Puu-19.150 Chemistry of pulping and bleaching

Fibre engineering

(Mitikka-Eklund, M., Halttunen, M., Melander, M., Ruuttunen, K. and Vuorinen, T.: Fibre engineering, 10th international symposium on wood and pulping chemistry, Japan, 7-10 June 1999, Vol 1. pp 423-439)

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Fibre engineering

- Fibre engineering describes any practical, controllable act of making a positive change in the fine structure of a fibre for its end use.

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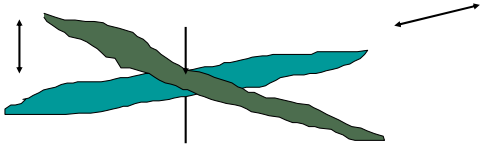
Fibre engineering - tailoring of fibre properties

Flexibility
- Internal structure / charge

Strength
- internal structure
- internal surfaces



Bonding ability
- Surface structure and chemistry

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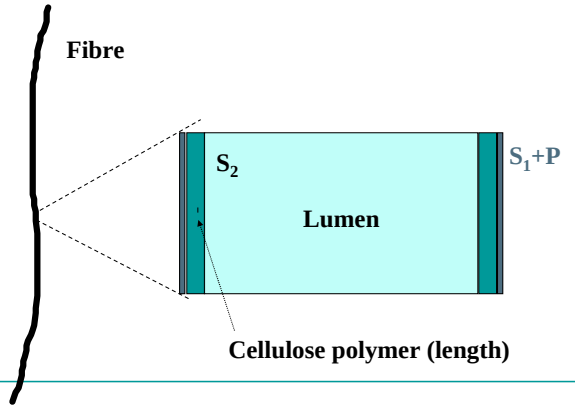
Dimensions of fibre and its substructures



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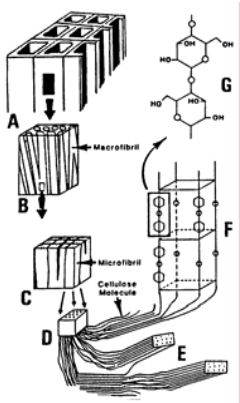
Cellulose fibrils



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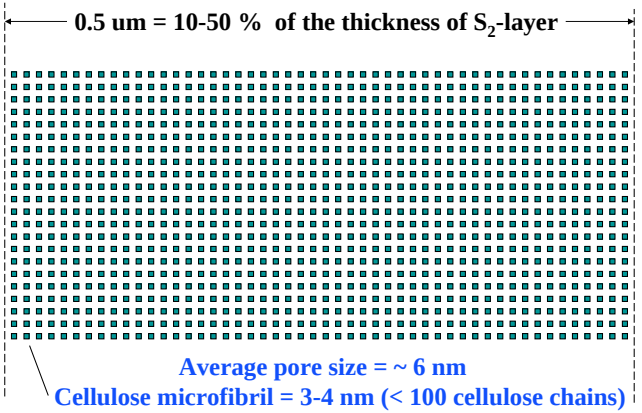
Dimensions in S_2-layer



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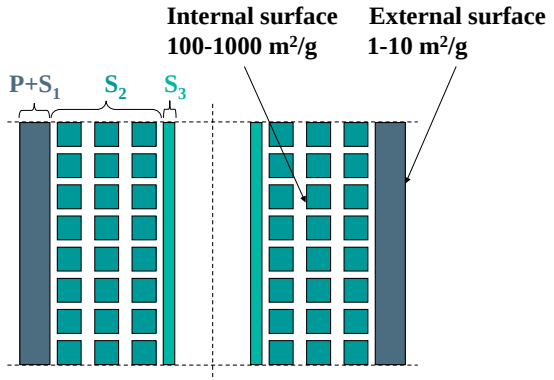
Fibre engineering



In wet fibre water takes 70 % of the volume of cell wall

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Methods to improve fibre properties

- Attachment of polymers with desired functionalities on external surfaces,e.g:
  - adsorption of carboxymethylcellulose (cmc) or other polymers
  - Sorption of xylans on fibres

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Sorption of CMC on pulp fibres

- CMC, carboxymethylcellulose, is an anionic polymer
- CMC has similar chain conformation than cellulose
- → *enabling association with cellulose microfibrils*
- → *more charged groups on the fibre surface*
- CMC is not able to penetrate into the cell wall
  → sorption on fibres (e.g. ECF spruce kraft pulp fibres)
- CMC on fibres increases water sorption (and water retention value, WRV)
- The amount of sorbed CMC increases with the beating level

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Sorption of CMC on pulp fibres

Beating (rev.)	*CMC (% on pulp)*	*WRV (g/g)*	*WRV (g/g) Untreated*
-	0.52	1.70	1.33
4000	4.18[a]	2.04	
4000	7.26[a]	2.08	
1000	0.63	1.96	1.55
2000	0.78	3.45	1.64
4000	0.94	5.36	1.77
7000	0.87	8.21	2.07

DP 700-800, [a] low DP
pH 12.5

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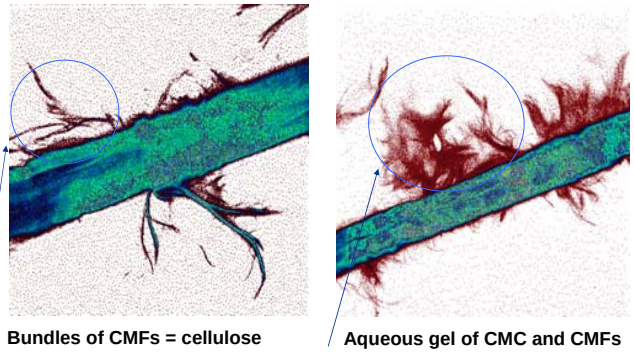
CLSM of wet, beaten pulp fibres

