Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.


# Supporting Information

## Experimental:

### *Preparation of bulk $VO_2$(B):*

$VO_2$(B) was prepared from $NH_4VO_3$ (Aldrich) solution dissolved in oxalic acid by hydrothermal technique similar to previously reported by Xie and the co-workers.[1] In typical procedure 1 mmol of $NH_4VO_3$ was dissolved in 15 ml of deionized water, then 1 M oxalic acid (Aldrich) was added drop-wise until pH 1.3. The mixture was then placed in a 23 ml Teflon lined autoclave with stainless steel shell and kept for 1 day at 200 °C. After cooling down to room temperature the product was washed with deionized water and pure ethanol at least three times to remove any impurities. Finally, the $VO_2$(B) was dried in air at 60 °C for 2-3 h.

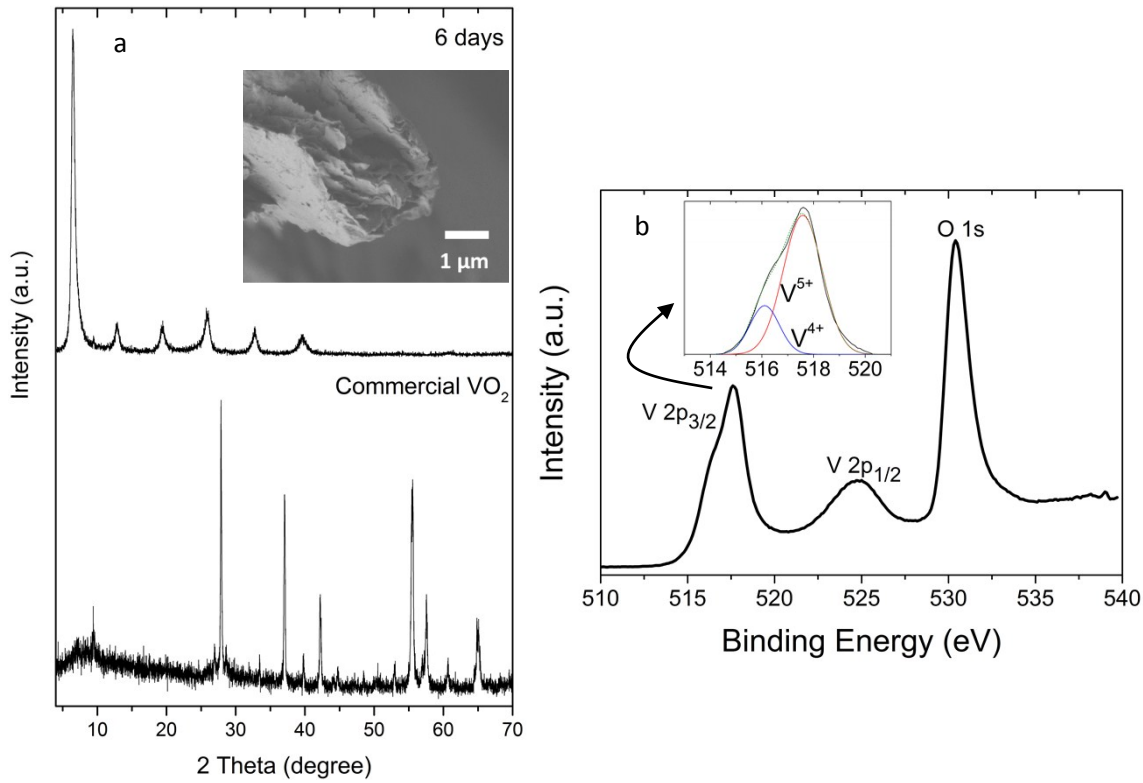


Figure S1: (a) Powder XRD patterns for commercial $VO_2$ (which matches well with the standard pattern for $VO_2$(M), (JCPDS No. 082-0661)), compared with that after 6 days of reflux in water at 60 °C; inset in (a) shows the SEM image of the exfoliated $V_2O_5.nH_2O$ material obtained from $VO_2$(M) after 6 days of reflux. (b) XPS spectrum for $V_2O_5{\cdot}0.55H_2O$ nanosheets; inset in (b) shows the deconvolution of V $2p_{3/2}$ peak.

