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В настоящем сборнике представлены тезисы докладов участников XV Юбилейной всероссийской научной конференции (с международным участием) Мембраны-2022. Доклады посвящены научным и научно-практическим аспектам современной мембранной технологии, в том числе поднимаются проблемы получения новых мембранных материалов, мембран, решению задач фильтрации жидких и газовых сред с точки зрения теории и практики.

Предназначено для студентов, аспирантов, научных сотрудников и инженеров-технологов широкого круга специальностей, интересы которых связаны с мембранной технологией.

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TRANSPORT CHARACTERISTICS OF NANOPOROUS VITREOUS MATERIALS DOPED WITH SILVER HALIDES

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One of the challenges of modern technologies is the development of principles of direct preparation of new multifunctional materials with important and refined properties. The silver-containing glasses obtained in this research work can find potential applications in sensors, photonics, nanobiotechnologies, etc.

The research work is devoted to the study and correlation between structural parameters and electrosurface properties of micro- and macroporous glasses containing or not containing AgHal (Hal = Cl, Br, I) in the $NaNO_3$ aqueous solutions indifferent to the SiO_2 surface and in the solutions of $AgNO_3$ and KHal, containing ions, which are charge-determining for AgHal nanocrystals.

AgHal-doped nanoporous glasses (NPG) were prepared on the basis of high-silica (SiO_2 > 95 %) micro- (MIP, pore radii 1.5-1.6 nm) and macroporous (MAP, pore radii 18.4-25.2 nm) glasses [1]. The relative content of Ag_2O, found by X-ray fluorescence (XRF) and atomic absorption spectroscopy (AAS), are given in table 1. It can be seen that the doping of wide-pore MAP glasses, whose pore radius is 12–15 times greater than that of MIP, proceeds more efficiently. The amount of silver in AgHal-MAP glasses is 3-4 times greater than in AgHal-MIP.

Table 1. Relative Ag_2O content in the composite membranes under study.

Method	AgCl-MIP	AgCl-MAP	AgBr-MIP	AgBr-MAP	AgI-MIP	AgI-MAP
XRF	0.32	1.12	0.22	1.12	0.24	0.91
AAS	0.75	3.55	0.82	3.44	0.58	1.70

Characterization of the NPG structure was carried out by scanning electron microscopy (SEM). The elemental distribution over the frontal and chip surface of the composites was studied by dispersive X-ray analysis (EDX). It was found (fig. 1) that the distribution of the doping components over the bulk of the sample is heterogeneous.

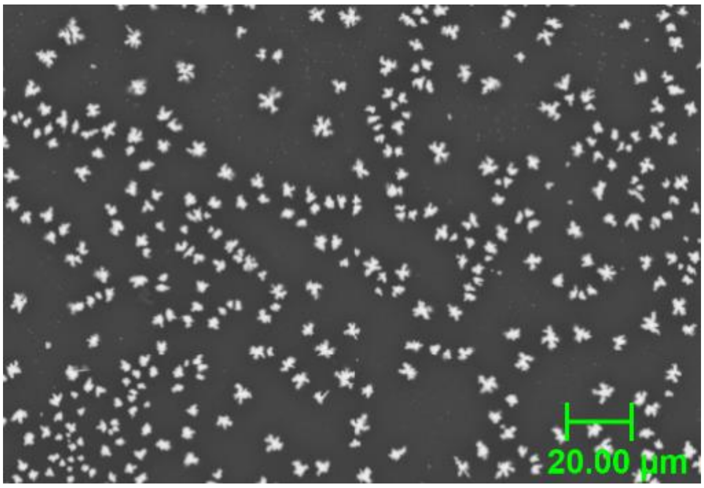

Figure 1. SEM image of the frontal surface of AgI-MAP glass.

X-ray diffraction (XRD) analysis confirmed the formation of cubic chlorargyrite AgCl, cubic bromargyrite AgBr, cubic and hexagonal iodoargyrite AgI phases in the composites. X-ray photoelectron spectroscopy (XPS) measurements were carried out to evaluate the surface composition as well as the chemical state of individual elements. The all XP spectra of AgCl- and AgBr-doped glasses exhibit the signals of the elements Ag, C, Cl/Br, O, Si. The Ag 3d peaks are located at 374.8 and 368.8 eV.

The efficiency coefficients (α), equal to the ratio of specific electrical conductivities of the porous and bulk solutions, were calculated from specific electrical conductivities of the membranes. The α values of basic silicate and composite materials are close to each other in an indifferent electrolyte. In $AgNO_3$ solutions, the main influence on the electrical conductivity of AgHal-doped MAP materials is exerted by Ag^+ ions located in the pore space.

The zeta potential (ζ-potential) was found by the streaming potential method taking into account the surface conductivity and the electrical double layers (EDL) overlap. The results are compared with the ζ-potentials found from the electrophoretic mobility of composite particles (laser Doppler electrophoresis). Doping of MIP membranes, first of all, affects the amount and structure of secondary silica in the pore space, which, accordingly, affects the structure of EDL and the value of ζ-potential. Doping of MAP materials directly affects the characteristics of the solid surface of pores. Electrophoretic measurements in an indifferent solution of $NaNO_3$ showed that the ζ-potential of AgHal-MIP particles increase as a result of doping. It has also been established that the ζ-potential is practically independent on the type of halide ion. Doping of MAP particles did not lead to noticeable changes in the ζ-potential in $NaNO_3$solution.

It has been found that for AgCl-, AgBr- and AgI-doped glasses, the structure of the EDL in nanopores and on the open surface of a porous particle differ significantly in the $AgNO_3$ solution. The greatest changes are observed for AgBr-MAP and AgI-MAP glasses – ζ-potentials have different signs: the streaming potential is negative, the electrophoretic mobility of particles is positive.

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