Vanadium Oxide Cathodes for Beyond Li-Ion Energy Storage

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Introduction

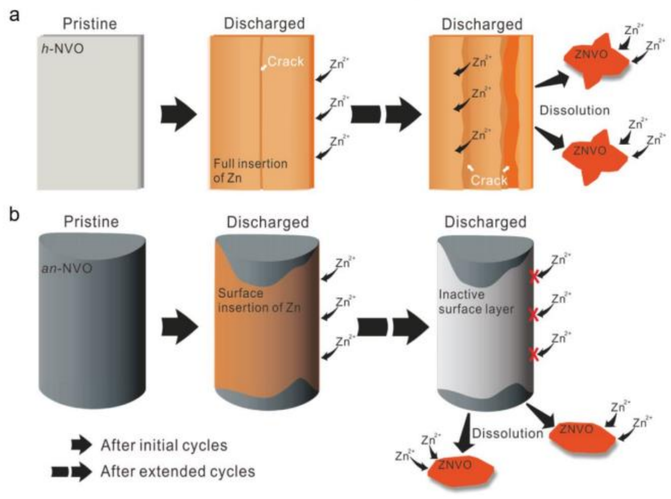


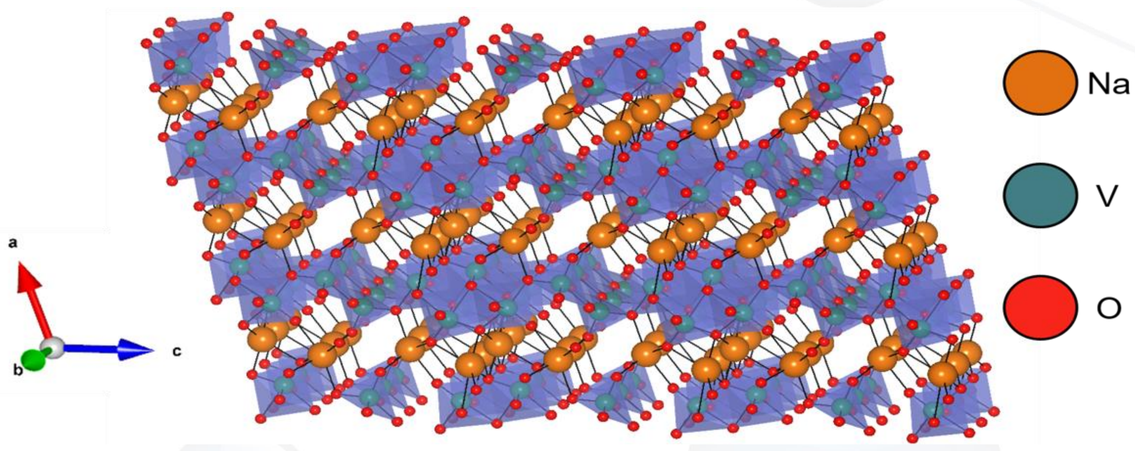
Fig. 1: Zn-ion storage mechanism of **a)** hydrated NVO nanobelts **b)** anhydrous NVO nanorods[2]

- Rechargeable battery systems based on aqueous electrolytes are promising due to low cost and high safety[1]
- In aqueous Zn-ion systems, the energy storage mechanism of sodium vanadate (NaV_3O_8) has been shown to be altered through morphology and the presence of structural water
- Zn-ions access the NVO bulk in the hydrated nanobelts [h-NVO], but only access the surface in anhydrous nanorods [an-NVO]
- Hydrated-NVO shows higher capacities, but lower capacity retention than the anhydrous-NVO. This is coupled to the different ion storage mechanisms of the two materials. Here, a dehydrated NVO nanobelt was prepared to decouple the effects of hydration and morphology and was compared