Untreated **Treated with CMC**



Bundles of CMFs = cellulose microfibrils

Aqueous gel of CMC and CMFs

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Sorption of CMC on pulp fibres

- Confocal laser scanning microscopy (CLSM) revealed the external gelated structure of beaten and CMC treated fibres
- As a result strong interfibre bonding denser sheets were obtained
- Sheet properties of pulps treated with electrolyte solution and CMC:
  - Decreased density
  - Improved bonding properties (bonding ability and tensile strength)

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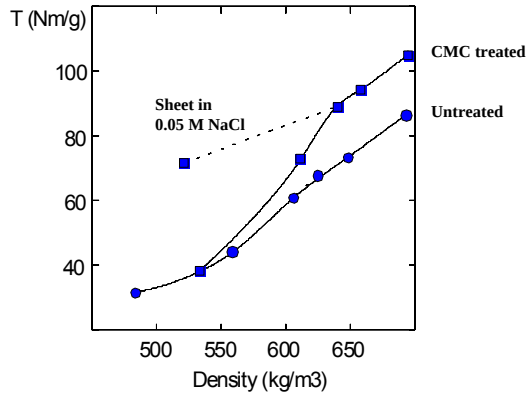
Effects of CMC on sheet properties



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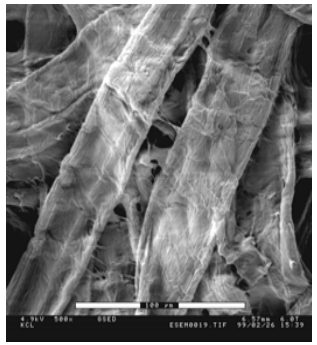
ESEM – pictures (sheeted in water)

Untreated

Treated with CMC



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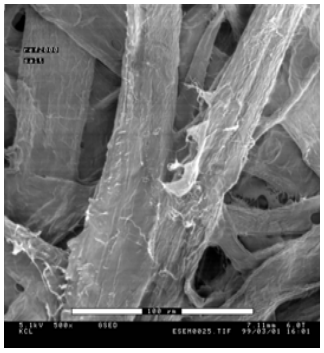
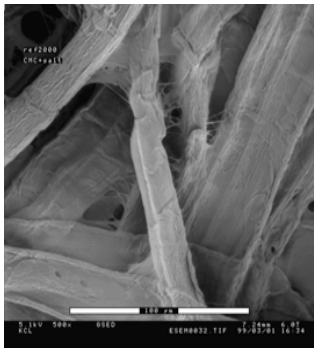
ESEM – pictures (sheeted in 0.05M NaCl)

Untreated



Treated with CMC



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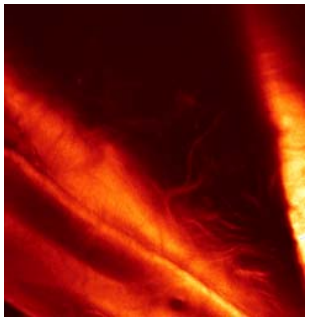
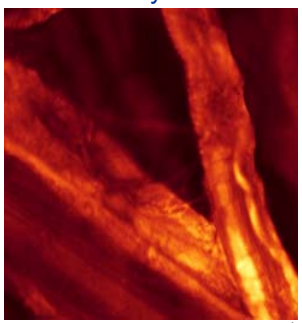
CLSM-pictures (pulp in water)

CMC-treated pulp

Wet



Dry



(pictures by M. Blomstedt)

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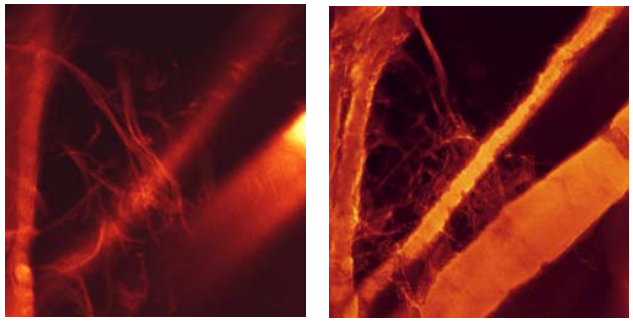
CLSM-pictures (pulp in 0.05M NaCl)

CMC-treated pulp

Wet Dry



(pictures by M. Blomstedt)

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Sorption of xylan on cellulose fibres

- A large amount of hemicelluloses are dissolved from the cell wall during the initial stage of kraft pulping
- As a result of endwise peeling, glucomannans are largely depolymerized and dissolved
- A fraction of xylans are dissolved as polymers during kraft pulping
  - DP 50-100
- Dissolved xylans can be resorbed on fibres

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Sorption of xylan on cellulose fibres

- Resorbed xylans may have both positive and negative effects on the properties of pulp:

  \+ increase bonding within or between fibres

  \- a barrier between for diffusion of residual lignin from the fibres

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Summary

- Fibre engineering involves modification of the fine structure of fibres in order to improve fibre properties for the end use
- External surface structure of pulp fibres can be tailored with polymeric compounds, such as CMC, that are unable to penetrate into the cell wall

→ *interfibre bonding is increased*

→ *sheet strength is increased*

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Summary

- A part of dissolved xylan polymers can be sorbed back on the cellulose fibres

→ *increased intrafibre or interfibre bonding*

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