2012 IUFRO CONFERENCE
DIVISION 5 - FOREST PRODUCTS
8›13 JULY'12
ESTORIL CONGRESS CENTRE
LISBON – PORTUGAL
www.iufro2012.org

The wood fibre structure how to be utilised?

Lennart Salmén
Innventia

INNVENTIA

The wood fibre as a material resource

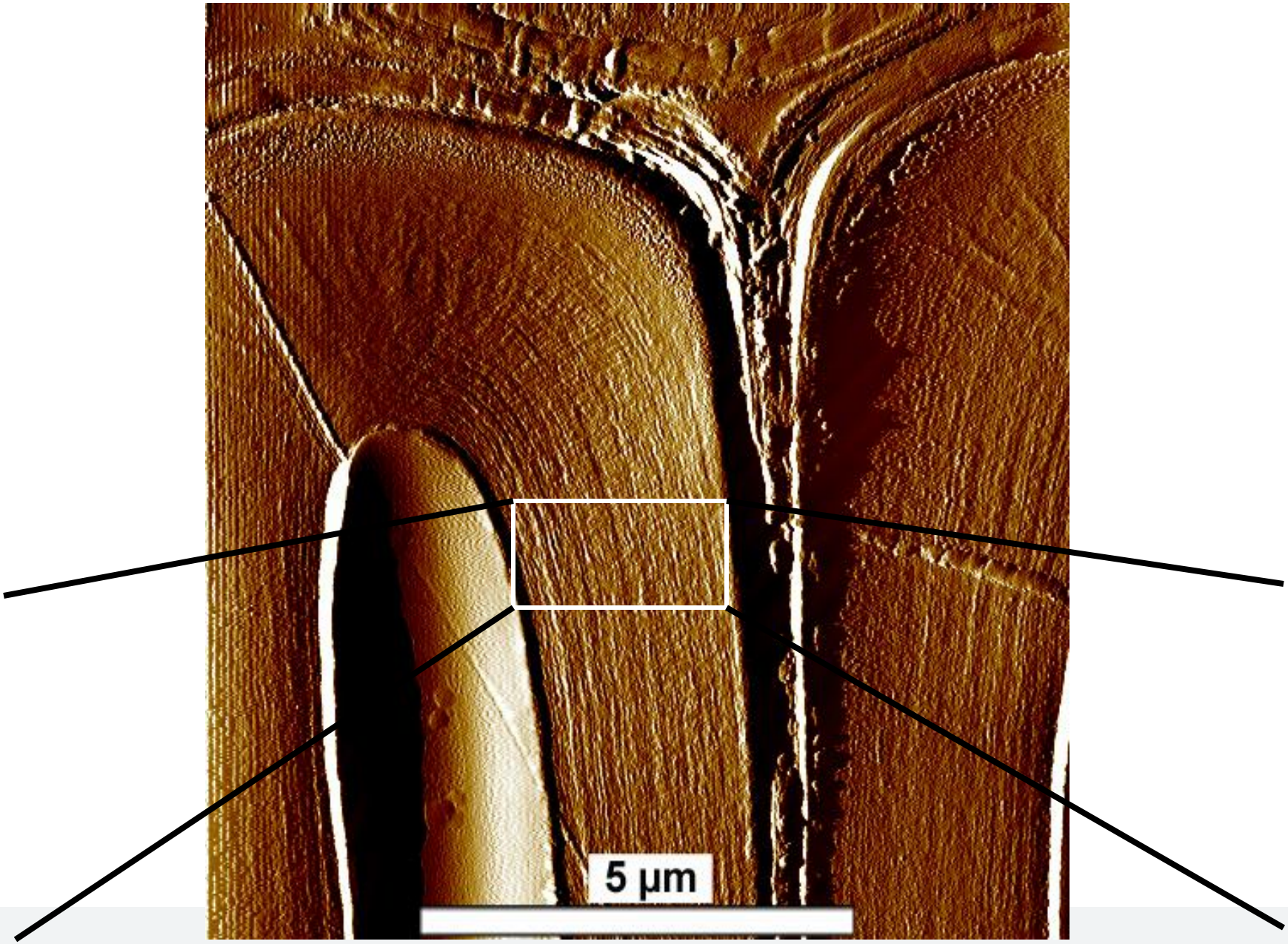
- **Increasing demand for utilising wood fibres**
  - **Cellulose;**
    - **replacing cotton**
    - **derivatives**
  - **Hemicelluloses**
    - **barrier films**
  - **Lignin**
    - **carbon fibres**

The wood fibre structure

- ***Cellulose aggregation***
- ***Polymer orientation***
- ***Matrix polymer interactions***
- ***Lignin/cellulose cooperation***

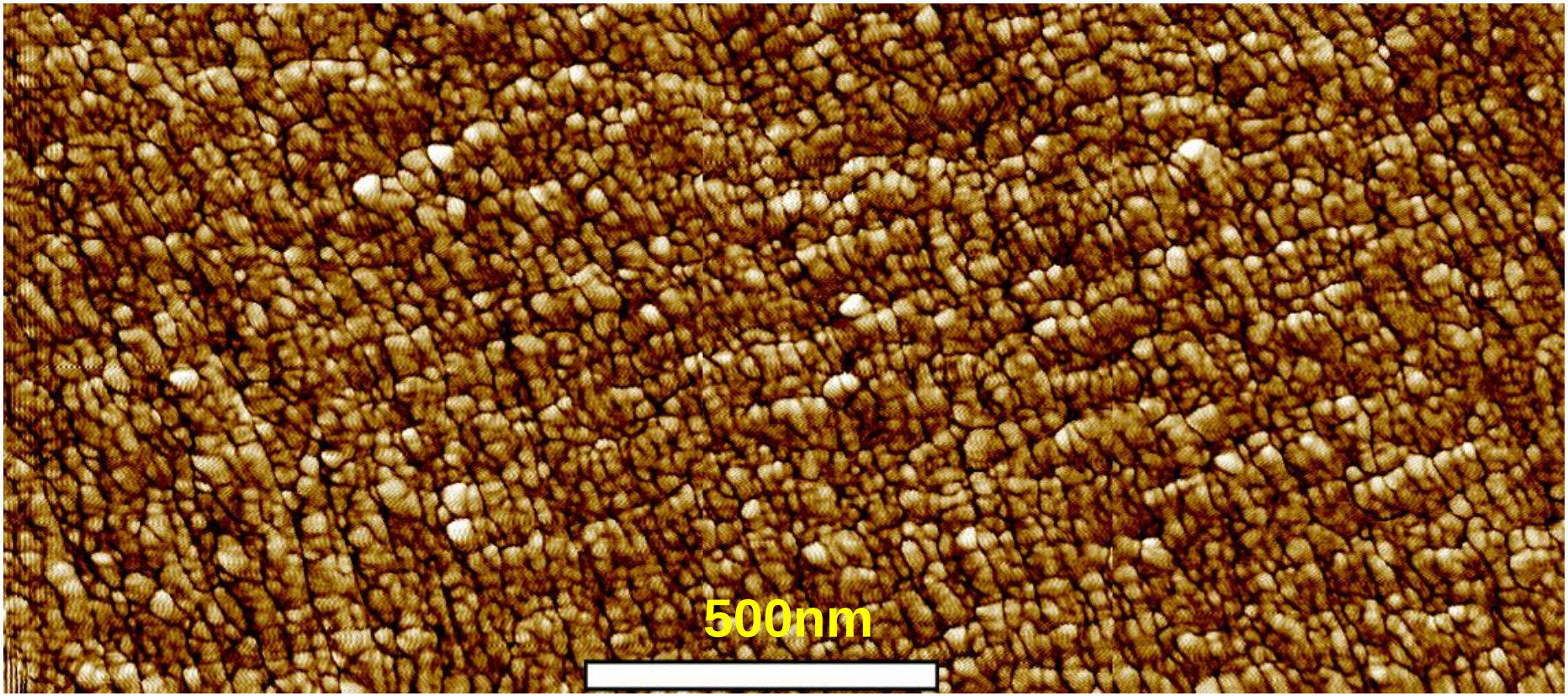
Cellulose

- **Using ability**
  - **accessibility**
- **Obstacles**
  - **thermodynamic preference for aggregation**