Materials

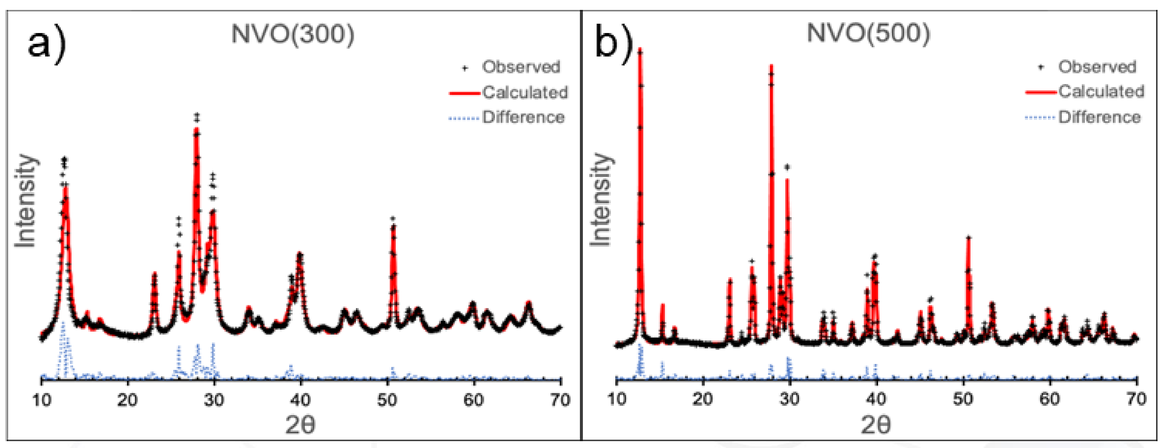
NVO(300): Prepared by annealing hydrated precursor at 300 °C
NVO(500): Prepared by annealing hydrated precursor at 500 °C

Structural Characterization



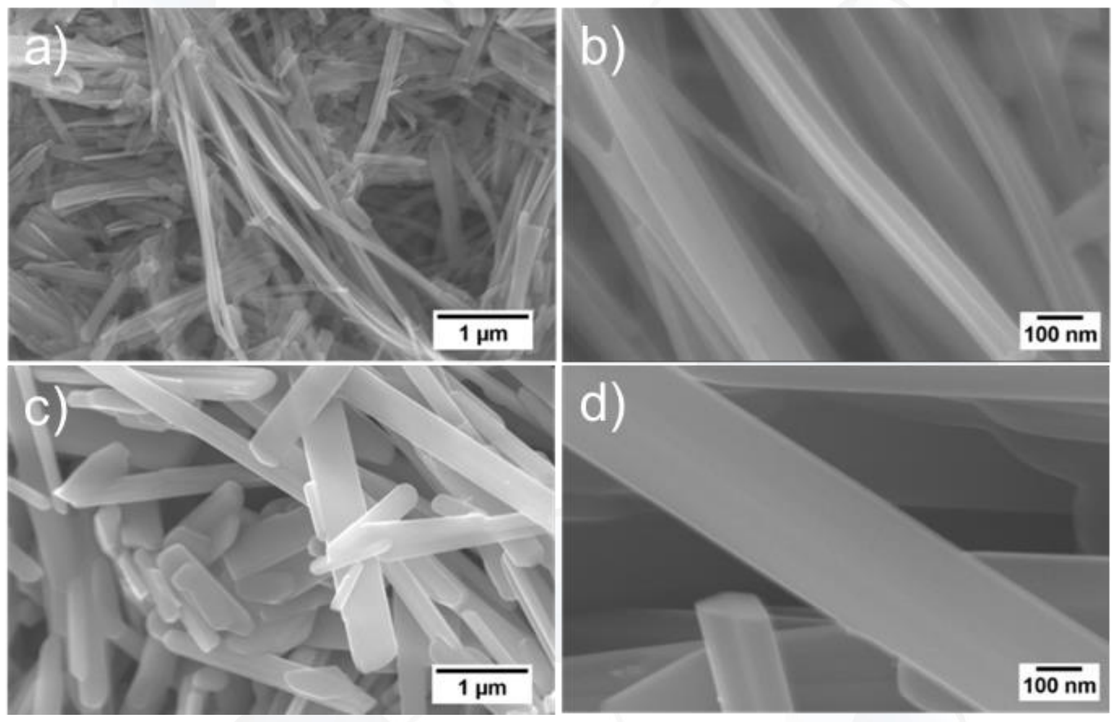
NVO structure: V_3O_8 layers separated by Na-ions occupying the octahedral sites between the layers

XRD



Refined *XRD* patterns of **a)** NVO(300) **b)** NVO(500) reveal similar structures between NVO(300) and NVO(500), but increased crystallinity in NVO(500)

