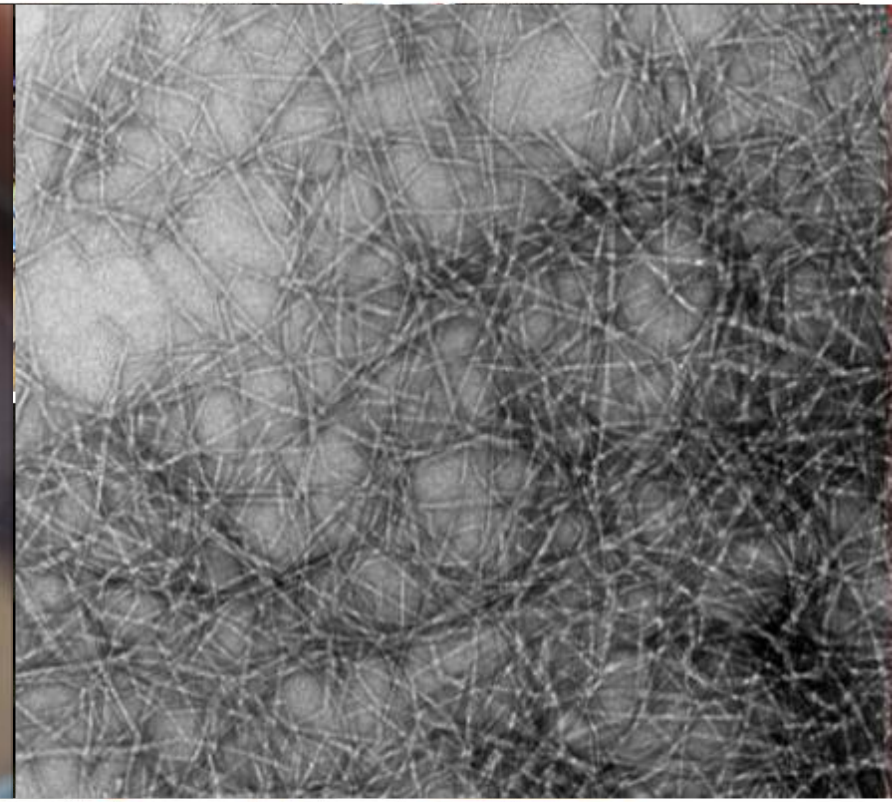
BILLERUDKORSNÄS



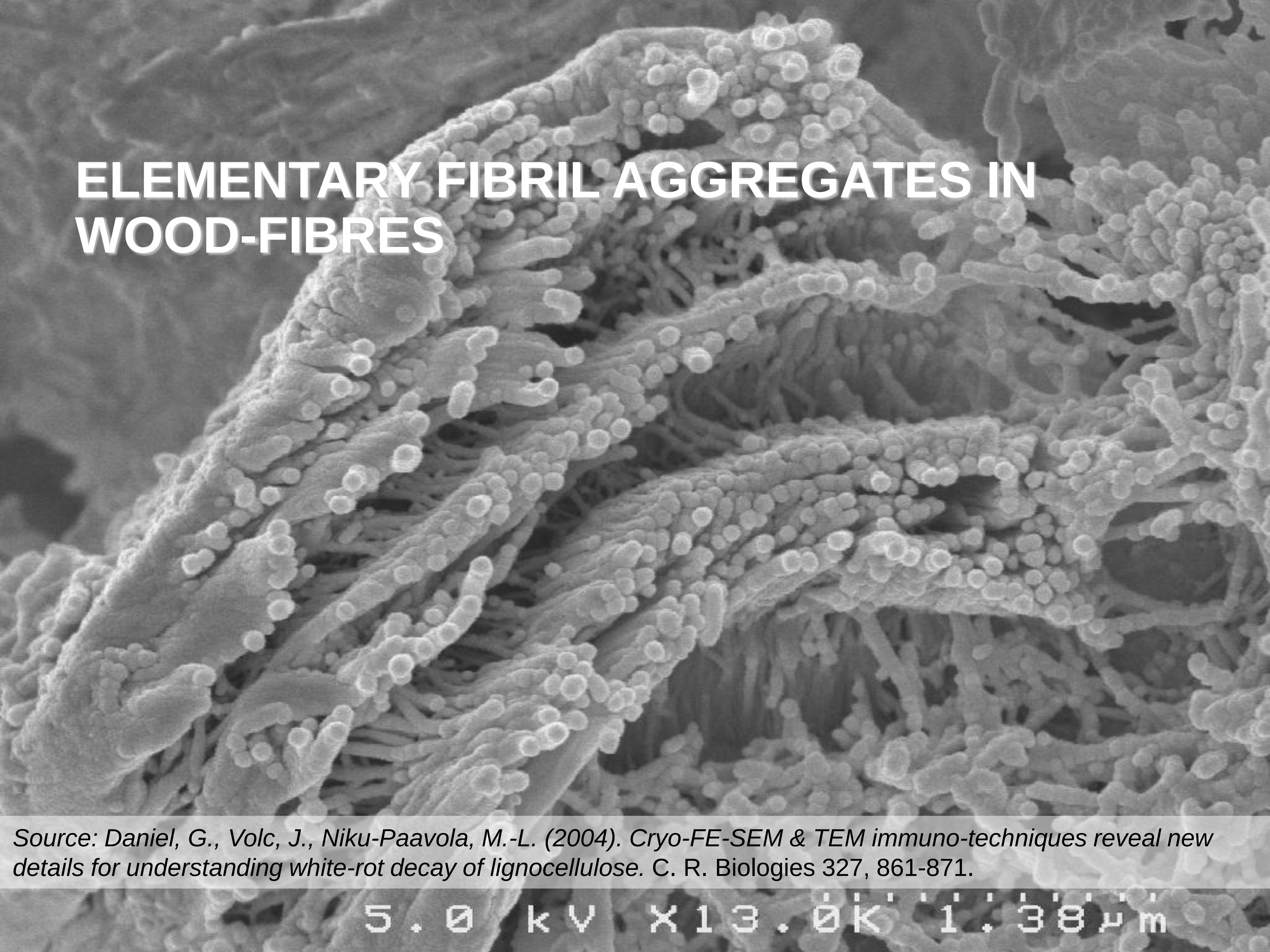
POSSIBLE APPLICATIONS FOR NANOCELLULOSE IN PACKAGING

2013-11-18 | Mikael Ankerfors

NOMENCLATURE

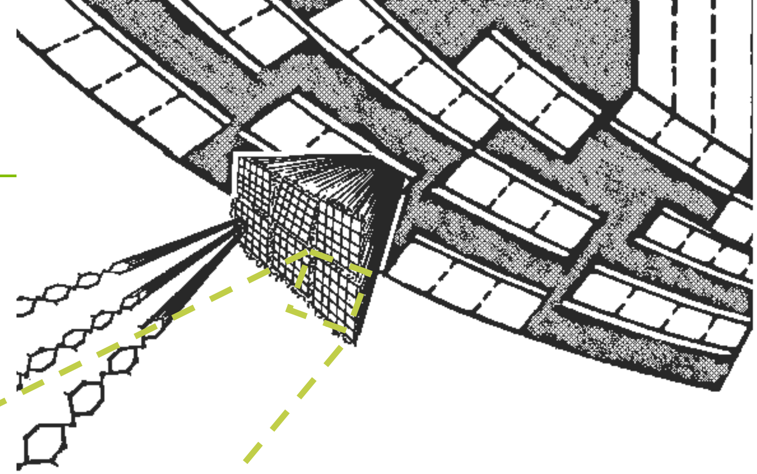
- Microfibrillated cellulose (MFC) - Original name since the 1980’s
- Nanocellulose = Collective name for all types of nanocellulose. Used for this material the last 7 years.
  - Other nanocelluloses are NanoCrystalline Cellulose (NCC) and Bacterial NanoCellulose (BNC)
- Nanofibrillated cellulose (NFC) = new name started to be used 5-6 years ago
- Cellulose nanofibrils (CNF) = has been around for over 15 years, but poorly used. This is however now the suggested standardized name for the material.
  - In the same standardization NCC is coild cellulose nanocrystals (CNC)