INNVENTIA

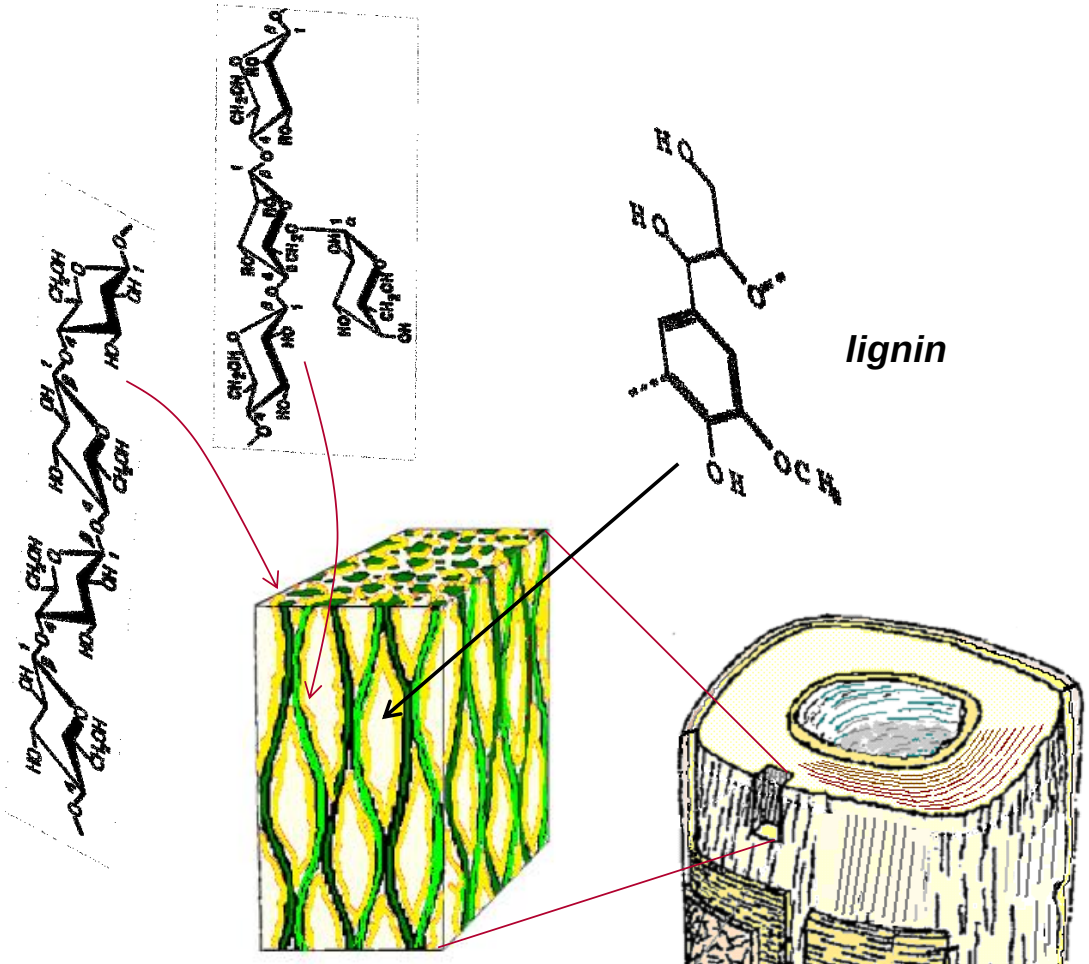
Ultra-structure across cell wall



lumen side

middle lamella side

Three dimensional cellulose structure

