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## FORMATION OF ELECTRODES FOR LITHIUM ION BATTERIES USING AN AQUEOUS BINDERS

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Currently, lithium-ion batteries are one of the most widely used power sources in military, medical, household and industrial electronic devices [1]. To date, this type of chemical current sources has the highest specific energy, but this is not enough even for existing equipment. In order to achieve the best specific characteristics, research in this area does not stop and to this day new materials are being searched for, as well as modification of already used materials.

When examining the electrode, it is known that each of its components (active material, conductive carbon material, current collector and binder) has a huge contribution to the performance of the device as a specific capacity, multiple cycling, high-quality charge/discharge process, etc. The mass fraction of the polymer binder content in the composite electrode is very small, however, this component plays a very important role for the electrochemical parameters of devices. To date, the most common polymer binder for electrochemical energy storage is polyvinylidene fluoride (PVDF), which, in turn, dissolves in small types of solvents, and one of them used in the manufacture of electrodes is N-methyl-2-pyrrolidone. This solvent is toxic to the body, therefore, various polymers that dissolve in more environmentally friendly solvents are being studied, and as an example, aqueous polymers can be identified that show quite good results, however, they are much cheaper, more environmentally friendly, and also make the electrode manufacturing process faster [2]. The purpose of this work was to develop the technology of forming electrodes using an aqueous solvent and various carbon conductive additives, as well as to study their effect on the specific characteristics of electrode materials.

In this work, the technology of forming positive (based on  $\text{LiFePO}_4$ ) and negative electrodes (based on  $\text{Li}_4\text{Ti}_5\text{O}_{12}$  and graphite) using aqueous solvents (styrene butadiene rubber (SBR) and carboxymethylcellulose (CMC)) was mastered: the optimal composition was found, homogeneous electrode coatings were obtained. In order to understand the behavior of aqueous polymers, more precisely styrene-butadiene rubber and carboxymethylcellulose, electrodes based on them were

obtained separately. The obtained electrode surfaces after drying using these polymers turned out to be not homogeneous, cracked and had poor adhesion to aluminum foil, these are samples with a coating thickness of 400  $\mu\text{m}$ . To solve this problem, it was decided to use these polymers together in a 1:1 ratio. Since SBR has good elasticity, viscosity, and CMC - strength. However, it was not possible to obtain satisfactory results.

Galvanostatic cycling of cells was performed on an 8-channel analyzer of MTI-BST8-MA power supplies in the voltage range 2-4 V. The charge/discharge current of the cell was set at the rate of 10 mA per gram of cathode coating. Figure 1 shows the discharge curves of cells with a positive electrode based on  $\text{LiFePO}_4$  and various polymer binders (4% by weight): SBR, CMC and SBR:CMC. The discharge current is 10 mA/g.

According to this graph (Figure 1), it can be seen that the sample using SBR as a polymer binder showed the lowest capacity. The sample with CMC showed the highest capacity.

Despite the fact that the sample using CMC has a higher capacity, it cannot be used only when creating a composite electrode, because the electrodes with large thicknesses will crack strongly and have poor adhesion to aluminum foil. The best option is to use these two polymers together, despite a slight loss of capacity.