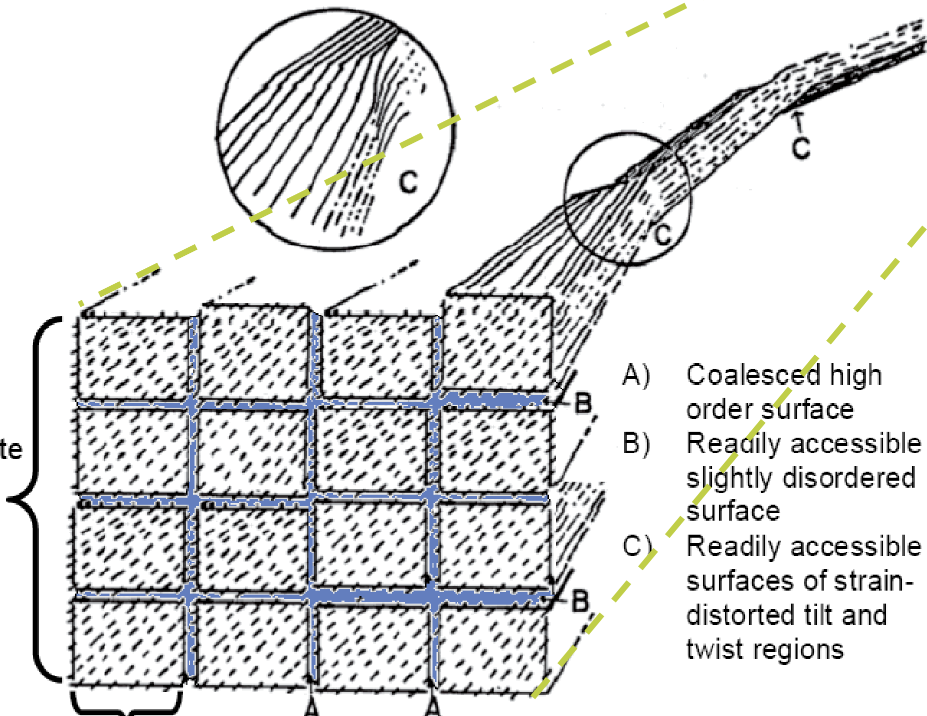
ELEMENTARY FIBRIL AGGREGATES IN WOOD-FIBRES



Source: Daniel, G., Volc, J., Niku-Paavola, M.-L. (2004). Cryo-FE-SEM & TEM immuno-techniques reveal new details for understanding white-rot decay of lignocellulose. C. R. Biologies 327, 861-871.

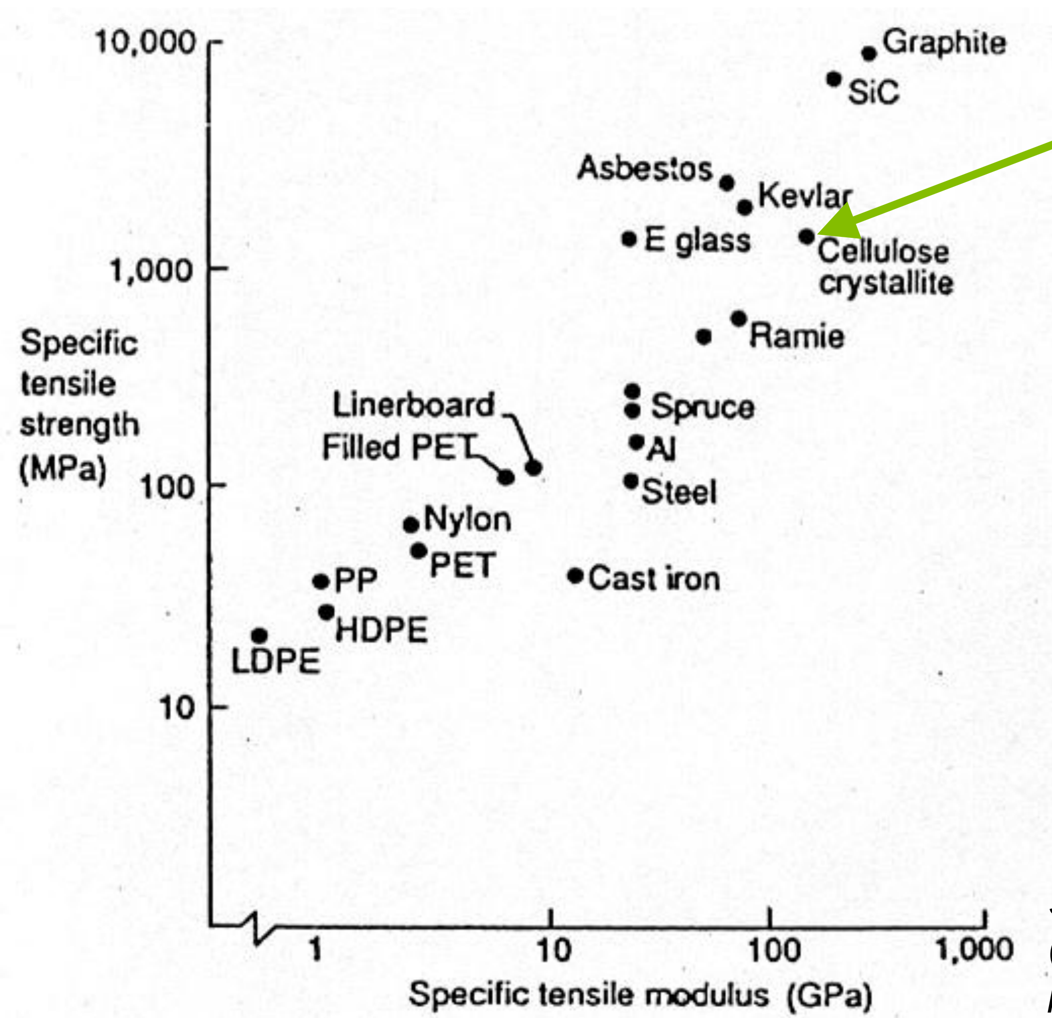
ORGANISATION OF CELLULOSE IN FIBRES





Adapted from: Rowland and Roberts 1972

WHY IS IT INTERESTING?



