Lignocellulosic medium density fiberboards without synthetic adhesives: properties enhancement through the addition of cellulose nanofibers

Dyna Theng[a,c], Gerard Arbat[b*], Quim Tarrés[a], Marc Delgado-Aguilar[a], Fabiola Vilaseca[a], Bunthan Ngo[c], Pere Mutje[a]

[a] Grupo LEPAMAP. Departamento de Ingeniería Química, Universitat de Girona, España.

[b] Departamento de Ingeniería Agraria y Tecnología Agroalimentaria, Universitat de Girona, España.

[c] Royal University of Agriculture, Cambodia.

Introduction

Sustainable, green and environmental friendly materials for various applications are receiving increased attention, while the demand of forest products, including softwoods, hardwoods, and mixtures of different wood species is also increasing. As the biomass from crops has similar chemical composition to that of hardwoods, it could be used to as a substitute for wood fiber in the production of wood-plastic composites. Abdul Khalil et al [1] reported that the incorporation of cellulose nanofibers (CNF) into other polymers is an important strategy for producing nanocomposites with higher mechanical performance. The present work aims to develop medium density fiberboard (MDF) made from thermomechanical pulp (TMP) of corn biomass reinforced with eucalyptus nanofibers. The main purpose of the research is to enhance the mechanical properties of binderless corn MDF , relative to commercial MDF.

Experiment

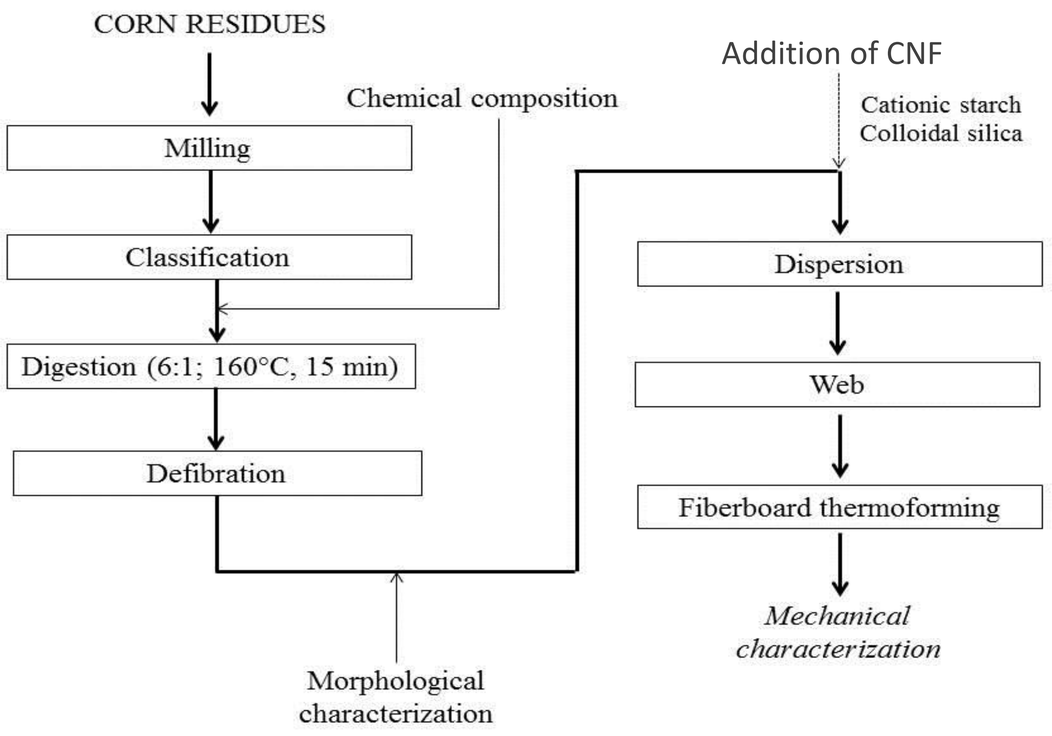

Fig. 1. Flow chart of experimental work

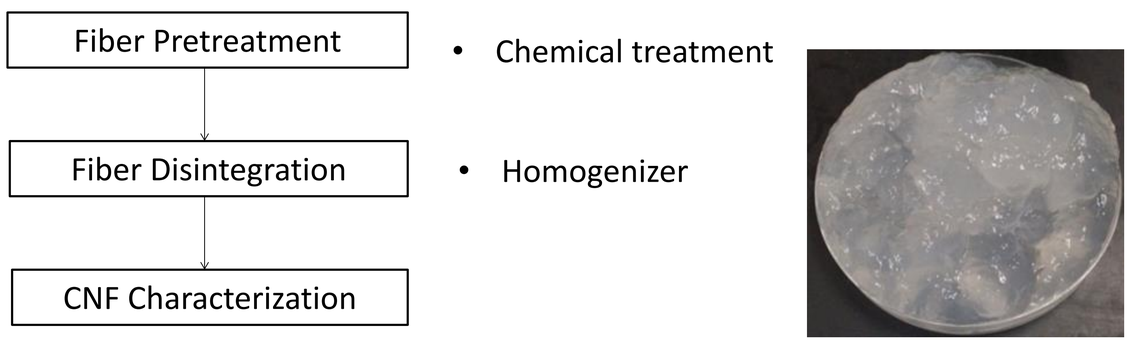

Fig. 2. Main processes involved in producing CNF from Eucalyptus pulp and 5 mmol CNF

