

Preliminary results of the application of carboxymethylated cellulose as a reinforcing agent in papermaking

H. Oliver-Ortega, Q. Tarrés, M.A. Pèlach, M. Alcalà, M. Delgado-Aguilar and P. Mutjé

Outline

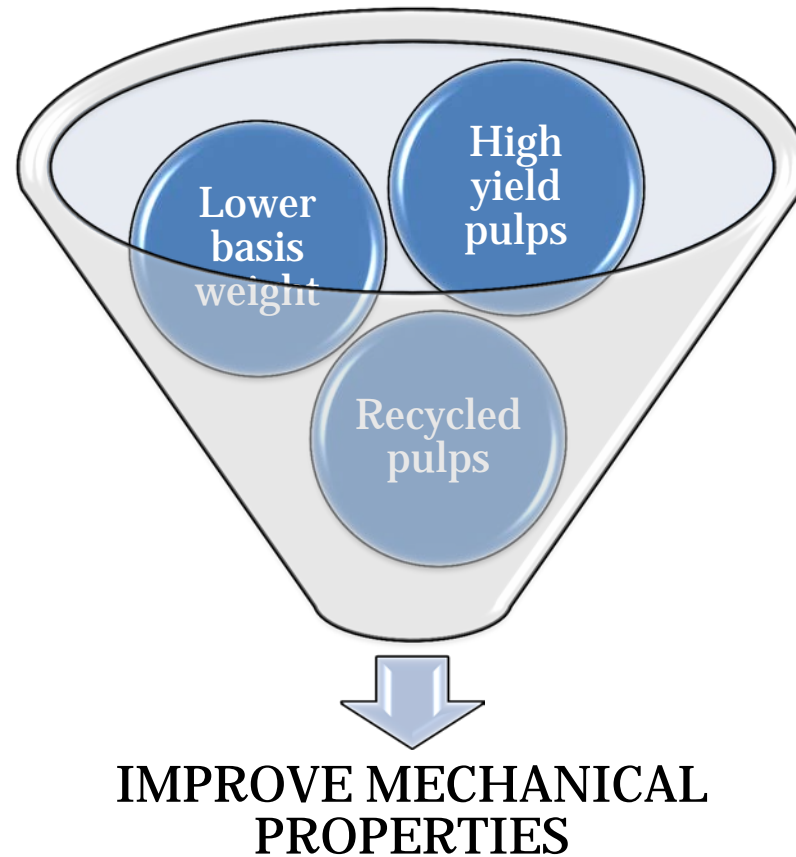
- i. The need of improving mechanical properties of paper
- ii. CMC as a dry strength agent
 - i. CMC in BKHP
 - ii. CMC in Recycled Fibres
- iii. Conclusions