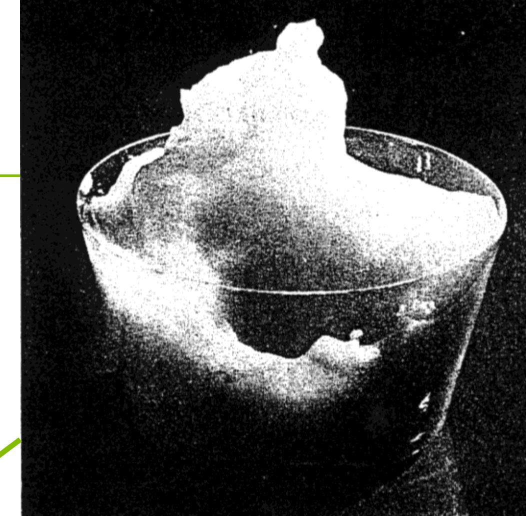
Cellulose crystallite

E≈140 GPa

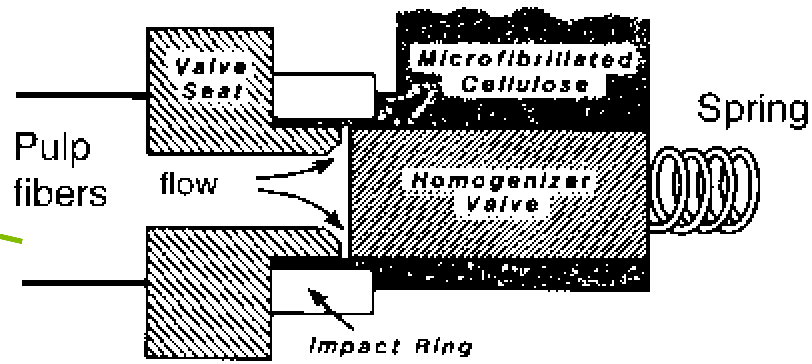
Source: Hongu, T and Phillips, G.O. (1997). New Fibres, Woodhead publishing

MFC IN THE 1980'S

Energy consumption = 30000 kWh/tonne



Pulp → Homogenisation → MFC



Source: Turbak, A.F., Snyder, F.W. and Sandberg, K.R. (1983). J. Appl. Pol. Sci.: Appl. Pol. Symp. 37: 815-827.

Source: Lindström, T. and Winter, L. (1988). Mikrofibrillär cellulosa som komponent vid papperstillverkning. STFI-meddelande C159 (internal STFI-report)

MAJOR PROBLEMS

- Extensive clogging
- High energy consumption (over 30000 kWh/tonne)

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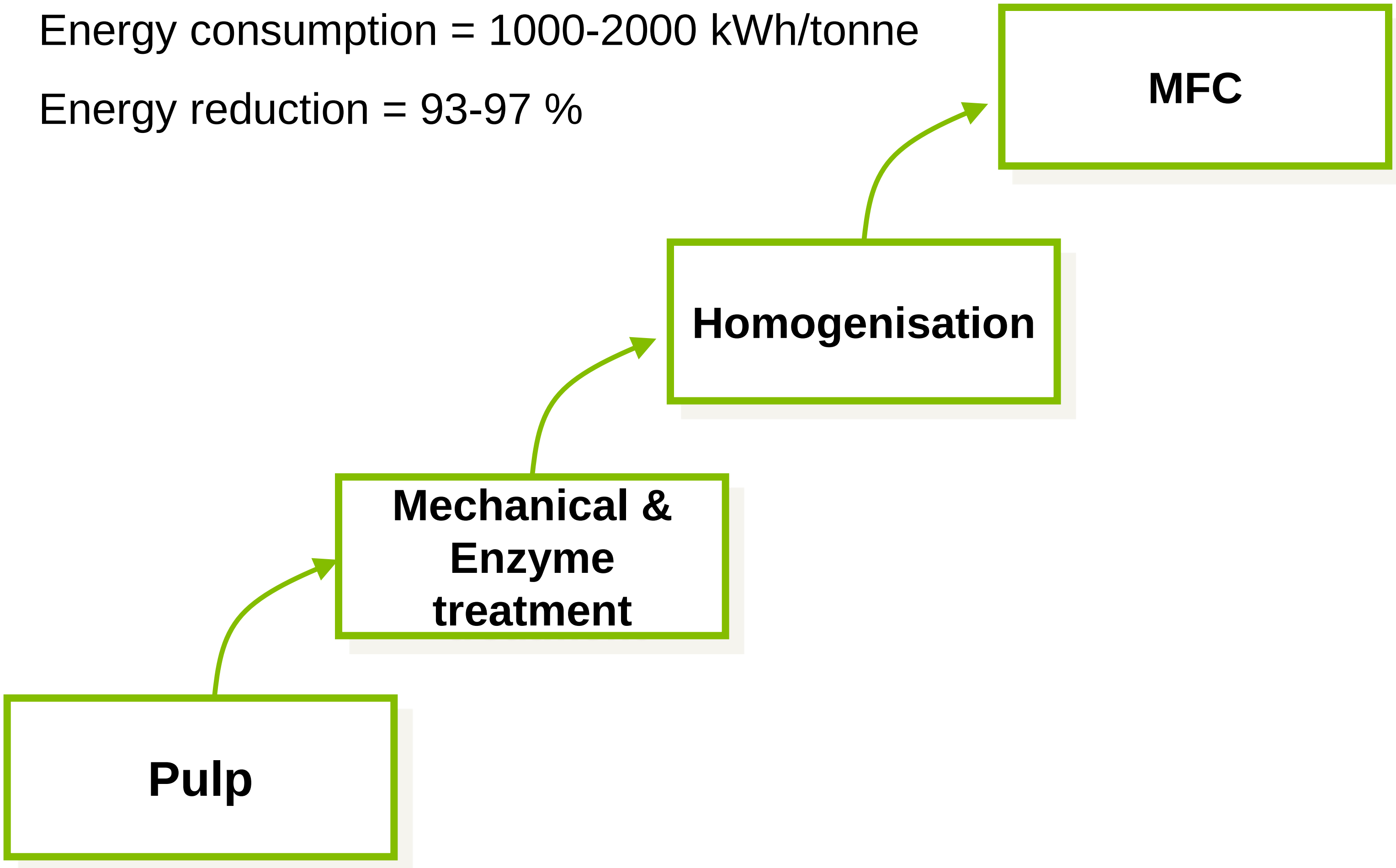
ENZYME-BASED PRE-TREATMENT

