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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

LEPAMAP
Laboratori d'Enginyeria Paperera i Materials Polímers

Alternative Techniques for Improving Tensile Strength of Packaging Papers

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Introduction

- In papermaking, recycling is viewed as a central part of its activities.
- The proportion of recovered fibers used worldwide during the paper manufacturing has reached about 54%, and in some papergrades, such as containerboard and newsprint paper, the rate of recycled fibers is even higher.
- The environmental awareness of society together with petroleum depletion has resulted in an intensive use of paper for packaging during last years.

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Introduction

- In this sense, the use of recycled fibers has been a great opportunity to reduce the consumption of virgin fibers.

- However, the recycling process causes a deterioration of fibers leading to a decrease in the final mechanical properties of paper. Typically, this loss has been solved by applying mechanical beating of fibers or by the addition of high quality recycled fibers.

- However, despite the gain in mechanical properties, the mechanical beating has also negative effects (Hubbe et al., 2007). The deterioration of fibers and the increase of fines fraction involve in turn a reduction on pulp suspension dewatering.

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Introduction

- Therefore, the search of new fiber treatments to reduce or replace mechanical beating has been one of the main objectives of last years.

- One of the most important methodologies (in number of publications and patents) has been the incorporation of cellulose nanofibers (CNF) on the pulp suspension.

- Another option to be considered is the use of enzymes as biobeating treatment.

- Other authors demonstrated the effect of sodium carboxymethylated cellulose (CMC) on the mechanical properties of recycled paper.

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Objective

The main objectives of this work are:

- The present work pretends to reduce the use of mechanical treatment in the production of recycled papers by applying different strategies.
- For this reason, recycled cardboard boxes were subjected to two different sequences.
- On one hand, repulped cardboards were refined in a bio-beating system and CNF was added in the recycled slurry.
- On the other hand, CNF was initially added to recycled slurry followed by CMC addition. The effect of a drainage agent added at the treated pulp and a final was taken into account.

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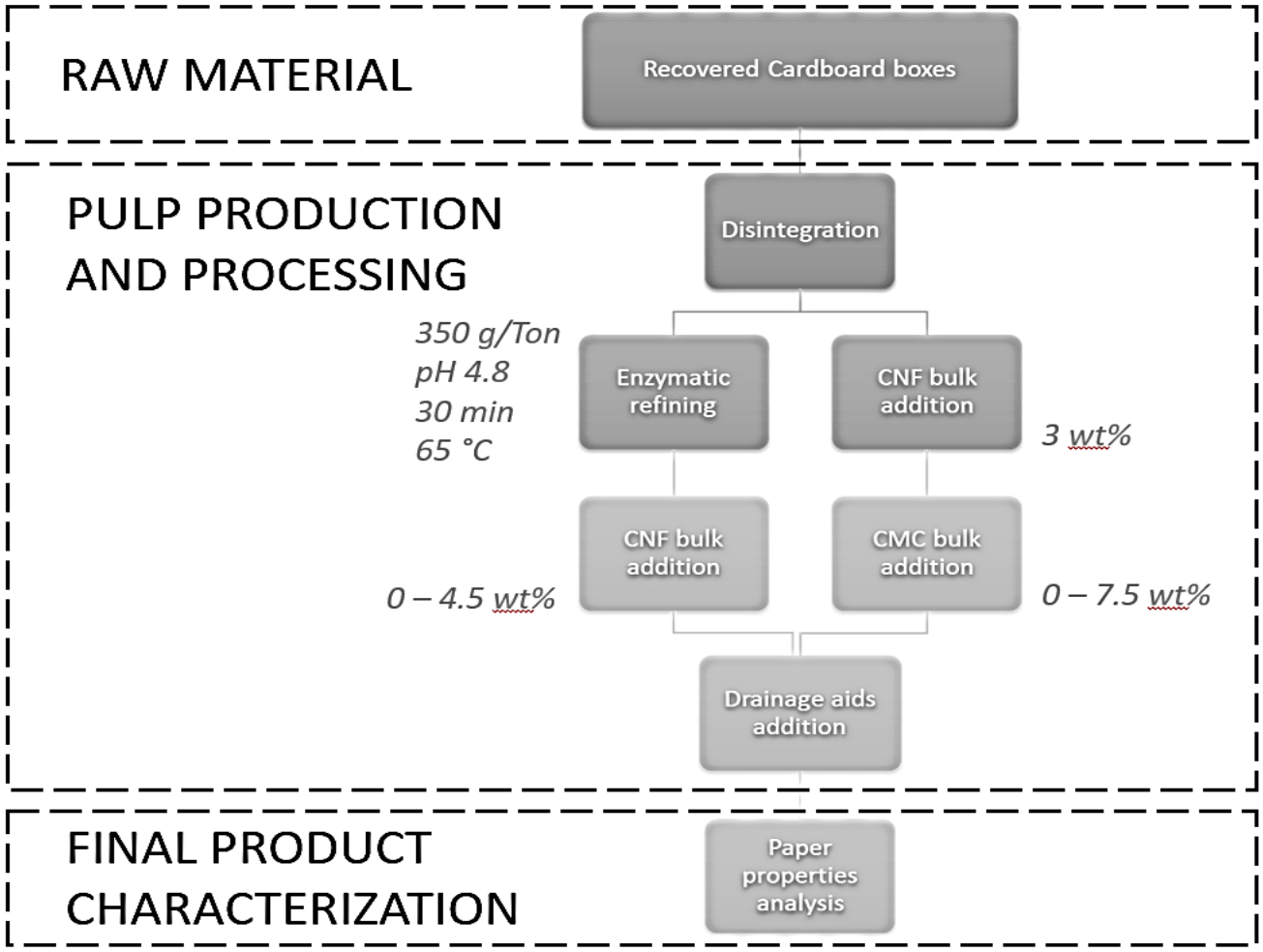
Methodology



