

High capacity V-based metal hydride electrodes for rechargeable batteries

10/2017

Scientific Achievement

The kinetics and thermodynamics of corrosion were controlled to develop a high capacity metal hydride electrode of V-Ti-Ni-Cr.

Significance and Impact

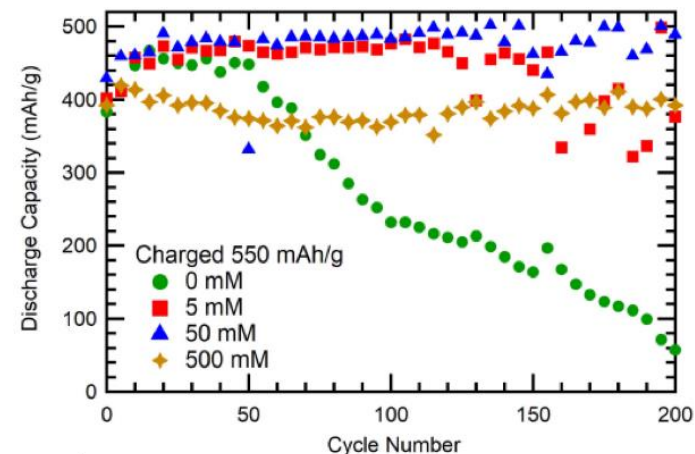
Early transition metals absorb large amounts of hydrogen, but quickly lose capacity in rechargeable aqueous batteries. Systematically addressing the corrosion mechanisms gave cyclability, and up to 600 mAh/g (nearly twice that of state-of-the-art MH electrodes). With JPL engineering, V-Ti-Ni-Cr alloy electrodes were designed into a MH-air system with a calculated energy density comparable to Li-ion cells.

Research Details

Vanadium dissolution was suppressed by removing oxygen from the system, plus either:

- increasing vanadate ion concentration in the electrolyte, or
- increasing Cr content in the alloy.

H. Yang, N.J. Weadock, H. Tan, and B. Fultz, "High capacity V-based metal hydride electrodes for rechargeable batteries," *J. Mater. Chem. A* 2017, DOI: 10.1039/C7TA07396H.



Cycling performance of coin cells containing $\text{Ti}_{29}\text{V}_{62}\text{Ni}_9$ electrodes with KVO_3 additions to the KOH electrolyte, charged to 550 mAh/g.



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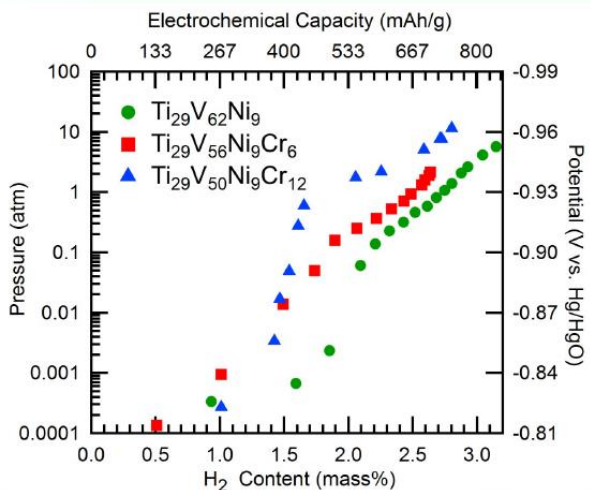
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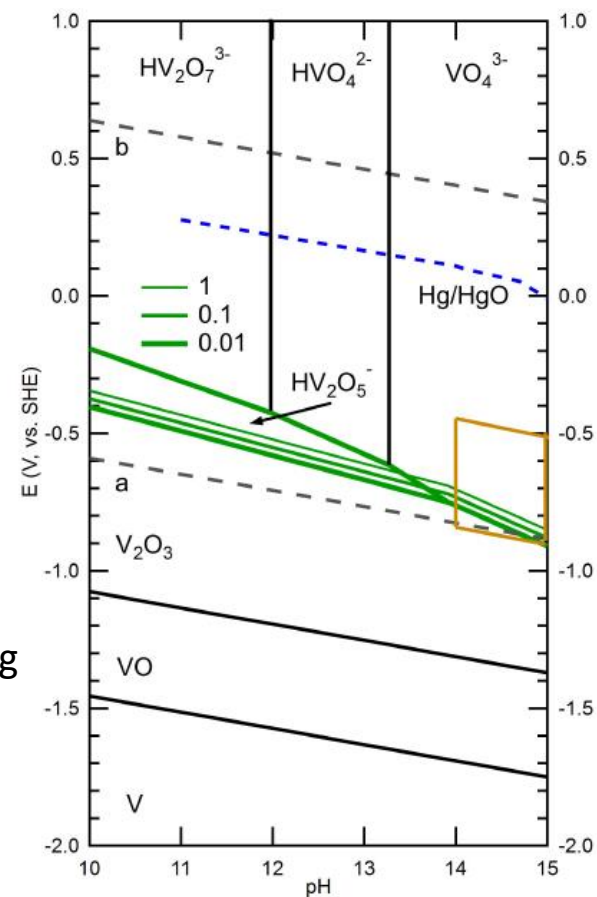
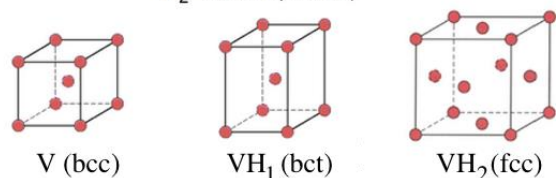
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Backup Slide: High capacity V-based metal hydride electrodes for rechargeable batteries

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(Left) Vanadium forms a hydride of composition VH_1 and a dihydride of composition VH_2 (with hydrogen mass fraction $2/51 \sim 4$ wt%). Formation of VH_1 and VH_2 are at very different pressures. It is unclear if $V \leftrightarrow VH_1$ occurs in an electrochemical cell, and there has been confusion with corrosion of V.



(Right) The Pourbaix diagram shows that V corrodes and dissolves in strong alkaline solution as VO_4^{3-} (vanadate) ions, accompanied by $2H_2O + O_2 + 4e^- \leftrightarrow 4OH^-$

Minimizing oxygen availability improves cycle life, but was not effective unless combined with either:

- 1) Adding vanadate ions (the reaction product) to the electrolyte to suppress the forward reaction (this is new).
- 2) Alloying with Cr, perhaps like Cr in stainless steel (known previously). This is even more effective without oxygen (new).



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