BIPOLAR MEMBRANES

P. Barath[1,2], *V. Novák*[1], *J. Vondrák*[2], *M. Sedlaříková*[1]

[1] *Institute of Electrotechnology, Technical University of Brno, 602 00 Brno*
[2] *Institute of Inorganic Chemistry AS CR, 250 68 Řež near Prague*

Corresponding author: Peter Barath (peter.barath@phd.feec.vutbr.cz)

Introduction

The bipolar membrane (FuMA-Tech) was investigated to characterize their suitability to use in H_2-O_2 fuel cells. Bipolar ion exchange membranes have both cationic and anion selective regions or layers combined in series. Our first experiments included the impedance and voltammetrical measurements and the determination of the membrane ionic conductivity.

Experimental

Following membrane was use:

- BIPOLAR MEMBRANE (Fumatech GmbH, Membrane type: FT-BM)

Bipolar membranes consist of an anion layer and a cationic layer which are connected by means of a patented process. The connection is chemically and mechanically very stable. On the boundary between anion membrane (AEL) and cationic membrane (CEL) water is splitted in OH^- and H^+ ions when exceeding a potential difference of approximately 0,8V. Thus, attention must be given to the right poling. The CEL must be directed towards the cathode (positive), the AEL must be directed towards the anode. If the membrane is used in wrong position for a longer period of time, the boundary layer may be destructed, and mono-layers will separate. Mechanical properties at very low thickness (0.2-0.25mm) are excellent.

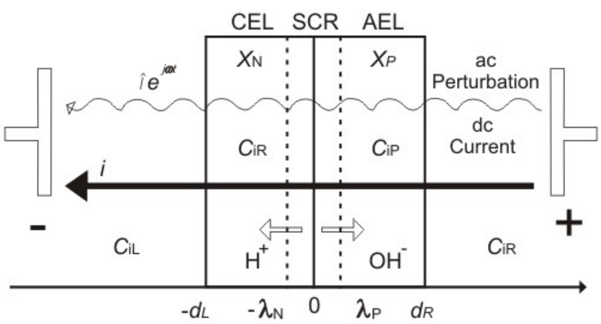


Fig. 1 *Sketch of bipolar membrane under current flow in reverse polarization. In order to obtain the impedance of BM, a small sinusoidal perturbation of amplitude i and AC frequency ω is superimposed to the DC current, i [1].*

Membrane conductivity was measured using impedance spectroscopy and cyclic voltammetry. Measurement was done with an Autolab PGSTAT 30 instrument (Eco Chemie B.V.) supplied with FRA and GPES software.

Results and discussion

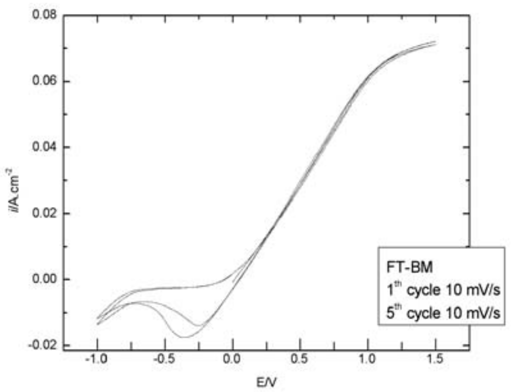
The instrument was connected to a 4-probe electrode measurement cell with current platinum electrodes and reference Hg-HgO, RCE101 electrodes. Membrane resistivity was determined by extrapolating the linear part of the Nyquist plot to the real axis of the impedance spectrum. To measurement the membrane conductivity at the relative humidity 100%, the sample was stored in distilled water for 48 hours. Experiments were performed in 1M solution of potassium hydroxide (KOH) in an anion selective region of the FT-BM and acetic acid (CH_3COOH) cationic selective region.

This measurement gave the ionic conductivity of the membrane in an electrolyte. Impedance measurements using the FRA-2 module with the frequency range from 10 kHz to 1Hz. The equivalent circuit for measure cell can be expressed as a resistance Rs in the series with the constant phase element CPE1 parallel Rp (boundary between membrane and electrolyte) (see Fig.3 right).

The membrane resistance was determined from the impedance spectrum. Ionic conductivity σ ($S.cm^{-1}$) of membrane was determined owing to the following relation:

$$\sigma = \frac{l}{R_{MEM}.S}$$

where l is the membrane thickness (cm), S is the membrane surface exposed to the electric field (cm^2), R_{MEM} the membrane resistance (Ω).



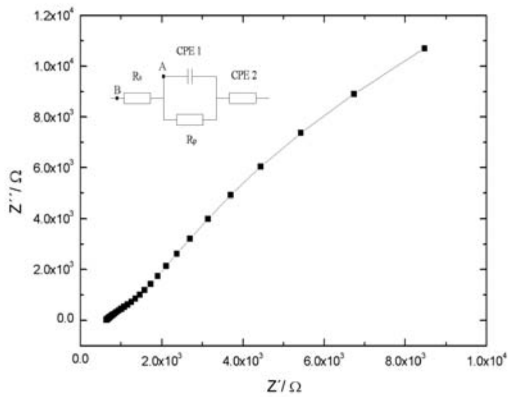


Fig. 2 *(left) Cyclic voltammogram of the FT-BM.*

Fig. 3 *(right) Impedance spectroscopy of the FT-BM*

Conclusions

The formation of a space charge in a bipolar membrane polarized in blocking direction is clearly visible both from voltammetry and impedance measurements. Blocking properties of such a membrane should be similar to a P-N junction in semiconductors, and could be investigated by low frequency impedance spectroscopy. However, the movement of the ions in a blocking membrane is very slow. It is necessary to keep the membrane at constant voltage long time before recording the impedance spectrum.

The ionic conductivity of FT-BM is σ = 5,5 $\mu S.cm^{-1}$. Our aim is to combinate a bipolar membrane with a catalyst MnO_x/C for anionic selective region and Pt/C for cationic region in H_2-O_2 FC. [2]

Acknowledgements

This work was supported by the Czech Science Foundation (No. 104/06/1471), Ministry of Environment (No. SN/171/05), KJB 208 130 604, MSM 0021630516.

References

1. H. Holdik, A. Alacaraz, P. Ramirez, S. Mafé, Journal of Electroanalytical Cemistry 442(1998) 13-18
2. J. Vondrák, B. Klápště, J. Velická, M. Sedlaříková, J. Reiter, I. Roche, E. Chainet, J. F. Fauvarque, M. Chatenet, *J. New Mat. for Electrochem. Syst.* (2005) in press.