Low waste process of rapid cellulose transesterification using ionic liquid/DMSO mixed solvent: Towards more sustainable reaction systems

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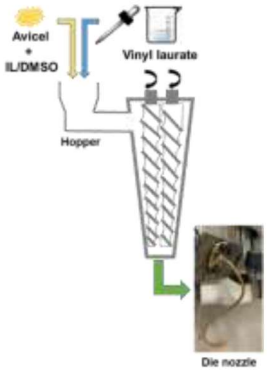
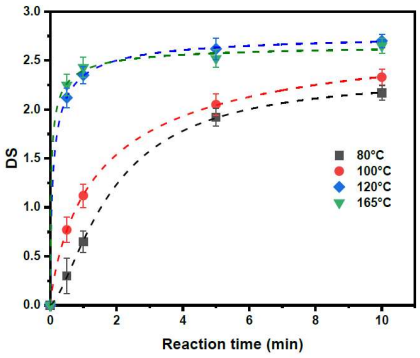
Abstract

The global transition from fossil fuel-based plastics to bio-based feedstock alternatives remains slow (2% of the production volume of petrochemical polymers in 2018) [1]. However, the potential is much higher, but the low oil prices and a lack of political support are currently hampering this growth. The recent progress in the elaboration of new functional biomass derived materials shows that the renewable side of these materials does not guarantee the sustainable development [2]. In contrast, reaction/process design and waste minimization play a key role here. In the previous research of our group a successful employment of ionic liquids based solvent systems allowed direct synthesis of various cellulose thermoplastic derivatives in batch conditions. In particular, low toxic 1-ethyl-3-methyl-imidazolium acetate (EmimOAc) shows not only great cellulose dissolution properties, but also acts as a catalyst for the transesterification of cellulose using vinyl esters, without the requirement for any additional catalyst [3,4]. In this study, reactive extrusion (REX) was used as a fast and direct method for microcrystalline cellulose transesterification with vinyl laurate as acyl donor in EmimOAc system using DMSO as a co-solvent in order to continuously produce cellulose thermoplastics. It was demonstrated that cellulose laurate can be synthesized with different degree of substitution (DS) and high reaction efficiency (RE). The low amounts of solvent during the process provides high cellulose concentration (20 wt%) mild chemical modification within minutes of reaction and without depolymerization of the cellulose backbone. Temperature was found to have a significant influence on the reaction kinetics and the DS, particularly during the first seconds of the reaction. To examine the sustainability of the process E-factor was employed for two different reaction systems. Thermal and processing properties of obtained cellulose laurates were investigated and it was found that the samples with DS of 2.5 and higher can be easily extruded showing low melt viscosity values. EmimOAc was recovered and reused for subsequent cellulose transesterification exhibiting high catalytic activity.

Keywords: Cellulose, Chemical Modification, Reactive Extrusion, Ionic Liquids, Sustainability





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