Electrochemical performance of carbon-coated K, Ni and S doped lithium manganese oxide spinel

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Rapid increase of demand for energy and power storage forces scientists to search for improvement of existing and well-known battery materials for most demanding purposes, including fast-growing automotive market and sustainable energy production. These fields of Li-ion batteries application requires compounds that are electrochemically and structurally stable, environmentally friendly and low-cost.

One of the compounds that mostly meets demands mentioned above is $LiMn_2O_4$ – manganese oxide spinel (LMO). In addition to these traits LMO has a high operating voltage and acceptable capacity. Nevertheless, material is not totally free of flaws due to its structural instability caused by Jahn-Teller distortion effect and manganese dissolution in liquid electrolytes, especially in elevated temperature conditions, which are unavoidable in electric and hybrid electric vehicle systems [1,2]. This results in poor capacity retention and gradual deterioration in battery performance.

Mentioned flaws can be overcome by synergistic doping lithium, manganese or oxygen sublattices by elements like potassium (increasing structural stability and Li^+ diffusion coefficient) [3], nickel (increasing structural stability and energy density by shifting voltage of cell to higher potentials due to high-potential Ni redox couples) [4,5] or sulfur (increasing structural stability) [6,7]. In addition, modified LMO can be successfully coated with carbon obtained by controlled pyrolysis of sucrose to improve surface stability (suppression of SEI development), enhance rate cycling performance and rate capability (greatly increasing electronic conductivity of the material) [8]. Combination of these modification results in material that exhibits superior electrochemical performance, especially in terms of large rate capability and cyclability, therefore being promising candidate for future lithium-ion batteries.

Carbon coated Li, Ni and S doped LMO materials with different dopants combinations obtained by sol-gel synthesis were characterized in terms of electrochemical properties. Compositions of most stable and effective carbon composites were determined. Diffusion coefficients of lithium ions for tested materials were determined. The obtained materials were characterized with following methods: powder X-ray diffraction (XRD), electrical conductivity studies (EC), galvanostatic charge/discharge tests (CELL TEST), electrochemical impedance spectroscopy (EIS), galvanostatic intermittent titration technique (GITT) and cyclic voltammetry (CV).

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