Energy consumption = 1000-2000 kWh/tonne

Energy reduction = 93-97 %



ENZYME-BASED MFC

MFC gel

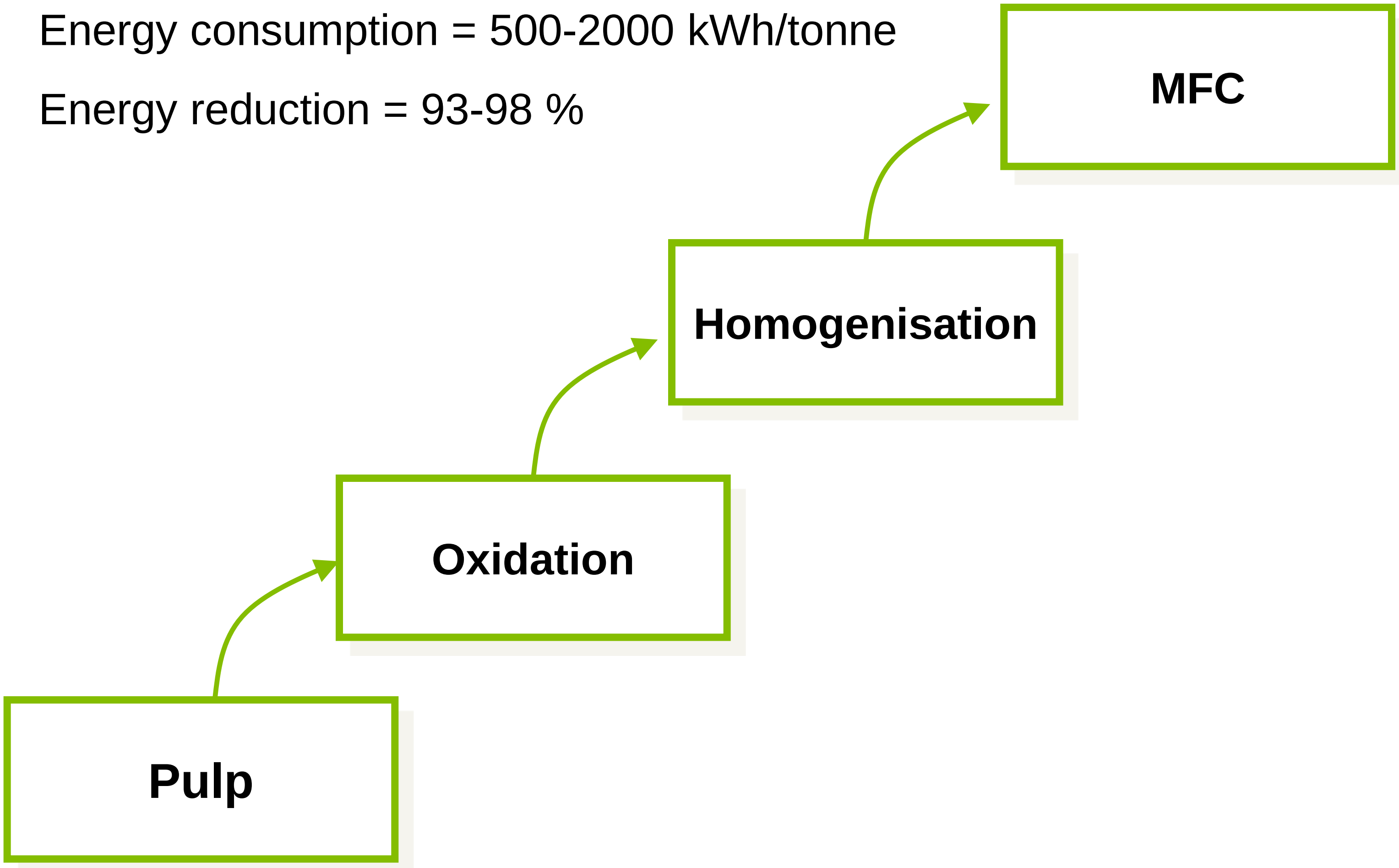
2 w-%

BILLERUDKORSNÄS

ANOTHER PRE-TREATMENT

Energy consumption = 500-2000 kWh/tonne

Energy reduction = 93-98 %




MFC gel
2 w-%

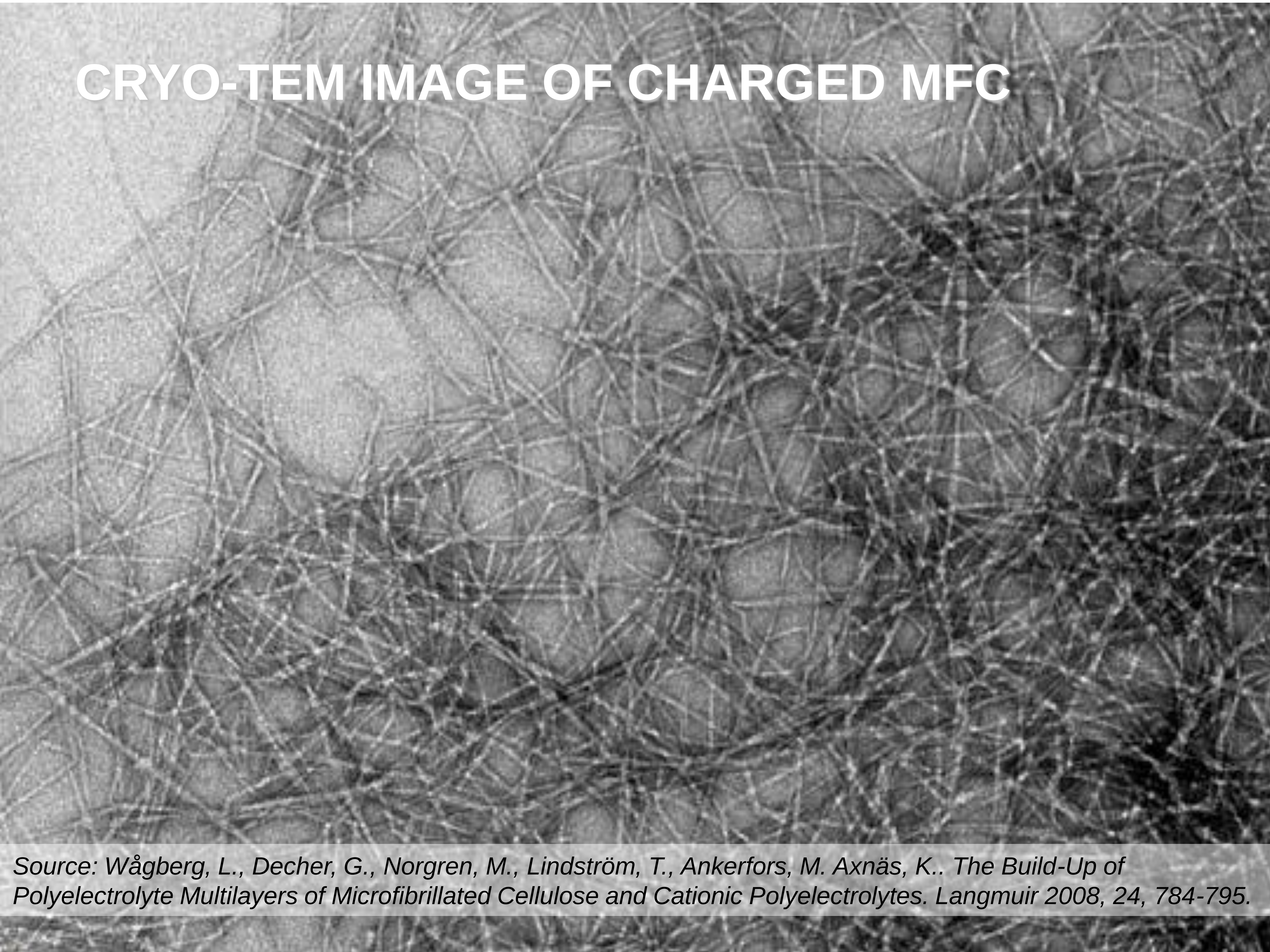

MFC gel
7 w-%

Pulp fibres

Enzyme MFC

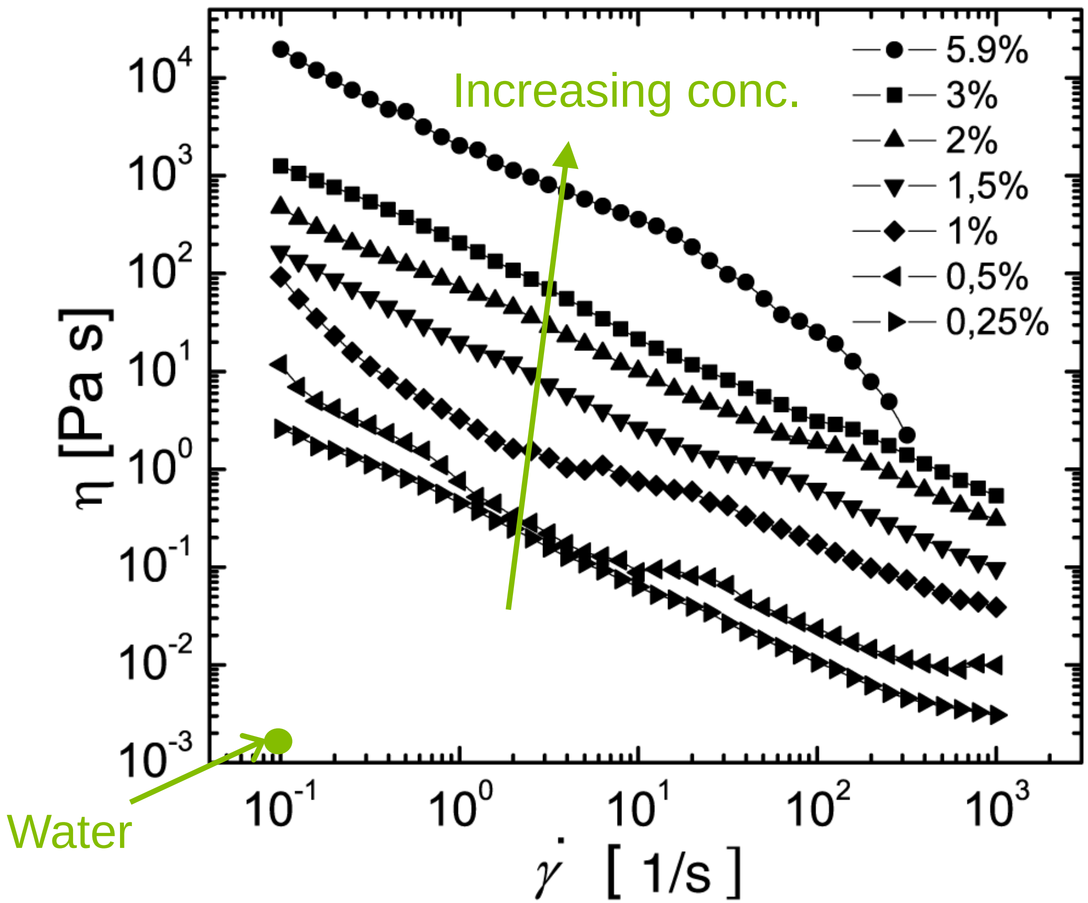
Source: Pääkkö, M., Ankerfors, M., Kosonen, H., Nykanen, A., Ahola, S., Österberg, M., Ruokolainen, J., Laine, J., Larsson, P. T., Ikkala, O. and Lindström, T. (2007): Biomacromolecules 8(6), 1934-1941.

