Hybrid Sodium-Potassium Vanadium Sulfate Batteries

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With lithium deemed the next gold market[1], combined with its low abundance, alternative intercalating ions have become ever more important for developing new material battery systems. The alternative ion principally being investigated is sodium due to its relatively similar electrochemical profile as lithium, high abundancy in the earth's crust and low cost. Sodium ion batteries have been stated as being a 'drop-in' technology to lithium ion, meaning that the same production lines can be used for both technologies. Other single ion chemistry technologies such as Mg[2], Zn[3] and K[4] have also been proposed.

Mixed metal systems are a novel approach to possible alternative battery systems[5] and several mixed alkalki metal materials have been studied as a way of improving the overall performance of a material, for example adding potassium into a hexacyanoferrate ($Na_xK_yFe[Fe(CN)_6]$) material improved its electrochemical performance by preventing the structure undergoing phase changes[6]. Currently, however, the use of dual ionic conductors in batteries to improve electrochemical performance is not well documented and specifically multi-ion battery systems have not been demonstrated in a full cell configuration to understand the role of multi-ion intercalations.

This study investigates a series of mixed sodium-potassium vanadium sulfate materials, and demonstrates this 'dual-ion' intercalation approach. The air sensitive sodium vanadium sulfates are synthesizable under relatively low temperature solution based synthesis over a range of compositions. The structure-property relationships of these materials are investigated using x-ray diffraction, Fourier transformed infrared spectroscopy, and Raman spectroscopy and combined with electrochemical data such as galvanostatic cycling and differential capacity analysis to elucidate the structural and electrochemical changes of these materials with different compositions.

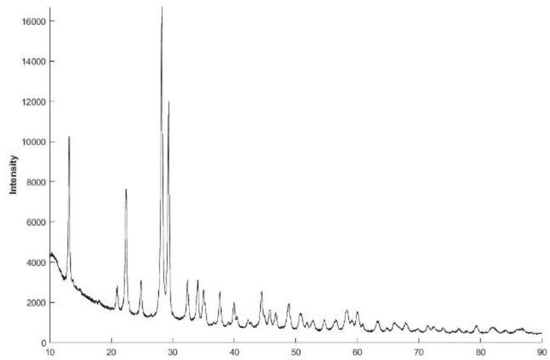

Figure 1: A powder x-ray diffraction pattern of $Na_3V(SO_4)_3$

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