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Electrochemical Properties of Li-Ion Batteries Anode Material: $Li_{3.8}Cu_{0.1}Ni_{0.1}Ti_5O_{12}$

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Abstract : In some types of Li-ion batteries carbon in the form of graphite is used. Unfortunately, carbon materials, in particular graphite, have very good electrochemical properties, but increase their volume during charge/discharge cycles, which may even lead to an explosion of the cell. The cell element may be replaced by a composite material consisting of lithium-titanium oxide Li4Ti5O12 (LTO) modified with copper and nickel ions and carbon derived from sucrose. This way you can improve the conductivity of the material. LTO is appropriate only for applications which do not require high energy density because of its high operating voltage (ca. 1.5 V vs. Li/Li+). Specific capacity of Li4Ti5O12 is high enough for utilization in Li-ion batteries (theoretical capacity 175 mAh·g-1) but it is lower than capacity of graphite anodes. Materials based on Li4Ti5O12 do not change their volume during charging/discharging cycles, however, LTO has low conductivity. Another positive aspect of the use of sucrose in the carbon composite material is to eliminate the addition of carbon black from the anode of the battery. Therefore, the proposed materials contribute significantly to environmental protection and safety of selected lithium cells. New anode materials in order to obtain Li3.8Cu0.1Ni0.1Ti5O12 have been prepared by solid state synthesis using three-way: i) stoichiometric composition of Li2CO3, TiO2, CuO, NiO (A- Li3.8Cu0.1Ni0.1Ti5O12); ii) stoichiometric composition of Li2CO3, TiO2, Cu(NO3)2, Ni(NO3)2 (B-Li3.8Cu0.1Ni0.1Ti5O12); and iii) stoichiometric composition of Li2CO3, TiO2, CuO, NiO calcined with 10% of saccharose (Li3.8Cu0.1Ni0.1Ti5O12-C). Structure of materials was studied by X-ray diffraction (XRD). The electrochemical properties were performed using appropriately prepared cell Li|Li+|Li3.8Cu0.1Ni0.1Ti5O12 for cyclic voltammetry and discharge/charge measurements. The cells were periodically charged and discharged in the voltage range from 1.3 to 2.0 V applying constant charge/discharge current in order to determine the specific capacity of each electrode. Measurements at various values of the charge/discharge current (from C/10 to 5C) were carried out. Cyclic voltammetry investigation was carried out by applying to the cells a voltage linearly changing over time at a rate of 0.1 mV·s-1 (in the range from 2.0 to 1.3 V and from 1.3 to 2.0 V). The XRD method analyzes show that composite powders were obtained containing, in addition to the main phase, 4.78% and 4% TiO2 in A-Li3.8Cu0.1Ni0.1O12 and B-Li3.8Cu0.1Ni0.1O12, respectively. However, Li3.8Cu0.1Ni0.1O12-C material is three-phase: 63.84% of the main phase, 17.49 TiO2 and 18.67 Li2TiO3. Voltammograms of electrodes containing materials A-Li3.8Cu0.1Ni0.1O12 and B-Li3.8Cu0.1Ni0.1O12 are correct and repeatable. Peak cathode occurs for both samples at a potential approx. 1.52±0.01 V relative to a lithium electrode, while the anodic peak at potential approx. 1.65±0.05 V relative to a lithium electrode. Voltammogram of Li3.8Cu0.1Ni0.1Ti5O12-C (especially for the first measurement cycle) is not correct. There are large variations in values of specific current, which are not characteristic for materials LTO. From the point of view of safety and environmentally friendly production of Li-ion cells eliminating soot and applying Li3.8Cu0.1Ni0.1Ti5O12-C as an active material of an anode in lithium-ion batteries seems to be a good alternative to currently used materials.

Keywords : anode, Li-ion batteries, $Li_4O_5O_{12}$, spinel
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