Polarization of the Lithium Batteries During a Discharge

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Peculiarities of processes that go inside an electrochemical battery under or after some influence on the battery are conditioned by relevant physical and chemical properties of the battery's inner medium. To more comprehensively study properties of the battery's inner medium, we can study peculiarities of processes that go inside the electrochemical battery for many values of a relevant parameter of an influence. To get necessary data on a system during a reasonably short time we should acquire them for values of this parameter during proper short-time influences and pauses after them. However, we should answer the question about proper recovery of the system before each influence. In the intensive research method, the data are acquired in the framework of a regular set of short-time actions on a system and pauses, the actions follow in the order of an increase of their "strength", and a reasonable minimal duration of the actions and the pauses is selected / 1 /. Instead of a foggy requirement of complete recovery of studied systems before each influence, the method accents a regular procedure of data acquisition and we also expect that systems under an influence will forget differences of pre-influence conditions after an influence time that less than the recovery time. A great number of the experimental data for many values of a relevant parameter of an influence allow us to search for some inner criteria of whether the duration of the actions and the pauses was selected reasonably judging on the results of the research. The recent study / 2 / of the properties of lithium batteries small-current discharges and recovery after them showed effectiveness of such approach. Nevertheless, it is necessary to continue research on the method.

It is known that battery recovery after a discharge can take a very long time. Investigations of discharge and recovery properties of the lithium batteries show the lithium battery polarization has some part that is conditioned by changes of the battery inner medium. We can't affirm that the battery inner medium initial state (the state before the research) is the unchangeable base state. Consequently, it is not clear if long time relaxation must lead the battery inner medium to the initial state and if the concept of the complete recovery of the battery has the positive sense. In this case, the values of the battery polarization have also only relative meaning and it is more essential to acquire data during some regular procedure to have the reliable way to compare them.

In the framework of the intensive research method, the battery polarization can be defined and calculated as following difference: with respect to the studied battery's initial open circuit voltage before research or with respect to the studied battery's open circuit voltage before each discharge. The battery polarization in the second definition, "dynamic" polarization, takes into account only polarization changes during the corresponding discharge. The battery polarization in the first definition, "full" polarization, takes into account not only battery discharge properties but recovery ones too.

Here, we present the results of processing of experimental data on discharge of the lithium batteries using different definitions of the battery polarization. The experimental data have been obtained by the intensive research method / 1 /. The VARTA CR 2032, CR 2016 GP, ENERGIZER CR 2025, BR 2020, and BR 2325 lithium batteries were used at the study.

Some of the results of the research are presented in Fig. 1-2. Fig. 1-2 give us multidimensional diagrams of the index of susceptibility of the quantity HI to changes of discharge conditions for one of the studied batteries for two definition of the battery polarization H. The quantity I stands for the discharge current, R stands for the outer load resistance. The values of the index in Fig. 1-2 are not averaged. The battery polarization in X-axes in both diagrams are with respect to the battery initial open circuit voltage before research (the first definition of the battery polarization).

As we can see from the diagrams, both of them give qualitatively the same picture of peculiarities of discharge processes in the studied batteries. However, the curves of the index for different discharges in Fig. 2 show more clearly the trend to follow some unique-for-all-discharges curve after some discharge time, at least for the small discharge currents. The main cause of differences between the diagrams is conditioned by contributions of battery recovery properties to derivatives of HI with respect to R (at the same discharge time t) in the case of the diagram in Fig. 1.

It is necessary to emphasize two points. The first one is that diagram in Fig. 2 characterizes battery discharge properties only. The second point is that, despite of lack of battery complete recovery before each discharge, the curves of different discharges in Fig. 2 are in rather good co-ordination after some discharge time. It is possible that the "dynamic" polarization can also describe quick processes at the beginning of discharge and recovery /3/.

Consequently, the battery "dynamic" polarization (it is calculated with respect to the battery's open circuit voltage before each discharge) looks like a not bad choice to compare battery discharge properties in conditions of not full recovery after previous discharges.

Acknowledgements

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References

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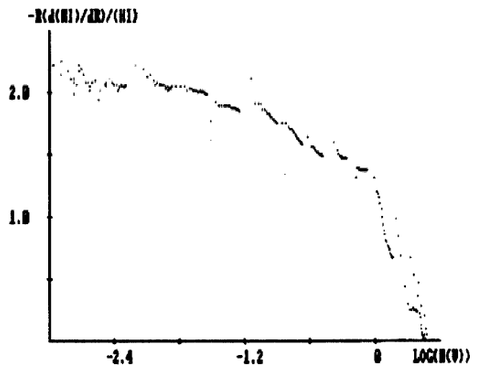

Fig. 1. –R(d(HI)/dR)/(HI) versus log(H), H is calculated with respect to the battery initial open circuit voltage.

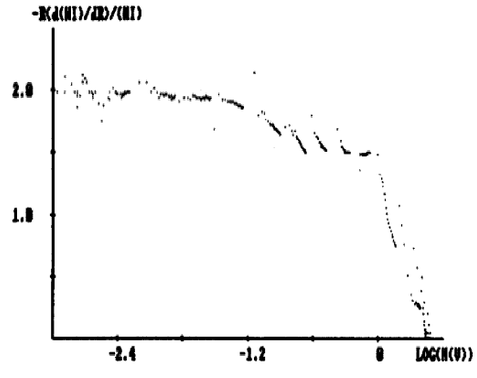

Fig. 2. –R(d(HI)/dR)/(HI) versus log(H), H in the function is calculated with respect to the battery open circuit voltage before each discharge.