CLEAN ENERGY STORAGE WITH SODIUM-ION BATTERIES

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INTRODUCTION

Efficient storage of cleanly-generated energy from renewable sources is critical for widespread implementation of these technologies. Electrochemical energy storage is particularly attractive due to the high energy density and power capabilities of such systems. We have investigated ambient-temperature, non-aqueous, sodium-ion electrochemical systems that have the potential to fill the storage needs of renewable energy generation, while focusing on materials that are environmentally-friendly and Earth-abundant to ensure sustainable and rapid development of a clean energy future.

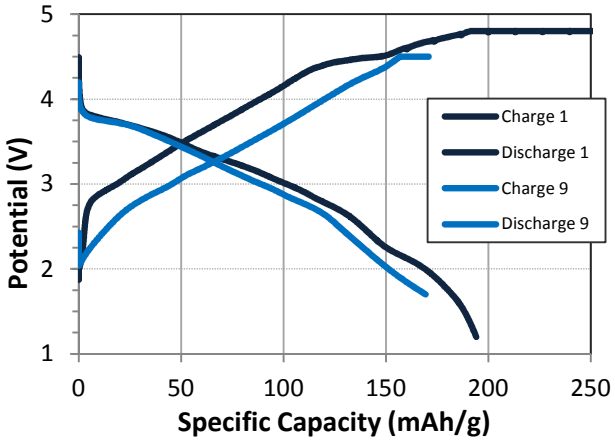

Figure 1. Voltage profile of $Na_{0.6}Li_{0.6}Mn_{0.75}Ni_{0.25}O_{2.35}$ vs. Na/Na^+. Conditions: galvanostatic cycling 15 mA/g, 1 M $NaPF_6$ in propylene carbonate electrolyte, glass fiber separator.

EXPERIMENTAL

2D-layered oxide cathode materials provide high energy density owing to high specific capacities (>160 mAh/g) at an average cell potential of 3 V vs. Na/Na^+.[1,2] In order to minimize the use of toxic or expensive elements, we have focused on manganese-rich formulations such as $Na(Mn_{1/3}Fe_{1/3}Ni_{1/3})O_2$ and $Na_xLi_yMn_{0.75}Ni_{0.25}O_{2.35}$, $x + y = 1.2$ (Figure 1).[1,3,4] Pairing these with high-capacity and environmentally-friendly anodes based on carbon and titanium compounds can provide theoretical energy densities of *ca.* 150 Wh/kg in a Na-ion battery, comparable to commercially available Li-ion technologies (Figure 2).

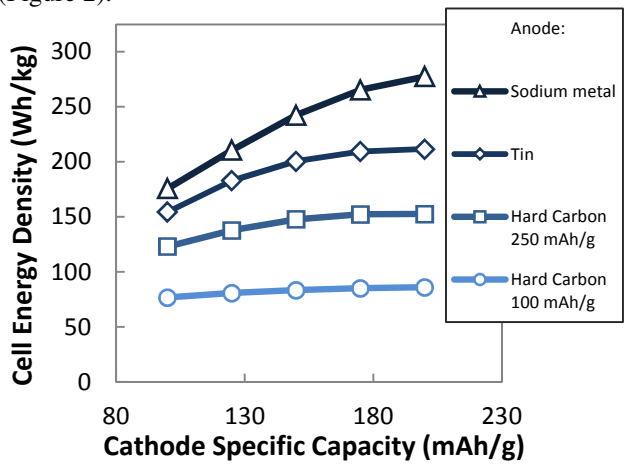

Figure 2. Theoretical energy densities of sodium-ion batteries consisting of $NaMO_2$ (M = Mn, Ni) cathodes against various anode materials; calculations were performed using the BatPac Model[5].

REFERENCES

[1] M. D. Slater, D. Kim, E. Lee, C. S. Johnson, *Advanced Functional Materials* **2012**, *in press*.
[2] N. Yabuuchi, M. Kajiyama, J. Iwatate, H. Nishikawa, S. Hitomi, R. Okuyama, R. Usui, Y. Yamada, S. Komaba, *Nat Mater* **2012**, *11*, 512.
[3] D. Kim, E. Lee, M. Slater, W. Lu, S. Rood, C. S. Johnson, *Electrochemistry Communications* **2012**, *18*, 66.
[4] D. Kim, S.-H. Kang, M. Slater, S. Rood, J. T. Vaughey, N. Karan, M. Balasubramanian, C. S. Johnson, *Advanced Energy Materials* **2011**, *1*, 333.
[5] P. A. Nelson, K. G. Gallagher, I. Bloom, D. W. Dees, ANL-11/32, Argonne National Laboratory, Argonne, IL USA **2011**.