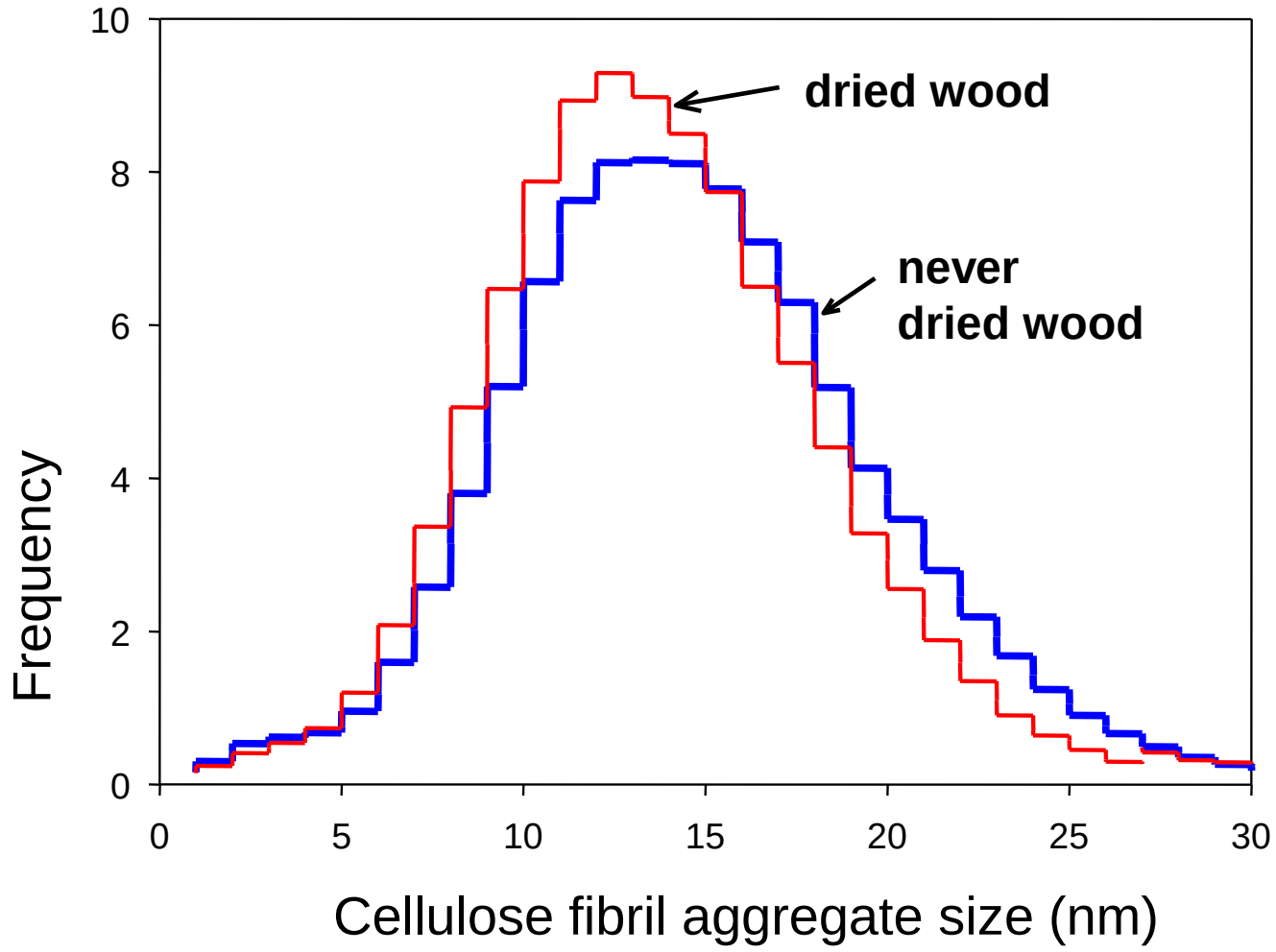


lignin

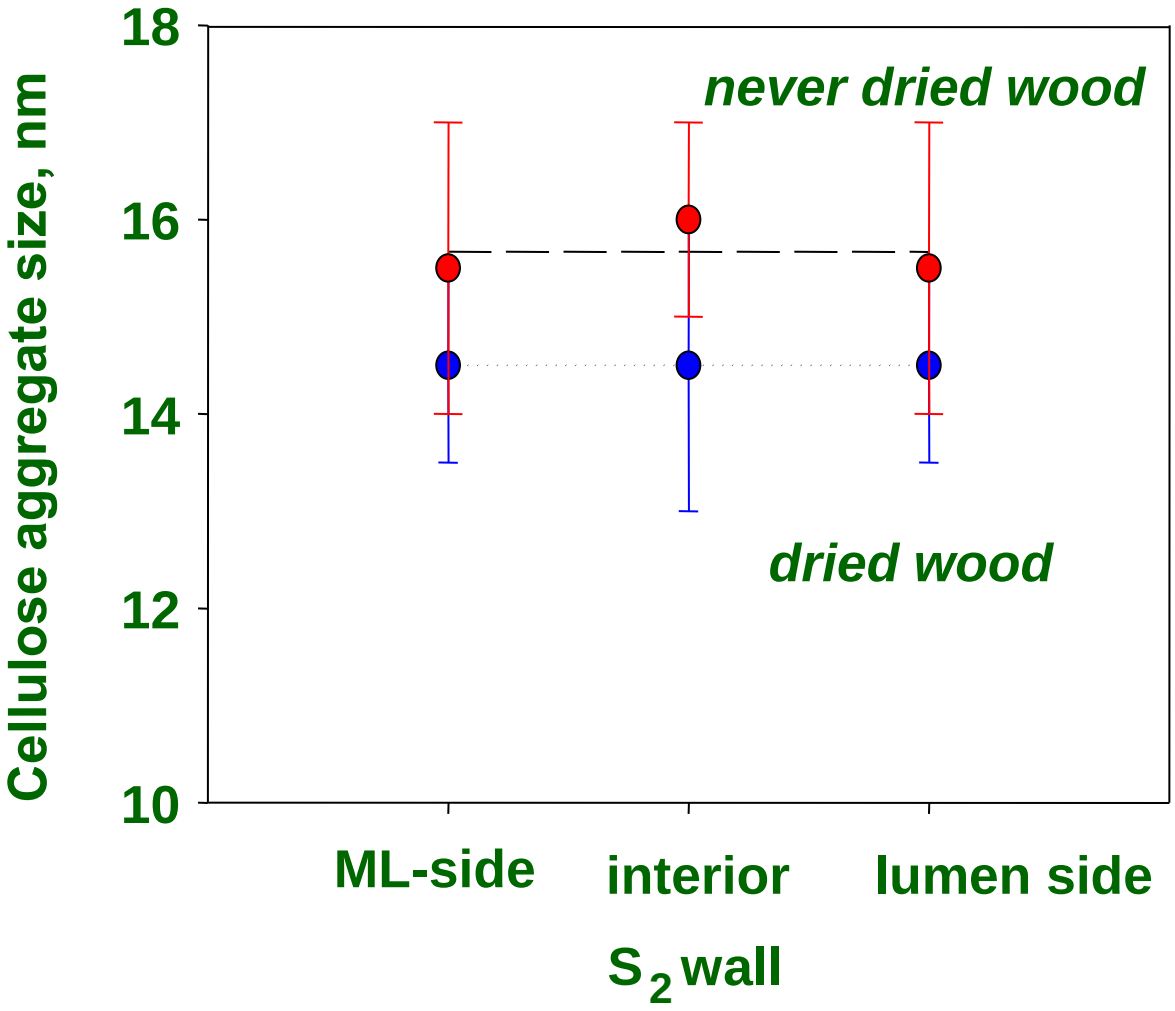
cellulose/hemicellulose
undulating structure

