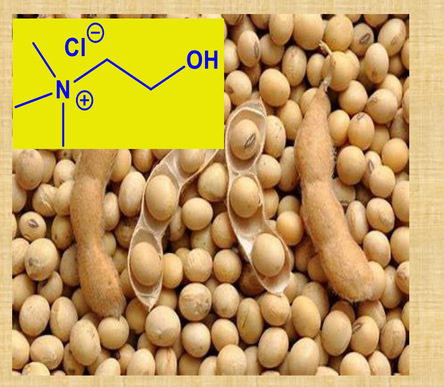
Dissolution and extraction of biopolymers with biobased ionic liquids

Jean-Pierre Mbakidi [a], Mahasoa-Salina Souvenir Zafindrajaona [a,b], Dalila Saaoui [a], Katia Bacha [a], Magdalena Bendova [b], Sandrine Bouquillon [a]

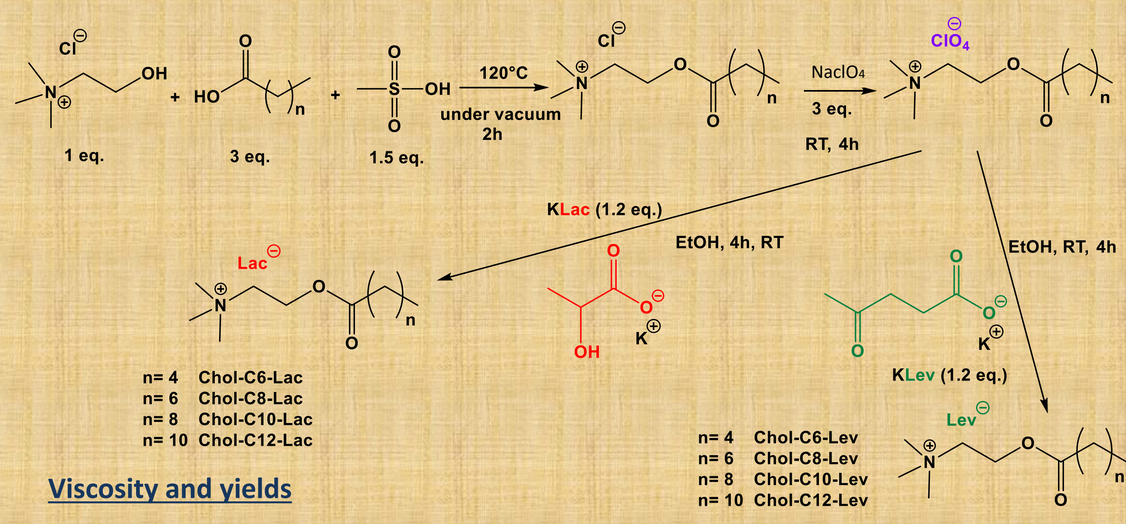
[a] Université de Reims Champagne-Ardenne, Institut de Chimie Moléculaire de Reims (ICMR), CNRS UMR 7312, UFR des Sciences Exactes et Naturelles, Bât 18, BP 1039, F-51687 Reims Cedex 2, France
[b] Institute of Chemical Process Fundamentals of the CAS (IPCF) - Rozvojová 135/1, 165 00 Prague 6, Czech Republic
✉ jean-pierre.mbakidi@univ-reims.fr

Introduction

In the current context linked to questions about sustainable development, manufacturers want to replace petrochemical raw materials with renewable resources. In this context, a new category of solvents has emerged as an alternative to traditional ones, the category of ionic liquids. If these ones are biosourced, they can be bio- and eco-compatible. In this work, we have developed biosourced ionic liquids based on the choline, which can be found in particular in soy. These low toxic solvents (eco- & cyto-toxicity collaboration with SEBIO UMR I-02 and MEDyC UMR CNRS 7369) have been used in the dissolution of biopolymers (cellulose or Kraft lignin) for their transformation or their extraction from Douglas wood bark. This application of these biosourced solvents could enable the development of sustainable chemistry as part of the bioeconomy in sectors such as materials and pharmaceuticals.