The need of improving mechanical properties of paper

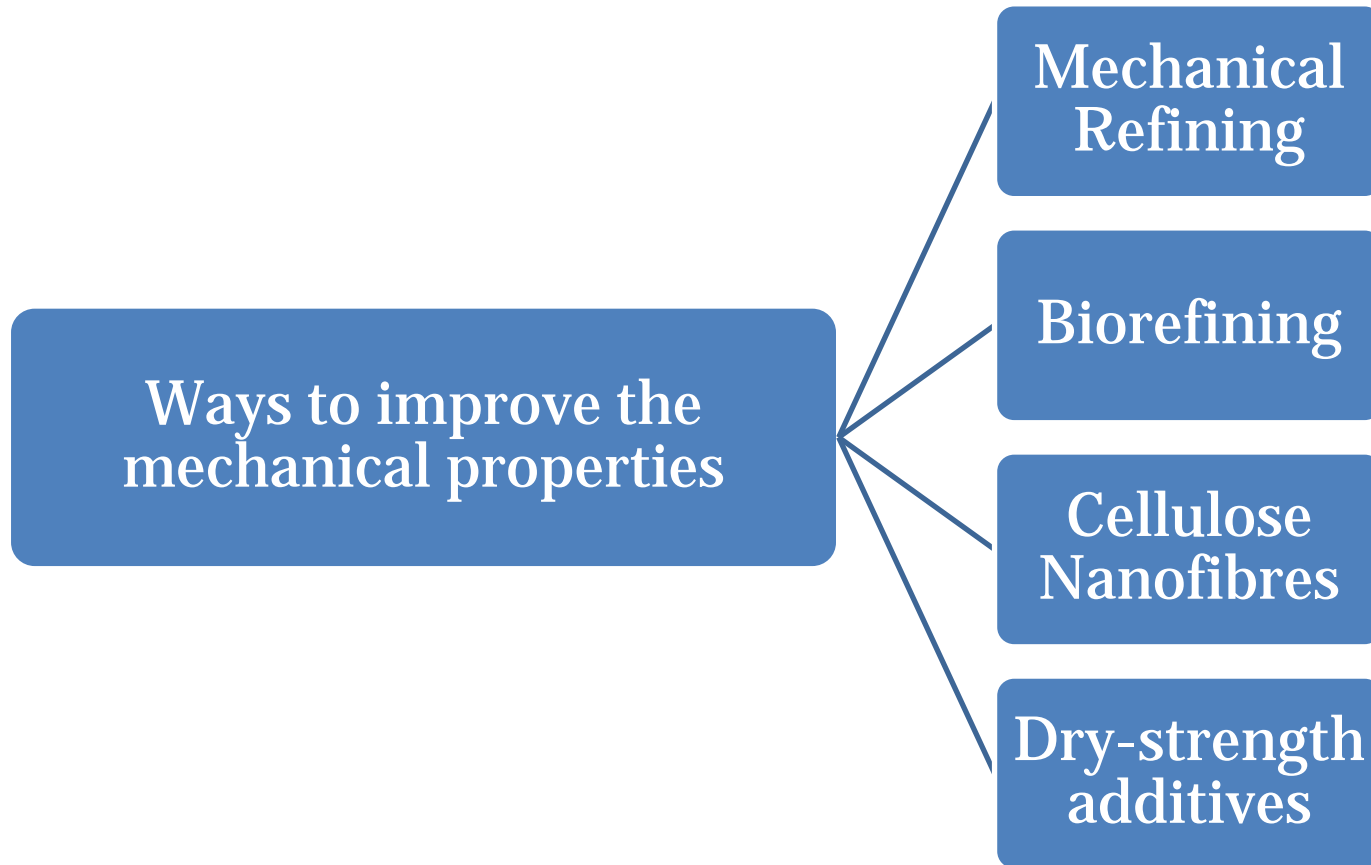
Paper production requires large amounts of cellulosic fiber, whereas the world's forested lands and croplands have a finite capacity to supply such resources [...]. The industry can be expected to view recycling as a central part of its activities. Basis weights of various paper-based products can be expected to decrease over the coming decades, and more of the fiber content will be replaced with fillers such as calcium carbonate. Such trends will place intense demands upon chemical-based strategies to enhance bonding [...] reducing the amount of new forest resources.

