Influence of the oxidation degree of CNF in nanopaper transparency

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Abstract

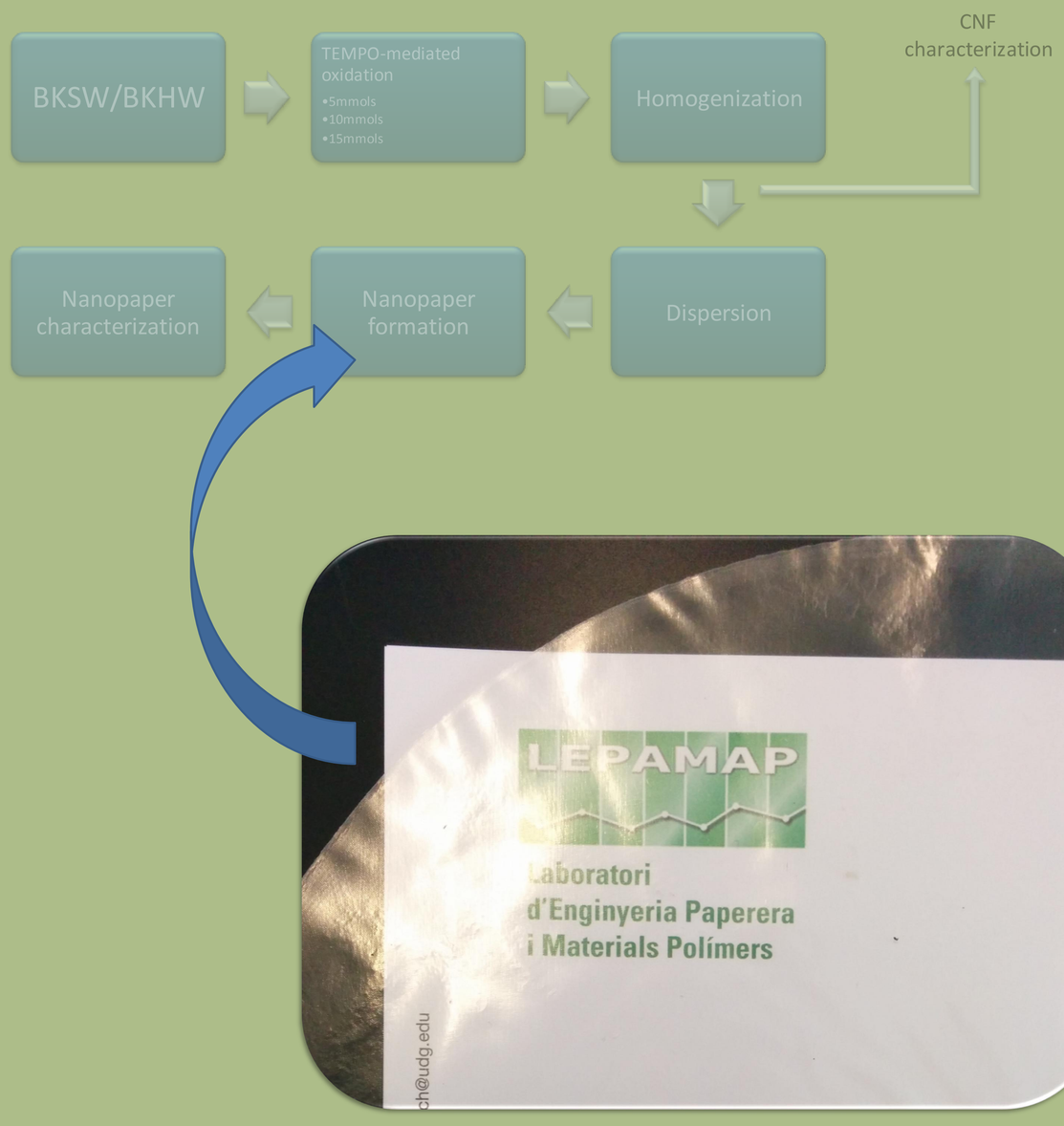
The chemical deconstruction of fibres has an important role during the extraction process of cellulose nanofibres (CNF). One of the most common methodologies to facilitate the fibre opening is the TEMPO-mediated oxidation. The degree of oxidation, a part from its incidence on production costs, influences directly on morphological and intrinsic properties of CNF through degree of polymerization. Consequently, nanopaper made of these CNF may show a wide range of mechanical properties, porosity and transparency. In the present work, the incidence of the oxidation degree of CNF on the nanopaper transparency has been studied for two types of cellulose source, bleached Kraft softwood (pine) and hardwood (eucalyptus). It was observed that the level of transparency of nanopapers was increased with the degree of oxidation of cellulose nanofibres. Also, some differences between softwood and hardwood nanofibres were found, in agreement with their intrinsic composition with respect to the type and amount of hemycelluloses.

