DIELECTRIC PROPERTIES OF THE LITHIUM-POLYMER BATTERY DURING CHARGE AND DISCHARGE

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ABSTRACT

Abstract: Dielectric spectroscopy has been widely used for the analysis of electrochemical processes in batteries that are influenced by many variables. The results of dielectrical spectroscopy measurements are modeled very successfully by using electrical equivalent circuits. In this work the frequency dependence of impedance, dielectric permittivity and dielectric loss of Lithium-Polymer battery is analysed in detail. Dielectric properties have been studied over a range of frequency from 20 Hz to 200 kHz. Differences in impedance spectras between fully charged and discharged battery as well as other states of charge is observed and discussed.

Keywords: Dielectric spectroscopy; lithium-polymer battery; state of charge.

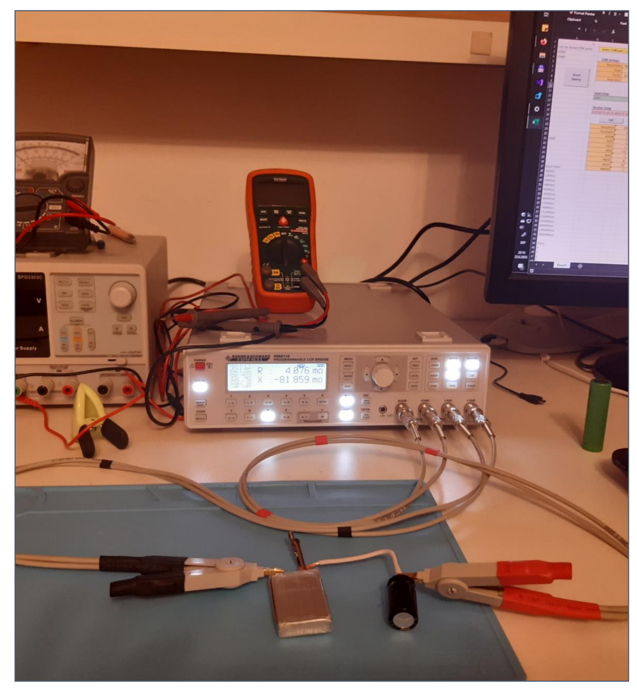

***Figure 1.** Experimental setup for a measuring of the dielectric properties of the LiPo battery.*

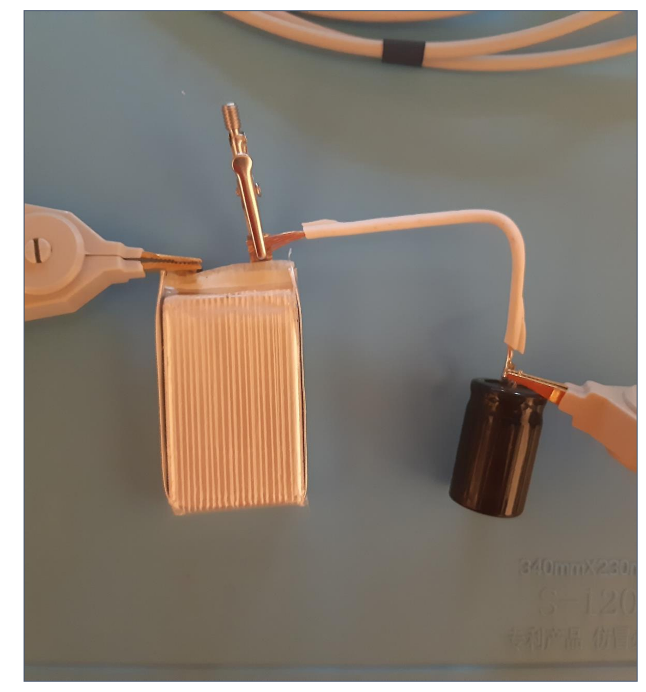

***Figure 2**. LiPo battery in series with capacitor for DC blocking and instrument protection.*

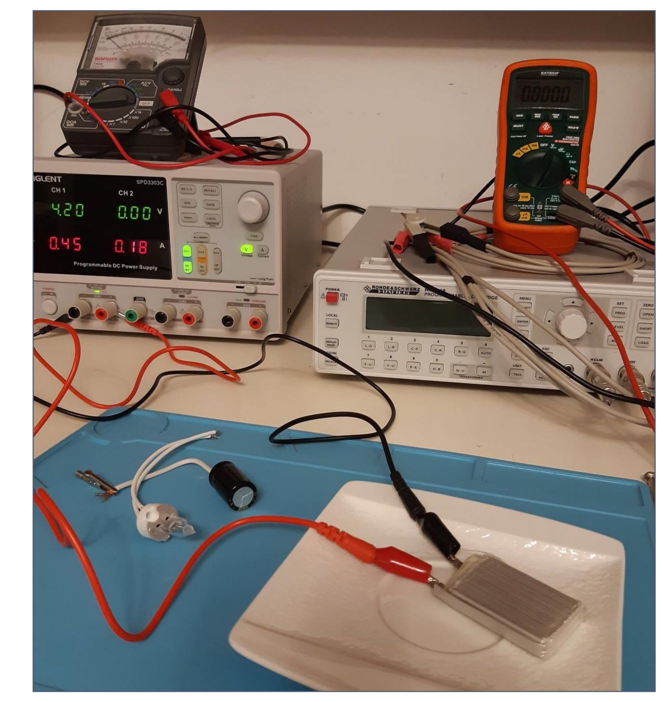

***Figure 3**. Experimental setup for LiPo charging.*

RESULTS AND DISCUSION

Impedance analysis

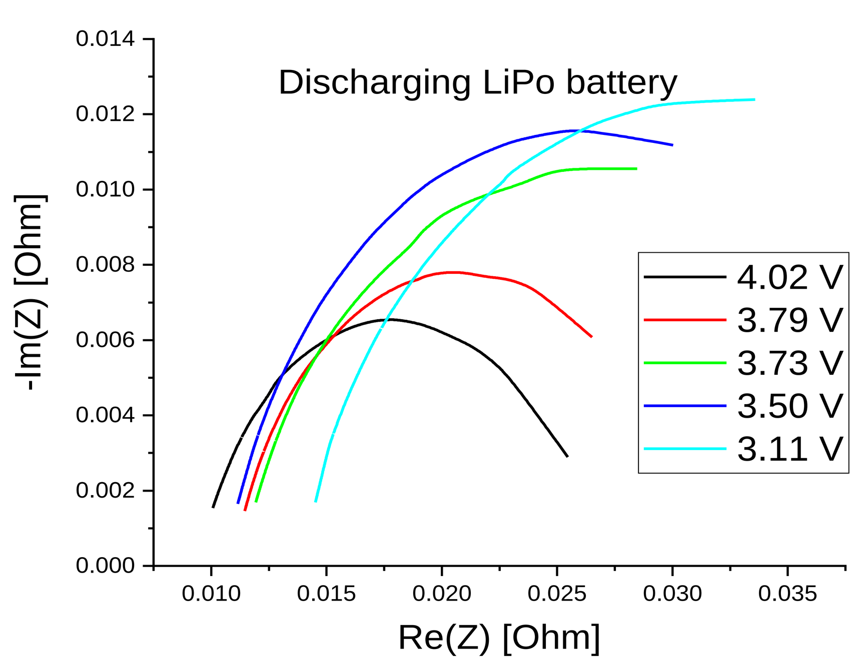

***Figure 4.** Change of the impedance spectrum showing the dependence on the state of charge during the first discharge process, at 28 °C and at frequency range from 600 Hz – 20 Hz.*

