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RESEARCH FOR SUSTAINABLE DEVELOPMENT

Fabrication of Sodium Ion Rechargeable Battery Using Earth Abundant Orthosilicates

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1 INTRODUCTION

Recently, various high capacity anode materials have been developed for sodium ion batteries. However, on the cathode side, the capacity is often low. The reason is the intrinsic limit of intercalation-type cathodes, which can only accommodate one sodium ion per transition metal core (Zhu *et al.*, 2015). Magnesium metal provides two electrons per atom, giving it an attractive volumetric capacity than Lithium metal. It also reduces the battery cost due to its natural abundance in the earth's crust as the fifth most abundant element. It also provides higher volumetric capacities than Lithium metal (3832 mAh cm^{-3} for Magnesium and 2061 mAh cm^{-3} for Lithium) (Mohtadi and Mizuno, 2014). Rechargeable aluminium-based batteries have an advantage due to their low manufacturing cost and low flammability, together with three-electron-redox properties leading to high capacity. During the last three decades aluminium-based batteries have encountered several problems, such as cathode material disintegration, low cell discharge voltage capacitive behaviour without discharge voltage plateaus and insufficient cycle life with rapid capacity decay (Lin *et al.*, 2014).

Olivine type structures ($MgMSiO_4$) also use as the cathode material and in Li_2FeSiO_4, the SiO_4^{-4} tetrahedral is arranged in the same way as in the MgMSiO4. In olivine type $MgMSiO_4$ the theoretical capacity exceeds 300 mA h g^{-1} and operational voltage is expected to be higher than the common magnesium battery. SiO_4^{-4} which are expected to cause lattice stabilization for magnesium intercalation through the presence of strong Si-O bonds (Orikasa *et al.*, 2014).

Within manganese-based poly-anion-type compounds, Li_2MnSiO_4 (LMS) is attractive mainly for the possible two-electron exchange reaction, giving a theoretical capacity of 333 mA hg^{-1}. However, LMS materials still have numerous issues. First, it is hard to obtain a high-purity phase of LMS, Secondly, their poor electrical conductivity and low lithium diffusion coefficient severely limit the rate performance (Hu *et al.*, 2013). But poly-anion type compounds such as lithium metal phosphates and silicates are used in rechargeable batteries due to good practical merits such as high safety, low cost and constant voltage.

Lithium ion batteries also have some problems. They require protection from