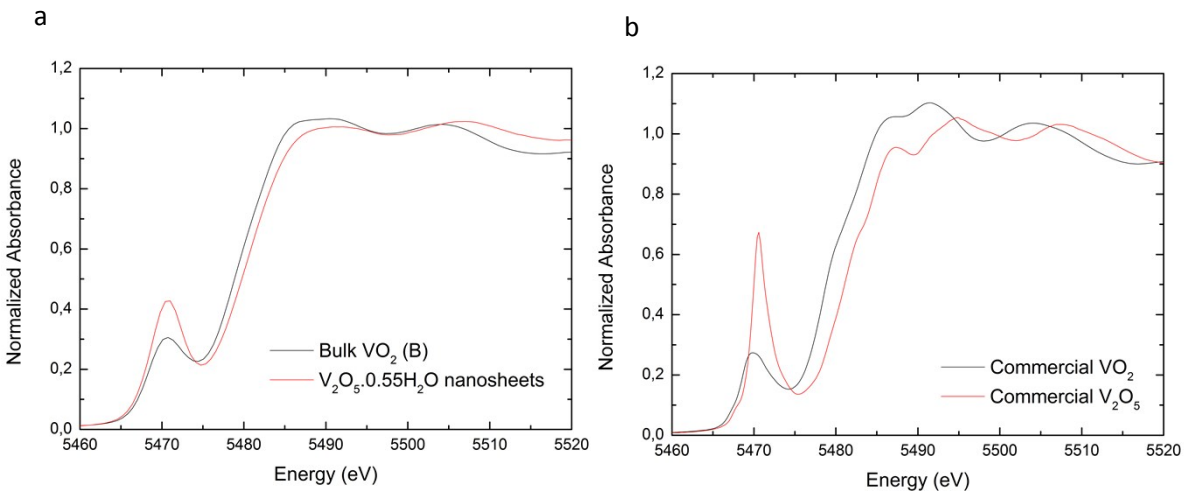


Figure S2. (a) Vanadium K-edge XANES spectra of $V_2O_5{\cdot}0.55H_2O$ nanosheets (red line) and $VO_2$(B) (black line); (b) Vanadium K-edge XANES spectra of standard commercial $V_2O_5$ (red line) and $VO_2$ (black line).

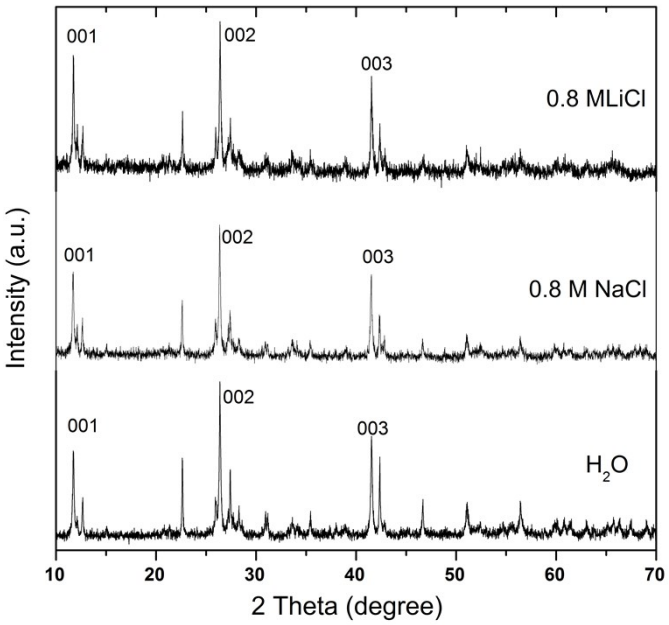


Figure S3: Powder XRD patterns for $VO_2$(B) after refluxing for 24h at room temperature in pure deionized water, 0.8 M NaCl solution, and 0.8 M LiCl solution.

