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PAPER

A new outlook on solubility of carbohydrates and sugar alcohols in ionic liquids

Lucinda J. A. Conceiçao,[a,b] Ewa Bogel-Łukasik[b] and Rafał Bogel-Łukasik*[a]

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Ionic liquids are innovative media characterised by an easy tunability of physical and chemical properties with the potential for broad usefulness in a wide spectrum of chemical applications. One example of such an application is a complex biorefinery concept leading to the exploitation of the biomass for the production of energy (heat, power, fuel) and value added products. Until now ionic liquids have proven their feasibility to dissolve selectively biomass as a whole as well as individual carbohydrates. This work demonstrates the solubility of carbohydrates and value added products—sugar alcohols—which can be obtained from biomass through the biorefinery concept. The novelty of our investigation includes either solubility studies of sugar alcohols or an involvement of unexplored ionic liquids yet. In this research, a variety of ionic liquids constituted by imidazolium, pyridinium and phosphonium cations was applied. Furthermore, anions of ionic liquids, attractive from a point of view of a broad application, such as: 2-(2-methoxyethoxy)ethylsulfate, hydrogen sulfate, thiocyanate, tricyanomethanide, tetrachloroferrate, perfluorobutane sulfonate and tosylate were investigated. In this work, it was discovered that solubility of carbohydrates and sugar alcohols can exceed even 75 wt% at an easily achievable temperature depending on the choice of the ionic liquid.

Introduction

Carbohydrates and their derivatives are the most abundant organic compounds in nature. Depending on their molecular weight, carbohydrates can be divided between low molecular carbohydrates, such as mono-and disaccharides, and more complex, high molecular weight oligo-and polysaccharides. Carbohydrates are important constituents of animal and human's world because they are among the most important building blocks of cell walls, exoskeletons and regulators of the human body's functions. They are major constituents of the plant kingdom. Due to a general presence of carbohydrates in nature, recently a focus has been dedicated to the processing of carbohydrates to a variety of products. The methodology leading to this transformation, called biorefinery, aims at a maximal exploitation of the carbohydrate-rich raw material to produce energy (fuel, heat, power) and the high value added products (*e.g.* chemicals).[1]

Sugar alcohols are among high value added products originated in the biorefinery of the carbohydrate biomass. The most popular sugar alcohols are xylitol and mannitol. Xylitol is an artificial sweetener which is adsorbed slowly without increasing a sugar level in the blood that makes it an alternative sugar for diabetes.[2] Due to this feature, xylitol is extensively used in the "sugar-free" chewing gums, dietary drinks and foods. Xylitol is also a "toothfriendly" sugar substitute because of a plaque-reducing effect.[3] Furthermore, xylitol is recognised as a building block from the biomass biorefinery that serves for the synthesis of many chemicals.[4] The second sugar alcohol mentioned, mannitol, is broadly used *e.g.* in medicine as a drug carrier to the brain and to other organs of the human body.[5] Mannitol, similarly to xylitol, is used as a sweetener and as a booster of a cooling effect in mint candies and chewing gums.[6]

From the numerous applications of carbohydrates and their products *e.g.* sugar alcohols, it can be concluded that the efficient methods of processing of these compounds are crucial for their successful application. One of the initial steps of each process is dissolution of the reagent(s) in the defined solvent. Unfortunately, carbohydrates and their derivatives such as sugar alcohols are soluble in water and rather poorly soluble in most of organic solvents. Water is not the best solvent for the majority of the organic compounds, thus, this obstacle hinders its application in specific processes. Therefore, novel solvents for carbohydrates and organic chemicals are required. Ionic liquids (ILs) seem to be one of the "*aurea mediocritas*" as they reveal a large solvating capacity and are selective solvents for either various organic chemicals[7–9] or carbohydrates.[10] ILs are salts which facilitate more sustainable applications in reactions[8,11] and separations[12] mostly due to their unique properties, such as a high thermal stability[13,14] and great solvent power.[7,9,15,16] Furthermore, a very low vapour pressure of ILs reduces a risk of exposure that is a

[a]*Laboratório Nacional de Energia e Geologia, I.P., Unit of Bioenergy, Estrada do Paço do Lumiar 22, 1649-038, Lisboa, Portugal. E-mail: rafal.lukasik@lneg.pt; Fax: +351217163636; Tel: +351210924600 ext. 4224*
[b]*Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516, Caparica, Portugal*