M. A. Hubbe, 2014

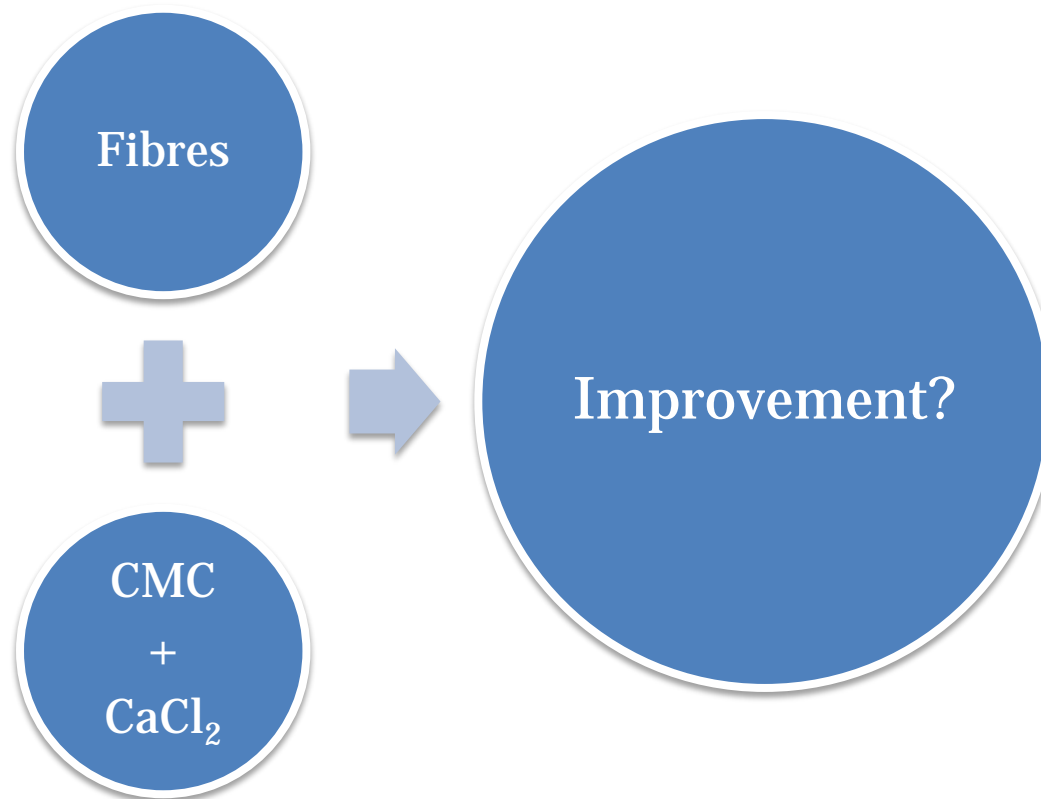
The need of improving mechanical properties of paper



