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SECOND INTERNATIONAL CONFERENCE ON ELECTRON MICROSCOPY OF NANOSTRUCTURES

ДРУГА МЕЂУНАРОДНА КОНФЕРЕНЦИЈА О ЕЛЕКТРОНСКОЈ МИКРОСКОПИЈИ НАНОСТРУКТУРА

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Nickel manganite-carbonized alginate composite for use as energy storage electrodes

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High fossil fuel consumption has a negative impact on the environment as it causes pollution and greenhouse effect that is one of the main reasons for global warming. This negative phenomenon adds to rising socioeconomic differences and the limited quantity of fossil fuels available for energy production and they all together cause technology and science to develop other energy production and storage solutions. One of the perspectives is electrical energy production and storage in fuel cells, batteries and supercapacitors. Batteries and supercapacitors store energy via ion intercalation/insertion, redox or capacitive electrochemical processes [1]. Nickel-manganite is a versatile material used in many technology applications. One of the established uses is as a supercapacitor electrode. The advantage of this type of material is the earth abundance of required metals, compared to noble metals, and simplicity of the synthesis methods, along with high redox activity. Metal-oxide battery materials are usually combined with activated carbon to enhance the specific surface area and add to energy storage capacity via surface charge accumulation [1], [2]. Activated carbon is usually made by pyrolytic carbonization of carbon-rich organic compounds such as sodium alginate and subsequent chemical activation.

In the current work, nickel manganite was synthesized via sol-gel combustion synthesis method with glycine as fuel and nitrate ions as oxidizers. Post-combustion amorphous powder was calcined at temperatures between 300 and 800 °C. Powders were structurally characterized via X-ray diffraction crystallography (XRD) and Fourier transform infrared spectroscopy (FTIR). Their morphology was examined with SEM, FESEM and TEM microscopy. Chemical analysis was conducted with X-ray photoelectron spectroscopy (XPS). Results revealed that the samples sintered at 400 and 800 °C are pure cubic spinel nickel manganite with the space group $Fd\bar{3}m$ and partially inverse structure, while materials calcined at the temperatures between 500 and 700 °C consist of perovskite $NiMnO_3$, cubic spinel $NiMn_2O_4$ combined with manganese oxide – Mn_2O_3. FESEM and TEM microscopy revealed nanocrystalline structure with a high agglomeration degree. Selected area electron diffraction (SAED) confirmed XRD analysis. To obtain activated carbon, sodium alginate was carbonized in nitrogen atmosphere. Nickel manganite-carbonized sodium alginate composite was made by carbonizing lyophilized nickel manganite-alginate hydrogel. Obtained materials, including synthesized nickel manganite, carbonized sodium alginate and nickel manganite-carbonized sodium alginate were characterized via FESEM and TEM microscopy, XRD analysis, XPS, and FTIR spectroscopy. Obtained materials were tested as energy storage electrodes in a three electrode cell setup in 6 M KOH aqueous solution as electrolyte. Methods embedded in electrochemical characterization were cyclic voltammetry (CV), electric impedance spectroscopy (EIS) and constant current chronopotentiometry at different current densities to obtain galvanostatic charge-discharge (GCD) curves. Results show considerable charge storage activity, which can be ascribed to oxido-

reduction reactions of manganese ions and charge accumulation on the surface of the activated carbon.

References:

[1] J Liu *et al.*, Advanced Science **5** (2018) p. 1700322.
[2] L Qie *et al.*, Energy & Environmental Science **6** (2013) p. 2497.
[3] The authors acknowledge funding from the Ministry of Education, Science and Technological Development of the Republic of Serbia, contract number 45103-68/2022-14/200053.