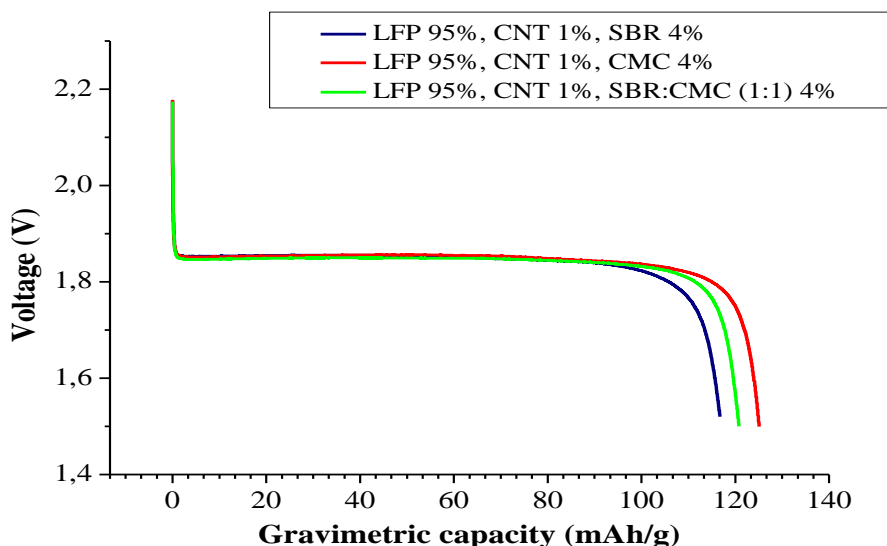


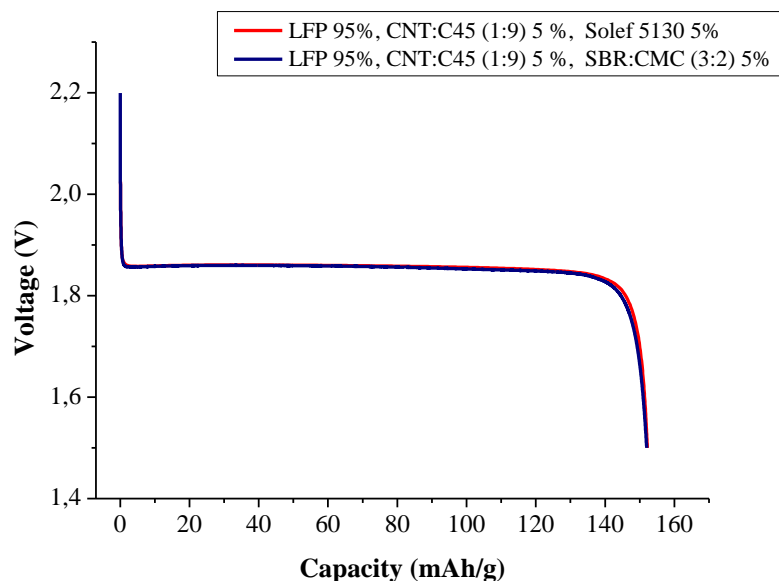
Fig. 1 - Galvanostatic discharge curves of cells with a positive electrode based on  $\text{LiFePO}_4$  and various polymer binders (4% by weight): SBR, CBR and SBR:CMC. Current – 10 mA/g

By selecting the composition of the electrode paste, electrodes with thicknesses of 200, 400 and 600 microns were obtained, which did not crack after drying. Moreover, after several experiments, it was found out that the SBR in the electrode paste should be slightly more than CMC.

The most optimal composition turned out to be: 90% active material; 4.5% carbon black C45; 0.5% CNT; 3% SBR; 2% CMC.

A comparison of the best obtained result of testing an electrochemical cell with a cathode mixed with water with the results of testing an electrochemical cell with a cathode of the same composition, but already with a polymer binder PVDF is shown in Figure 2, showed that the

replacement with a water-soluble polymer did not affect the capacity of the electrochemical



cell.

Fig. 2 - Galvanostatic discharge curves of cells with a positive electrode based on  $\text{LiFePO}_4$  and various polymer binders (4% by weight): Solef5130 and SBR:CMC. Current – 10 mA/g

Testing data were also obtained for an electrochemical cell with a graphite anode with a water-soluble polymer polymer binder and a  $\text{LiFePO}_4$  cathode with a PVDF binder (Figure 3). A mixture of SBR and CMC polymers was used as a polymer in a ratio of 3:2 by volume

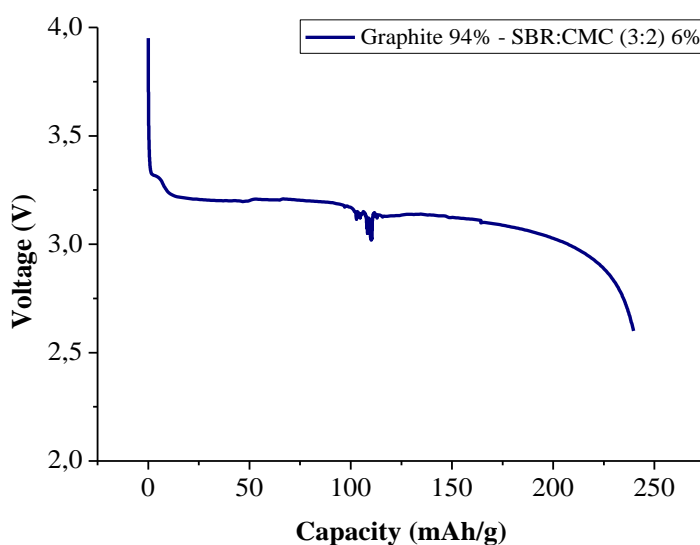


Fig. 3 -Bit curve of the sample using graphite with a water-soluble polymer as an anode

The capacity in this graph is shown per gram of the active anode material - graphite. In this electrochemical cell, the anode and cathode are not balanced, which greatly affects the capacitance value. This experiment tested the operability of an electrochemical cell with this composition. The electrochemical studies of the cells carried out during the work showed that the use of water-soluble polymers did not affect the capacity of the electrochemical cell. From this it can be concluded that the replacement of traditional polymers with water-soluble ones is carried out without loss of capacity.

### References

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