The need of improving mechanical properties of paper

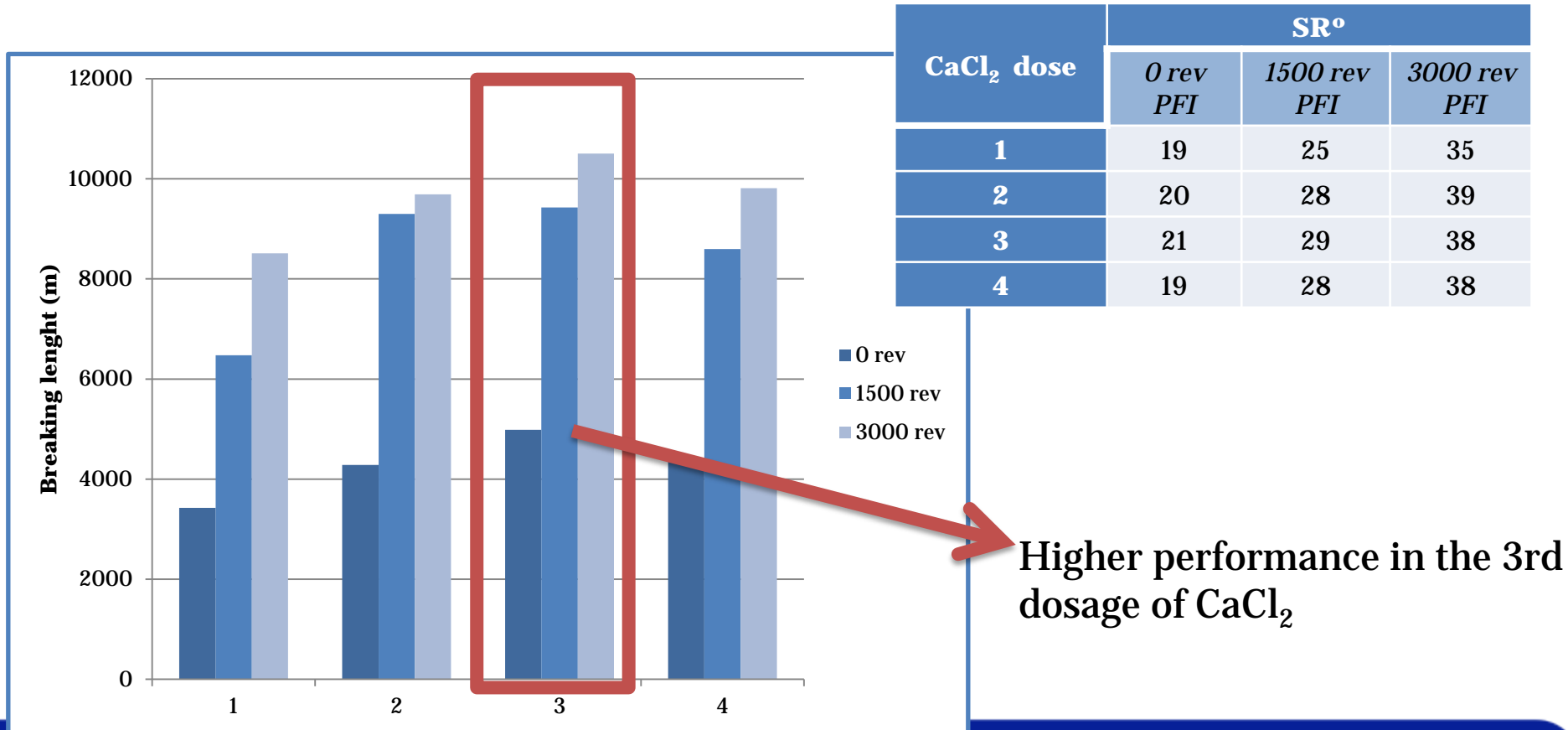


CMC



CMC in BKHP

Effect of the CaCl_2 in 4% CMC reinforced virgin fibres

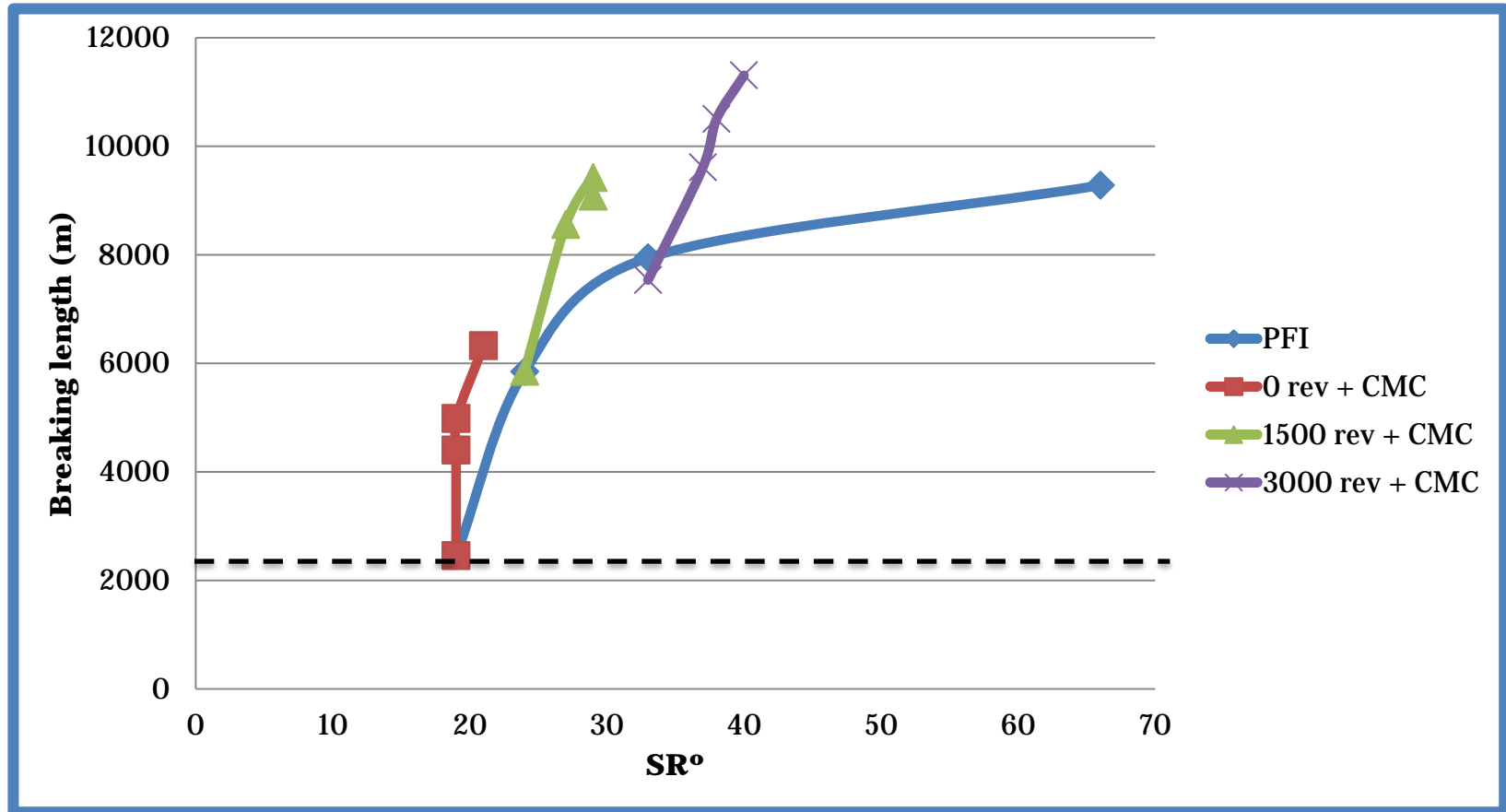


CMC in BKHP

3rd dosage of CaCl₂ applied in different % CMC

Mechanical Refining	Breaking length (m)				SR°			
	<i>Initial</i>	<i>2% CMC</i>	<i>4% CMC</i>	<i>6% CMC</i>	<i>Initial</i>	<i>2% CMC</i>	<i>4% CMC</i>	<i>6% CMC</i>
0 rev PFI	2456	4400	4983	6327	19	19	19	21
1500 rev PFI	5854	8562	9426	9083	24	27	29	29
3000 rev PFI	7538	9621	10505	11309	33	37	38	40

CMC in BKHP



CMC in BKHP

We improve the tensile properties without a significant impact in the drainage properties...how it affect the other physical properties?

Sample	Density (g/cm ³)	Bulk (cm ³ /g)	Void volume (%)	Air permeability (s/100cm ³)
<i>0 rev PFI</i>	0,560	1,79	62,66	1,58
<i>0 rev PFI + 4% CMC</i>	0,605	1,65	59,66	1,765
<i>1500 rev PFI</i>	0,630	1,59	58,02	3,16
<i>1500 rev PFI + 4%CMC</i>	0,710	1,41	52,65	6,36
<i>3000 rev PFI</i>	0,703	1,42	53,16	14,47
<i>3000 rev PFI + 4CMC%</i>	0,714	1,40	52,38	20,285