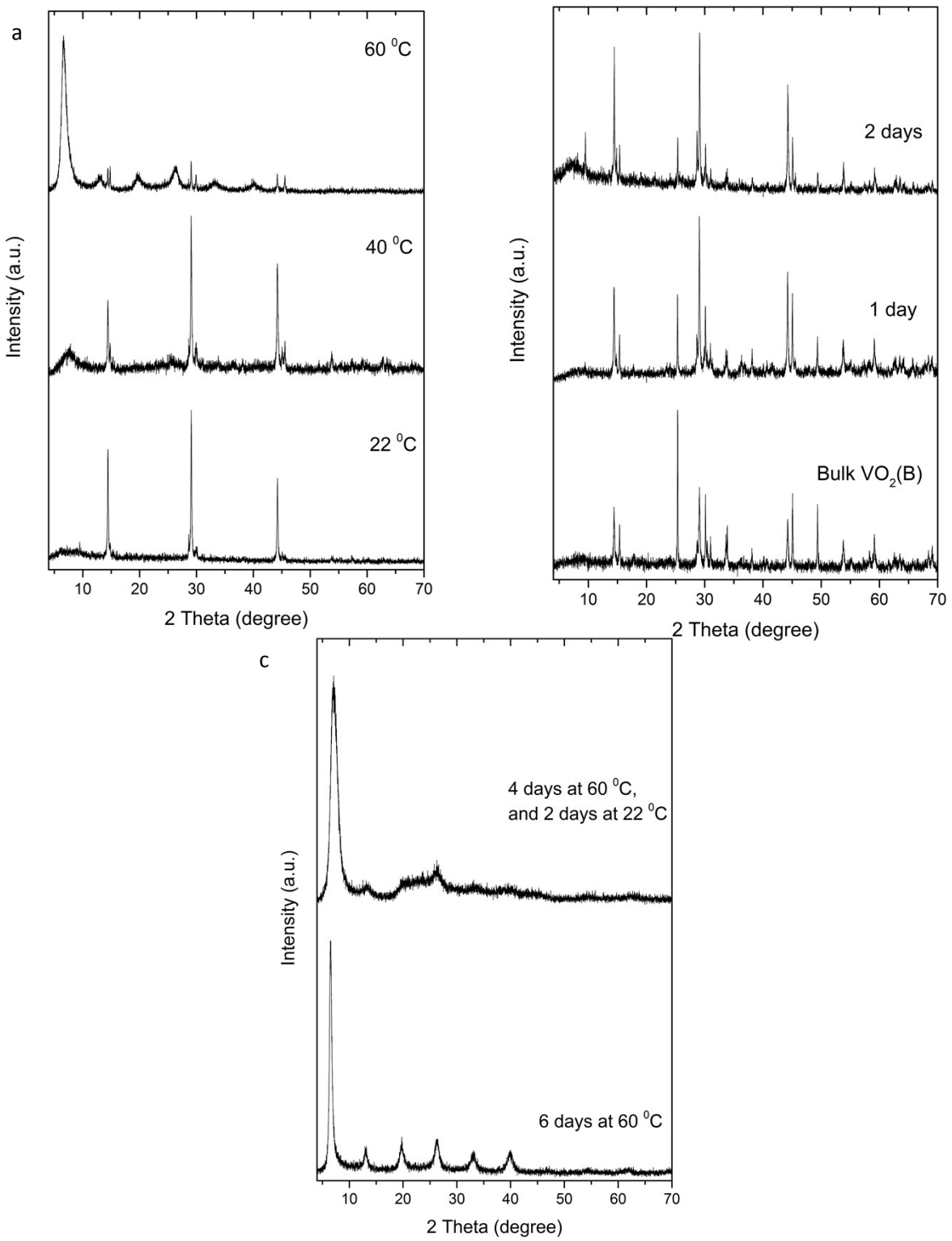


Figure S4: (a) Powder XRD patterns for $VO_2$(B) after refluxing in water for 5 days at 22 °C, compared with that refluxed in water for the same period at 40, and 60 °C; (b) powder XRD patterns for bulk $VO_2$(B), compared with that refluxed in water for 1 and 2 days at 60 °C; and (c) powder XRD patterns for $VO_2$(B) after refluxing in water for 6 days at 60 °C, compared with that refluxed in water for 4 days at 60 °C and 2 days at 22 °C.