INNVENTIA

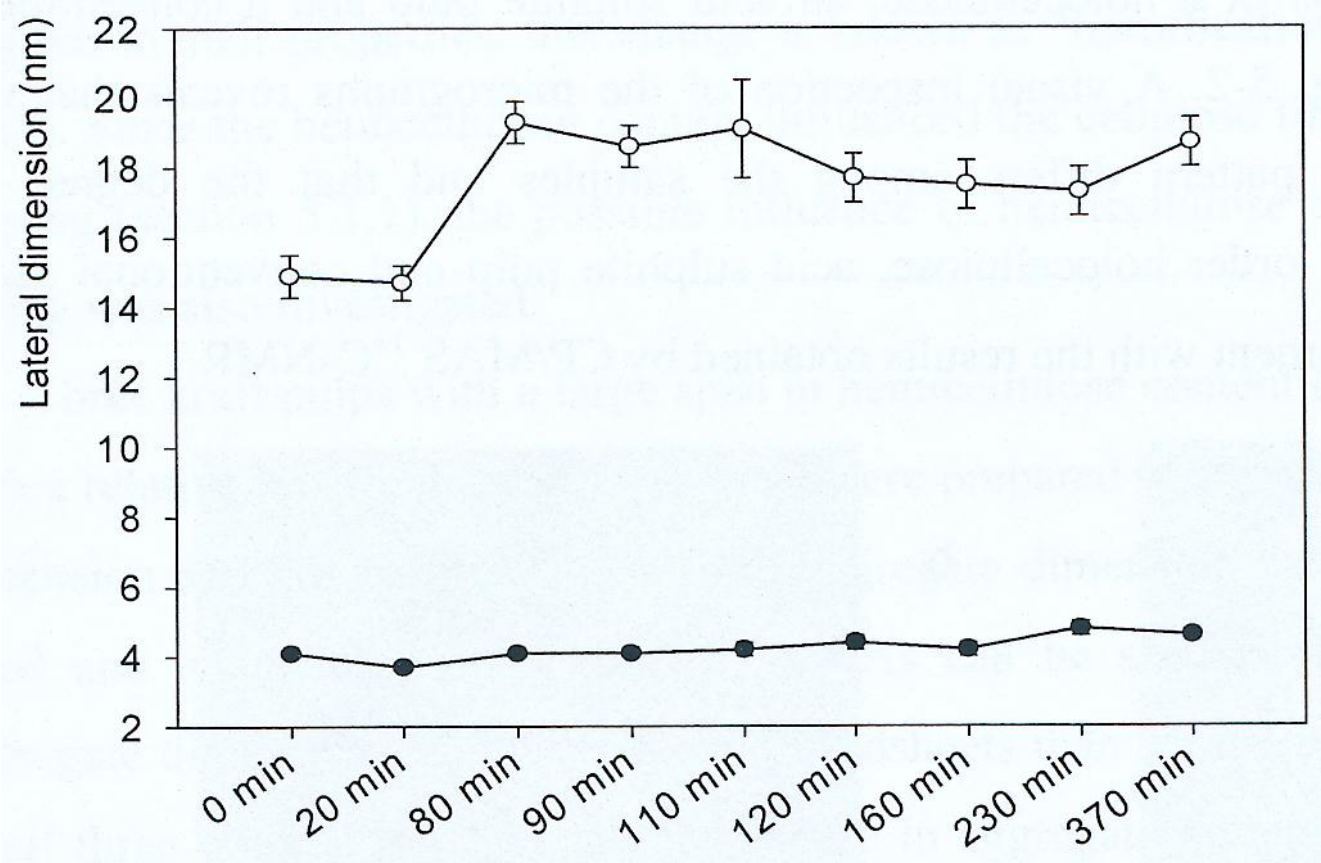
Aggregate size distribution



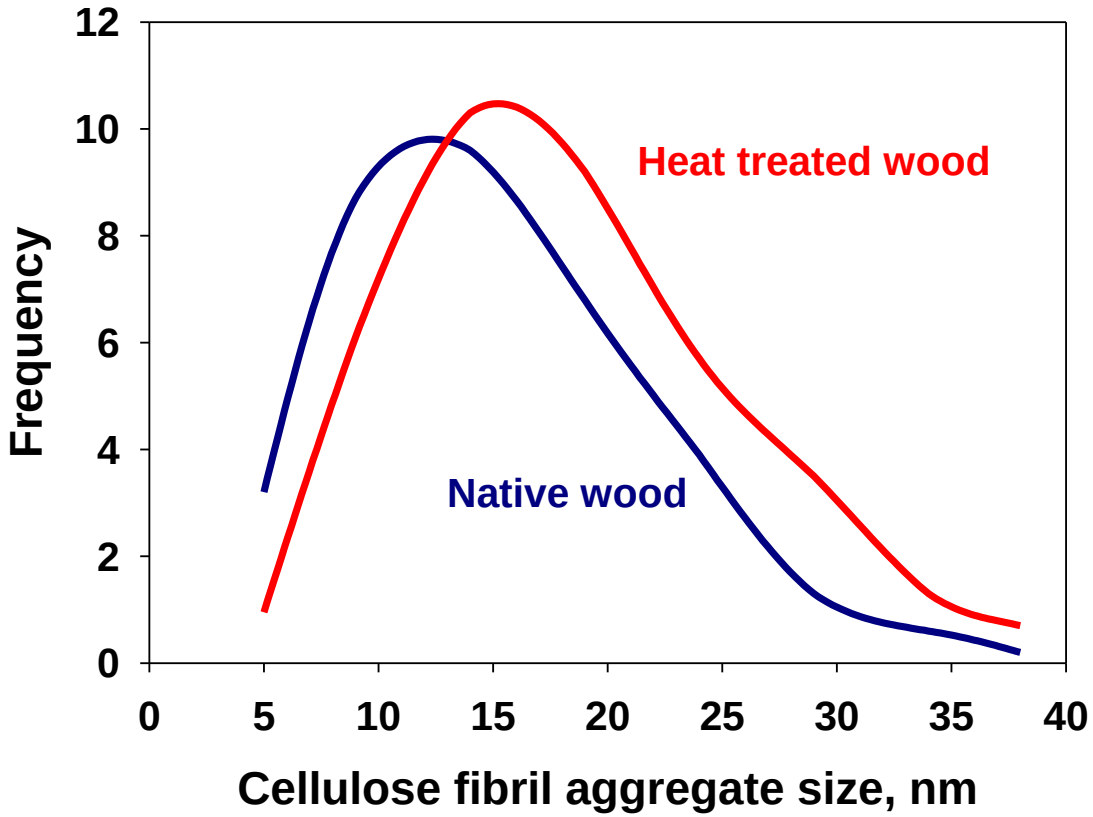
Aggregate size - drying



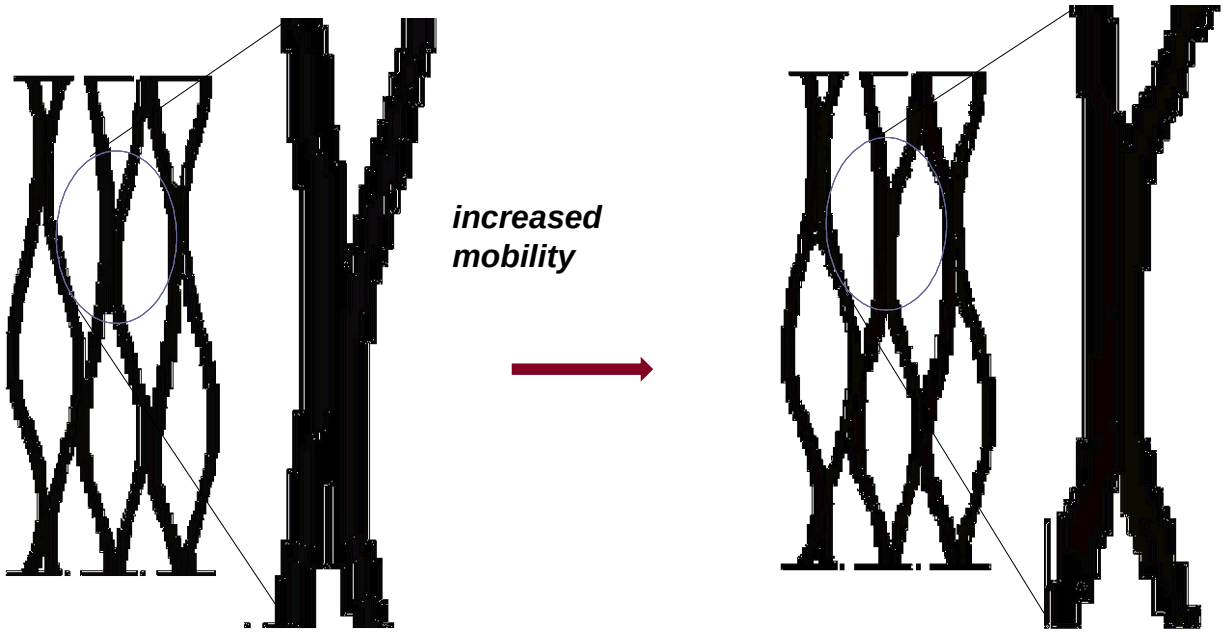
Cellulose aggregates during cooking