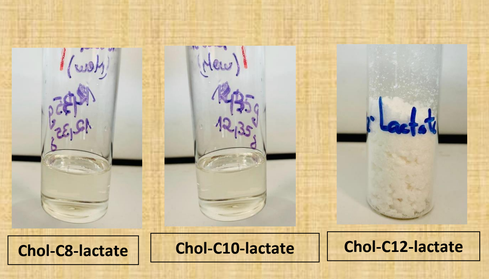


Synthesis of biobased Ionic Liquids (ILs) [1,2]



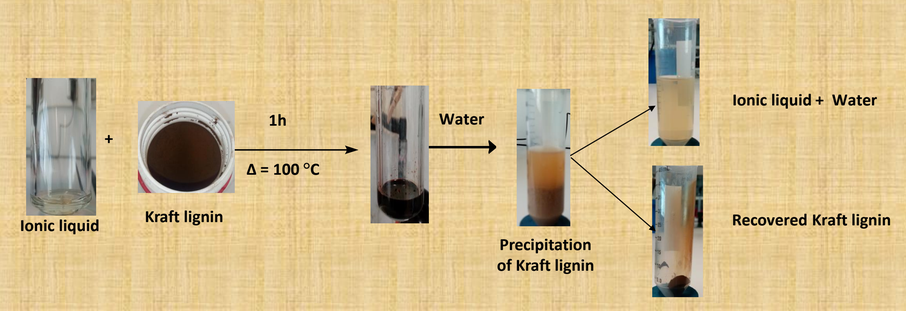
Viscosity and yields

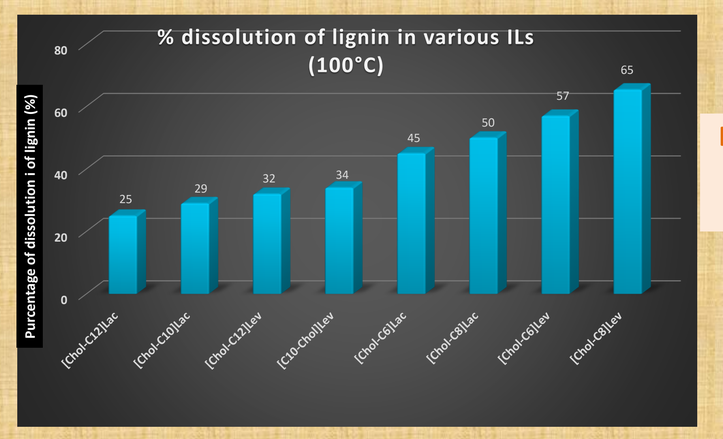
Ionic liquid	Aspect	Yield (%)	Viscosity (cP) at 60°c
Chol-C6-Lac	Colorless oil	60	19.8
Chol-C6-Lev	Colorless oil	70	28.4
Chol-C8-Lac	Colorless oil	79	49.3
Chol-C8-Lev	Light beige wax	76	67.8
Chol-C10-Lac	Slightly yellow wax	60	Nd
Chol-C10-Lev	Slightly yellow wax	71	Nd
Chol-C12-Lac	White wax	57	Nd
Chol-C12-Lev	White wax	59	Nd


Chol-C8-lactate | Chol-C10-lactate | Chol-C12-lactate

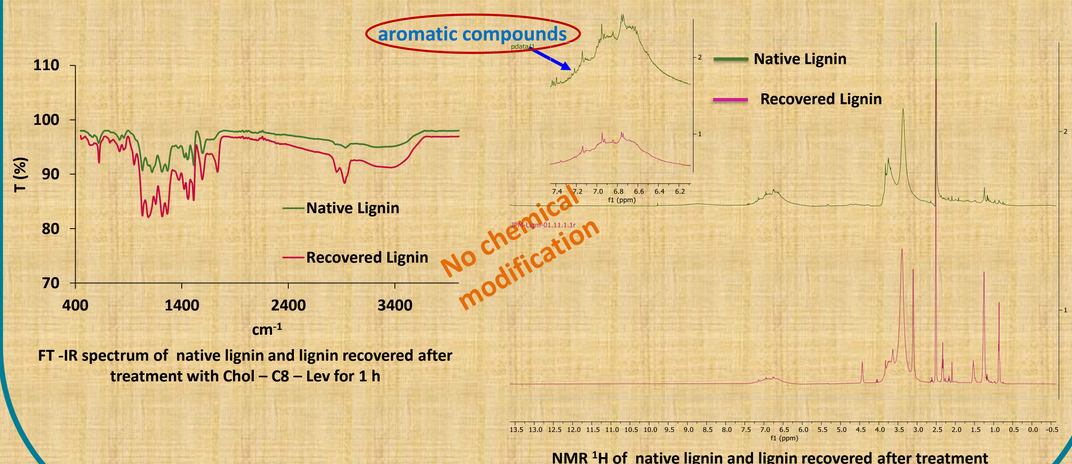
Better yield & high viscosity

Dissolution of the Kraft lignin [3]





