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Probing of the Sodium Intercalation mechanism into Nano-sized V_2O_5 for Sodium-ion Batteries

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In recent years, numerous efforts have been made to develop high performance rechargeable batteries to use for large scale applications such as electrical energy storage systems (ESS). Lithium ion batteries have been the most popular and widely used batteries in portable devices like cell phones, laptops, etc. However, it has some constraints to be used for large scale applications as the cost for the raw materials for lithium is expensive. There have been ongoing studies searching for alternative shuttle ions and sodium can be one of the possible substitutes since it is more abundant and cheaper. High performance materials with large sodium storage capacities are required for the realization of sodium-ion batteries. Vanadium pentoxide (V_2O_5) is considered as promising active material due to its unique crystal structure with large interlayer spacing of 4.4 Å. It is known that layered V_2O_5 is electrochemically active when the electrode was applied in NIBs but exhibiting less noticeable performances. Herein, we designed the novel composite electrodes which consist of V_2O_5 nanoparticles and carbon and investigated the electrochemical energy storage mechanism of the electrode materials. Due to the incorporation of carbon-based material, the charge transfer resistance was significantly improved compared to the electrode with V_2O_5 alone. Accordingly, the nano sized V_2O_5/C composite has shown a superior reversible capacity as well as high rate capability. The electrodes with fully charged-discharged states have been further investigated by ex situ XRD and the result reveals the reversible sodium de/intercalation. Ex situ TEM analysis of the fully discharged electrode shows both crystalline and amorphous phases of $Na_2V_2O_5$. In addition, NEXAFS spectroscopy is employed to monitor the oxidation stage changes of vanadium ions upon Na^+ insertion/extraction and it is found that the redox (V^{4+}/V^{5+}) is responsible of the delivered capacity.

Biography:

Mr. Ghulam Ali is a final year PhD candidate at Center for Energy Convergence Research, Korea Institute of Science and Technology, Seoul, South Korea. He received his M.Phil degree in solid state physics from the University of the Punjab in 2010. During PhD program, he is doing his research work on the synthesis and electrochemical properties of cathode materials for lithium, sodium and magnesium ion batteries. Moreover, he is specialized in characterizing the cathode materials using synchrotron x-ray based advanced techniques such as EXAFS and NEXAFS at Pohang accelerator laboratory (PAL), South Korea and has more than three years experience to work at PAL. His research work has been published in high ranked journals such as Nanoletters, journal of material chemistry A (front page cover image), ACS Applied Materials & Interfaces, Electrochimica Acta and more.