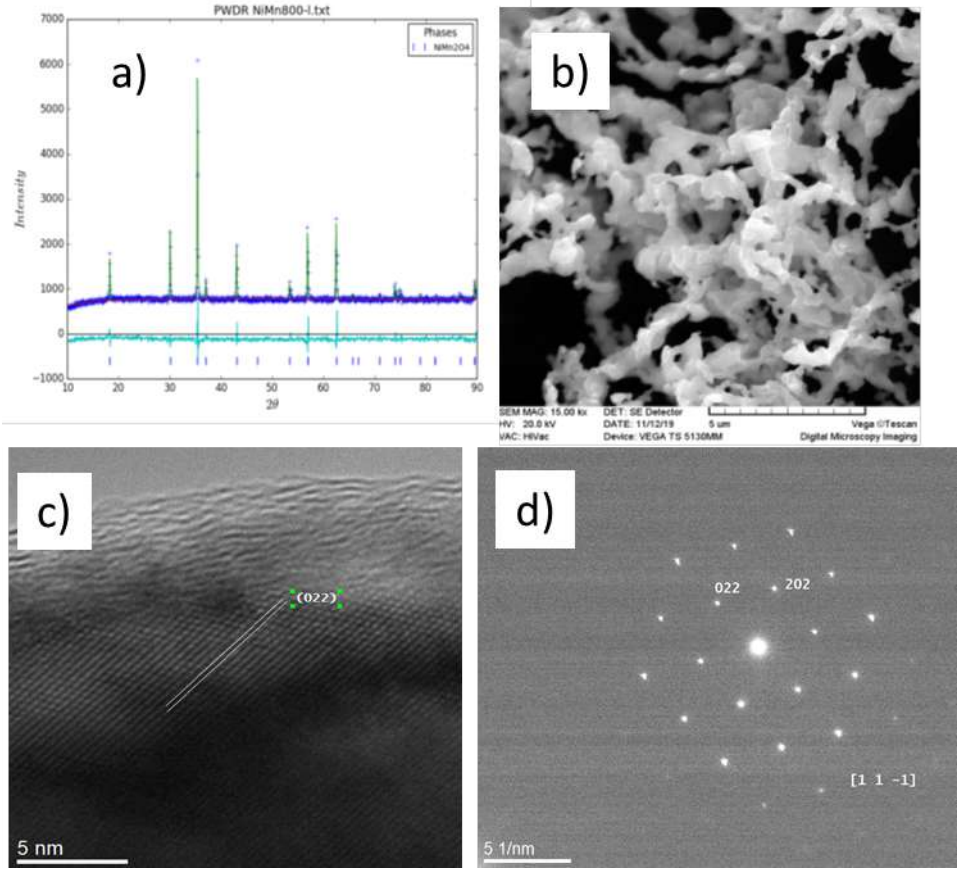

Figure 1. a) XRD pattern, b) SEM micrograph, c) TEM micrograph, d) SAED pattern of $NiMn_2O_4$ calcined at 800 °C.

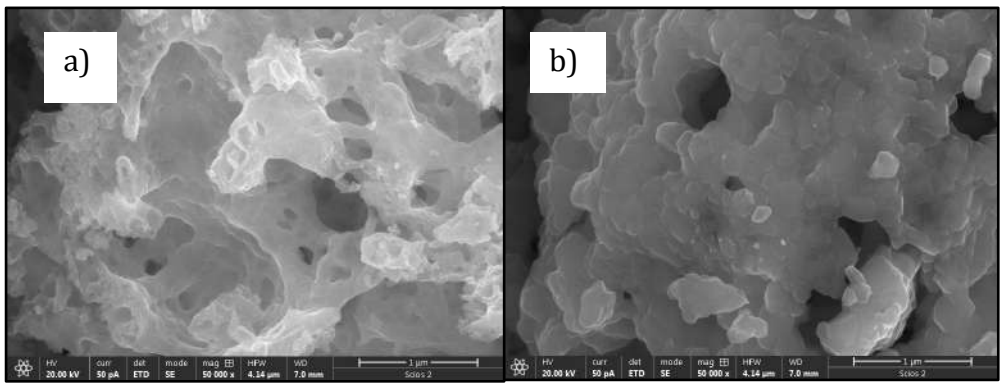

Figure 2. FESEM micrographs of $NiMn_2O_4$ a) calcined at 400 ºC b) calcined at 800 ºC.