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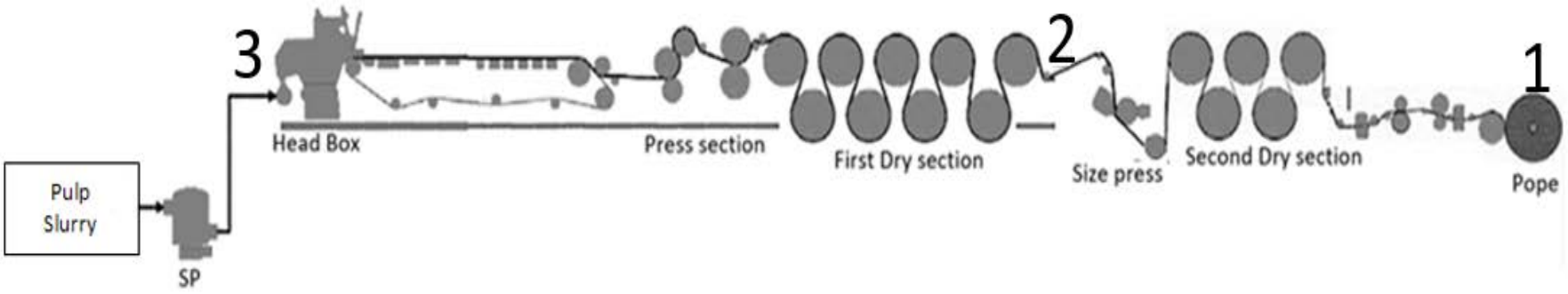
Methodology

- Mechanical properties of commercial Test Liner were evaluated for the purpose of setting the actual market requirement (Samples from step 1).



- Samples from step 2 correspond to paper before the size press, while samples from step 3 are representative of the former pulp suspension..

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Results and discussion

- Study of initial properties of commercial test liner:

	G (g/m^2)	BL_{MD} (m)	BL_{CD} (m)	E_{MD} (GPa)	E_{CD} (GPa)	IB (J/m^2)	AP (s)
Commercial test-liner	120	5534 ± 54	2457 ± 81	4.7 ± 0.1	1.8 ± 0.1	245 ± 12	25.7 ± 3
Uncoated paper	116	4943 ± 42	2194 ± 65	4.1 ± 0.2	1.6 ± 0.1	223 ± 18	21.2 ± 2
Isotropic papers	120	3401 ± 29		2.2 ± 0.3		202 ± 13	20.1 ± 1

