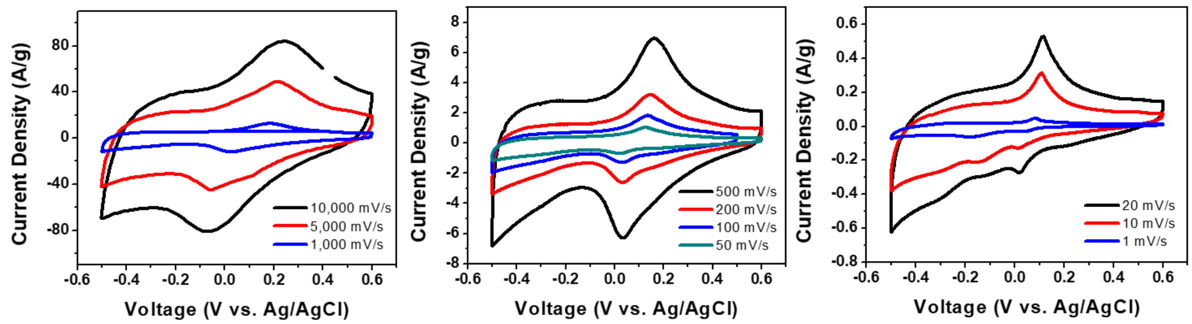


Figure S14. Cyclic voltammogram (CV) of material **1** at different scan rates.

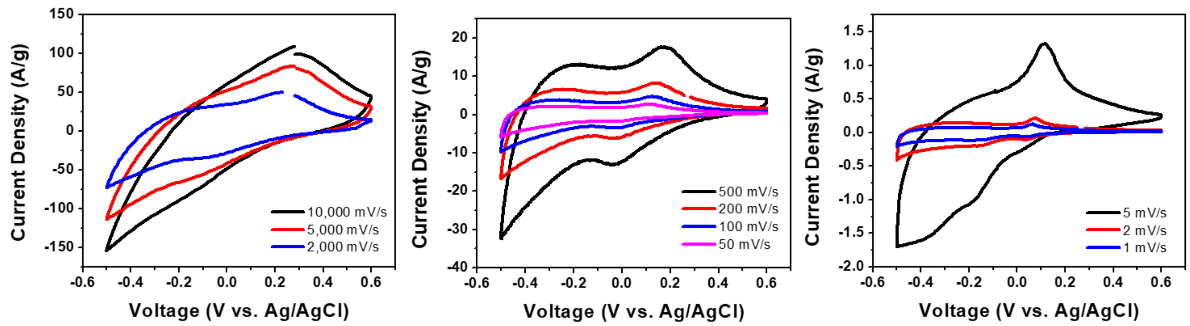


Figure S15. CV curves of material **2** at different scan rates.

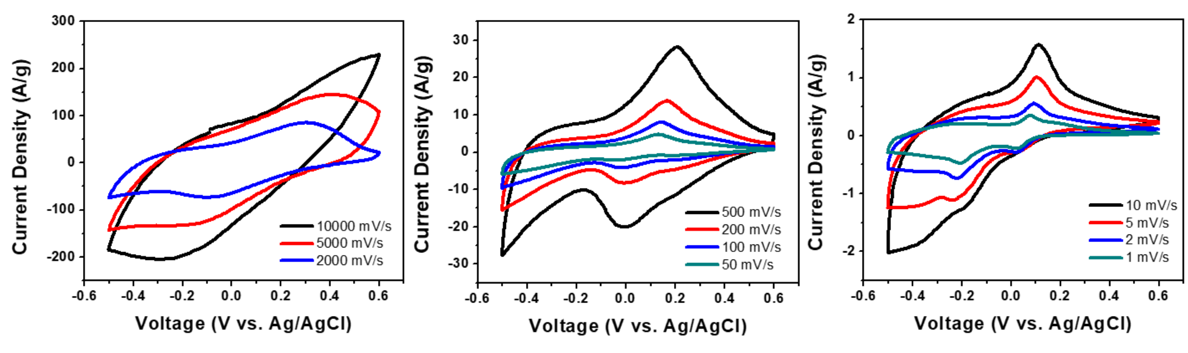


Figure S16. CV curves of m-WO_3 at different scan rates.