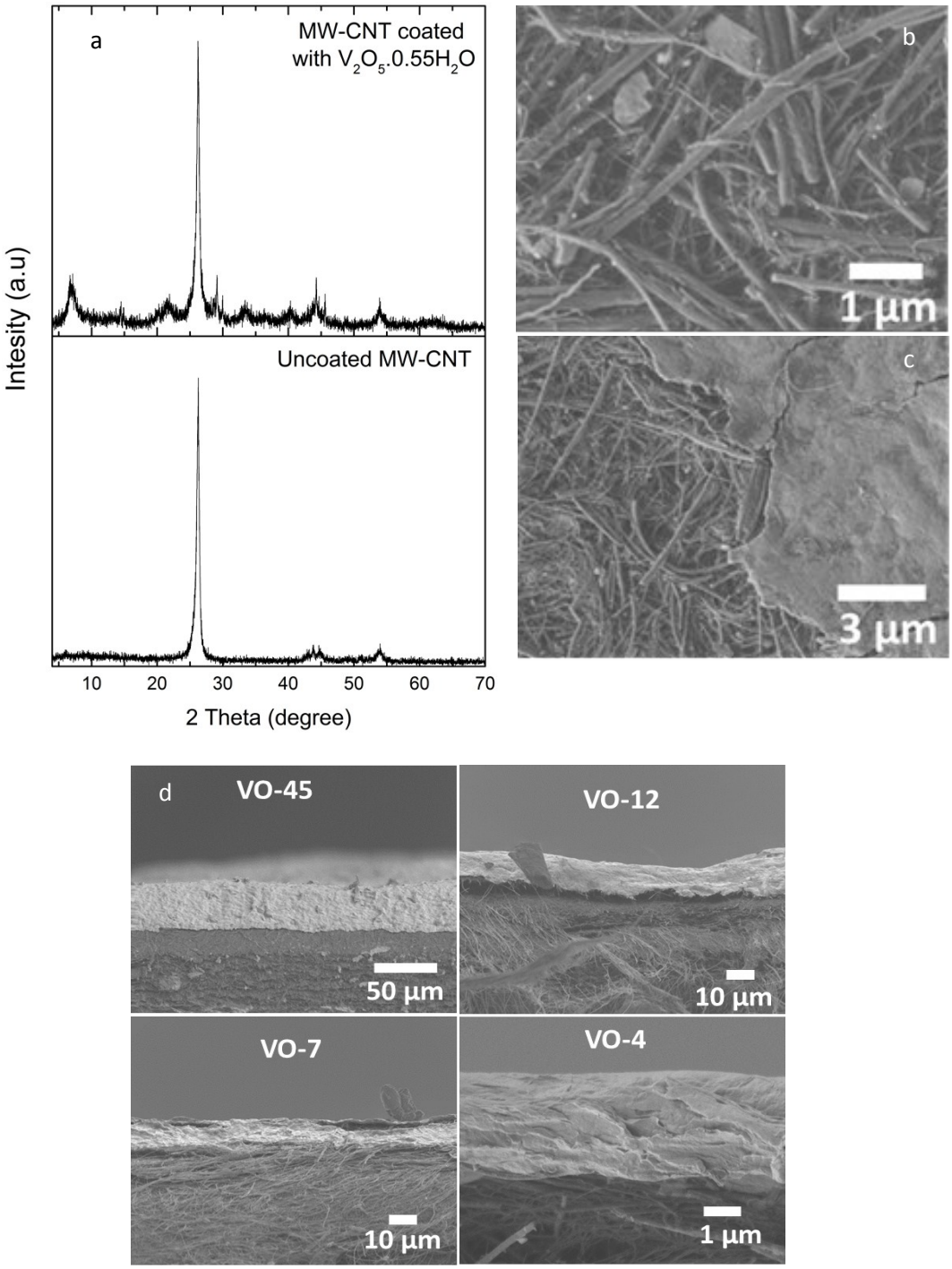


Figure S5: (a) Powder XRD pattern of uncoated MW-CNT and that coated with our exfoliated material using diluted suspension, (b) and (c) SEM images of the coated MW-CNT at different magnification. (d) SEM images of cross-section of the four electrodes used in our study.

