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TOPIC(s) : Alternative solvents

Ionic liquids for pretreament of textile fibres in a recycling context: a thermodynamic point of view

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PURPOSE OF THE ABSTRACT

Textile industry is one of the most pollutant in the world with only 1% of the textile waste being recycled to be re-introduced into the garment production. Moreover, the use of persistent additives, such as dyes or per/polyfluoroalkyl substances (PFAS) [1], put a strain on the environment. One of the technical challenges is to design environmental-friendly solvents able to dissolve fibres and/or their additives without degrading them.

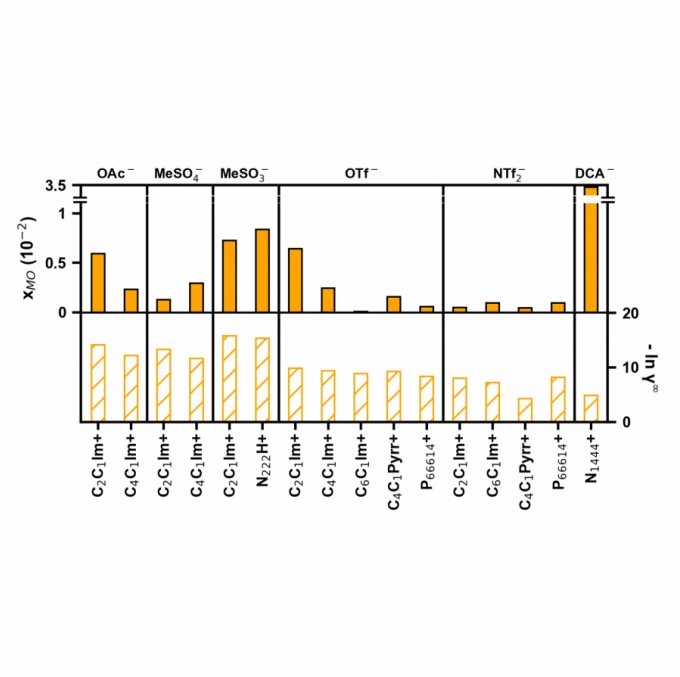
Ionic liquids are a class of alternative solvents that showed interesting properties for these applications. They are salts liquid at room temperature, their low vapour pressure makes them non-volatile, which is a non-negligible step towards the development of eco-friendly processes, and they showed solvation properties that are promising for recycling textile waste [2]. In addition, the infinity of combinations of cations and anions allows the design of ionic liquids answering to the current preoccupations.

In this study, we characterized the interactions of ionic liquids with different components of textiles, in order to find the best solvents for a mild and selective recycling process. After an in-silico screening [3], we gave an overview of the solubility of textile dyes, namely Methyl Orange (MO), Crystal Violet (CV) and Disperse Red 13 (DR13), in ionic solvents. With isothermal titration calorimetry method (ITC) [4], we measured excess properties of mixtures of ionic liquids and fluorinated precursors from water-repellents, such as perfluorobutanoic acid (PFBA) and 6:2 fluorotelomer alcohol (6:2 FTOH). Finally, we estimated the interactions of ionic liquids and textile polymers (cotton and polyester) via fibre dissolution and contact angle measurements.

Ionic liquids were able to strongly interact with these different types of solutes. Imidazolium and ammonium-based ionic liquids, such as 1-butyl-3-methylimidazolium acetate [C4C1Im][OAc] or tributylmethylammonium dicyanamide [N1444][DCA], were particularly able to dissolve textiles dyes. These results and the in-silico screening method were tested by the discolouration of polyester fibres previously dyed with DR13. Ionic liquids were able to extract the dyed accordingly with the thermodynamic studies. As far as the fluorinated compounds were concerned, some chemical or quasi-chemical interactions could be identified, namely with carboxylate-based ionic liquids.

We show that computational screening combined with experimental thermodynamic measurements allow the identification of the best ionic liquids with solvation properties of textile additives and their separation from textile fibres.

FIGURES



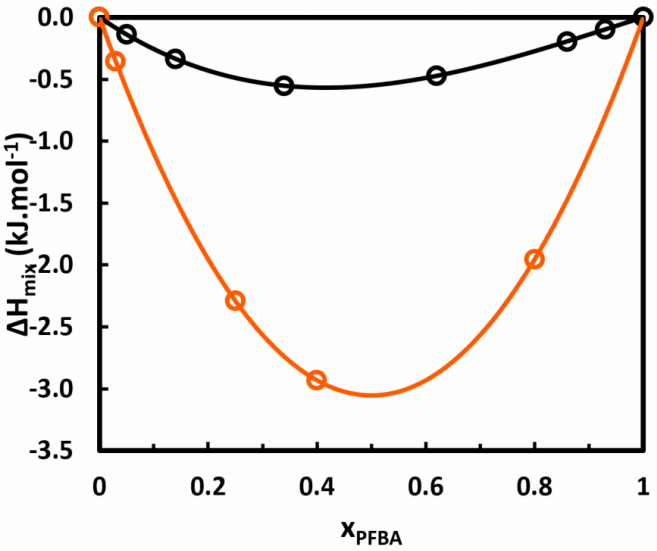


FIGURE 1

Interactions of Methyl Orange with ionic liquids

Top: Solubility of MO in ionic liquids, as mole fraction

Bottom: COSMO-SAC calculated infinite dilution activity coefficients in ionic liquids

FIGURE 2

Mixing enthalpy of Perfluorobutanoic acid + ionic liquid mixtures

Mixing enthalpy (y axis, kJ/mol) of PFBA in [C2C1Im][MeSO3] (black) and [C4C1Im][NTf2] (orange), as a fonction of the composition (x axis, mole fraction of PFBA)

KEYWORDS

Textile recycling | Ionic liquids | In-silico screening | Experimental thermodynamic measurements

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