Electrochemical Characterization of SnP_3/C Composite as a New Anode Material for Next Generation K-Ion Batteries

Rakesh Verma, Pravin N. Didwal, Chan-Jin Park
Department of Materials Science and Engineering, Chonnam National University, 77, Yongbongro, Bukgu, Gwangju 61186, Korea

E-mail: parkcj@jnu.ac.kr

Lithium-ion batteries (LIBs) have been successfully used to power small portable electronic devices due to their high energy density. However, it is still debatable whether mineral resources for LIBs can meet the increasing demands associated with the expansion of LiBs into the area of large scale energy storage systems. Therefore, scientists are searching for alternatives to LIBs, which are based on earth-abundant elements including Na, K and Mg. Among them, potassium-ion batteries (PIBs) appear to be a more promising candidate due to an abundance of K: ~900 times higher than that of Li. Recently, there has been growing interest in K-based batteries, such as K-ion, $K\text{-}O_2$ and K-S batteries. The standard redox potential of K is lower than that of Na and moreover even below that of Li in non-aqueous electrolytes (*i.e.* PC and EC/DEC). Thus, PIBs can possibly deliver a higher cell potential compared to SIBs and LIBs. As an PIB anode, carbonaceous materials are capable of intercalating K-ions, delivering a capacity of up to 273 mAh g^{-1}. However, their cyclability is not acceptable. Alloy based materials have shown a potential as anode materials for PIBs. Phosphor has a high theoretical capacity of 2594 mAh g^{-1} by forming a binary phase of K_3P with K. Nevertheless, few alloy-based anode compounds haven been reported to date for PIBs.

In the present study, SnP_3/C composite as a potential anode material for PIBs was synthesized by a high energy ball-milling. The phase purity, crystal structure and morphology of the synthesized materials were characterized by XRD, SEM and TEM. Furthermore, the electrochemical characteristics of the SnP_3/C electrodes were investigated through cyclic voltammetry, electrochemical impedance measurement, and cyclic charge-discharge tests. The effect of the K-insertion/deinsertion process on the crystal structure of SnP_3 was examined by the ex-situ XRD patterns recorded at various stages of discharge and charge. Lastly, we further demonstrate the practical feasibility of K-ion batteries by constructing full cells. We consider that this work can suggest a guideline to open up new research opportunities in the development of K- ion batteries.

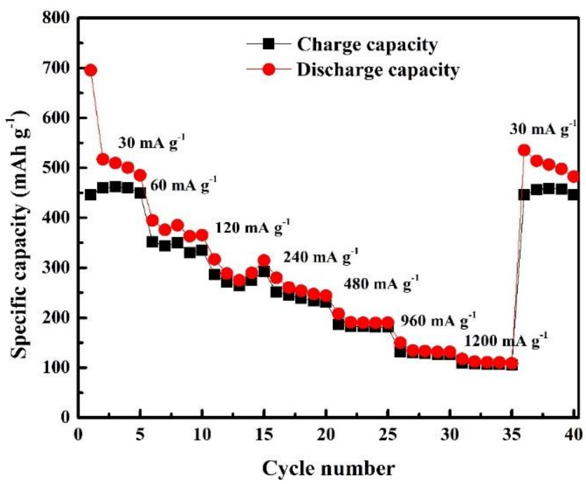

Fig. 1. Rate capability of the SnP_3/C electrode for K-ion batteries.