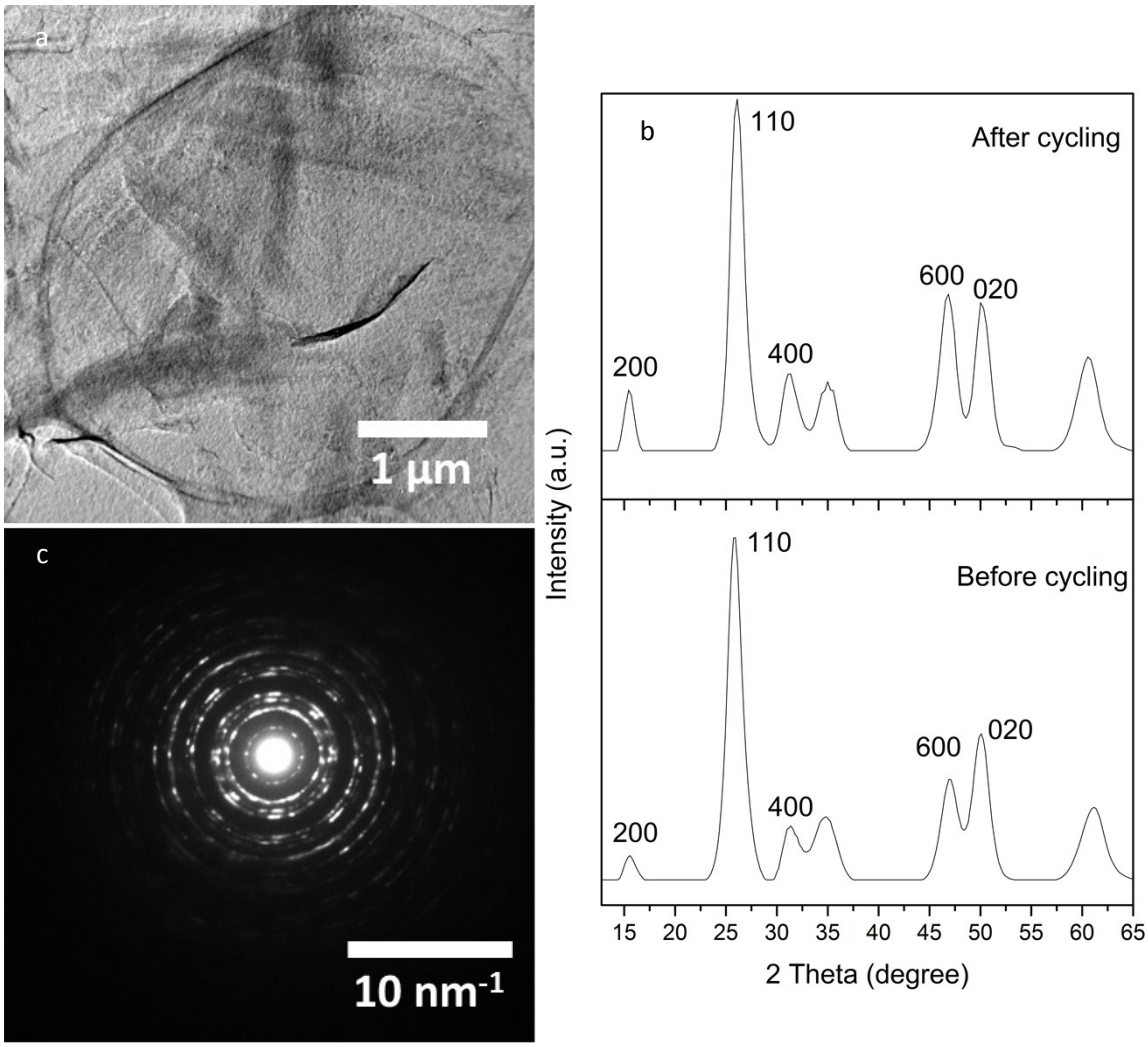


Figure S6: (a) TEM image and (b) the corresponding SAED pattern of $V_2O_5.0.55H_2O$ nanosheets obtained from electrode VO-45 after the electrochemical cycling for 20 cycles. (c) Simulated powder pattern obtained from the SAED pattern