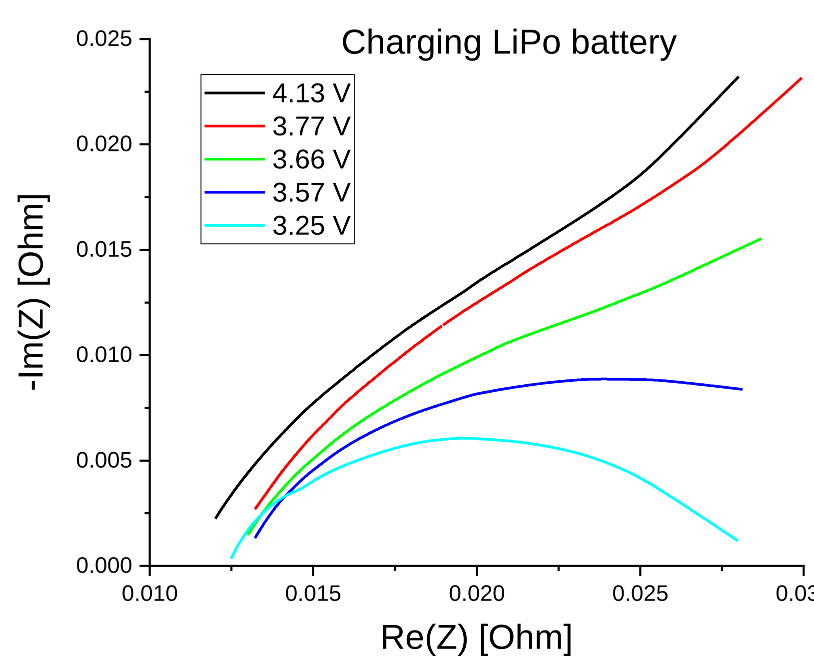

***Figure 5.** Change of the impedance spectrum showing the dependence on the state of charge during the first charge process, at 28 °C and at frequency range from 600 Hz – 20 Hz.*

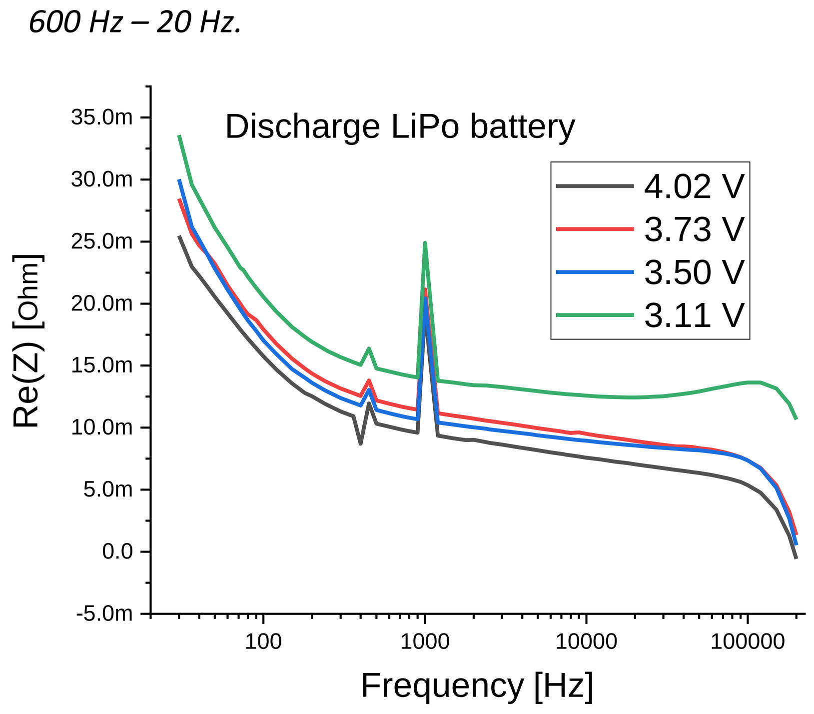

***Figure 6.** Change of the real part of the impedance showing the dependence on the state of charge during discharging battery, at 28 °C and at frequency range from 20 Hz – 200 kHz.*

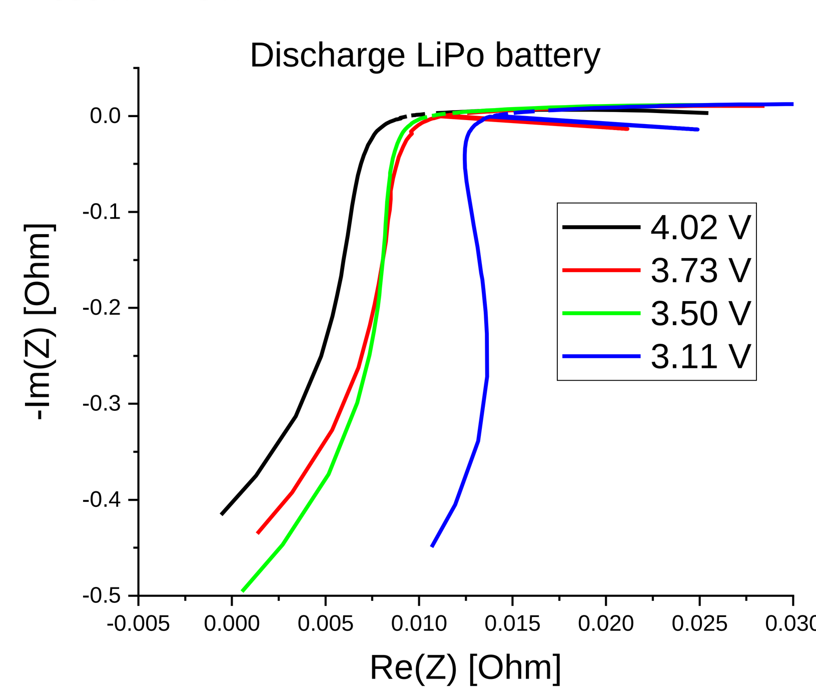

***Figure 7.** Change of the impedance spectrum showing the dependence on the state of charge during discharging battery, at 28 °C and at frequency range from 200 kHz – 20 Hz.*