G: basis weight; MD: machine direction; CD: cross direction

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12%

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Results and discussion

- Evolution of mechanical properties front mechanical refining

R. Intensity (REV)	°SR	BL (m)	E (GPa)	IB (J/m²)	AP (s)	l_w^f* (µm)	Fines** (%)
0	44 ± 1	3064 ± 41	4.3 ± 0.1	165 ± 15	14 ± 1	755 ± 21	45.9 ± 0.4
500	47 ± 0	3438 ± 51	4.7 ± 0.1	208 ± 18	26 ± 3	711 ± 31	52.0 ± 0.6
1000	53 ± 1	3877 ± 39	5.0 ± 0.2	311 ± 26	34 ± 1	672 ± 22	55.8 ± 0.2
1500	61 ± 1	4356 ± 48	5.8 ± 0.1	397 ± 37	71 ± 4	603 ± 30	58.2 ± 0.3

** Mean fiber length weighted in length; **Percentage of fines, in length*

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Results and discussion

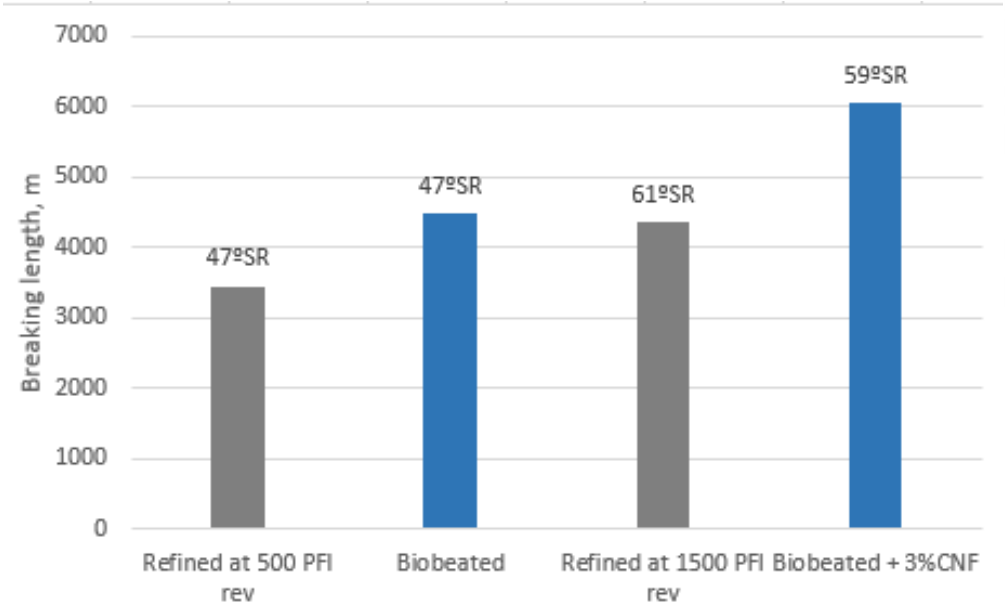
- First strategy to improve mechanical properties

	CNF (%)	°SR	BL (m)	E (GPa)	IB (J/m²)	AP (s)	l_w^f* (µm)	Fines** (%)
Untr	0	44 ± 1	3064 ± 41	4.3 ± 0.1	165 ± 15	14 ± 1	755 ± 21	45.9 ± 0.4
Enz.Tr	0	47 ± 1	4473 ± 55	5.8 ± 0.1	372 ± 21	62 ± 3	752 ± 33	46.2 ± 0.2
	1.5	52 ± 1	5123 ± 37	5.8 ± 0.1	425 ± 33	98 ± 2	751 ± 24	46.1 ± 0.2
	3.0	59 ± 1	6038 ± 61	5.8 ± 0.1	467 ± 24	124 ± 2	751 ± 22	46.4 ± 0.3
	4.5	64 ± 1	6689 ± 60	5.9 ± 0.2	502 ± 18	177 ± 4	748 ± 19	46.7 ± 0.4