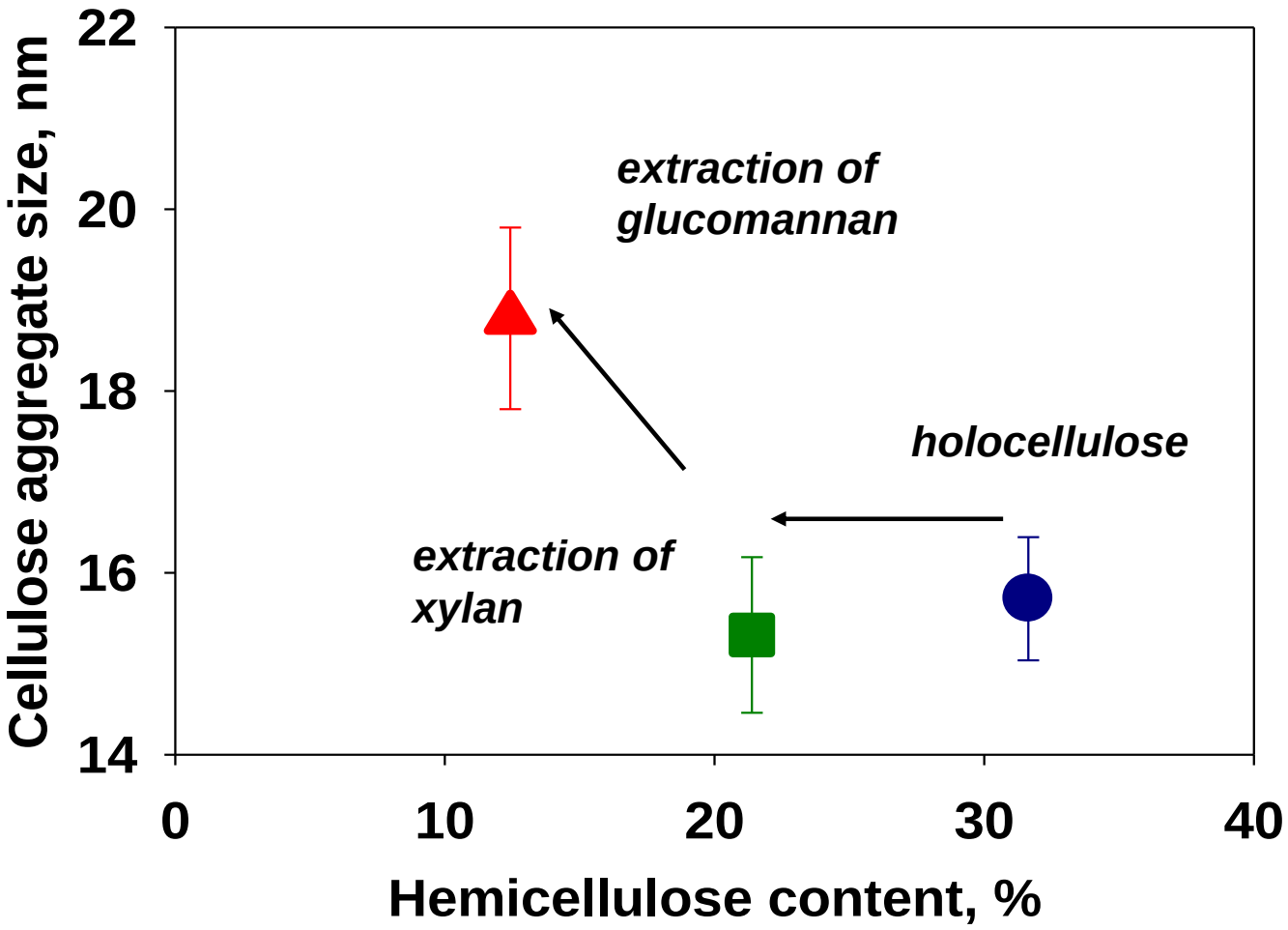
Aggregation due to heat treatment



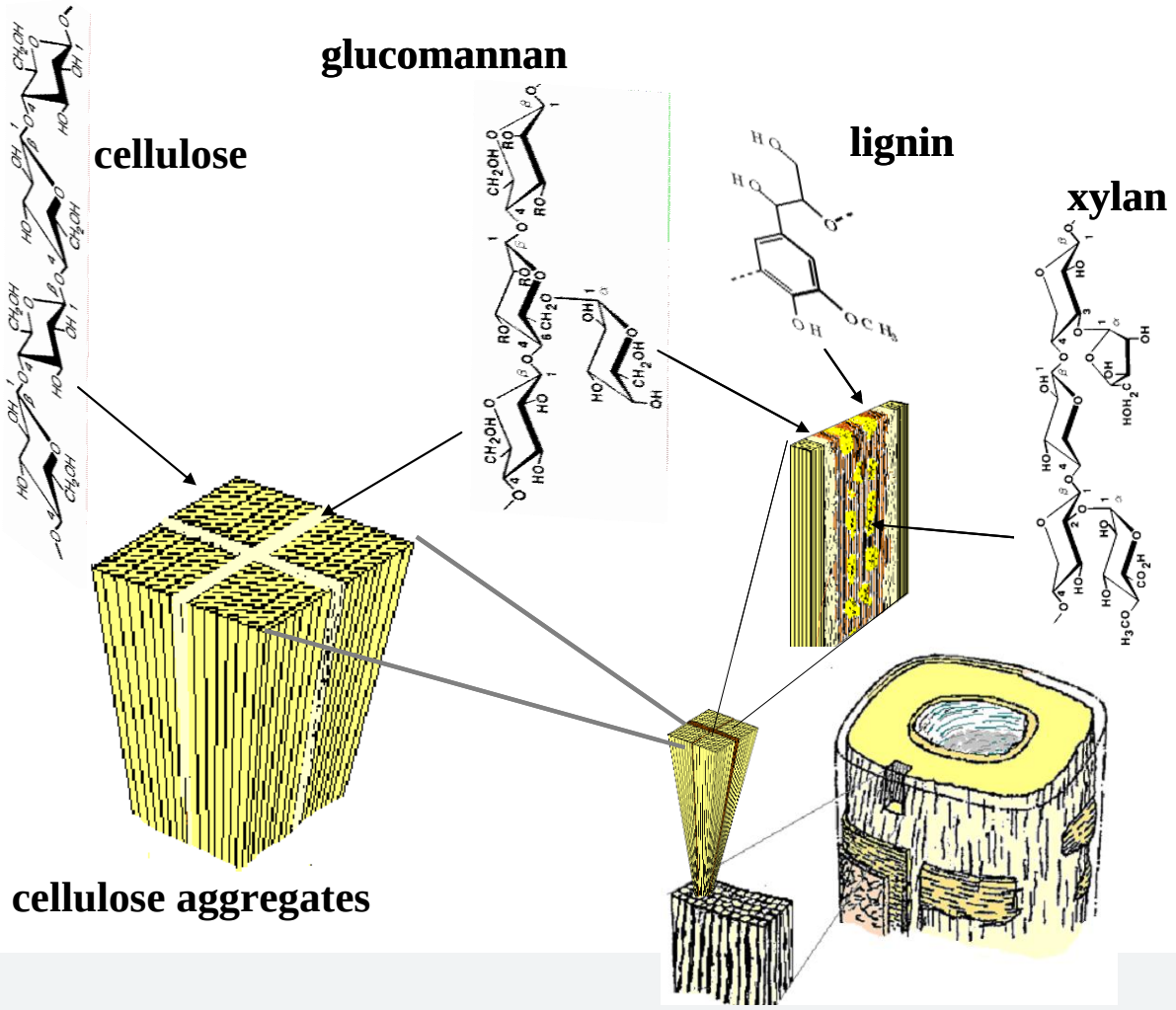
Aggregering av cellulosa



Effects of hemicelluloses



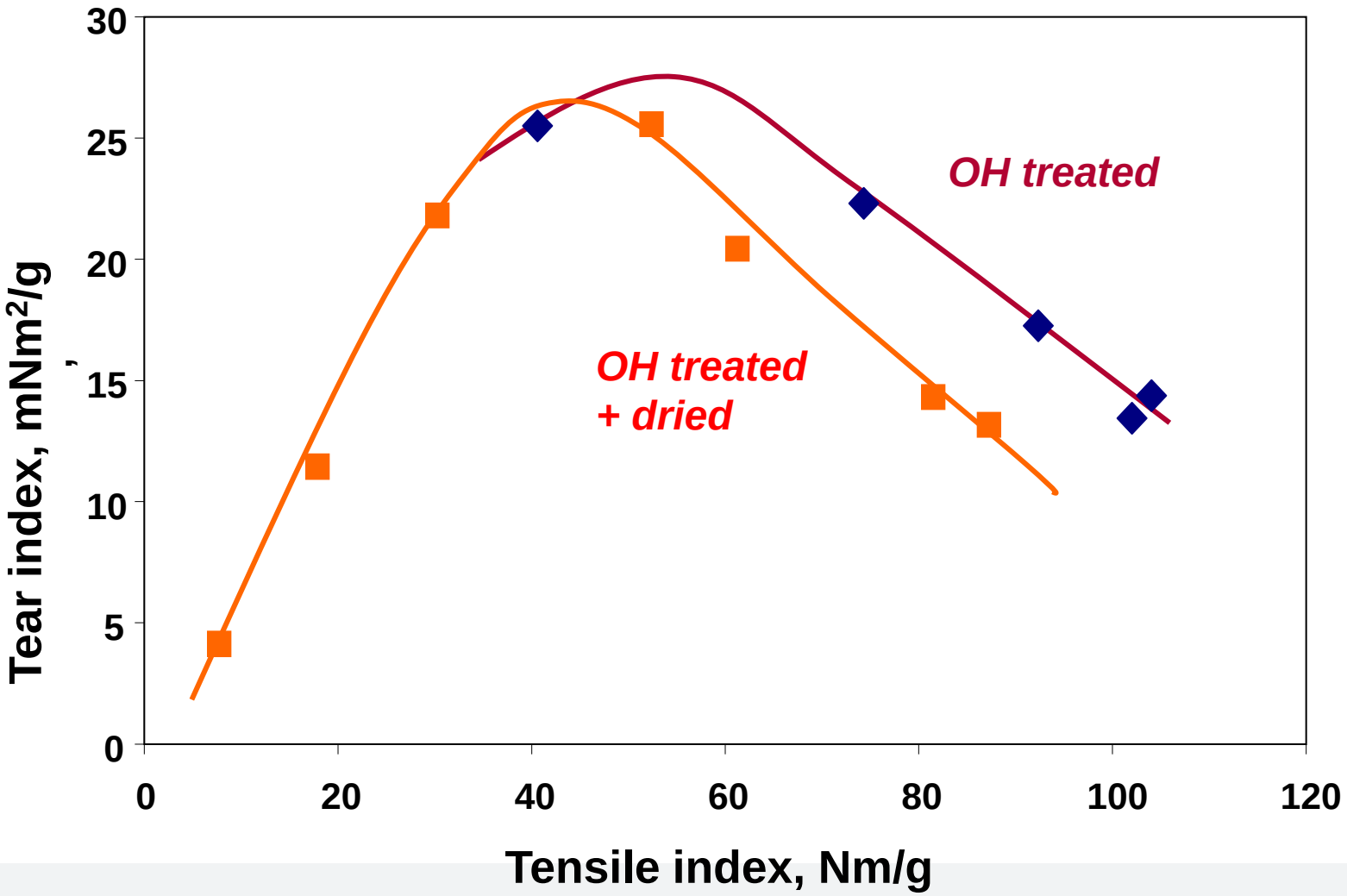
Structure around cellulose aggregates



Manipulation cellulose aggregate size

Sample	Aggregate thickness (nm)	Rewet zero-span (Nm/g)
Never Dried pulp	26.8 +/- 0.8	137 +/- 6
De-aggregated pulp (NaOH)	24.4 +/- 0.5	118 +/- 5
Re-aggregated pulp (dried)	35.0 +/- 2.5	

