RESEARCH INTO THE DEPENDENCE OF THE PARAMETERS OF LITHIUM-ION BATTERIES ON THE COMPOSITION AND CONCENTRATION OF SALTS AND ORGANIC COMPOUNDS IN THE ELECTROLYTE.

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It is impossible to imagine the modern world without electronic devices. The rapid development of technology has brought various devices firmly into our lives. Thanks to advances in miniaturization, the number of wearable devices is increasing, which has led to a growing interest in miniature power supplies.

The modern stage of technological development is characterized by the ever-increasing penetration of electronics into all spheres of life and activities of people. According to American statistics up to 80% of the total industry volume is occupied by electronics. Achievements in the field of electronics contribute to the successful solution of the most complex scientific and technical problems, increasing the efficiency of scientific research, creating new types of machinery and equipment. Development of effective technologies and control systems includes/requires obtaining materials with unique properties, improving the processes of collecting and processing information. Covering a wide range of scientific, technical and production problems, electronics is based on achievements in various fields of knowledge. At the same time, on the one hand, electronics poses challenges to other sciences and production, stimulating their further development, and on the other hand, equips them with qualitatively new technical means and research methods.

Lithium-ion batteries have become the core technology elements of energy storage systems for electronic devices, electric transportation and renewable energy grids. The resources and technologies required for their production and deployment will shape the leaders of the energy transition Researchers are challenged to improve the parameters of batteries, improve its lifetime, and reduce the demand for key ingredients needed for their production,.

In our research we are focused on appliance of organic-inorganic hybrid composition to improve battery performance.

Hybrid materials are one of the growing new material classes at the edge of technological innovations. Hybrid materials are composites made by synergistic combination of organic and inorganic components at the nanometer or molecular level, a feature that makes them different from traditional composites where the constituents are at the macroscopic (micrometer to millimeter) level. [1]

As part of our research on application of hybrid materials in lithium batteries, we have studied the influence of composition and concentration of salts and organic compounds in the electrolyte for lithium batteries performance. The main aim of the experiments was to determine the optimum electrolyte composition at which the samples battery would show the least degradation.

Degradation of Lithium-ion battery reveals as decrease in the capacity and energy density during their cycling and storage. Degradation pass faster in heavy-duty modes,

when charging/discharging is made with current exceeding 1C (i.e. with current required to fully discharge the battery it in 1h). In our tests a charge/discharge current at level of 5C was applied. This “hard mode” allowed to make fast tests and achieve results in couple of days instead of weeks as it was in case of current on 0.5C - 1C level.

Sample batteries were assembled manually in CR2032 case, according to scheme shown on fig 1. Since pure Li and moisture sensitive electrolyte were used, all preparation steps and batteries assembling were performed in glovebox in argon atmosphere. In these tests a commercial Li chips (Ø = 1 cm) and commercial foil with LCO (supplier) was used as cathode. Area of cathode was equal to one cm2, it gives maximum capacity of couple μAmp/h.

Samples were tested with NEWARE BTS battery testing system, which enables parallel measurement of many samples with different parameters

Battery degradation was defined as a decrease of capacity after a certain number of charge-discharge cycles. The analysis was based on the number of cycles that passed before the capacity dropped twice.