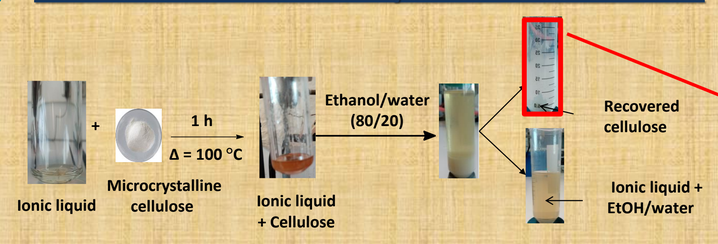
Efficient dissolution of lignin up 65% (mass)

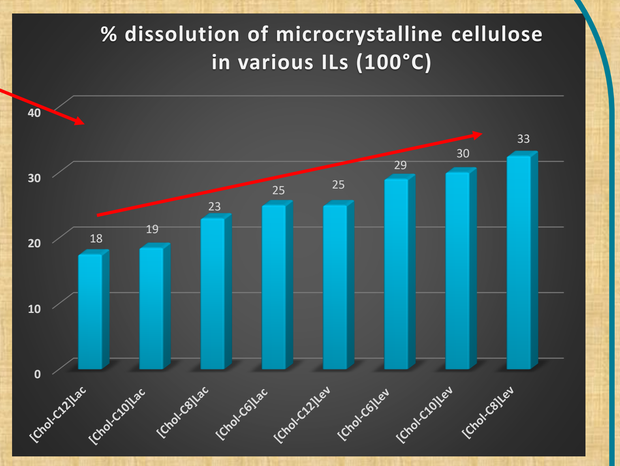


FT -IR spectrum of native lignin and lignin recovered after treatment with Chol – C8 – Lev for 1 h

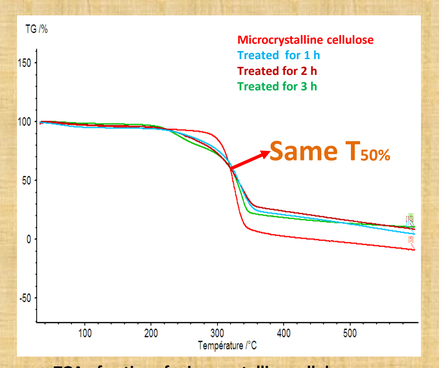
NMR ^{1}H of native lignin and lignin recovered after treatment with Chol – C8 – Lev for 1 h

Dissolution of microcrystalline cellulose [4]

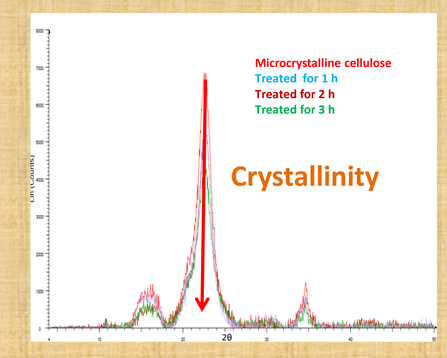




FT -IR spectrum of cellulose and of recovered cellulose after treatment with Chol - C12 - Lac for 3 hours



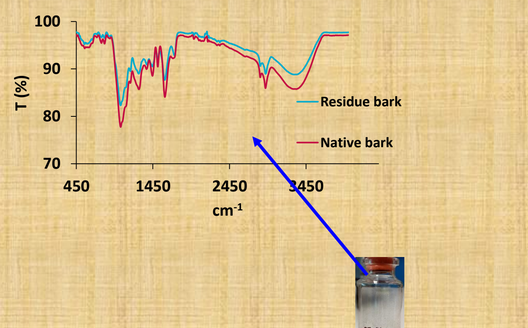
TGA of native of microcrystalline cellulose and recovered cellulose