Tear - tensile – aggregate size

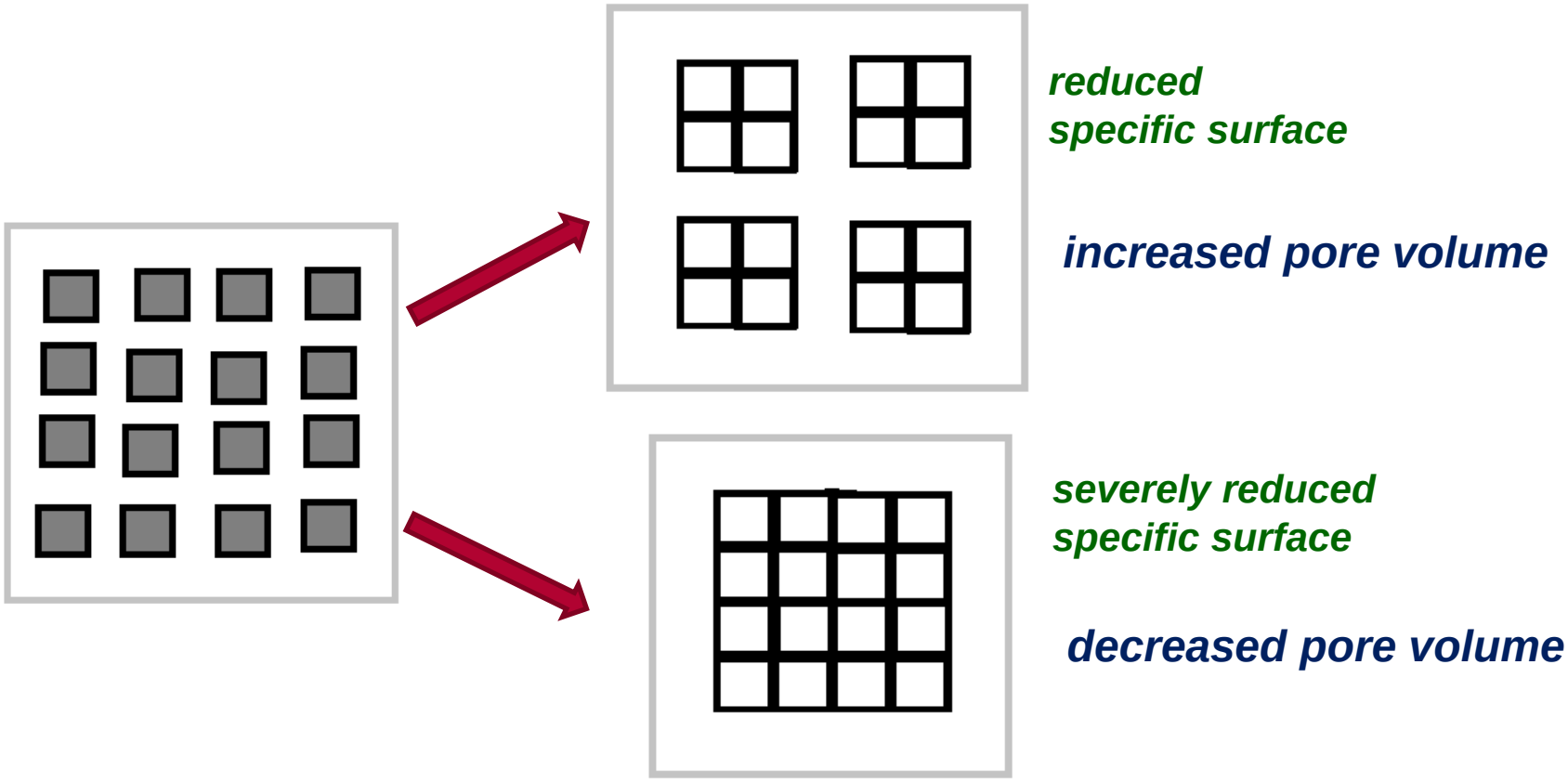


Pulping challange

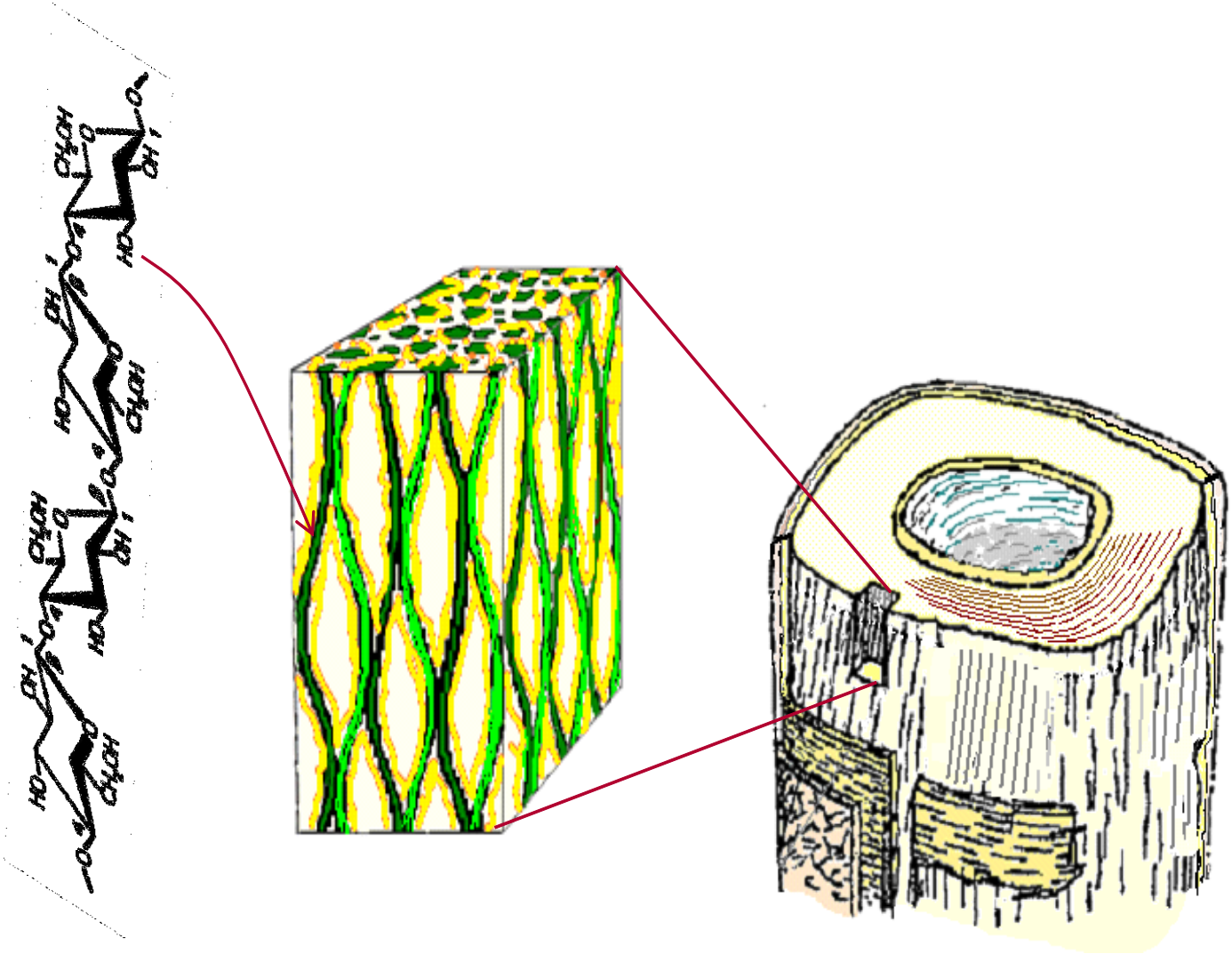
- ***Restrict aggregation***

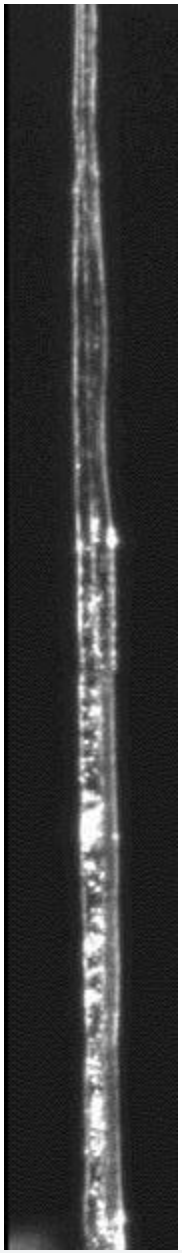
- ***Increasse cellulose specific surface area***