Results and Discussion

Table 1 shows the results of CNF characterization. The carboxyl content (methylene blue and conductimetry groups) was about 2 mmol of COOH groups per gram of fiber. This parameter is the main factor that determines the extent of nanofibrillation of the fibers and the PD (352). The PD value places the CNF in low PD nanocellulose group. The yield was very high, up to 95%. The cationic demand is also high (1459 µeq-g/g.). The results indicate that can be indicated that the behavior that fines have higher CD for neutrality than fibers[2]. For WRV, the average value was 8 g/g which is typical for beaten papermaking pulps.

Table 1: Results for the characterization of CNF

Carboxyl groups (methylene blue)	0.99 mmol/g
Carboxyl groups (Conductimetry)	1.00 mmol/g
Yield	95 %
Cationic demand (CD)	1459 µeq-g/g
Water Retention Value (WRV)	8.3 g/g
Polymerization degree (PD)	352

Fig. 3. Diagram of MDF production made of corn biomass with CNF incorporation

Table 2: Chemical characterization of corn biomass and corn TMP

Materials	Ash (%)	Extractives (%)	Lignin (%)	Holocellulose (%)	Yield (%)	Length (µm)	Width (µm)	Fines (%)	°SR
Corn biomass	3.2	3.1	16.0	77.6	-	-	-	-	-
Corn TMP	2.4	3.3	15.7	80.1	87.1	653	24	59.7	44

°SR; Schopper-Riegler degree

The chemical composition of the TMP fibers changed when compared with the initial corn biomass (Table 2). Ash content decreased considerably (0.8%) due to the steam and defibrillation processes, while the lignin from fibers had a small water-soluble fraction, as is reflected in the lignin content of the TMP (15.7%). The hollocellulose (80.1%) increased, reflecting a decrease of other chemical components. In relation to the properties of the TMP fibers properties, the length and width of TMP fibers were 653µm and 24 µm, respectively. The aspect ratio (which is a parameter which reflects to the order of magnitude of the fiberboard's mechanical properties) of the fibers was approximately 27. Schopper-Riegler degree (°SR) was 44, value in concordance with the fines (59.7%) is slightly high.

Figure 4 shows the results of the modulus of rupture of binderless MDF made of TMP corn biomass reinforced with CNF and commercial MDF. The results indicate that the mechanical properties of MDF made from corn biomass increased linearly with increasing %CNF, from 29MPa (0% CNF) to 52 MPa (2% CNF). This is consistent with the review of Abdul Khalil et al [1]

.

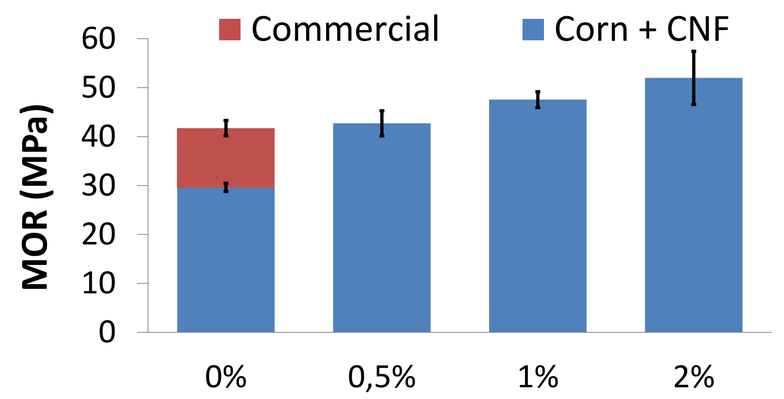

Fig. 4. Modulus of Rupture (MOR) of MDF made of corn biomass with %CNF and commercial MDF

Conclusions

Binderless lignocellulosic medium density fiberboard with CNF reinforcement was fabricated. The effects of CNF on the MDF properties showed excellent reinforcing capacity as the strength linearly improved. The maximum strength was 52MPa with 2% CNF, about double that of the MDF without CNF incorporation. This result was higher than that for commercial MDF (42MPa).

Acknowledgement

The authors thank the Erasmus Mundus Techno II Project for financial support and Dr. John Schiller, Honorary Senior Fellow, University of Queensland, Australia for English edition.

References

1. Abdul Khalil, H.P., et al., *Production and modification of nanofibrillated cellulose using various mechanical processes: a review.* Carbohydr Polym, 2014. **99**: p. 649-65.
2. Orblin, E. and Fardim, P. *Interactions between cationic polyelectrolyte and pulp fines*. BioResources, 2011. 6: p. 2340-2355.