

Electrical conductivity of some ionic liquids in dimethylformamide and dimethylsulfoxide

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Abstract. Ionic liquids (IL) are competitive materials for "Green Chemistry", in particular for environmentally friendly electronics. IL are capable of dissolving both polar and non-polar substances, have low volatility and practically exclude the possibility of ignition, have low toxicity, and can also be reused after cleaning. However, the high viscosity of IL makes it difficult to use them at low temperatures. For this reason, their mixtures with other solvents are of great interest. Despite a significant number of studies of the physico-chemical properties of IL, there is no information necessary for practical application on the properties of their solutions in polar solvents.

Purpose of the work. Investigation of the electrical conductivity of dilute and concentrated solutions of four ionic liquids in DMFA and DMSO depending on concentration and temperature, determination of thermodynamic characteristics of the association of IL in dilute solutions, establishment of the connection of the conductivity of dilute solutions of IL with the dielectric properties of solvents and determination of the possible structure of ion pairs in concentrated solutions.

Research objectives:

1. Measurement of the electrical conductivity of dilute solutions of four IL in DMFA and DMSO and determination of the thermodynamic characteristics of the association of IL ions in solutions based on the data obtained.
2. Determination of the dependences of the conductivity of dilute dimethylformamide and dimethyl sulfoxide solutions of the studied IL on the dielectric properties of the solvent. Generalization of the results of the study of the specific EP of dilute solutions of IL in DMFA and DMSO.
3. Measurement of the electrical conductivity of concentrated solutions of four IL in DMFA and DMSO and the establishment of patterns of changes in conductivity in a wide range of concentrations and temperatures. Determination of the structure of ion pairs in concentrated solutions.
4. Determination of the activation energy of the conductivity of dilute and concentrated solutions of IL in DMFA and DMSO and establishment of its

dependence on the nature of the solvent, the concentration of the solution and temperature.

Scientific novelty of the work. For the first time in the temperature range of 20 – 85oC and in a wide range of concentrations, the specific EP of solutions of 1-butyl-3-methylimidazolium bis{(trifluoromethyl) sulfonyl}imide (IZH-1), 1-butyl-3-methylpyridinium bis{(trifluoromethyl)sulfonyl imide (IZH-2), trihexyltetradecylphosphonium chloride (IZH-3) and trihexyltetradecylphosphonium bromide (IZH-4) in dimethylformamide and dimethyl sulfoxide. The regularities of changes in the EP of the studied solutions depending on the concentration and temperature are established. Thermodynamic characteristics of the association of IL in DMFA and DMSO are determined. A relationship has been established between the value of the EP of the IL solutions and the dielectric characteristics of polar solvents. The results of measurements of specific EP for dilute and concentrated solutions of IL in DMFA and DMSO are summarized. The distance between the particles in concentrated solutions is calculated and the structure of ion pairs in concentrated solutions of IL is established.

Theoretical and practical significance of the work. The numerical values of the specific EP obtained in this work make it possible to carry out thermodynamic calculations of processes occurring in non-aqueous solvents, using them as reference material. The regularities of changes in the specific EP depending on the concentration and temperature established in the work make it possible to estimate the values of the specific EP of dilute and concentrated dimethylformamide and dimethyl sulfoxide solutions of IL without measurements. The importance of the conducted research is confirmed by the fact that the work on the study of EP solutions of IL is included in the development program of the D.I. Mendeleev RCTU "Priority-2030", the project "Laboratory of materials for Energy storage systems and hydrogen energy".

The following provisions are submitted for protection:

1. The results of measuring the EP of dilute and concentrated solutions of four IL in DMFA and DMSO in the temperature range of 20-85oC in increments of 5oC.
2. The values of the thermodynamic characteristics of the association of four IL in DMFA and DMSO.
3. Regularities of changes in the EP value of dilute solutions of IL depending on the dielectric characteristics of the solvent.

4. Results of generalization of temperature and concentration dependences of specific EP of dilute and concentrated solutions of four IL in DMFA and DMSO.

5. Results of calculation of the numbers of solvent molecules bound to ions (solvate numbers) in dilute solutions and the distance between ions in concentrated dimethylformamide and dimethyl sulfoxide solutions of four IL.