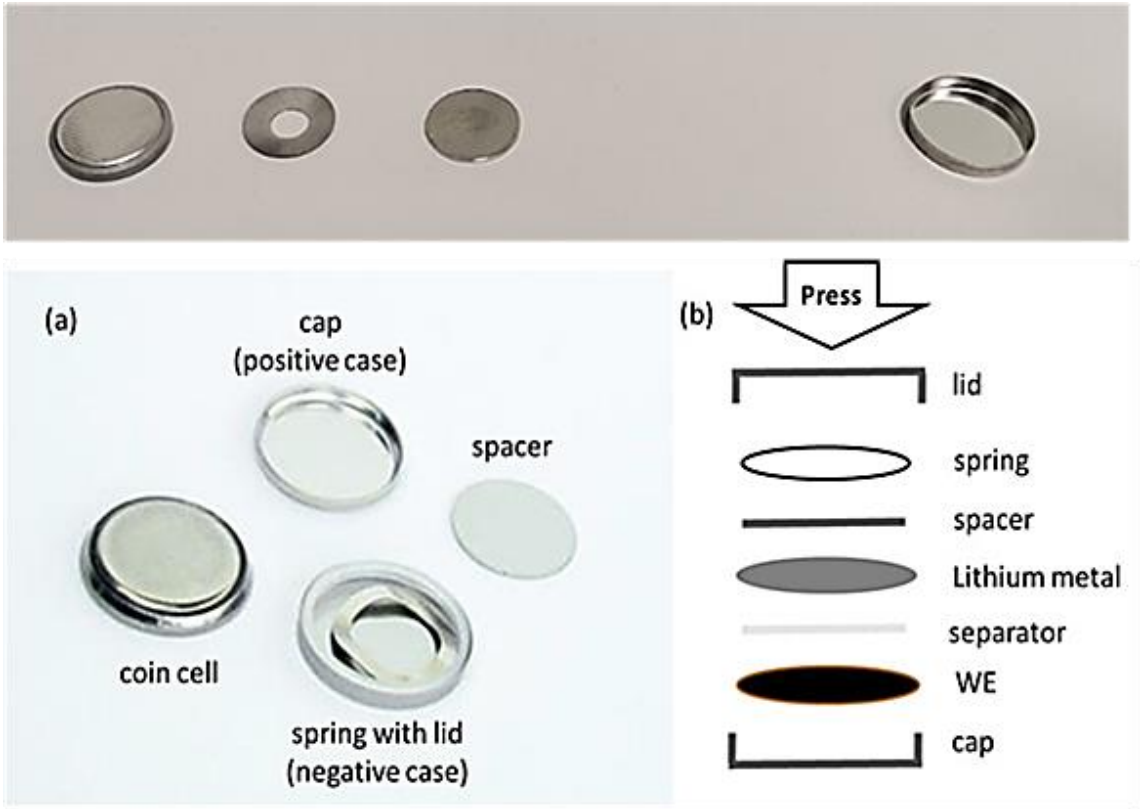

Figure 1 Components for making samples [2]

During research lots of tests were performed to determinate optimal components and their concentration in hybrid electrolyte.

First step of research was to determine optimal non-organic salt concentration in organic electrolyte.

After few initial tests we have chosen a pair of components for further anayzis - Lithium-Tetra Fluoroborate in PC. The best results were received for Lithium-Tetra Fluoroborate in PC (1.5M concentration). This sample has good capacity (very close to theoretical) at start of tests and pass more than 100 cycles (108+/-5% cycles) before capacity drops down two times Fig. 2. Other samples, with different concentration were down after 80-90 cycles.

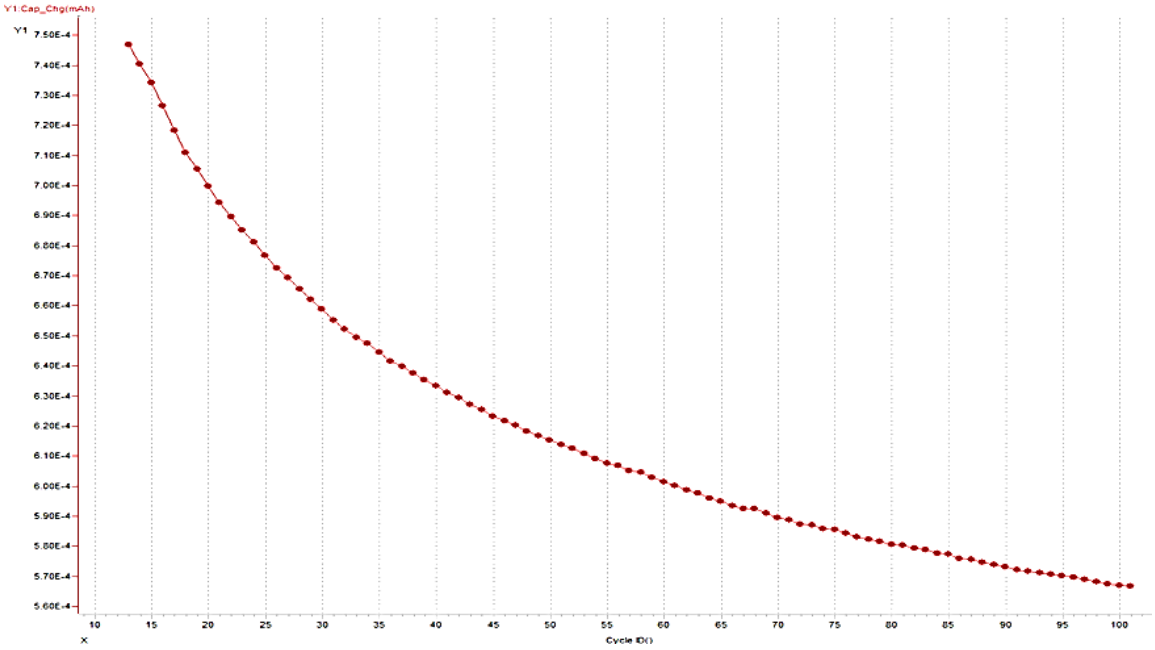

Figure 2 Testing of nonorganic electrolyte (LiBF4 with solvent 1M concentration)

Next step of our research was to determinate organic material and its concentration for hybrid electrolyte. After literature review, and few tests we've decide to use 1-Ethyl-3-Methyl Imidazolium-Tetra Fluoro Borate as organic components. This material was later used as addition in hybrid electrolytes.

