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Electrokinetic characteristics of porous glasses of various composition in NaCl and KNO_3 solutions

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Porous glasses (PG) – products of thorough chemical processing of two-phase alkaline-silicate glasses of a certain composition, containing various compounds in the pore channels have been the objects of systematic study. One of the classes of such nanomaterials are materials with magnetic properties – magnetic sorbents, membranes, matrices for drug immobilization or for obtaining nanostructured composite materials with ferroelectric and multiferroid properties, etc. In this work, magnetite-containing PGs were produced by introducing an iron (III) oxide into the batch when melting sodium borosilicate glass.

Since it is known that K^+ ions show specificity to the charged silica surface, in comparison with the indifferent Na^+ ion, it became interesting to conduct a comparative analysis of PG of different composition. The present work is devoted to investigations of the transport and equilibrium characteristics (efficiency ratio α, counterion transport numbers n_+, electrokinetic potential ζ) of high-silica micro- (mean pore radii 1.5–2.5 nm – MIP) and macroporous (mean pore radii > 10 nm – MAP) sodium borosilicate glasses Fe-4 containing (Fe_3O_4) and not containing (8V-NT) a magnetite phase in NaCl and KNO_3 solutions (0.1–10^{-4} M).

The results of the study have shown that the efficiency ratio α (equal to the ratio of the specific electrical conductivities of pore and free solutions) obtained for MIP glasses of both compositions were close both in NaCl and in KNO_3 solutions. The values of α decrease with increasing electrolyte concentration in accordance with the decrease in the contribution of ions of double electric layer (DEL) to the electrical conductivity of the pore solution. It was found that the values of the transport numbers of sodium and potassium counterions n_+ also practically do not depend on the introduction of about 5% of iron oxide into the base sodium borosilicate glass of the MIP PGs. Note that n_+ values of Na^+ ions are larger than those of specifically adsorbed K^+ ions at $C \leq 0.01$ M. At $C = 10^{-4}$ M all membranes have high selectivity ($n_+ = 0.87–1.00$). The efficiency coefficients and counterion transport numbers of MAP Fe-4 were larger than those of MAP 8V-NT membranes due to the larger surface charge of Fe-4 porous glass. The values of the electrokinetic potential were found by the method streaming potential. A comparison of the concentration dependences of the electrokinetic potential for membranes shows that the chemical composition of the MIP glass practically does not affect the values of the ζ-potential in the neutral pH range. The obtained results also indicated that $|\zeta|$ values of MAP Fe-4 membranes are larger than zeta potential of MAP 8V-NT membranes. This phenomenon is apparently associated with a larger surface charge of iron-containing glasses. The values of $|\zeta|$ in KNO_3 solutions less than in NaCl due to the higher specificity of K^+ ions, leading to a greater degree of filling of the Stern layer.

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