CRYO-TEM IMAGE OF CHARGED MFC



Source: Wågberg, L., Decher, G., Norgren, M., Lindström, T., Ankerfors, M. Axnäs, K.. The Build-Up of Polyelectrolyte Multilayers of Microfibrillated Cellulose and Cationic Polyelectrolytes. Langmuir 2008, 24, 784-795.

SHEAR THINNING BEHAVIOUR OF MFC – EFFECT OF CONCENTRATION



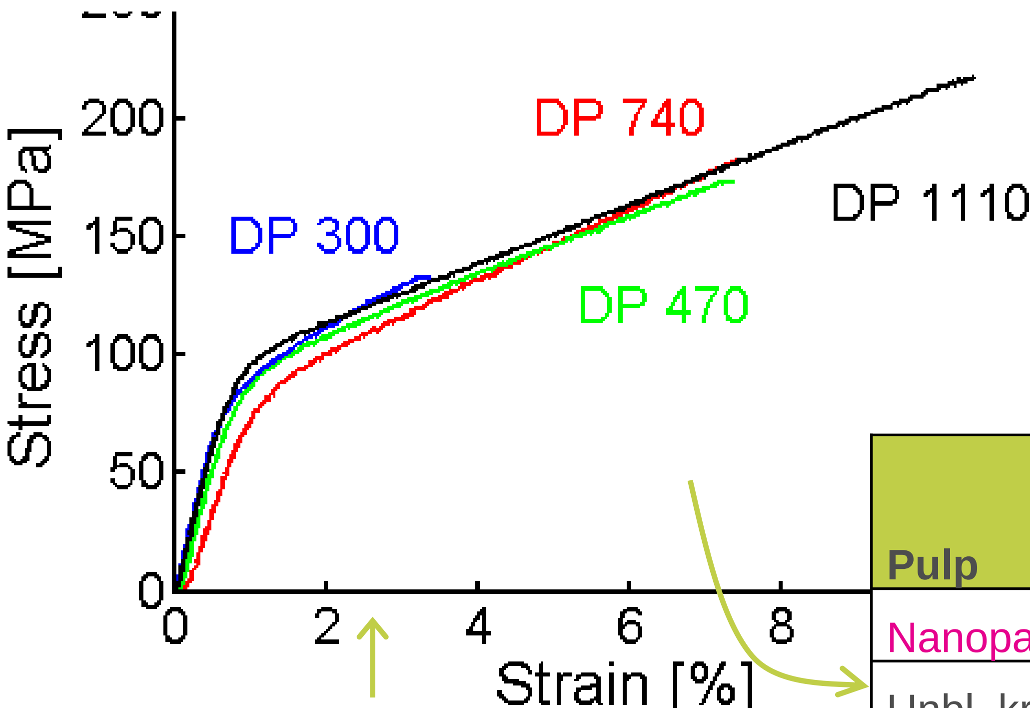
Source: Pääkkö, M., Ankerfors, M., Kosonen, H., Nykanen, A., Ahola, S., Österberg, M., Ruokolainen, J., Laine, J., Larsson, P. T., Ikkala, O. and Lindström, T. (2007): Biomacromolecules 8(6), 1934-1941.

FILM OF CHARGED MFC

Source: Siro, I., Plackett, D., Hedenqvist, M., Ankerfors, M., Lindström, T. Journal of Applied Polymer Science 117, 3601-3609 (2010).

Mikael Ankerfors, Innventia AB

STRESS-STRAIN CURVES FOR FILMS OF DIFFERENT MFCS



”Nanopaper”: Strongest cellulose-based material made by man

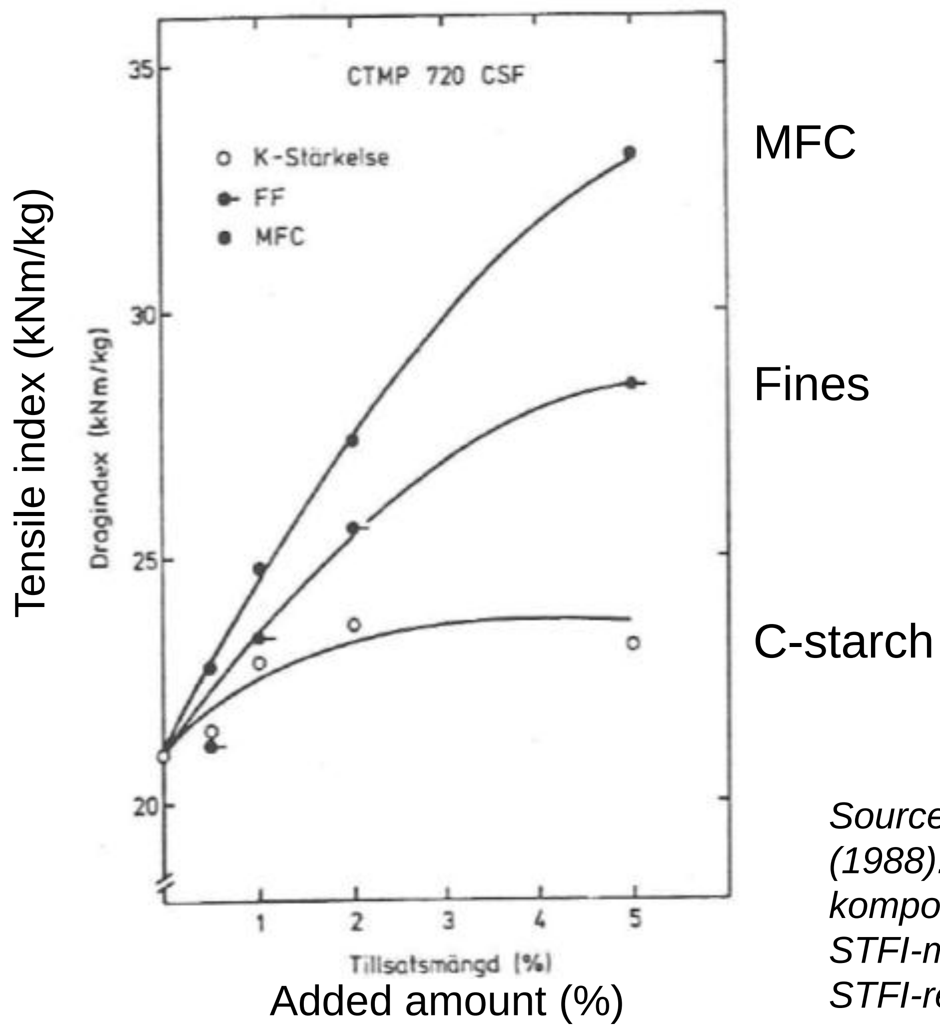
Pulp	Stress at brake [MPa]	Young’s Modulus [GPa]	Strain at break [%]
Nanopaper	~200	10-20	6-12
Unbl. kraft	64	5	4
Bl. kraft SW	54	5	5
Bl. kraft HW	34	4	4
Newsprint	16	2	2
Ground wood	6	1	1

