$Co_2Mo_3O_8$/reduced Graphene Oxide Composite: Synthesis, Characterization and its Role as Prospective Anode Material in Lithium Ion Batteries

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Abstract

$Co_2Mo_3O_8$/Reduced Graphene Oxide ($Co_2Mo_3O_8$/rGO) composite was synthesized by following a single step solid state reduction procedure (named it as Graphenothermal reduction procedure). So-prepared $Co_2Mo_3O_8$/rGO composite was characterized using a multitude of characterization techniques, which confirmed the formation of the composite. Electron micrographs clearly showed that the composite consisted of submicron sized (lateral) and 50 nm thick hierarchical hexagonal nanoplatelets of $Co_2Mo_3O_8$ attached to thin graphene layers of rGO. Raman scattering analysis not only confirmed the presence of $Co_2Mo_3O_8$ and rGO in the composite but also revealed that the defects present in rGO are more than that in GO. Through thermogravimetric analysis, the amount of rGO present in the composite was found to be ~22% by weight. Co 2p, Mo 3d, C 1s and O 1s X-ray photoelectron energy peaks were clearly identified. The analysis of these peaks confirmed the oxidation states of the respective elements in the stoichiometric $Co_2Mo_3O_8$. As-synthesized $Co_2Mo_3O_8$/rGO composite was tested as an anode material in the half-cell configured lithium ion batteries. When cycled at 60 mA/g current density and in the 0.005-3.0 V range, $Co_2Mo_3O_8$/rGO composite delivered an excellent reversible specific capacity of ~954 mA h/g that corresponds to 82% capacity retention at the end of the 60th cycle, which is higher than the theoretical capacity of both $Co_2Mo_3O_8$ and graphene. Moreover, $Co_2Mo_3O_8$/rGO composite exhibited excellent rate capability. A reversible specific capacity of 471 mA h/g (at a current density of 1000 mA/g) was delivered at the end of the 31st cycle. The value increased to 1006 mA h/g when the current density was switched to 100 mA/g at the end of the 36th cycle. Redox peaks in the cyclic voltammetry (CV) curves revealed that electrochemical conversion and electrochemical adsorption and desorption type reaction mechanism are the primary reasons for lithium ion storage. A constant area under the CV curves throughout the tests was noticed, which is an indication of stable capacity while the CV results are in line with the galvanostatic cycling (GC) results. From the CV and GC results, it is concluded that higher specific capacity, longer cycle life, and better rate capability are due to the excellent synergy between $Co_2Mo_3O_8$ and rGO in the composite.

References

[1] B. Das et. al, RSC Adv., **4** (2014), 33883.
[2] S. Petnikota et. al, Electrochim. Acta, **178** (2015), 699.

Figures

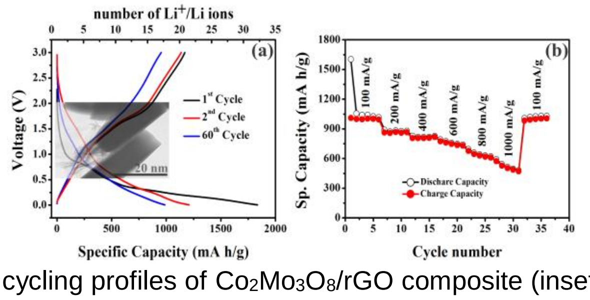

Figure 1 (a) Galvanostatic cycling profiles of $Co_2Mo_3O_8$/rGO composite (inset bright field TEM image) at 60 mA/g current density and in the voltage range of 0.005-3 V, (b) rate capability of the $Co_2Mo_3O_8$/rGO composite.