Impedance modeling

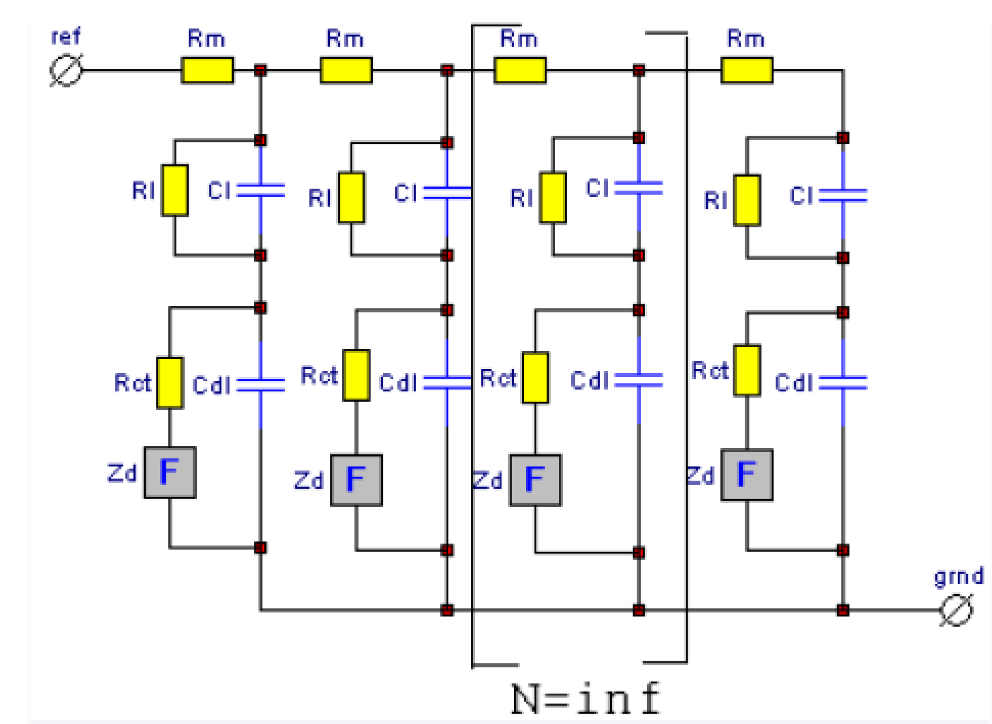

Figure 8. *Equivalent circuit of the lithium battery impedance for simulating electrochemical reaction at porous surface hindered by passivating layer, with subsequent finite-length diffusion followed by secondary reaction (Li-ion intercalation electrode impedance).*