Source: Henriksson, M., Berglund, L.A., Isaksson, P., Lindström, T., Nishino, T. Cellulose Nanopaper Structures of High Toughness. Biomacromolecules 2008, 9, 1579-1585.

Source: Fellers et al. (1983) Carton board. Profitable use of pulps and processes.

MFC USED AS DRY STRENGTH AGENT – OLD NEWS

MFC wet-end *addition* to CTMP



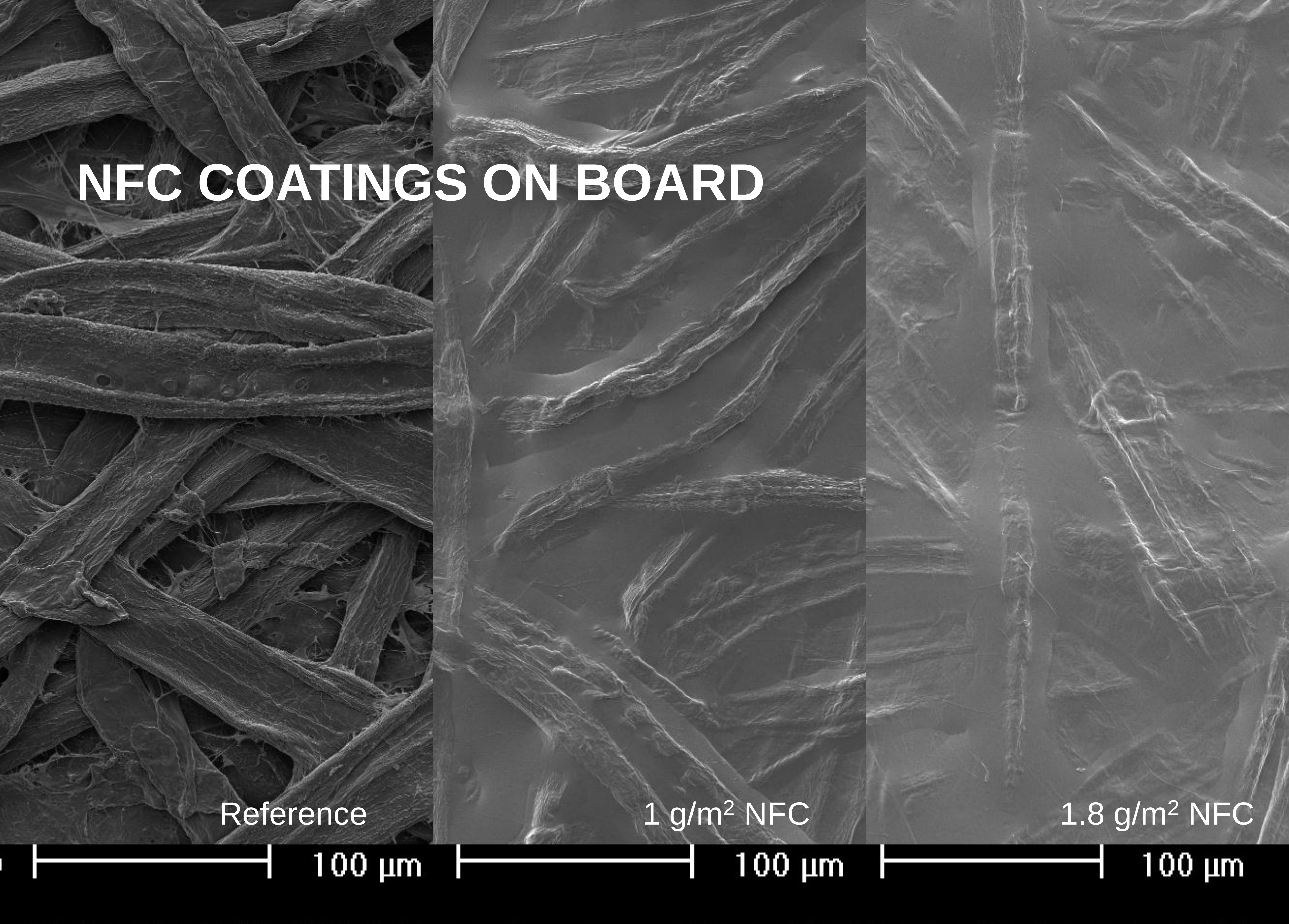
Source: Lindström, T. and Winter, L. (1988). Mikrofibrillär cellulosa som komponent vid papperstillverkning. STFI-meddelande C159 (internal STFI-report)

MFC IS INTERESTING FOR PAPER APPLICATIONS

- As a dry strength agent
- As an oxygen barrier material for packaging
- As an additive in coatings
- As a surface strength agent to reduce linting and dusting


