

1. Introduction

The study of the interactions of metal ions with polymers in solutions is an actual task, the solution of which will allow one not only to deepen the knowledge of the reactions in the solutions, but also to find new solutions to some technical problems, such as, for example, increasing the efficiency of water purification from metal ions, creating new sensors or biomedical diagnostic labels and active catalysts. The properties of such systems are largely determined by the interaction between the ions and polymer in the aqueous solutions, which includes the hydration of ions and polymer macromolecules, complexation, and electrostatic interaction [1].

The main characteristic of the interaction of metal ions-complexing agent with the polymer ligands is the constant of complexation, which, according to the main provisions of physical chemistry [2], is associated with the standard change in the Gibbs' energy during the reaction. This value is integral and depends on the change in both the enthalpy and entropy during binding. The enthalpy and entropy contributions to the Gibbs' energy of complexation are usually not specially estimated. Even for low molecular weight complexes, such data are rare in the literature [3].

Meanwhile, for the polymer-salt systems, the values of enthalpy and entropy of complexation are of particular interest, since they make it possible to clarify the complex mechanism of the interaction of ions with macromolecules. The copper (II) complexes are characterized by high activity and selectivity in various processes due to the metal-ligand interaction [4-6]. The ligands PEG and PVP are also widely used as ligands [7-9]. In turn, the mixtures of copper with PEG and PVP are widely used today as catalysts for the C–N bond formation, cross-coupling reactions, azide-alkyne cycloaddition, synthesis of substituted imidazoles and indole [10-14]. Earlier, the polymer-metal complexes based on palladium (II), iron (III) chloride and polyvinylpyrrolidone were synthesized and their structure was studied [15,16]. A palladium-polyvinylpyrrolidone complex PdCl₂-PVP demonstrated catalytic activity in the oxidation of octene-1 [17]. There are practically no data on the thermodynamic data on the complexation of PEG and PVP with the copper (II) ions in the aqueous solutions.

The aim of this work is to present the results of studying the complexation process, using the potentiometric method, comparing the thermodynamic characteristics (Gibbs' energy, enthalpy, entropy) of the complexation process of the copper (II) ions with the water-soluble non-ionic polymers PEG and PVP, and the investigation of the morphology of the copper polymeric complexes. A comparative analysis of the thermodynamic parameters of the formation of the polymer complexes of copper (II) has been carried out and their stability has been assessed.

2. Experimental part

Copper chloride CuCl₂·2H₂O, polyethylene glycol (molecular weight 10,000, Aldrich), polyvinylpyrrolidone (molecular weight 40,000, AppliChem, Germany),