of $V_2O_5.0.55H_2O$ before and after cycling (simulation done using CRISP 2.2 program).[2]

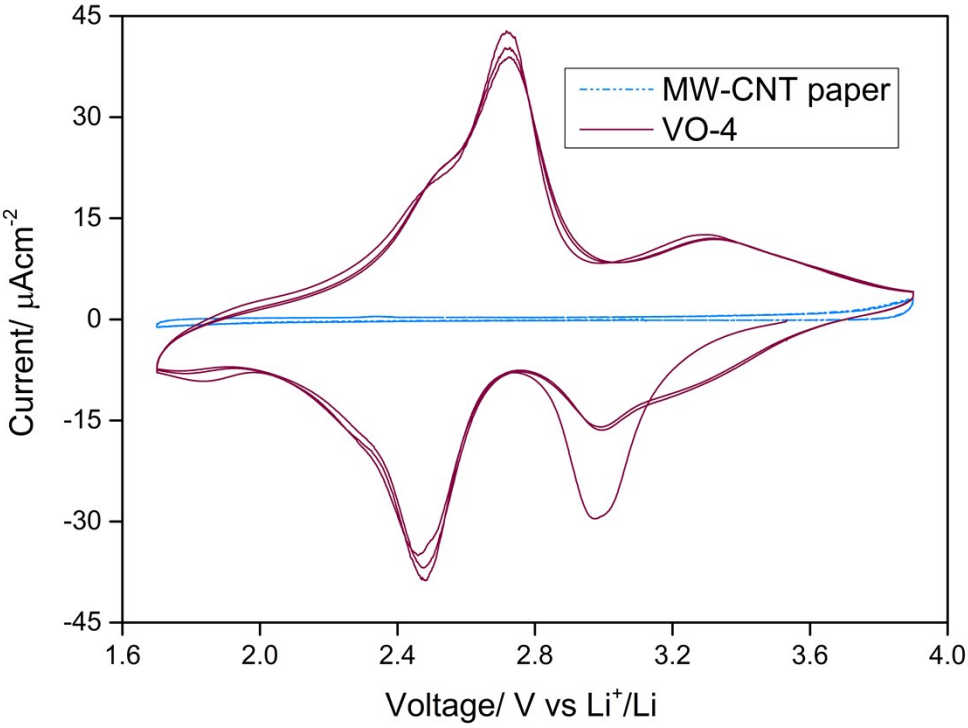


Figure S7: Cyclic voltammograms of the uncoated MW-CNT paper and electrode VO-4 (MW-CNT paper coated with the exfoliated vanadium oxide).