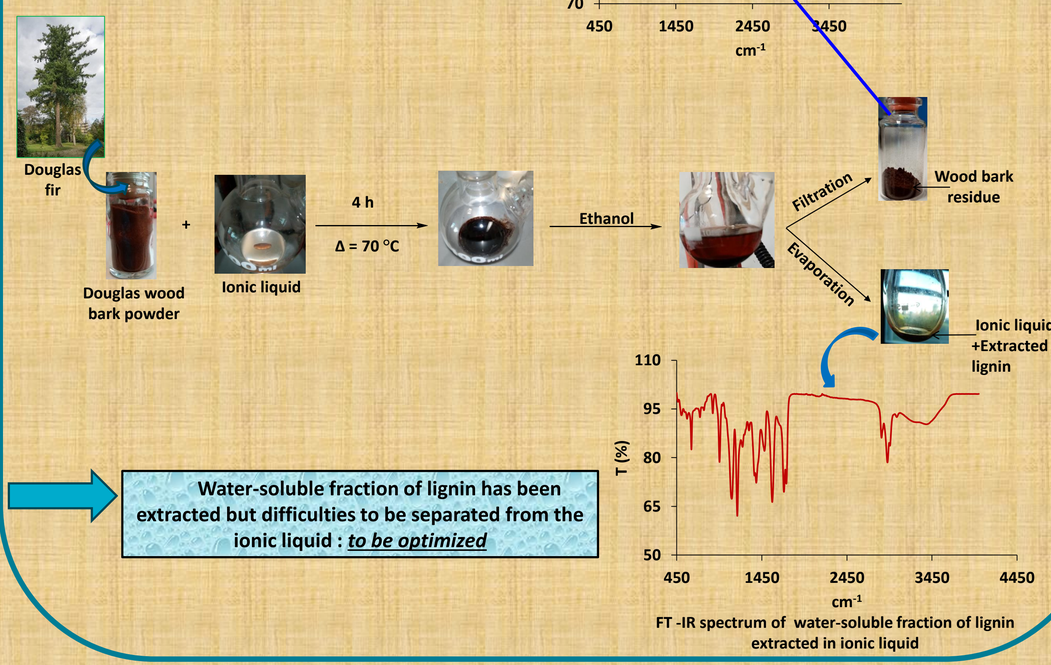


XRD of native microcrystalline cellulose and of recovered cellulose

Extraction of lignin from Douglas wood bark

❖ **Lignin represents approximately 25% of lignocellulosic biomass**





Water-soluble fraction of lignin has been extracted but difficulties to be separated from the ionic liquid : *to be optimized*

FT -IR spectrum of water-soluble fraction of lignin extracted in ionic liquid

Conclusion and perspectives

In this work, new choline-based ionic liquids were synthesized with high yields through a three-steps procedure.

These ionic liquids show a remarkable effect in biomass (cellulose and lignin) dissolution without releasing toxic substances into the environment; furthermore, they can also be used as solvent for extracting lignin from bark of Douglas wood. We will continue the analysis of the extracted lignin by confocal Raman imaging and by size exclusion chromatography. The study will be extended to the functionalization of lignin to produce new biomaterials.

References

1- J.-P. Mbakidi & S. Bouquillon PCT/EP2020/070365
2- J.-P. Mbakidi, I. Barjhoux, K. Aguibi, A. Geffard, D. Rioult, M. Palos Ladeiro, S. Bouquillon. Synthesis of New Betaine-Based Ionic Liquids by Using a "One-Pot" Amidation Process and Evaluation of Their Ecotoxicity through a New Method Involving a Hemocyte-Based Bioassay. ACS Sustain. Chem. Eng. 2021, 9 (46), 15427 - 15441.
3- J.-P. Mbakidi, A. Kerkache F. Lazar, S. Bouquillon S. Dissolution of Cellulose and Lignin with Biobased Ionic Liquids. J. Solut. Chem. 2022, 51(3), 345 - 356.

Acknowledgments

We thank both URCA and the FEDER (Amisolver Excellence Framework) for post-doctoral scholarships (D.S. and J.P.M.) and financial support as well as the SATT Nord for financial support for an engineer position (J.P.M.).