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There are about 10^{18} combinations of cations and anions in the structure of ionic liquids (ILs) nowadays, made of a multitude of possible substitution patterns and substituted aromatic or aliphatic groups, and a wide variety of functional groups. The unusual thermodynamic properties of ILs result from the type of cohesive interaction, charge distribution, structuration, and polarity. Even though ionic liquids have found only a limited industrial application so far, their molecular structure and supramolecular organization as a complex, consisting of polar and non-polar domains that is reflected in the complexity of the thermodynamic properties of ILs and ILs mixtures, should be considered.[1] This structural variability of ILs is a motivation for systematic research and structural design, allowing to model or tune ILs with improved property profiles, including a reduced hazard to humans and the environment. The analysis of the thermodynamics data based on morphology of substance as well as the alkyl chain size is used to explore the effect on the ionic liquid properties and their interpretation.

Due to the large scale of possible applications of ILs, the knowledge of a wide range of physicochemical properties of both pure substances and their mixtures is required.[2] For this reason, in a continuation of a research project aimed at a thermodynamic study of 1–[(1*R*, 2*S*, 5*R*)-(–)-menthoxymethyl]-3-alkylimidazolium bis{(trifluoromethyl)sulfonyl}imide ionic liquids, where the alkyl chain length ranges from methyl to dodecyl, thermophysical properties such as density, speed of sound, and heat capacity were measured at a wide temperature range and atmospheric pressure. Experimental volumetric data were used to calculate the isentropic compressibility and isothermal expansion coefficient. In addition, owing to the lack of data caused by the diversity of ILs and the large number of commonly used molecular solvents[3] we decided to determine the excess properties and gain better understanding of the intermolecular interactions via the experimental data of excess molar volumes. A particularity in liquid-mixture behavior was revealed by characterization of excess molar volumes of

selected ILs from the above-mentioned homologous series with acetonitrile and methanol. The dependence of the excess molar volume on the composition of the mixture makes a link between the molecular phenomena and the observed bulk property.

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