Studies on spinel cobaltites, MCo_2O_4 (M = Mn, Zn, Fe, Ni and Co) and their functional properties

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ABSTRACT

Optimization of electrodes for charge storage with appropriate processing conditions places significant challenges in the developments for high performance charge storage devices. In this article, metal cobaltite spinels of formula MCo_2O_4 (where M = Mn, Zn, Fe, Ni and Co) are synthesized by oxalate decomposition method followed by calcination at three typical temperatures, viz. 350, 550, and 750 °C and examined their performance variation when used as anodes in lithium ion batteries. Phase and structure of the materials are studied by powder x-ray diffraction (XRD) technique. Single phase MnCo2O4,ZnCo2O4 and Co3O4 are obtained for all different temperatures 350 °C, 550 °C and 750 °C; whereas $FeCo_2O_4$ and $NiCo_2O_4$ contained their constituent binary phases even after repeated calcination. Morphologies of the materials are studied via scanning electron microscopy (SEM): needle-shaped particles of $MnCo_2O_4$ and $ZnCo_2O_4$, submicron sized particles of $FeCo_2O_4$ and agglomerated submicron particle of $NiCo_2O_4$ are observed. Galvanostatic cycling has been conducted in the voltage range 0.005–3.0 V vs. Li at a current density of 60 mA g^{-1} up to 50 cycles to study their Li storage capabilities. Highest observed charge capacities are: $MnCo_2O_4$ – 365 mA h g^{-1} (750 °C); $ZnCo_2O_4$ – 516 mA h g^{-1} (550 °C); $FeCo_2O_4$ – 480 mA h g^{-1} (550 °C); $NiCo_2O_4$ – 384 mA h g^{-1} (750 °C); and Co_3O_4 – 675 mA h g^{-1}(350 °C). The Co_3O_4 showed the highest reversible capacity of 675 mA h g^{-1}; the NiO present in $NiCo_2O_4$ acts as a buffer layer that results in improved cycling stability; the $ZnCo_2O_4$ with long needle-like shows good cycling stability.

KEYWORDS:

Oxalate decomposition method; Energy Storage Materials; Lithium ion batteries; Electrodes; Electrochemical properties; Metal cobaltite