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Measurements and correlations of electrolytic conductivity and molar heat capacity for the aqueous ionic liquid systems containing [Emim][$EtSO_4$] or [Emim][CF_3SO_3]

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A B S T R A C T

New data on electrolytic conductivity, κ, and molar heat capacity, C_P, for aqueous solutions of ionic liquids, 1-ethyl-3-methylimidazolium ethylsulfate [Emim][$EtSO_4$] and 1-ethyl-3-methylimidazolium trifluoromethanesulfonate [Emim][CF_3SO_3] obtained using a commercial conductivity meter and differential scanning calorimeter were reported here for temperature up to 353.2 K. The estimated measurement uncertainties for κ and C_P were 1 and 2%, respectively. The present κ and C_P data were reported as functions of temperature and composition. A modified empirical equation was used to correlate the temperature and composition dependence of the present κ data. An excess molar heat capacity, C_P^E, expression using the Redlich–Kister type equation for the latter's temperature and composition dependence was used to represent the measured C_P and C_P^E of the considered solvent systems. The applied correlations represented the κ and C_P measurements satisfactorily as indicated by an overall average deviation of 1.9 and 0.1%, respectively.

1. Introduction

By virtue of their appealing properties such as negligible vapor pressure, high thermal stability, and high electrolytic conductivity, room temperature ionic liquids (RTILs) have attracted the attention of various research groups [1–16]. Although, RTILs have been the focus of attention of these researchers for sometime, the data bank for physicochemical properties are still wanting, as in the case of electrolytic conductivity, κ, and molar heat capacity, C_P. Most studies reported on κ and C_P measurements are for pure systems; those for mixtures including aqueous RTILs are still scarce in the open literature [2,6–8,10,12,14–17].

As a continuation of our systematic investigations on the property measurements of RTILs, κ and C_P of the solvent systems, [Emim][$EtSO_4$] + H_2O and [Emim][CF_3SO_3] + H_2O, are presented here. Table 1 presents the available literature data for the considered systems. This table justifies the scarcity of data for κ and C_P for the studied solvent systems. Thus, in this work, κ and C_P were measured at normal atmospheric pressure and at temperatures up to 353.2 K using a commercial conductivity meter and differential scanning calorimeter (DSC), respectively. Both κ and C_P were presented and correlated as functions of temperature and composition. The obtained κ data were empirically modeled as a function of temperature and mole fraction of the RTIL in the solution using a modified equation from another researcher [18]. The temperature and composition dependence of the presented C_P values was correlated using an excess molar heat capacity, C_P^E, expression via a Redlich–Kister type equation.

2. Experimental section

2.1. Chemicals

The RTIL samples used were obtained from TCI Co. with stated minimum purity (in mass fraction) of $\geqslant 0.992$ for [Emim][$EtSO_4$] and $\geqslant 0.980$ for [Emim][CF_3SO_3]. The water mass fractions were determined to be $\leqslant 0.005$ and $\leqslant 0.007$ for [Emim][$EtSO_4$] and [Emim][CF_3SO_3], respectively. The RTILs were used without further purification. The liquid water used to prepare the aqueous solutions was processed in a Barnstead Thermolyne ultrapure water system (model Easy Pure 1052), which produced deionized water (Type I reagent grade) with a resistivity of 18.3 MΩ cm and TOC (total organic content) of less than 15 ppb. All weight measurements during the preparation of solutions were performed on a digital balance from Mettler-Toledo (model AL204) having an accuracy of $\pm 1 \times 10^{-4}$ g.

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