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Mechanical & barrier properties of bionanocomposites with Cellulose whiskers from Bagasse

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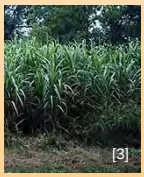
Objective

In the present work, agricultural residues sugar cane bagasse have been used to obtained cellulose whiskers. These nano-filler have then been used to prepare bionanocomposite with natural rubber (NR). Characterization of cellulose whiskers prepared will be carried out using Scanning and Transmission electron microscopy. The dimension of nanoparticles are in the range of other whiskers.

Thermal and mechanical properties have been analyzed for different percentage of whiskers. An important improvement of Young's modulus has been observed with only 5% of whiskers. Young's modulus is strongly increased with 10% whiskers (x20). Barrier properties to water vapour follow an other direction with first an increase of permeability till percolation threshold and then a decrease of WVP after this value close to 8% of whiskers.

Current work

Introduction



Natural fibers are produced in important quantity in the world and only a small portion is used in industry.

Meanwhile cellulosic nanocomposite materials appear since few decades[1] as innovative solution to obtain advanced materials with improved properties. [2]

The project aims to prepare cellulosic nano-crystallites (cellulose nanorods) from bagasse that is common in Egypt and France.

The prepared cellulose nanorods would be utilized in biodegradable packaging materials with improved mechanical strength properties.
In this poster we will present mainly whiskers obtained from bagasse and their impact in nanocomposite with natural rubber (NR).

Material & Methods

Cellulose Whiskers.

Bleaching: The bleaching treatment was performed with a solution made by equal parts of acetate buffer, aqueous chlorite (1.7 wt % in water) and distilled water at 80 °C during 4 h under mechanical stirring and was repeated 4 times. After each treatment the fibers were filtered and washed with distilled water.

Hydrolyses: Acid hydrolysis was achieved at 50 °C with 65 wt % sulphuric acid (pre-heated), for about 40 min, under mechanical stirring. The fiber content during all of these chemical treatments was about 4 wt % to 6 wt %. The suspension was diluted with ice cubs to stop the reaction and washed until neutrality by successive centrifugation.

Films Preparations

Some films with 100% raw whiskers have been made by solvent casting. Bagasse whiskers have been put in a water emulsion at 20% NR which has been cast in a small mold.

Films characterizations

Tensile test

When it was possible tensile tests were realised on 3 samples. at room temperature whith a speed rate at 0.01 mm/min.

Mechanical dynamic analysis (DMA)

The analysis was made at 1 Hz, temperature condition: from 100°C to 250°C with a speed rate of 3°C /min.

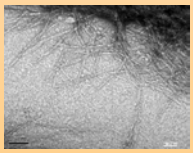
Water Vapour Permeability (WVP)

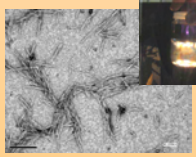
Measurements of WVP were carried out with the gravimetric cup method (ASTM E96-90, TAPPI T448 om-89) in an environment of 23°C and 50% RH using anhydrous calcium chloride as desiccant.

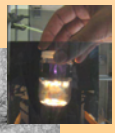
Results and discussion

- Whiskers characterisation

TEM characterisation of Bagasse Whiskers







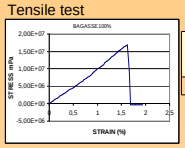
Source	L	D	L/D	Percolation Rate
Cotton	170.0	15.0	11.3	7.0%
Bagasse	96.7 +/- 49.8	7.5 +/- 2.3	12.8	5.0%
Palm tree	260.0	6.0	43.0	1.6%

Values was measured with image J

TEM and cross-polarized observations prove presence of **nanoscale whiskers** with classic L/D.

Film 100% bagasse whiskers

Tensile test



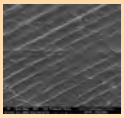
	Young's modulus (MPa)	Elongation at break (%)	Strenght at break (MPa)
BAGASSE	1498	1.8%	22

E_{cotton}=2013MPa; $E_{Palmtree}$= 7700MPa

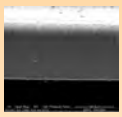
Obtention of 100% whiskers films with Bagasse with **similar Young's modulus** than other whiskers.

- Nanocomposites films

SEM analyses

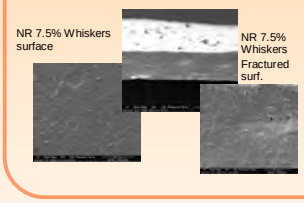


Natural rubber surface 200X



Natural rubber 100% (fractured surface) 150x

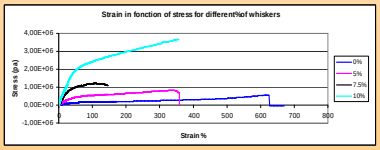
Homogeneous in mass with teflon mold marks on surface.

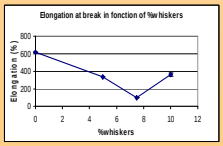


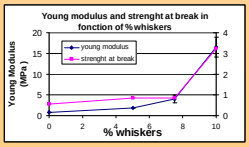
No important impact of whiskers on homogeneity.

Results and discussion

- Nanocomposites tensile test







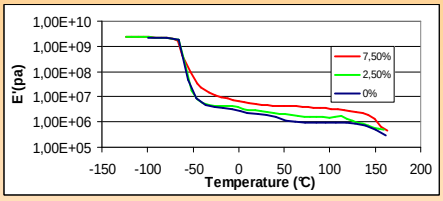
Concentration whiskers (w/w)	0%	5%	7,5%	10,00%
Young's modulus Mpa	0.77 +/- 0.12*	1.9 +/- 0.3*	4.00 +/- 1,84	16.60 +/- 4.81
Elongation at break %	622 +/- 110*	338 +/- 40*	102 +/- 3	365 +/- 40
Strenght at break Mpa	0.57 +/- 0.1*	0.84 +/- 0.30*	0.84 +/- 0.32	3.24 +/- 0.90

*: estimated standard deviation

- Addition of bagasse whiskers **increases Young's Modulus** but **decreases elongation.**

- Stiffer material has been obtained.

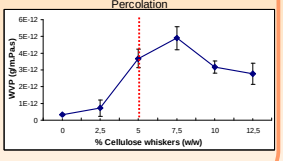
- DMA analysis



Rubbery plateau increases with % whiskers .

- WVP Measurements

Permeability to water vapour increases till **percolation** threshold



Conclusion & Perspectives

-This study allows to work on new agricultural residue for obtaining bio-nanoparticules. Their dimension are in the range of other whiskers

- Strong reinforcement with only 5% of whiskers has been proved by tensile test and DMA. Young's modulus is strongly increased with 10% whiskers (x20)

- Addition of whiskers in Natural Rubber increase water vapour permeability till a maximum at the percolation threshold (5%) by creating preferential pathways and capillarity diffusion

- Perspective would be to work with another source (rice straw), with a pre-treatement on whiskers, another matrice(gelatin) and other properties(biodegradability)

Acknowledgements:

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References

[1] Favier, V.; Chanzy, H.; Cavaille, J. Y., Macromolecules 1995, 28, 6365-6367.
[2] Samir, M. A. S. A.; Alloin, F.; Dufresne, A., *Biomacromolecules* **2005,** *6*, 612-626.
[3] Siloxy .com bagasse photo