ION-EXCHANGE PROCESSES UNDER THE INFLUENSE OF MAGNETIC FIELD

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Abstract

In this paper, the research results of the influence of magnetic field on the ion-exchange processes are reported. For the first time, it is experimentally demonstrated that magnetic field increases the electrodialysis current.

Keywords: magnetic field, electrolyte solution, polarization, water solution, water dipole, ion-exchange resin.

INTRODUCTION

Modern society imposes stringent requirements on water parameters. Increasing water needs will require the development of innovative purification technologies. Water treatment, when seawater surface or underground water are used as the source, may be performed using ion exchange membrane and electrolysis methods.Polarization and the decrease in the conductivity of the membrane, release of gasses at the electrodes (electrolysis), duration of the process and the destruction of the electrodes reduce the effectiveness of electrodialysis water purification technique. Magnetic field can change the equilibrium in the «ion exchanger – solution» system. Therefore studying of the influence of magnetic field on ion exchange processes is important.

The main goal of the research is to study the influence of magnetic field on the electrodialysis processes and the equilibrium in «ion exchange resin – solution» system.

EXPERIMENTAL RESEARCH

In order to examine the influence of magnetic field on the electrodialysis process an experimental setup was constructed. It includes: a three-chamber dialyzer, an amplifying circuit, two DC power sources, electric power cables, the measuring resistance, two permanent magnets, recording devices (milliammeter, an oscilloscope). Schematic diagram of the experimental setup is shown in Fig. 1.

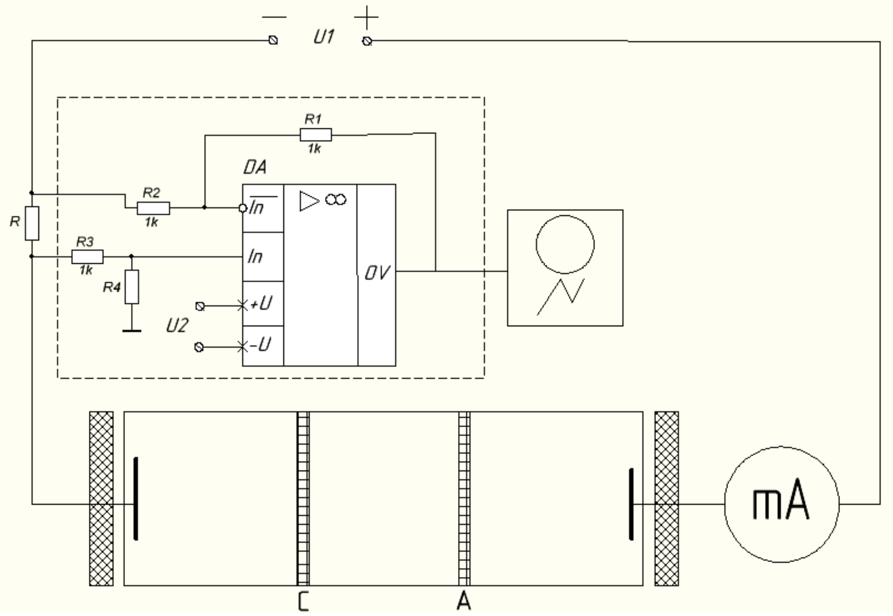

Figure 1.Schematic structure of the experimental setup.

Electrodialysis cell is consists of three chambers: the brine, the anode and cathode. The volume of each chamber is 15 ml. It was made of polymethylmethacrylate. This material has good resistance to acids and alkalis. Two Nd-Fe-B magnets with remanent magnetization 1.2 T were used. Anion-exchange membrane (MA-40) and cation-exchange membrane (MC-40) separates the anode and cathode chambers respectively. Schematic diagram of the structure of the experimental setupis shown in Fig. 1.