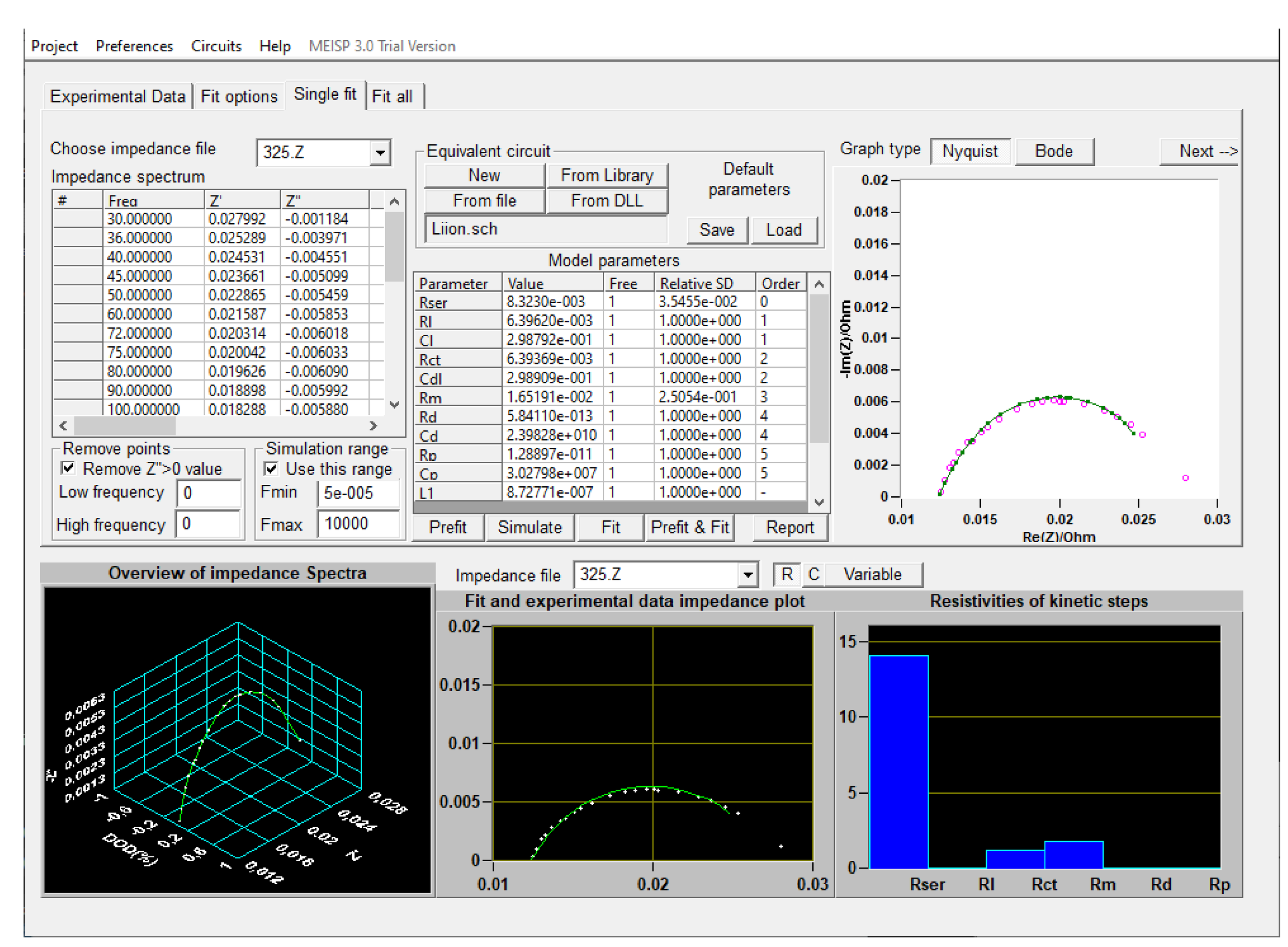

***Figure 9.** Fitting result of impedance spectra in MEISP software.*

CONCLUSIONS

Impedance spectra was measured using LCR Hameg 8118 instrument. Commercial Lithium polymer battery with nominal 1100 mAh and 3,7 V was connected in series with capacitor for DC blocking. Sixty-nine measurements were performed over a range of frequency from 20 Hz to 200 kHz, using 1.0 V sinusoidal signal and 4.2 V Bias. Acquisition of the real part (*R* or *Re(Z)*) and imaginary part (*X* or *Im(Z)*) of impedance is carried out with specially programmed VBA script for Excel.

Measurements was carried out for various state of charge for LiPo battery. First measurement was on fully charged battery. Then after each measurement battery was partially discharged and left to rest for min 4 hours, last one on fully discharged (to 3,00V) and then rested for 4 hours. After that battery was charged with approx. 220mAh (fifth of capacity), rested for min 4 hours, and then measured until fully charged.

With decreasing state of charge, the resistive parts of the impedance rise correspond to an increase in the internal resistance, and vice versa. It is hard to say that this is reversible process, because it is impossible to get same level for SOC (*State of charge*) although results are closely matched.

Fitting results of impedance spectra were performed using the MEISP software in frequency range from 20 Hz to 600 Hz. This range is chosen because of the middle frequency range has the decisive influence on the quality of the equivalent circuit. Chosen equivalent circuit was generic circuit modeled for simulating electrochemical reaction at porous surface hindered by passivating layer, with subsequent finite-length diffusion followed by secondary reaction (Li-ion intercalation electrode impedance). In the literature this range and this model is often associated in with the charge-transfer process, which describes the intercalation process of the lithium ions into active material of the electrodes. The all impedance spectra show excellent agreement with chosen electrical equivalent circuit.