EVALUATION OF SEVERAL ILS + TFE SYSTEMS FOR REFRIGERATION BY ABSORPTION TAKING INTO ACCOUNT THERMOPHYSICAL PROPERTIES

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Introduction: In the field of the working fluids for refrigeration by absorption there is a need for new refrigerant/absorbent pairs for domestic and industrial applications. Different ILs can be considered for a variety of applications by altering the anion–cation combination in the molecular structure. Thus, knowledge about the thermophysical properties of mixtures containing ILs becomes important in the design and operation of refrigeration by absorption. Shiflett and Yokozeki [1] had thought about H_2O, 2,2,2-trifluoroethanol (TFE), and 1,1,1,2-tetrafluoroethane as refrigerants and ionic liquids (ILs) as absorbents. Kim et al. [2] investigated the TFE + 1-butyl-3- methylimidazolium bromide, [bmim][Br] or TFE + 1-butyl-3-methylimidazolium tetrafluoroborate, [bmim][BF4] systems. Wang et al. [3] determined the vapour pressure of TFE + 1-ethyl-3-methylimidazolium tetrafluoroborate, [emim][BF4]. Currás et al. [4-8] and Salgado et al. [9,10] measured several properties of TFE + some ILs. In this work, we have done a compilation of densities, mixing enthalpies and vapour pressures of [emim][BF4], [bmim][BF4] and 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide [bmim][NTf2] with TFE at different pressures and temperatures in order to evaluate the most reliable pair for refrigeration by absorption.

Experimental: Density measurements were performed using an U-shape vibrating-tube densimeter operating in a static mode. The overall experimental uncertainty in the reported density values has been calculated by the law of propagation of uncertainty, resulting in a value of ($4\ 10^{-4}$ g cm^{-3}). Mixing enthalpies were determined by directly measuring the energy generated during the mixing using a high-precision differential scanning microcalorimeter from Setaram (micro DSC III). The uncertainty on the mixing enthalpy was estimated to be less than 1%. The experimental apparatus used for vapour pressure measurements is based on an isochoric technique. Uncertainties in pressure determination are 3% for the range $1<P/Pa<1000$ and 0.5% at higher pressures.

Results and Discussion: In a absorption system, the hydrostatic principle is used to maintain the pressure difference between the components, and so an absorbent solution with higher density is chosen to minimize the overall height of the refrigerator. In addition, for refrigerant/absorbent systems is preferable to have a negative or small positive enthalpy of mixing to increase the energetic efficiency of the process, especially in the case of heating systems. Furthermore, absorbents with low vapour pressures should be selected in favour of energy efficiency. Thus, we have obtained the following experimental trends for TFE + three ILs ([emim][BF4], [bmim][BF4] and [bmim][NTf2]):

Densities: ρTFE + [bmim][NTf_2]> ρTFE + [emim][BF_4]> ρTFE + [bmim][BF_4].

Mixing enthalpies: H_{mix} TFE + [bmim][BF_4]>H_{mix} TFE + [emim][BF_4]>H_{mix} TFE + [bmim][NTf_2] at 298.15K and H_{mix} TFE + [bmim][NTf_2]>H_{mix} TFE + [bmim][BF_4]>H_{mix} TFE + [emim][BF_4] at 323.15K. In Figure 1, we can observe these sequences.

Vapour pressures: low P_v[emim][BF_4] ≅ P_v[bmim][BF_4].

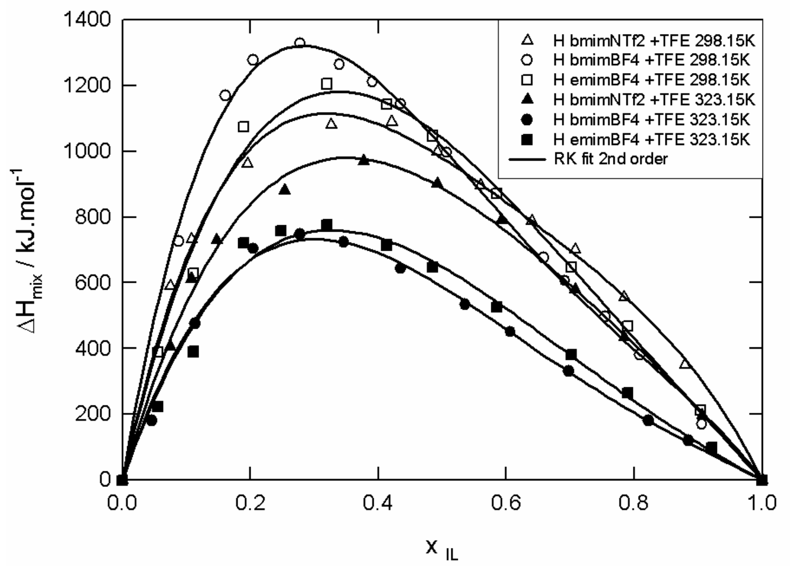

Figure1. Mixing enthalpies of three ILs + TFE against the mole fraction of IL.

Conclusions: With respect to the industrial application (refrigeration by absorption), from the point of view of the measured thermophysical properties in this case, the system containing the absorbent [bmim][NTf_2] is preferred at low temperatures. Nevertheless, other properties should be taken into account, such as corrosion with respect to the material of the piping, pumps, and other components of the refrigeration system, not be toxic, to be thermally stable, etc.

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