PAPER COATING

NFC COATINGS ON BOARD



Source: Aulin, C., Gällstedt, M., Lindström, T. (2010). Cellulose 17(3), 559-574

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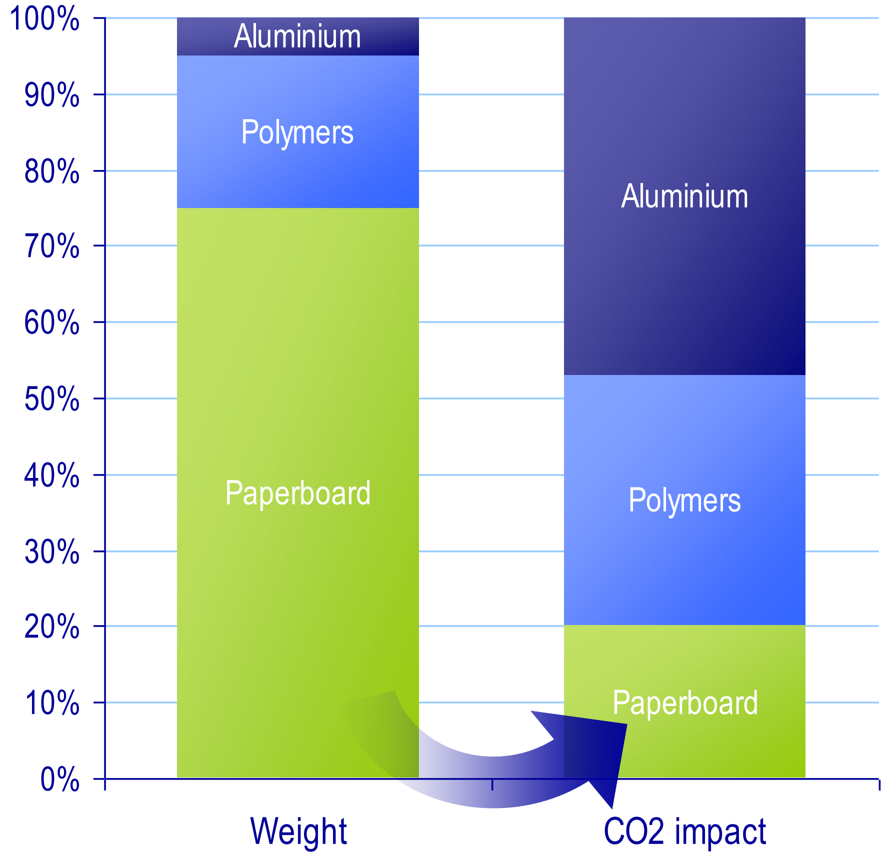
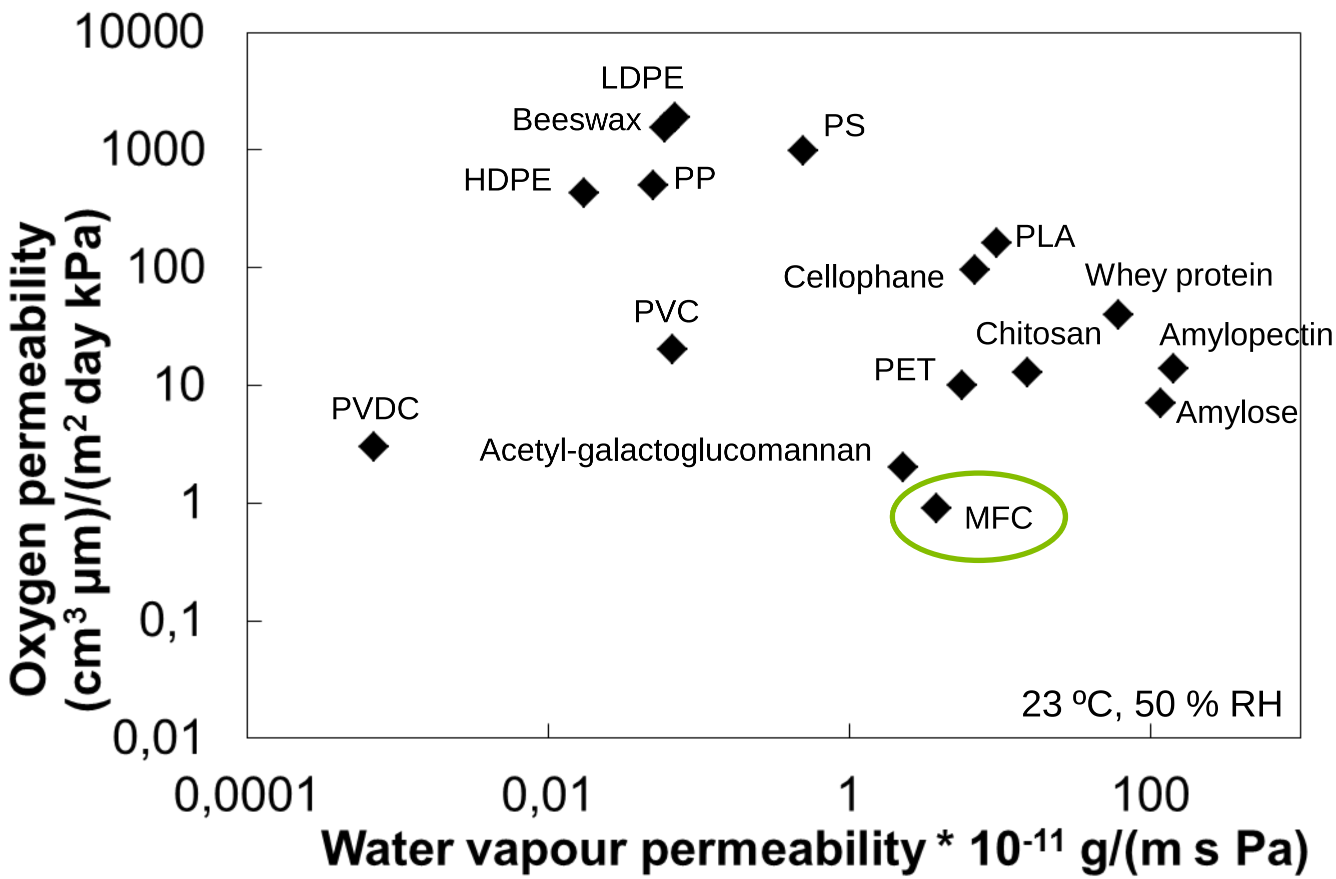
Renewables have low impact

Board is 75% of weight but only 20% of CO_2 impact



Courtesy: Tetra Pak

COMPARISON OXYGEN AND WATER VAPOUR PERMEABILITY FOR DIFFERENT MATERIALS



Source: Lindström, Aulin, Naderi, Ankerfors (2013). "Microfibrillated cellulose" in Encyclopedia of Polymer Science and Technology, 13th edition, John Wiley & Sons, USA. Accepted for publication.

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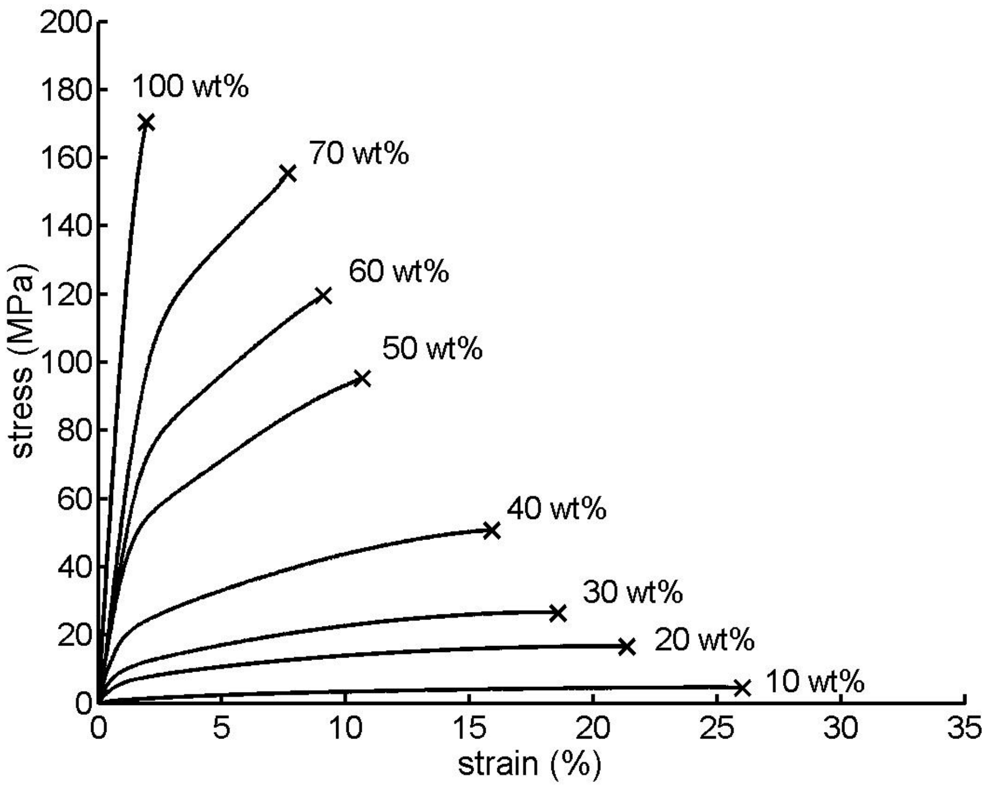
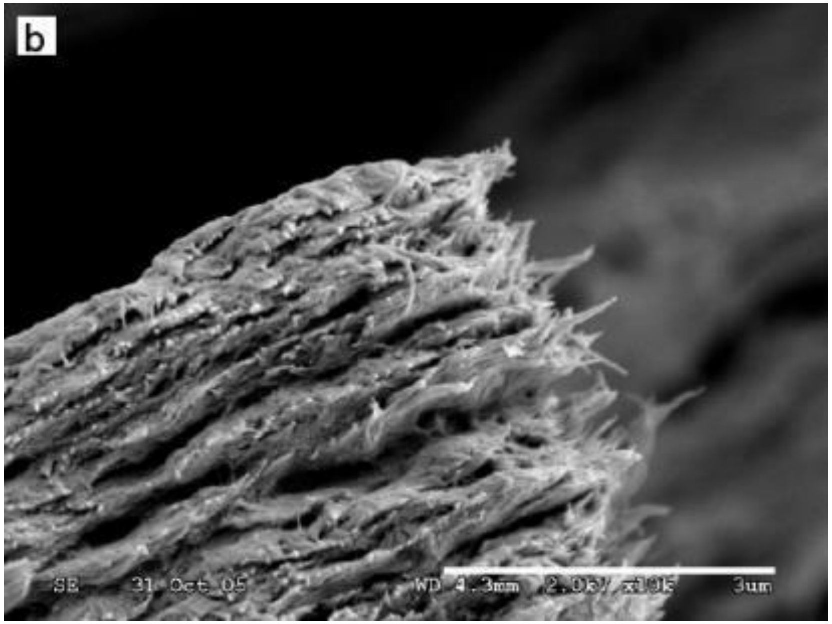
STARCH/GLYCEROL/MFC NANOCOMPOSITE





