DIFFUSION AND CONDUCTION PROPERTIES OF BILAYER PERFLUORINATED MEMBRANES MODIFIED BY HALLOYSITE NANOTUBES

[1]Ekaterina Titskaya, [1]Irina Falina, [2]Anatoly Filippov
[1]Kuban State University, Krasnodar, Russia, *E-mail: irina_falina@mail.ru*
[2]Gubkin University, Moscow, Russia, *E-mail*: *filippov.a@gubkin.ru*

Introduction

Nowadays, the problem of creating membranes with explicit asymmetric transport characteristics and catalytic properties, which can be successfully used in fuel cells, is relevant. Surface modification of commercial membranes is often used to create such materials. In addition, the creation of bilayer membranes whose layers differ in thickness and composition, is widely used. The purpose of this work was to study the asymmetry of electrotransport characteristics of bilayer MF-4SK membranes modified by halloysite nanotubes and dispersion of noble metals.

Experimental

Single- and bilayer laboratory samples of MF-4SK cast from a solution of polymer in DMF were investigated (Table 1): the initial MF-4SK membrane; MF-4SK bulky modified with halloysite nanotubes; bilayer samples containing non-modified and modified layers by halloysite and noble metals nanoparticles [1]. All membranes were synthesized by Dr. D. Petrova in the laboratory of functionalized aluminosilicate nanomaterials at Gubkin University.

Table 1: Objects of research

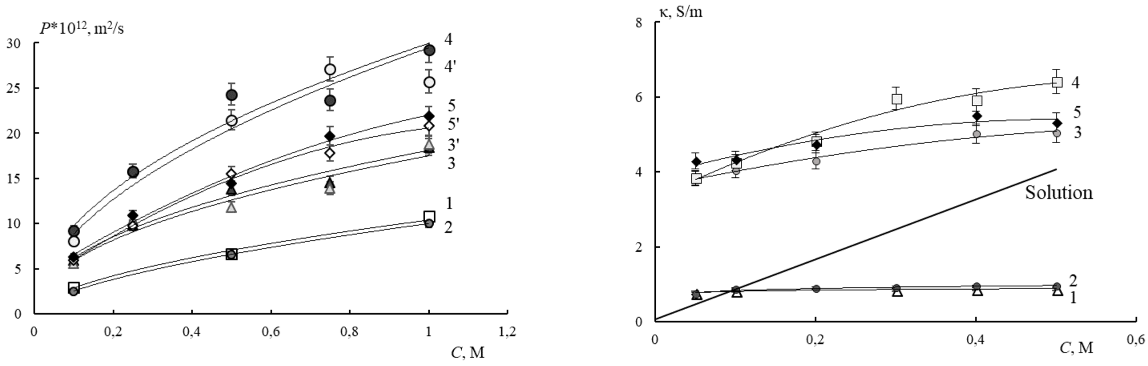
No	Membrane	Thickness 10^5, m	Layers	Modifier
1.	MF-4SK	19.6	Single-layer	-
2.	MF-4SK/Hall	17.6	Single-layer	4% Hall
3.	MF-4SK/2-Hall/Ru	19.7	Bilayer $h_{(mod.)}$=20% $h_{(nonmod.)}$=80%	I layer: 4% Hall + 2% Ru II layer: MF-4SK
4.	MF-4SK/2-Hall/Pd	19.9	Bilayer $h_{(mod.)}$=20% $h_{(nonmod.)}$=80%	I layer: 4% Hall + 2% Pd II layer: MF-4SK
5.	MF-4SK/2-Hall/Pt	22.1	Bilayer $h_{(mod.)}$=20% $h_{(nonmod.)}$=80%	I layer: 4% Hall + 2% Pt II layer: MF-4SK

Conductivity (κ, S/m) of the membranes in solutions of sodium chloride was measured by the mercury-contact method as the active part of the cell impedance. Diffusion permeability (P, m^2/s) of membranes was determined in two-compartment cell filled with electrolyte solution and water in opposite chambers. The diffusion flux through the membrane was determined on the basis of kinetic dependencies of electrolyte concentration in chamber with water, measured by conductometric method [2].

Results and Discussion

Concentration dependencies of diffusion permeability of the membranes in NaCl solutions are presented in Fig. 1a. Preparation of the bilayer membranes allows to graft asymmetric properties to them, so investigation of their diffusion characteristics was performed for different orientation of the samples towards the electrolyte flux. As can be seen from the Fig. 1a, diffusion permeability of bilayer samples is 3-5 times higher than of single-layer ones. However, the asymmetry of diffusion permeability for the studied membranes does not exceed the experimental error, despite the differences in the composition of the layers.

There were obtained concentration dependences of the membranes conductivity, presented on Fig. 1b. One can see that the conductivity of single-layer membranes has close value, while the conductivity of bilayer membranes is about 5 times higher than that of bulk samples. At the same time, the considerable influence of the noble metals nanoparticles on the conductivity of membranes was not observed.



a *b*

Figure 1. The concentration dependence of the diffusion permeability (a) and conductivity (b) of the membranes in NaCl solutions. Non-modified (3, 4, 5) and modified (3′, 4′, 5′) surface meet the electrolyte flux. (number on the curve corresponds to the sample number in Table 1).

The dependencies of the diffusion permeability and the conductivity were used to estimate the transport-structure parameters of the membranes in frames of two-phase conductivity model of the structurally inhomogeneous membrane [2], whose results are shown in Table 2.

Table 2: Transport-structure characteristics

Membrane	MF-4SK	MF-4SK/Hall	MF-4SK/2-Hall/Ru	MF-4SK/2-Hall/Pd	MF-4SK/2-Hall/Pt
f_2	0.07	0.11	0.15	0.27	0.13

It is seen that for bilayer membranes the parameter (f_2) characterizing the volume fraction of free solution in the membrane is greater than for single-layer samples. This fact explains the high values of electrotransport characteristics for bi-layer membranes and could be caused by the formation of microdefects between layers, filled with equilibrium solution.

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References

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