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DEVELOPMENT OF NANOCELLULOSE-BASED HIGH GAS BARRIER COMPOSITES FOR PACKAGING

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INTRODUCTION

Poly(lactide) (PLA) presents the advantage of being a biodegradable and renewable polyester with overall good mechanical properties, which makes it an interesting substitute for classical non-renewable polymers. However, PLA has limited gas barrier characteristics, property of greatest importance for packaging applications.

Cellulose Nanocrystals (CNC) is known for its high crystallinity, as well as the ability to form percolation networks in polymeric matrices, which was proven in previous studies, to be both beneficial for barrier and mechanical properties [1,2].

In this work, nanocellulose-based composites were prepared via solvent casting. The effects of unmodified and modified nanocellulose particles on the relaxation and barrier properties of PLA were investigated. The adhesion between the matrix and the filler was enhanced after chemical modification, as well as the barrier properties to oxygen (for high contents).

MATERIALS AND METHODS

Materials

- PLA 4060D (Ingeo™, NatureWorks), with 12% D-lactide content
- Spray-dried Cellulose nanocrystals (CNC) powder was provided by CelluForce, Canada

Methods

- CNC was surface grafted with Lauric Acid using the SolReact reaction [3]
- PLA/CNC-based composites were prepared via solvent casting
- SEM micrographs: EVO MA10 SEM from Zeiss with tungsten electrode
- Barrier properties: Gas Permeability Tester (GDP-C), Brugger, München

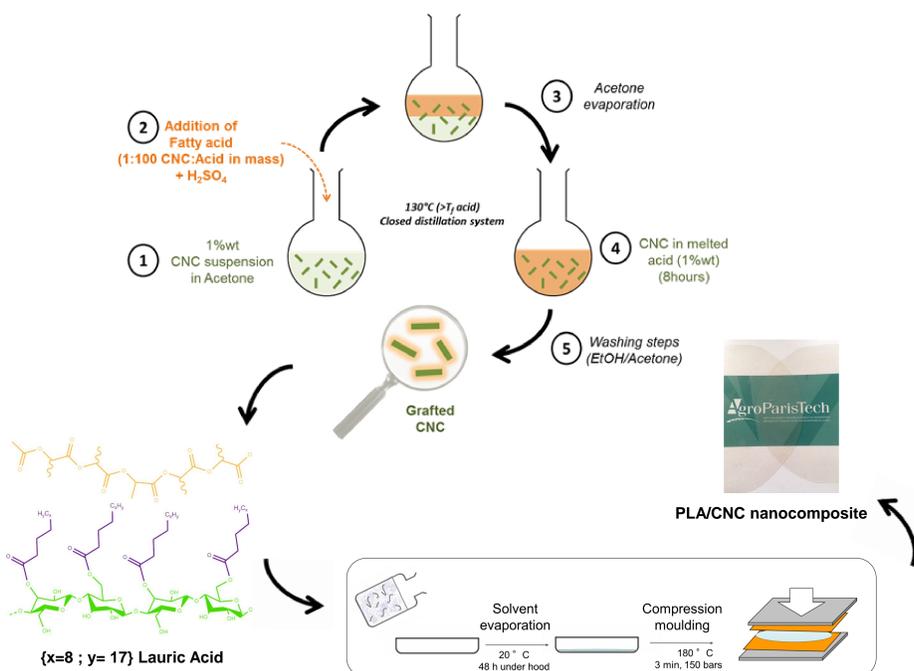


Fig. 1. Outline of the different steps to modify and form PLA/Nanocellulose-based composites

RESULTS AND DISCUSSION

Scanning Electron Microscopy

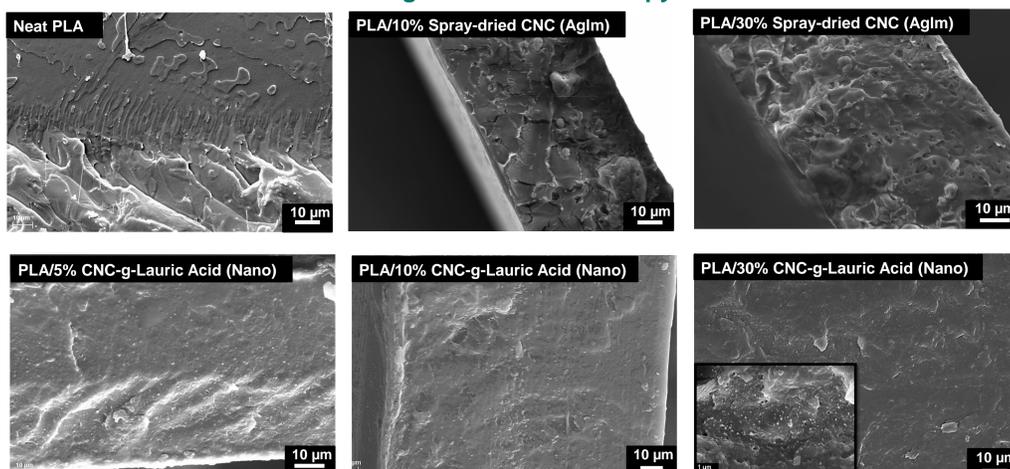


Fig.2. SEM micrographs of PLA and PLA/Nanocellulose-based composites (AgIm for agglomerated and Nano for nano-dispersed)