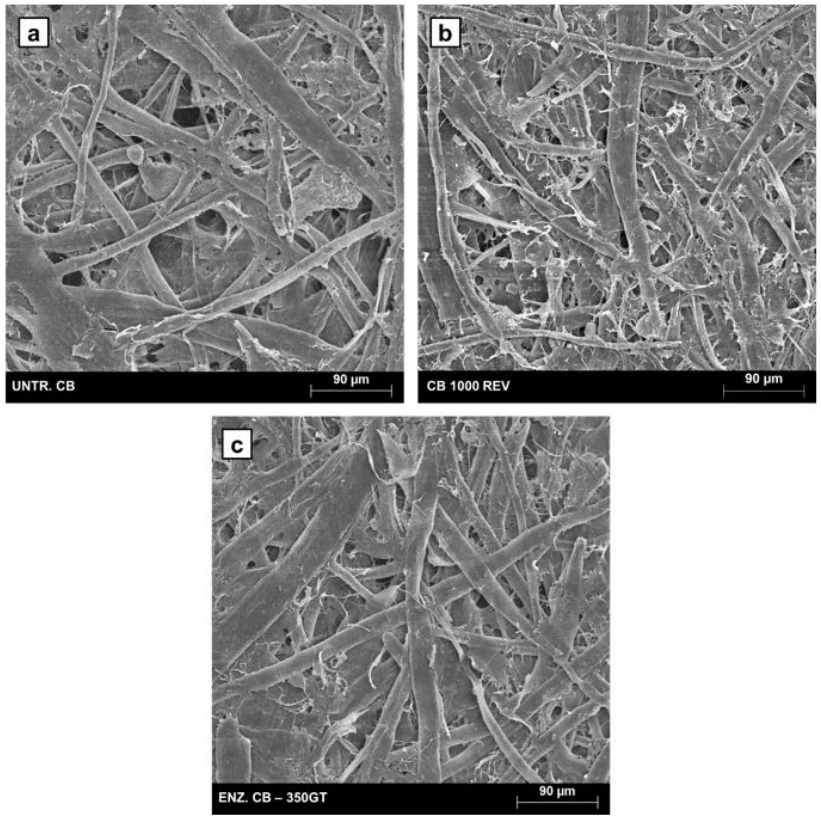
** Mean fiber length weighted in length; **Percentage of fines, in length*

Results and discussion

- Different mechanical properties at the same drainage degree



- Morphologic damage of fibers?



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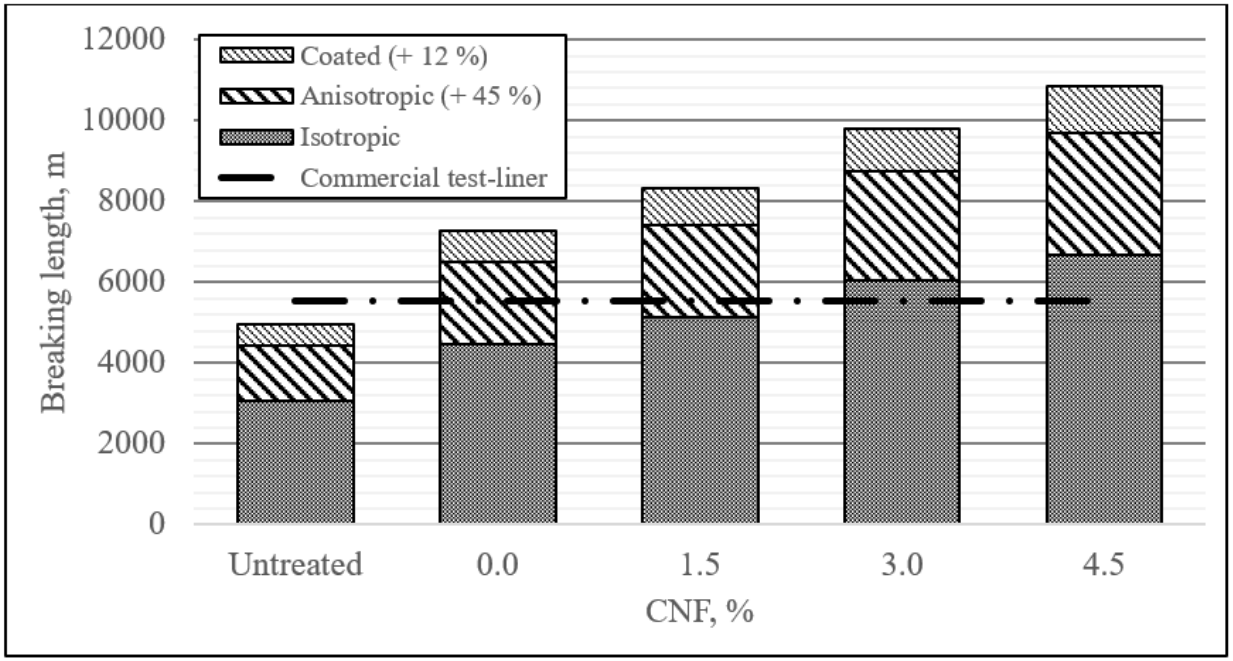
Results and discussion