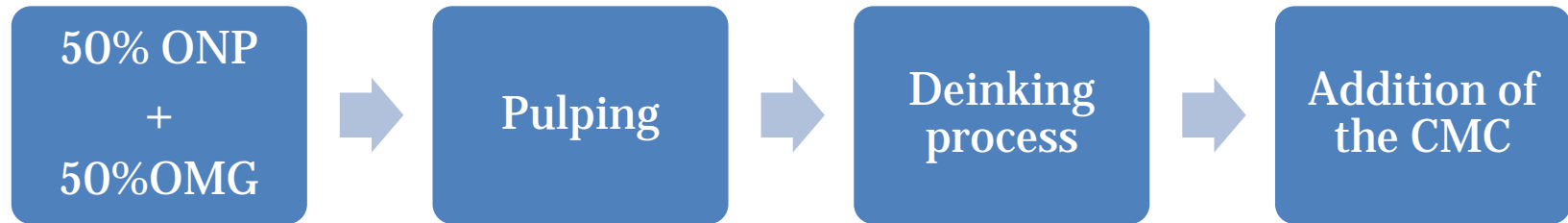
CMC in BKHP

And the other mechanical properties?

Sample	Tensile Strength		Internal bonding (J/m ²)	Burst index (J/m ²)	SR°
	Breaking length (m)	Tensile index (N·m/g)			
<i>0 rev PFI</i>	2456	24,08	77,07	43,65	19
<i>0 rev PFI + 4% CMC</i>	4983	48,85	195,33	136,84	21
<i>1500 rev PFI</i>	5850	57,35	420,27	237,51	24
<i>1500 rev PFI + 4% CMC</i>	9426	92,41	>1000	535,61	29
<i>3000 rev PFI</i>	7946	77,90	741,96	369,75	33
<i>3000 rev PFI + 4 %CMC</i>	10505	102,99	>1000	613,95	38