Source: Svagan, A.J., Azizi Samir, M.A.S., Berglund, L.A. Biomimetic Polysaccharide Nanocomposites of High Cellulose Content and High Toughness. Biomacromolecules (2007); 8(8); 2556-2563.

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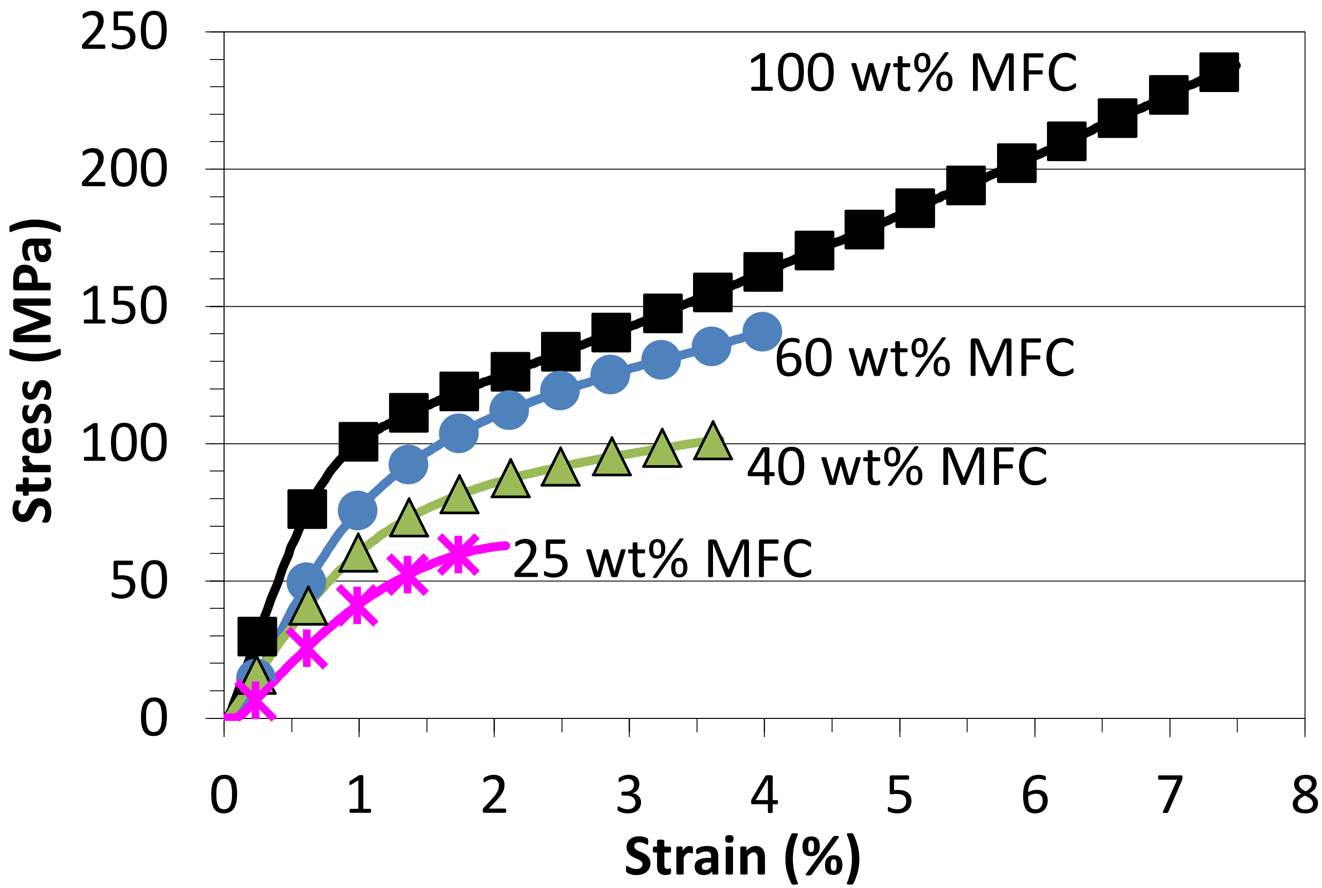
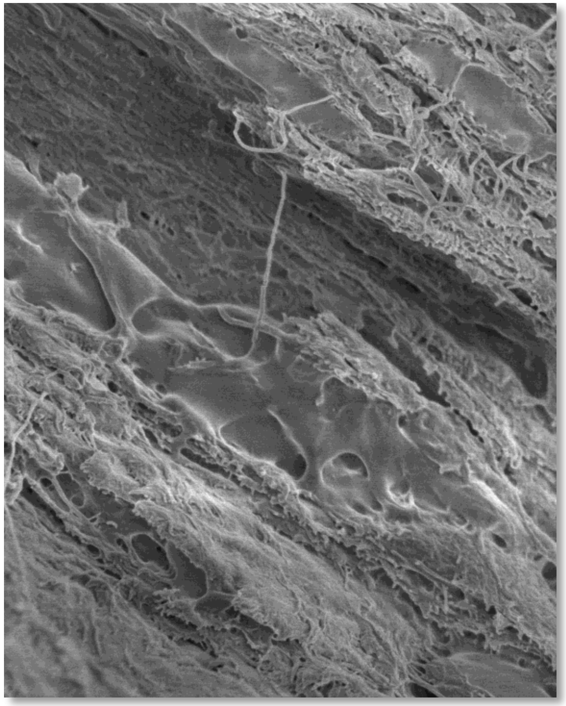
MECHANICAL PROPERTIES PLA-MFC NANOCOMPOSITE





Source: Larsson, K., Berglund, L.A., Ankerfors, M., Lindström, T. (2012). Polylactide latex/nanofibrillated cellulose bionanocomposites of high nanofibrillated cellulose content and nanopaper network structure prepared by papermaking route. Journal of Applied Polymer Science (2012), 125(3), 2460-2466.

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POTENTIAL USES FOR MFC IN PACKAGING

- Bio-nanocomposites in screw cap and/or top
- Nanobarrier inside the bottle
- Dry strength agent in board
- Rheology modifier in the food product

THANK YOU

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