- Evolution of mechanical properties on the paper machine



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Results and discussion

- Second strategy to improve mechanical properties

	CMC (%)	°SR	BL (m)	E (GPa)	IB (J/m²)	AP (s)	l_w^f* (µm)	Fines** (%)
Untr	0	44 ± 1	3064 ± 41	4.3 ± 0.1	165 ± 15	14 ± 1	755 ± 21	45.9 ± 0.4
3%CNF	0	57±1	4281±43	248±20	59±6	4.3±0.1	754±24	46.3±0.4
	2.5	63±0.5	5107±61	297±24	84±7	4.6±0.2	752±32	46.5±0.8
	5.0	67±0.5	5805±39	329±19	102±4	4.6±0.1	753±26	46.7±0.3
	7.5	71±1	6124±57	347±17	121±5	4.7±0.1	751±24	46.4±0.5

** Mean fiber length weighted in length; **Percentage of fines, in length*

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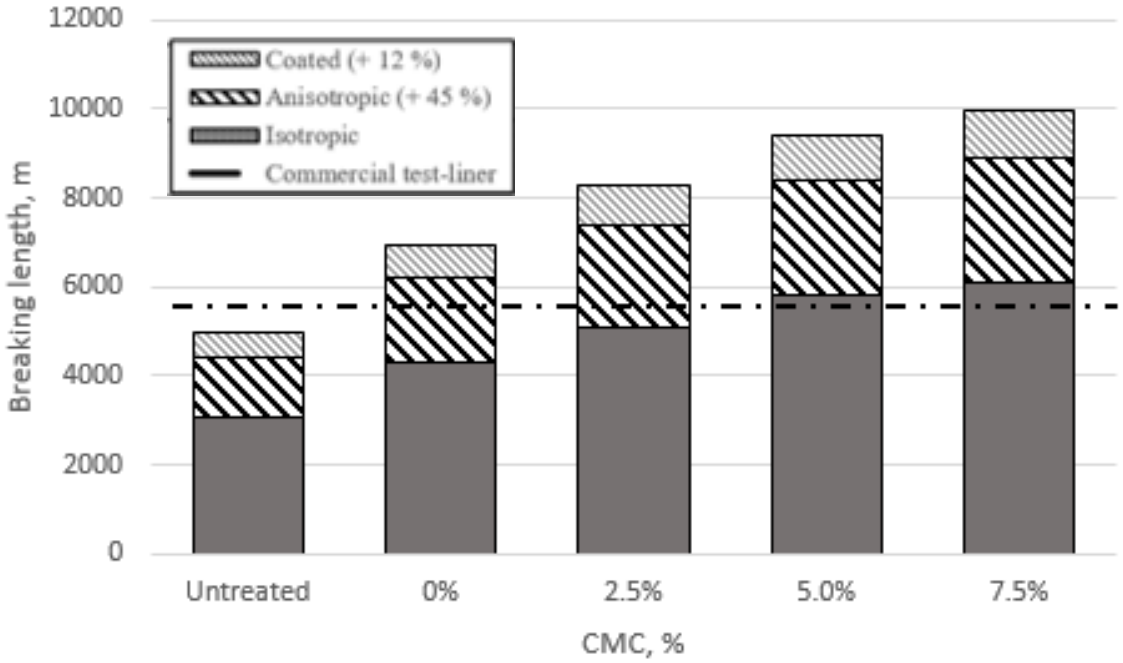
Results and discussion

- Evolution of mechanical properties on the paper machine



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Results and discussion

- How we can solve the problem of drainabitily capacity?

Polyethylen-imine amount (%)	3%CNF + 5%CMC			3%CNF + 7.5%CMC		
	Breaking length (m)	°SR	Breaking length reduction (%)	Breaking length (m)	°SR	Breaking length reduction (%)
0,0	5805±34	67±0.5	-	6124±26	71±0.5	-
0,1	5612±56	62±1.0	3,40	5978±37	65±0.5	2,38
0,2	5483±27	59±0.5	6,00	5769±41	62±1.0	5,80
0,3	5376±33	58±0.5	7,98	5622±28	60±0.5	8,20
0,4	5286±42	58±0.5	9,80	5504±36	58±0.5	10,13