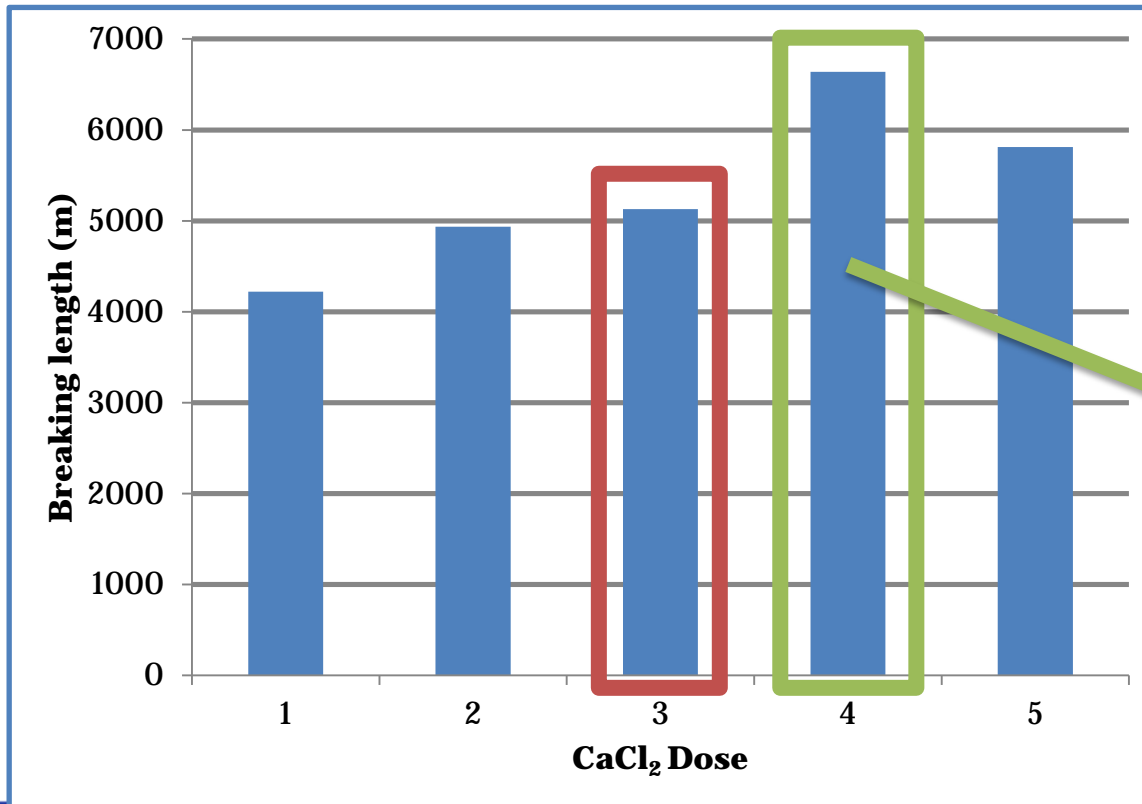
CMC in Recycled Fibres

CMC can be used as dry strength agent in BKHP fibres...what happens with recycled fibres?



CMC in Recycled Fibres

4% CMC and 5 different dosages of CaCl_2



CaCl ₂ Dose	SR°
1	58
2	62
3	60
4	63
5	63

Higher CaCl_2
dosage than in
BKHP

CMC in Recycled Fibres

Using the 4th dosage of CaCl_2

Sample	Density (g/cm ³)	Bulk (cm ³ /g)	Void volume (%)	Air Permeability (s/100cm ³)
Recycled	0,586	1,71	60,96	19,43
Recycled + 2%	0,596	1,68	60,27	32,19
Recycled+ 4%	0,633	1,58	57,82	39,10
Recycled+ 6%	0,620	1,61	58,68	47,46

CMC in Recycled Fibres

Sample	Tensile Strength		Internal bonding (J/m ²)	Burst index (J/m ²)	SR°
	Breaking length (m)	Tensile index (N·m/g)			
Recycled	3258	31,94	163,22	109,44	54
Recycled+ 2%	5303	51,99	232,69	155,86	56
Recycled+ 4%	6640	65,10	315,28	176,59	63
Recycled+ 6%	6112	59,92	365,91	176,33	63

CMC in Recycled Fibres

Sample ¹	Tensile Strength		SR ^o
	Breaking length (m)	Tensile Index (N·m/g)	
0% CNF	3326	32,63	64
1,5% CNF	4650	45,62	73
3% CNF	5068	49,72	84
4,5% CNF	6054	59,36	87

Sample ²	Tensile Strength		SR ^o
	Breaking length (m)	Tensile Index (N·m/g)	
Initial	3326	32,61	64
Enzymatic + 0% CNF	4460	45,59	66
Enzymatic + 1,5% CNF	5015	49,69	77
Enzymatic + 3% CNF	5421	59,35	80

¹Delgado-Aguilar, M., González, I., Pèlach, M.A., De La Fuente, E., Negro, C., Mutjé, P., 2015. Improvement of deinked old newspaper/old magazine pulp suspensions by means of nanofibrillated cellulose addition. *Cellulose* 22, 789–802.

²Delgado-Aguilar, M., Tarrés, Q., Puig, J., Boufi, S., Blanco, A., and Mutjé, P., 2015. Enzymatic Refining and Cellulose Nanofiber Addition in Papermaking Processes from Recycled and Deinked. *BioResources* 4, 5730–5743

CONCLUSIONS

- CMC can be used as a dry strength agent in virgin fibres and in recycled fibres obtaining significant enhancements of the mechanical properties.
- Although the increases in the mechanical properties, the drainage and the physical properties of the papers are slightly affected.
- The calcium cation seems to have a significant impact in the reinforcing mechanism.
- The mechanical properties achieved with the CMC let us to consider this paper for applications with higher requirements or reduce the basis weight or increase the amount of mineral fillers....
- As a future work, it could be interesting to use white waters instead of tap waters.

**Thanks you for your kindly
attention!**

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