Metrohm
Autolab

Application Area: Fundamental

Calculation of Cell Constants using the Autolab Microcell HC TSC70 and TSC1600

Keywords

Conductivity measurements, electrochemical impedance spectroscopy, EIS, TSC1600, TSC70, Microcell HC, cell constant, temperature dependent electrochemistry.

Introduction

In order to calculate the conductivity of an electrolyte, the cell constant must be known. For simple geometries, such as in the case of two parallel plates, the cell constant can be easily calculated from the dimensions of the separator between the plates, i.e., the separator thickness divided by the separator area.

In the case of more complex geometries, such in the case of the TSC70 and TSC1600 cells, the cell constant can be calculated using an electrolyte of known conductivity, i.e., a conductivity standard.

The relation between the conductivity σ $(\mathrm{S\ cm^{-1}})$ and the cell constant K_{Cell} $(\mathrm{cm^{-1}})$ is given by Equation 1.

$$\sigma = \frac{1}{R_s} K_{Cell} \qquad 1$$

Here, R_s is the electrolyte resistance (Ω).

The electrolyte resistance can be measured using an electrochemical impedance spectroscopy (EIS) measurement. The frequency range is chosen so that an approximatively linear Nyquist plot is obtained, therefore excluding very high frequencies where the parasitic inductive behavior of the cables is measured, and also very low frequencies where the influence of the diffusion layer is measured. The EIS data is then fitted with the equivalent circuit, shown in Figure 1.

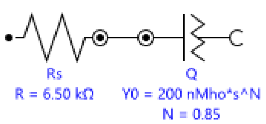

Figure 1 – Equivalent circuit describing the interface between a good ion conductor and an inert electrode.

Here, R_s is the electrolyte resistance and Q is the equivalent circuit element describing the charging of the double layer at the electrode-electrolyte interface.

Once the electrolyte resistance is known, the cell constant can be easily calculated with Equation 2.

$$K_{Cell} = R_s \cdot \sigma \qquad 2$$

The conductivity, however, is a temperature-dependent quantity. Therefore, it is important to perform the experiment at a fixed temperature where the conductivity of the electrolyte is well known.

Experimental setup

A Metrohm Autolab PGSTAT 204 equipped with a FRA32M module was used in combination with the Autolab Microcell HC equipped with the TSC70 and TSC1600 measuring cells was used for the measurements (Figure 2). This work system is suitable for performing temperature–controlled electrochemical measurements on volatile and non–volatile samples.

Figure 2 – Autolab PGSTAT204 with FRA32M module in combination with the Autolab Microcell HC.

The electrochemical cell is fitted with a glass-sealed platinum wire working electrode and a platinum crucible counter electrode. The electrochemical cell is then connected to a holder capable of controlling the temperature of the cell with a Peltier element, Figure 3.

Figure 3 – Overview of the cell holder and the electrochemical cell.

The cell holder is connected to the temperature controller, and interfaced with the PC via a serial RS-232 connection. The temperature control is fully integrated in the NOVA software allowing for a convenient, automated temperature control. For the measurements presented in this document, a TSC1600 cell is used, filled with the Metrohm 100 $\mu S/cm$ conductivity standard (6.2324.010). The same procedure is also valid for the TSC70 cell.

The temperature is set at 25 °C, corresponding to a conductivity of the standard solution of 100 $\mu S/cm$.

Experimental measurements

The EIS measurement is performed at open circuit potential (OCP) within a frequency range from 1 kHz to 1 Hz applying an AC amplitude of 50 mV (RMS). The recorded data is fitted automatically in real time by using a serial RQ equivalent circuit, as shown in Figure 1.

In Figure 4, the resulting Nyquist plot is shown (blue dots), together with the fit (blue line).

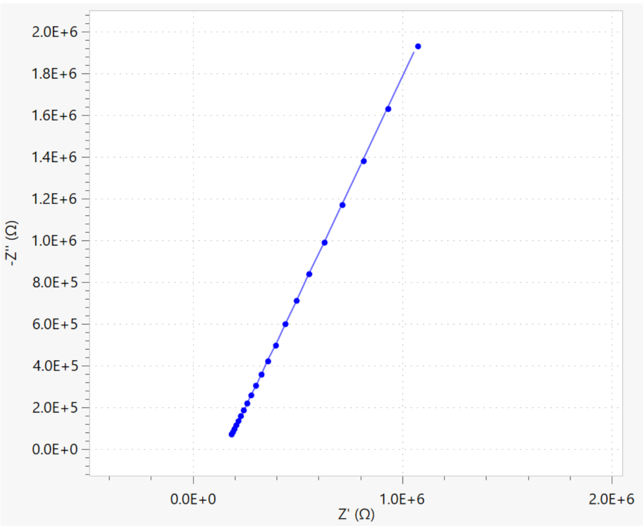

Figure 4 - The Nyquist plot of the Metrohm conductivity standard.

After the EIS measurement is finished, the R_s value is extracted and the cell constant is calculated using Equation 2.

For this example, in the case of the TSC1600 cell, the value of the cell constant was found to be 15.6 cm^{-1}.

It must be stressed that such values can slightly change, depending of the cleanliness of the cell and the purity of the standard.

Once the conductivity cell constant is known, the same measurement setup can be used for measuring the conductivity of different samples (see Equation 1) or for studying the temperature dependence of the conductivity for a certain sample.

Conclusions

The combination of the Metrohm Autolab PGSTAT204 equipped with the FRA32M module in combination with the Autolab Microcell HC setup was used for the determination of the conductivity cell constants of TSC1600 temperature controlled electrochemical cell.

Such a value is necessary to perform conductivity measurements of customer samples.

Date

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For more information

Additional information about this application note and the associated NOVA software procedure is available from your local **Metrohm distributor**. Additional instrument specification information can be found at **www.metrohm.com/en/products/electrochemistry**.