Serially with the electrodialysis cell, resistor R, was placed into the circuit, aimed to record signal which allows to evaluate the current flows in the circuit. Nominal resistance and power dissipation of the resistor are 0.95 Ohms and 0,125 Watts respectively. The signal recorded from this resistor is then amplified on amplifying circuit and transferred to an oscilloscope. As an amplification circuit was used differential amplifier circuit on the operational amplifier LM358, allowing to strengthen small, against interference signals. Amplification factor for this circuit is calculated as:

$$K = \frac{R1}{R2}$$

The nominal values for the resistors of the circuit must satisfy the following equation:

$$\frac{R1}{R2} = \frac{R3}{R4}$$

In our experiment, it was enough to set amplification factor = 10. Nominal resistance of

$$R1, R4 = 1{,}2\ \text{MOhm}; R2, R3 = 120\ \text{kOhm}$$

were used.

As the electrolyte, filling the central chamber, NaCl solution with a concentration of 10 g/l was used. The cathode and anode chamber was filled with distilled water. The potential difference, applied to the electrodes is 10 V, the current stabilization - 0.3 A. The registration began with turning on the DC sources, oscilloscope voltage signal proportional to the current flow.

Each series of experiments included electrodialysis with magnetic fields of two polarities with respect to the direction of the electric field and without the field. Sodium chloride solution was prepared once for all measurement cycles at a known concentration.

LeCroy oscilloscope was used for registration of current in the circuit through the electrodialysis cell. Current dependence of time, in the circuit, with magnets fixed in the longitudinal direction is shown in Fig. 2. Repeatability of graph shapes is observed.

It was revealed that when the magnet's North Pole is oriented towards the cathode, the effect is stronger. In the magnetic field there is a simultaneous compression of the graph along the time axis and an increase in the maximum current value. The area under the curve depends on the polarity of the magnetic field. With the same number of ions that can be explained by the influence of magnetic field on water electrolysis at the electrodes.

The effect of the magnetic field can be related to polarization of the dipoles of water. Magnetic field acts on ions in thermal motion. The hydrogen atoms of the water molecules are oriented along the magnetic field lines due to the Lorentz force. The cross section of the water molecule decreased in the direction of the electric field [1].

Orientation of water molecules must change the diffusion rate of ions in an aqueous solution in a magnetic field. We registered the rate of propagation of NaCl solution and Ni(NO3)2 along the height of the water column in a magnetic field for estimating the influence of magnetic field on the diffusion coefficient. For this two rectangular cuvettes were set into Jamin interferometer: one with distilled water and another with saturated saline solution at the bottom. The diffusion coefficient was evaluated by the movement of the leading edge of a saturated solution, which was registered at the wavelength of a helium-neon laser of the interferograms.

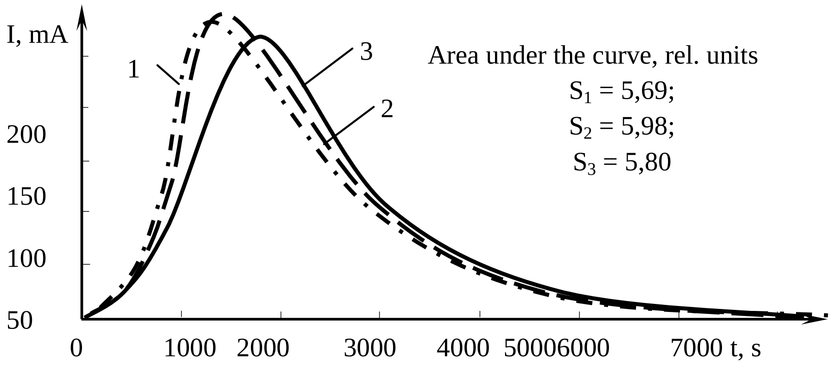

Figure 2. Electrodialysis current dependence on time. 1 - North Pole near the cathode, 2 - South Pole near the cathode *a*, 3 - without a magnetic field.

Selection of compounds can be explained by the fact that NaCl contains mainly spin nuclei, but Ni(NO3)2 has spinless nuclei. It has been proven that the magnetic field is less than 1.2 T, and its orientation relative to the direction of diffusion does not influence diffusion coefficient in the range of measurement error. It is known that the magnetic field does not affect the electrical conduction in solution [2].

CONCLUSION

Research results suggest the following:

1. The external magnetic field of 1.2T increases electrodialysis current by 9%.
2. The influence of the magnetic fields of less than 1.2 T on the diffusion of inorganic ions in aqueous solutions has not been detected.

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