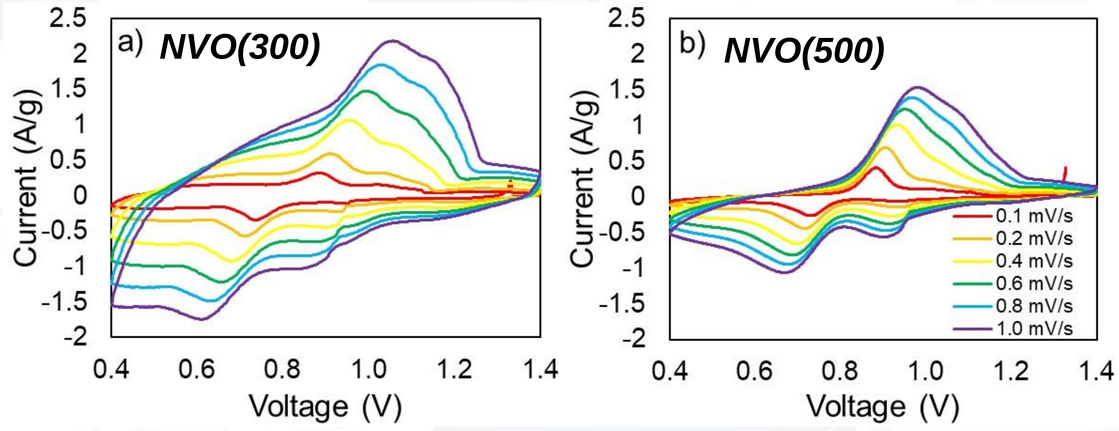
SEM



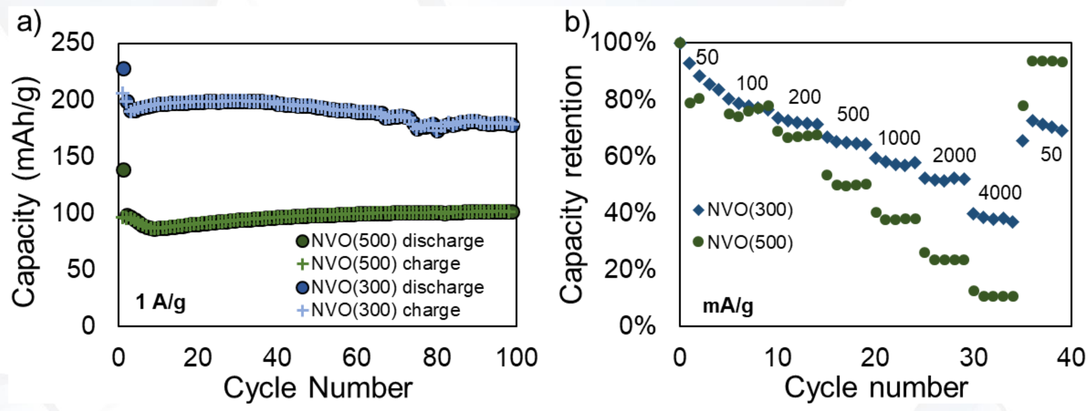
SEM images of **a), b)** NVO(300) **c), d)** NVO(500).

SEM reveals a nanobelt morphology for NVO(300), similar to previously reported hydrated NVO. This morphology is thinner than the nanorod morphology of NVO(500),

Electrochemical Characterization



Cyclic voltammetry between 0.4 and 1.4 V vs Zn/Zn^{2+} at various scan rates for **a)** NVO(300), **b)** NVO(500). The greater increase in current at higher scan rates in NVO(300) indicate larger diffusion coefficients than in NVO(500)



a) *Galvanostatic cycling* between 0.4 and 1.4 V vs Zn/Zn^{2+} at 1 A/g.
b) *Normalized rate capability* at 50, 100, 200, 500, 1000, 2000, and 4000 mA/g.

During extended cycling, NVO(300) shows much higher capacity delivered, with somewhat greater fade than NVO(500).
NVO(300) shows greater capacity retention at higher rates than NVO(500).

Summary

NVO (300) provides higher capacity than NVO (500). The capacity retention the NVO (500) material is higher due to reactivity limited to the surface of each particle, consistent with the lower capacity.

References and Acknowledgement

1. Armand, M. ; Tarascon, J. M. *Nature* **2008**, 451, 652-657
2. Kim, S. J., Tang, C. R., Singh, G., Housel, L. M., Yang, S., Takeuchi, K. J., Marschilok, A. C., Takeuchi, E. S., Zhu, Y. *Chemistry of Materials,* **2020**, 32, 2053–2060.

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