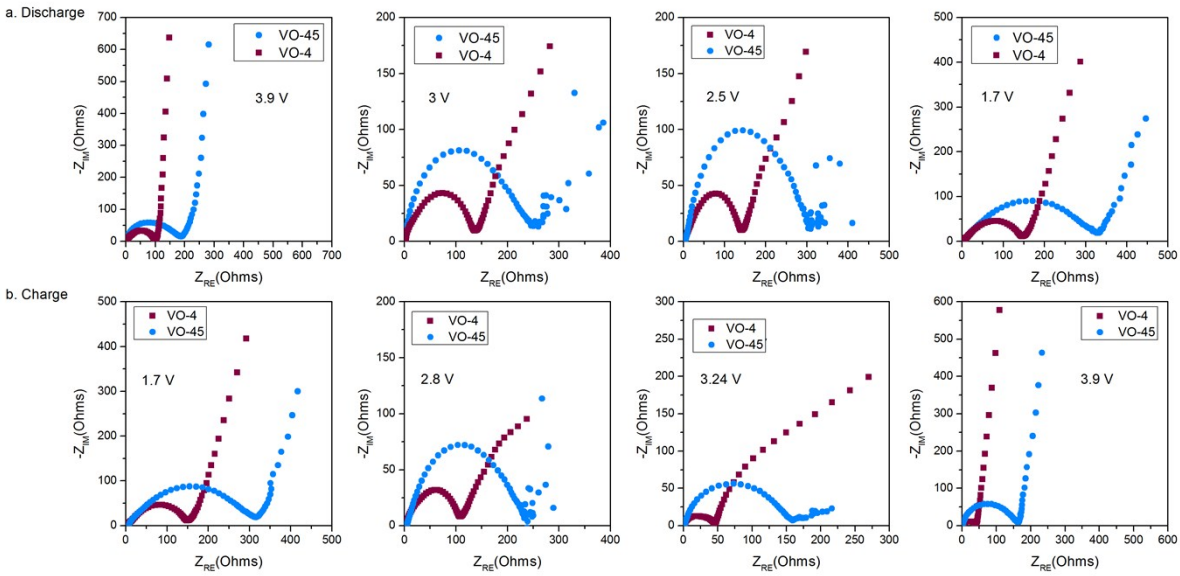


Figure S8: Electrochemical impedance spectroscopy (EIS) data collected for electrodes VO-45 and VO-4 at various voltages during discharge (a) and charge (b). The Nyquist plots shown above indicate that the electrode with a thicker oxide film (VO-45) is more resistive as compared to electrode VO-4.

Table S1: Comparison of the morphology and electrochemical performance of $V_2O_5.nH_2O$ reported in this study and previously reported work.

| Electrode Material Description | Morphology | Capacity / $mAhg^{-1}$ | C-rate or current density / $mAg^{-1}$ | Potential range / V | Reference |
|---|---|---|---|---|---|
| $V_2O_5.nH_2O$ / CNT paper | Ultrathin nanosheets | 280 | 200 | 1.7-3.9 | This work |
| $V_2O_5.nH_2O$ / CNT | Nanobelts | 241 | 200 | 2.0-4.0 | Xianhong Rui *et.al.* [3] |
| $V_2O_5.nH_2O$ xerogel / graphene | Ribbons | 239 | 30 | 1.5–4.0 | Guodong Du *et.al.* [4] |
| $V_2O_5.nH_2O$ xerogel | 2D flakes composed of thin acicular nanowires | 300 | 200 | 1.5–4.0 | Qiulong Wei *et.al.*[5] |
| $V_2O_5.nH_2O$ xerogel | Network of long ribbons | 250 | 0.1 C | 1.5-3.6 | Qi Liu *et.al.*[6] |
| $V_2O_5.nH_2O$ xerogel / 2% reduced graphene oxide | Network of long ribbons | 419 | 0.1 C | 1.5-3.6 | Qi Liu *et.al.*[6] |
| $V_2O_5$ aerogel | Network of ribbons | 291 | 0.25 C | 1.5-4.0 | Arianna Moretti *et.al.*[7] |

References:


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