REFERENCES

- E. Espino-Pérez, J. Bras, S. Domenek et al., Carbohydrate Polymers journal, 2018
- P. Dharal, D. Tarafder, A. Kumar et al., RSC Adv., 2015
- Espino-Perez, Domenek, Belgacem, Sillard, & Bras, 2014

In situ physical aging by Differential Scanning Calorimetry

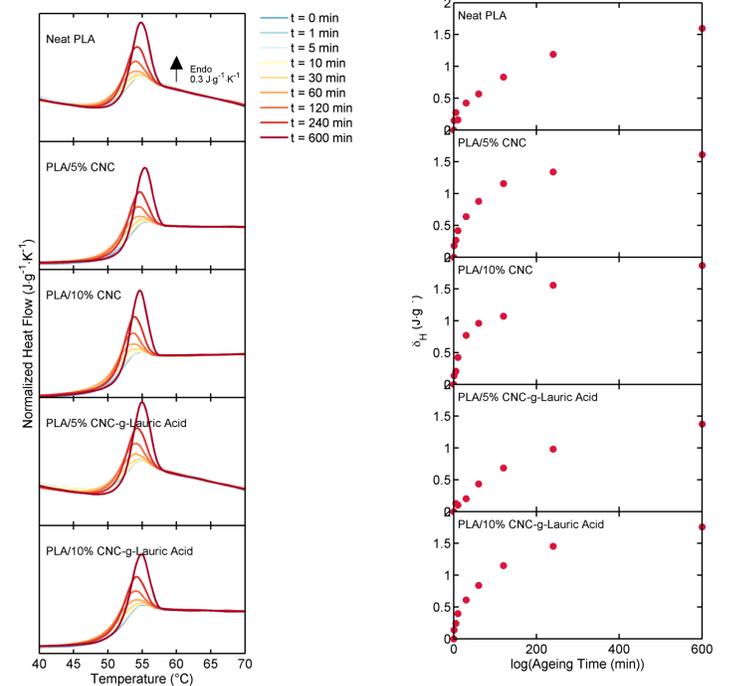


Fig. 3. Aging of PLA and PLA/CNC-based composites at $T_{ag} = T_g - 15^\circ \text{C}$ studied by DSC. (i) Normalized heat flow for t_{ag} ranging from 0 to 600 min, (ii) Enthalpy recovery as a function of aging time.

Permeation to oxygen

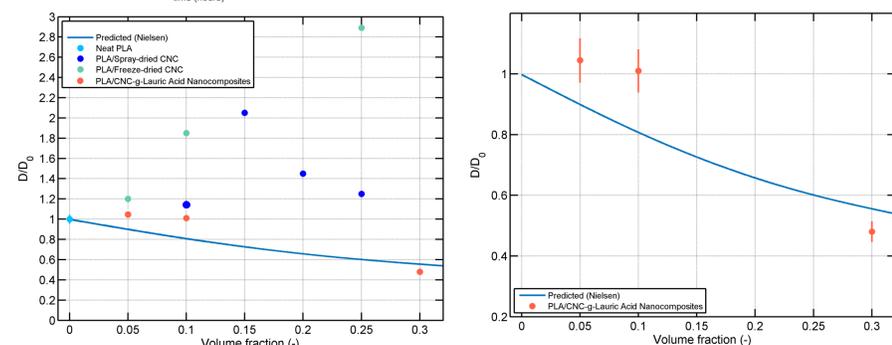
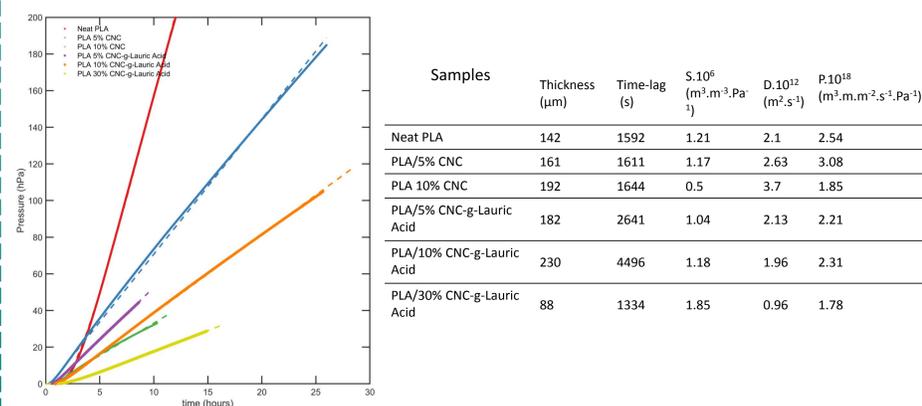


Fig. 4. i) Time-lag plot for oxygen permeation ii) Relative diffusivity for PLA, and PLA/CNC-based composites, Nielsen model included (1967)

CONCLUSIONS

- PLA/unmodified CNC showed severe aggregations and low interface adhesion
- The chemical modification (SolReact) enhanced the dispersion and the compatibility between the matrix and the nanoparticles → Creation of an interphase
- DSC curves proved the absence of any NP-induced plasticization or restriction on the PLA chains, while *in-situ* aging showed no significant changes in the relaxation behavior
- High CNC contents (PLA/30 wt.% CNC-g-Lauric Acid) nanocomposites exhibited improvement barrier-wise

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