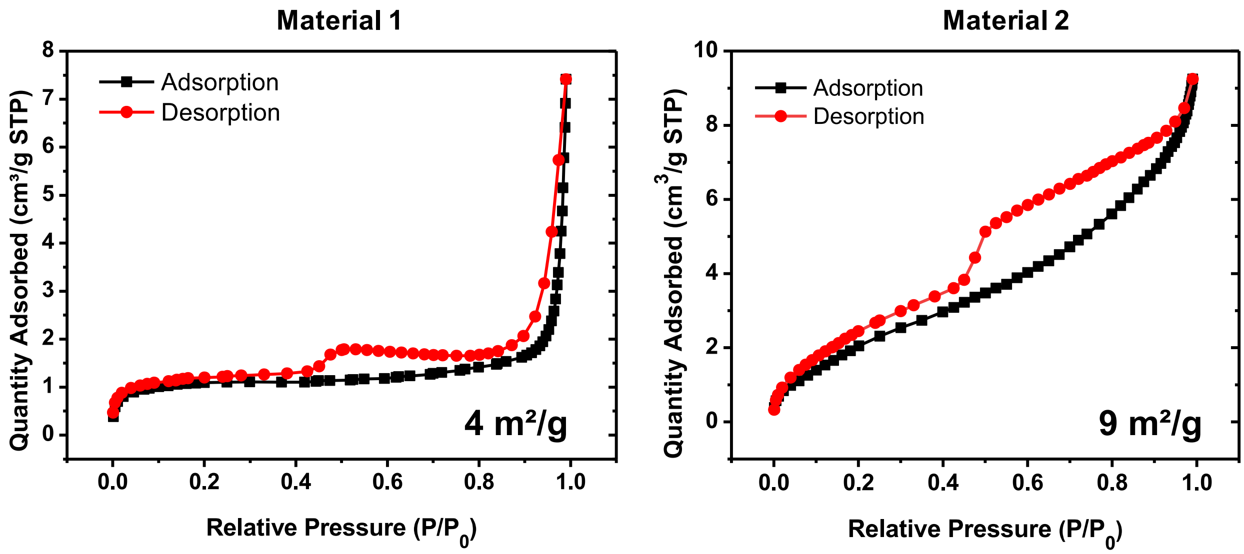
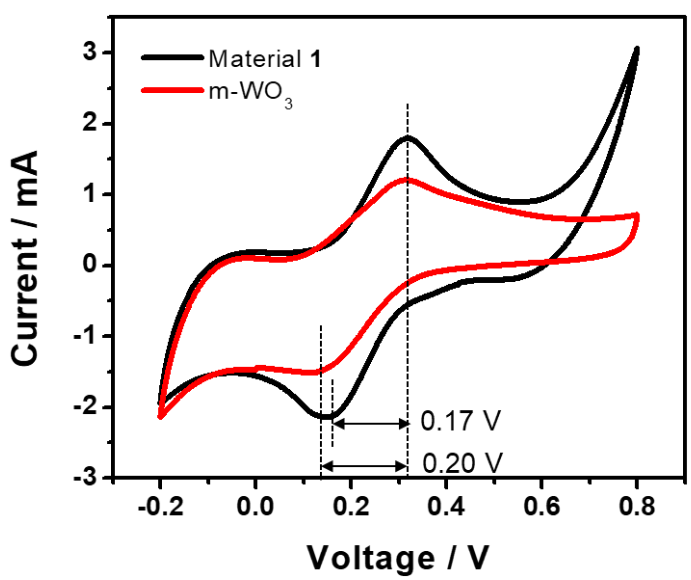


Figure S17. BET surface area of material **1** and **2**.



Material	k_0 ($cm{\cdot}s^{-1}$)
m-WO_3	1.29 x10^{-3}
Material **1**	1.64x 10^{-3}

Figure S18. CV curves of material **1** and m-WO_3 for the ferri/ferrocyanide redox couple (left). The electron transfer rate constants for material **1** and m-WO_3.

References:

1. N. Van, I. Tiritiris, R. F. Winter, B. Sarkar, P. Singh, C. Duboc, A. Muñoz-Castro, R. Arratia-Pérez, W. Kaim and T. Schleid, *Chem. Eur. J.*, 2010, **16**, 11242–11245.
2. R. Ramachandran, D. Jung, N. A. Bernier, J. K. Logan, M. A. Waddington and A. M. Spokoyny, *Inorg. Chem.*, 2018, **57**, 8037−8041.
3. N. Sharma, M. Deepa, P. Varshney and S. A. Agnihotry, *Thin Solid Films*, 2001, **401**, 45−51.
4. C. Chacón, M. Rodríguez-Pérez, G. Oskam and G. Rodríguez-Gattorno, *J. Mater. Sci: Mater Electron*, 2015, **26**, 5526−5531.