Introduction

Regular paper has intrinsic barriers as porosity, surface roughness or transparency, limited temperature, among others, that impede hosting electronic devices. Further, paper industry must invest in developing new papers with special properties. Nanocellulose has been of increasing interest as a sustainable and renewable material that has the potential for low cost and high mechanical performance. The native cellulose nanofibers are an attractive biocompatible nanomaterial. CNFs can be presented in various forms like aerogel, hydrogel or films of CNF (nanopaper), for instance. Mimicking papermaking processes, a cellulose nanofiber suspension can be used to prepare films simply by filtering the suspension to obtain a wet gel and allow time for evaporation of water. Reducing the diameter of the paper fibers decreases the optical scattering; therefore the nanopaper has excellent optical transparency. The present work aims to study the influence of the oxidation degree on nanopaper transparency.

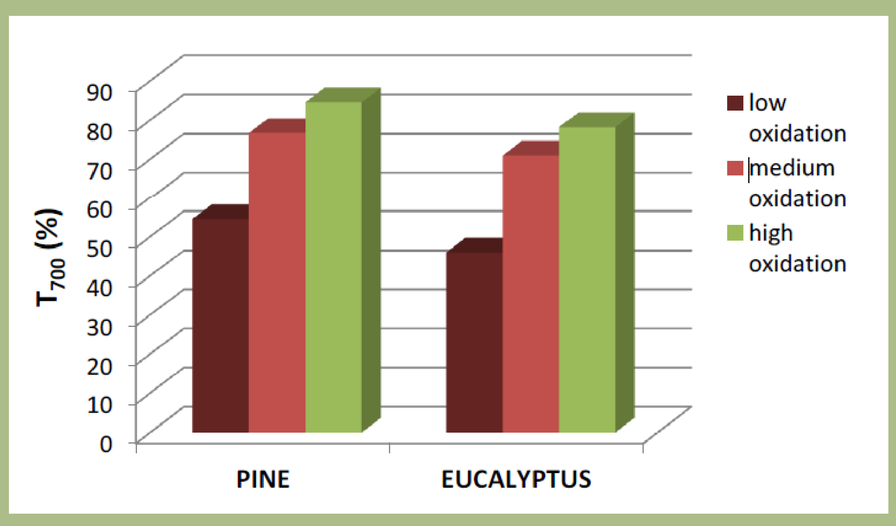
Experimental

The following flowchart shows the experimental procedure of the whole project:



Results and discussion

The graph below shows the transmittance at 700nm of each nanopaper made of different raw material and with different oxidation degrees.



As is possible to see, pine nanopapers are more transparent than eucalyptus ones for all oxidation degrees. This can be explained by the differences in chemical composition, specifically in xilane percentage. Bleached pine pulp has a xilane content lower than eucalyptus pulp. Moreover, while increasing the oxidation degree, transparency also increases. This fact is due to the chemical destructuration of fibres. While increaseing the severity of the oxidation, more crystalline surface is exposed.

Transparency is an important parameter for nanopaper's applications. Nanopapers must be transparents when they are used as support for printed microelectronics, antennas, sensors, magnetic papers, among others.

Conclusions

The main conclusions of this work are the following:

- It is possible to produce high transparent nanopaper with conventional paper formation techniques varying some parameters like pore size of the membrane.
- In general terms, pine nanopapers are more transparent than eucalyptus ones.
- Transparency is an important parameter for nanopapers, since depending on the application, the good performance of the device will depend on suppor transparency.
- The increase in transparency due to the increase of the oxidation degree is explained by the increase of crystalline surface on CNF and diameter reduction.

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