



Toetab TÜ ja TTÜ doktorikool
"Funktsionaalsed materjalid ja tehnoloogiad" (FMTDK)

**ESF projekt 1.2.0401.09-0079**

# SPECIFICATION OF IPMC EQUIVALENT CIRCUIT BY IMPEDANCE SPECTROSCOPY

Indrek Must, Andres Punning, Urmas Johanson, Tarmo Tamm, Alvo Aabloo

*IMS Lab, Institute of Technology, Tartu University, Estonia;*
e-mail: indrekm@ut.ee

IPMC (Ionic Polymer-Metal Composite) materials consist of thin polymer electrolyte membrane sheet covered with electrodes from both sides. Small electrical potential (1-5V) applied to the electrodes causes ion and solvent migration. As a result, the composite sheet bends towards the higher potential side. IPMC also has sensor properties. [1] In this work, IPMC constructed of Nafion sheet as polymer membrane with $Li^+$ counter ions and platinum electrodes is used.

The purpose of this work is to specify the equivalent electrical circuit between the electrodes of IPMC material. The typical equivalent circuit consist of a capacitor in series with a resistor representing ionic conductivity. A shunt resistor is added between electrodes representing electrochemical reactions [2].

In order to convert the impedance spectrum to more convenient frequencies, an extra resistor was added in parallel with the IPMC.

The analysis of Nyqvist plot (fig. 1) revealed two separate processes present in the material. The process at higher frequencies (fig 1 region 1) has about ten times smaller capacitance than the one at smaller frequency (fig 1 region 2), but causes higher conductivity. The presence of two semicircles can be explained by partial ageing of the material investigated, which can cause changes in electrolyte membrane and electrode composition.

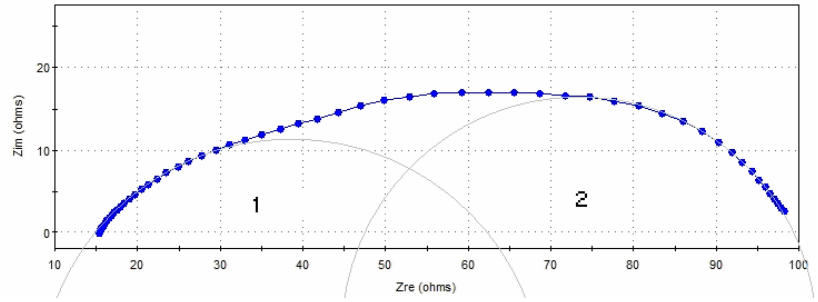


*Figure 1. Nyqvist plot of IPMC. A 100 ohm resistor is added in parallel with IPMC. The plot can be fitted by two semicircles.*

References

1. Shahinpoor, M *et al*. *Smart Mater. Struct*. **7** (1998).
2. Punning, A *et al*. *Journal of Intelligent Material Systems and Structures*, **14**, 1711-1724 (2009).