Sol-gel synthesis of $LiFePO_4$ for LIB based on lithium carbonate from Kazakhstani spodumene feedstocks

Assem Zhanabayeva[1,2*], Arailym Nalibayeva[1*], Dinara Zhumabayeva[1], Erlan Abdykhalykov[1], Zhumabay Bakenov[3], Gaukhar Bishimbayeva[1***]

[1]*D.V. Sokolsky Institute Institute of Fuel, Catalysis, and Electrochemistry, Almaty, Kazakhstan*

[2]*Department of Chemical Engineering, Kazakh-British Technical University*

[3] *School of Engineering of Nazarbayev Univtrsity, Astana, Kazakhstan*

*E-mail: a.k.zhanabaeva@mail.ru, **E-mail: aray77@mail.ru, ***E-mail: bigauhar@mail.ru

$LiFePO_4$ (LFP) cathode material with an olivine structure, in comparison with other cathode materials, has a number of positive properties, such as: high theoretical capacity and stability, low cost and environmental friendliness. The sol-gel method is one of the effective single-step methods for the production of LFP to control the structure of the electrode materials and provide a nanostructured homogeneous composition of the product particles. LFP was synthesized by sol-gel method from high-purity lithium carbonate obtained from spodumene raw materials of Kazakhstani deposits.

Lithium iron phosphate was synthesized by the interaction of lithium carbonate (Li_2CO_3), 9-aqueous iron (III) nitrate ($Fe(NO_3)_3\ 9H_2O$), ammonium dihydrogen phosphate ($NH_4H_2PO_4$) and citric acid, followed by drying and calcination of the resulting gel in an inert atmosphere.

The phase composition of the resulting powders ($LiFePO_4$) was determined by X-ray diffraction. The electrochemical properties of the synthesized electrode materials were studied by traditional research methods: cyclic voltammetry and galvanostatic charge/discharge curves. The data of cyclic voltammetry confirm the high intercalation reversibility of lithium ions in the obtained samples at the indicated potential limits.

The LIB with LFP2 cathode has an initial discharge capacity of 97 mAh/g, which is 60.6% of the theoretical capacity (1C=160 mAh/g). After 50 cycles, the discharge capacity has increased to 105 mAh/g. The width of the plateau in the battery indicates a large polarizability caused by the impurities present. The battery is stable, as indicated by the stability of the capacity of the first and fiftieth cycles.

Thus, by sol-gel method successfully synthesized and studied samples of lithium iron phosphate synthesized using lithium carbonate obtained from domestic spodumene and purified by us earlier to battery grade. The structure and morphology of the obtained cathode material correspond to the standard profile of lithium iron phosphate. The tests of the synthesized electrode materials in lithium half-cells and push-button cells showed good electrochemical properties, stable battery performance, high intercalation reversibility of lithium ions in the samples within potentials 2.5-4.3V.