In further tests, the best results were obtained for the hybrid electrolyte, which consisted of 1.9 ml of solution with 1.5M concentration (Lithium-Tetra Fluoroborate in PC) with addition of 1 ml of 1-Ethyl-3-Methyl Imidazolium-Tetra Fluoro Borate. The battery with this electrolyte shows very good capacity at start and could be cycled more than 200cycles before capacity drops down 2 times. Example results for this hybrid electrolyte are shown on Fig.3

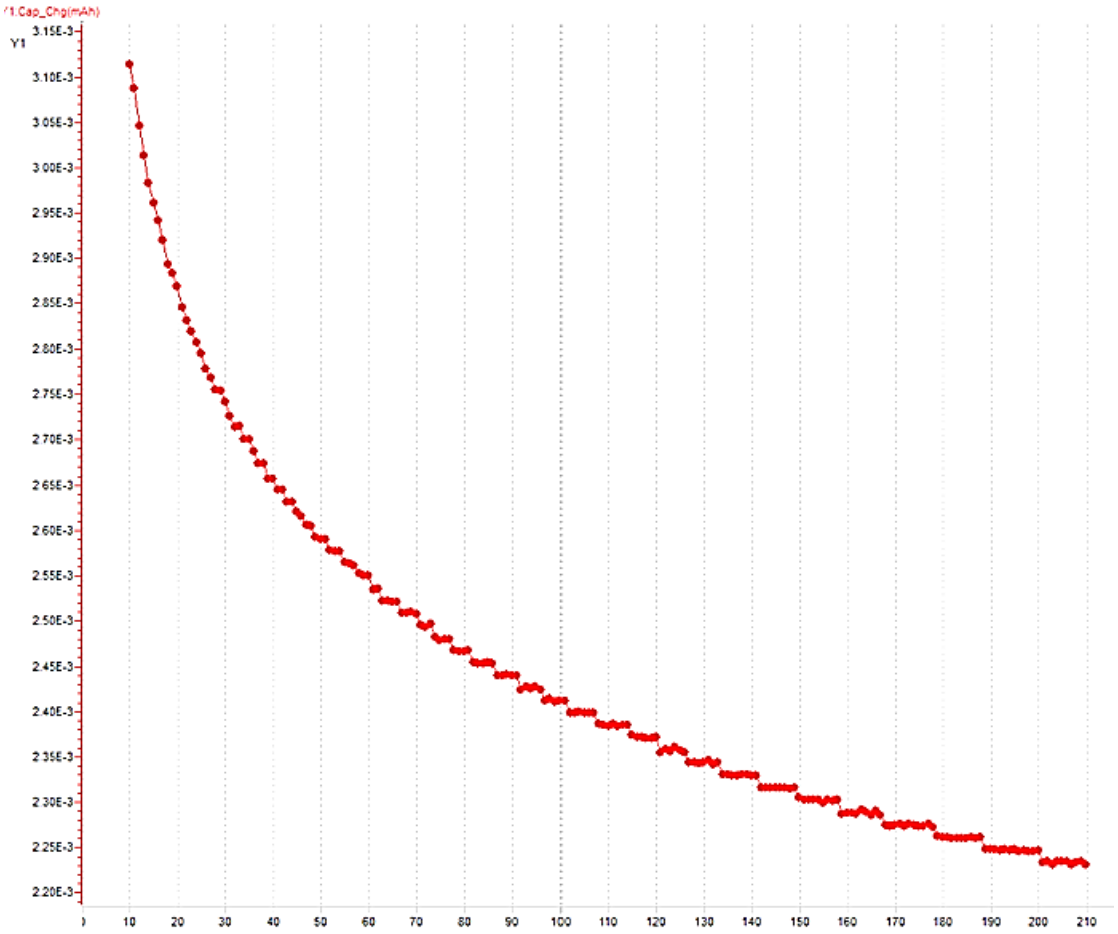

Figure 3 testing of hybrid electrolyte sample

These results prove the thesis of the doctoral research that the hybrid substances can improve the performance of lithium batteries.

Basing on results of research into dependence of the parameters of lithium-ion batteries on the composition and concentration of salts and organic compounds in the electrolyte we can make next step into improving properties of batteries and make better product.

References

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