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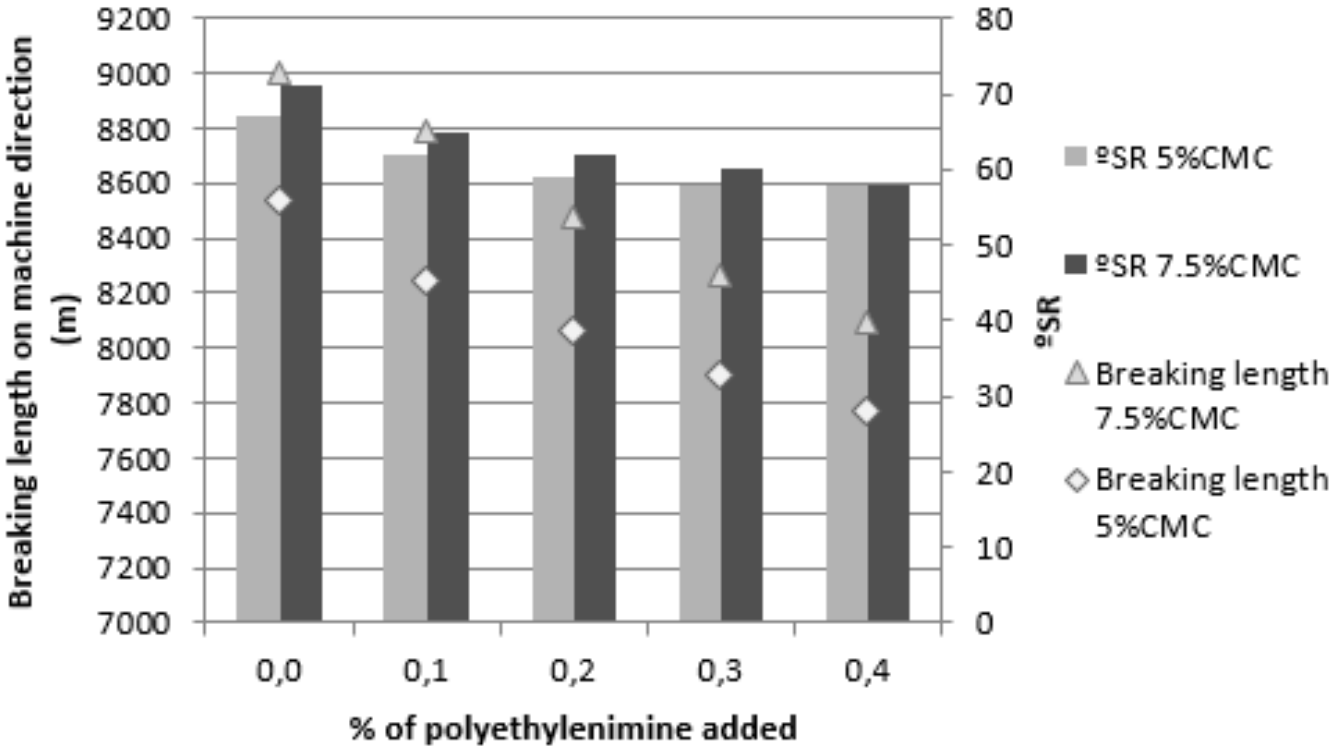
Results and discussion

- Evolution of mechanical properties and ºSR with drainage agent



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Conclusions

The main conclusions of this work are:

- The use of this bioprocess causes an increase of breaking length to 46% with only a 2.5 Schopper degree increase. Through biobeating process can be surpassed commercial test liner properties without mechanical refining.

- Was also confirmed the compatibility of biobeating process with enzymatic CNF addition.

- In addition, was also noted that CMC addition was compatible with enzymatic CNF addition. However, the addition of CNF and CMC cause the reduction of drainability of slurries.

- In this sense, the addition of drainage agent (polyethylenimine) was shown as an interesting option at slight amounts due to decrease of mechanical properties that produce.

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Conclusions

- If we compare the two technological sequences to improve mechanical properties of carbox recycled used on this work becomes clear that the use of biobeating process with 3% of enzymatic CNF is technically better than the other sequence.

- IThe implementation of this process can contribute to increase the life span of fibers, reduce the use of virgin fibers by reducing the basis weight or by introducing higher amounts of mineral fillers.

- It is obvious that these measures permit certain modulation, function of market requirements and runnability of slurry.

- Nevertheless, it's possible the study and application of other sequences as could be biobeating with CMC addition or biobeating with CNF and CMC addition.

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Thanks for your attention