Controling aggregate size

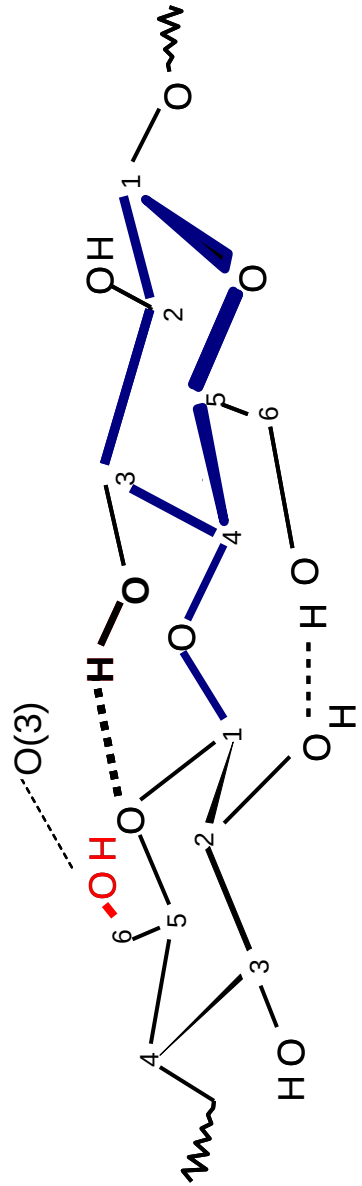


Highly organised cellulose aggregate structure

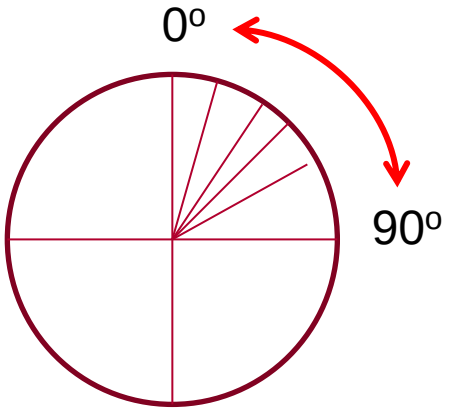




Polarisation FTIR for molecular orientation



Cellulose

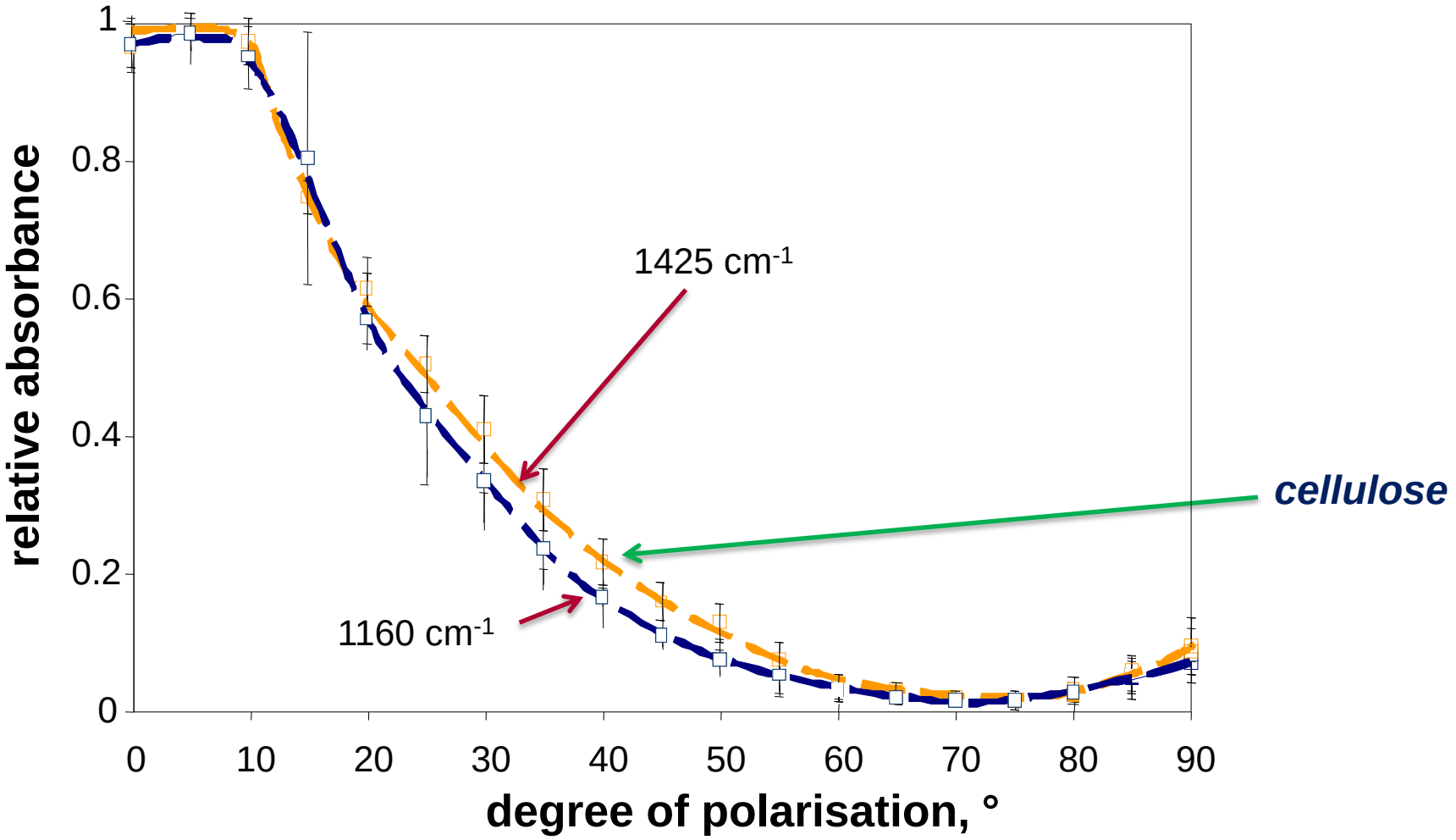


1160 backbone vibration

1425 C- OH bending vibration

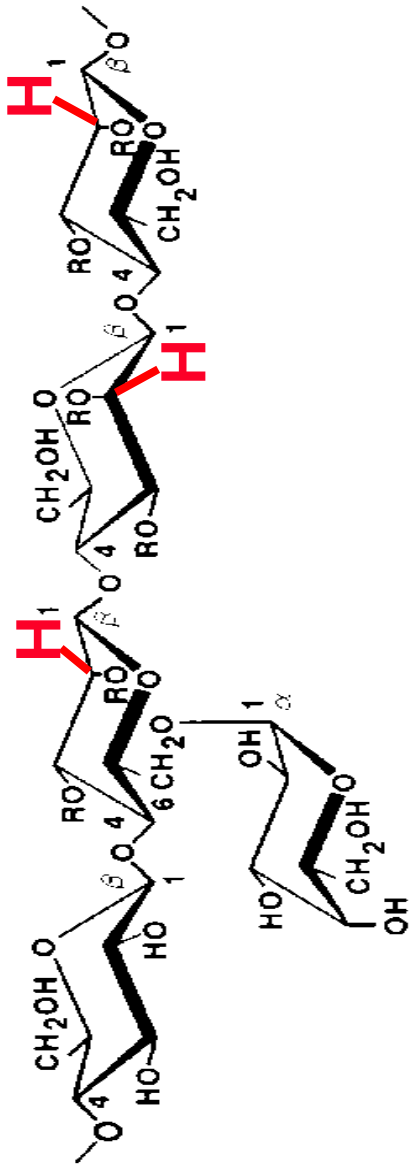
1316 C- H_2 wagging vibration

Orientation of cellulose groups in poplar



INNVENTIA

Polarisation FTIR for molecular orientation

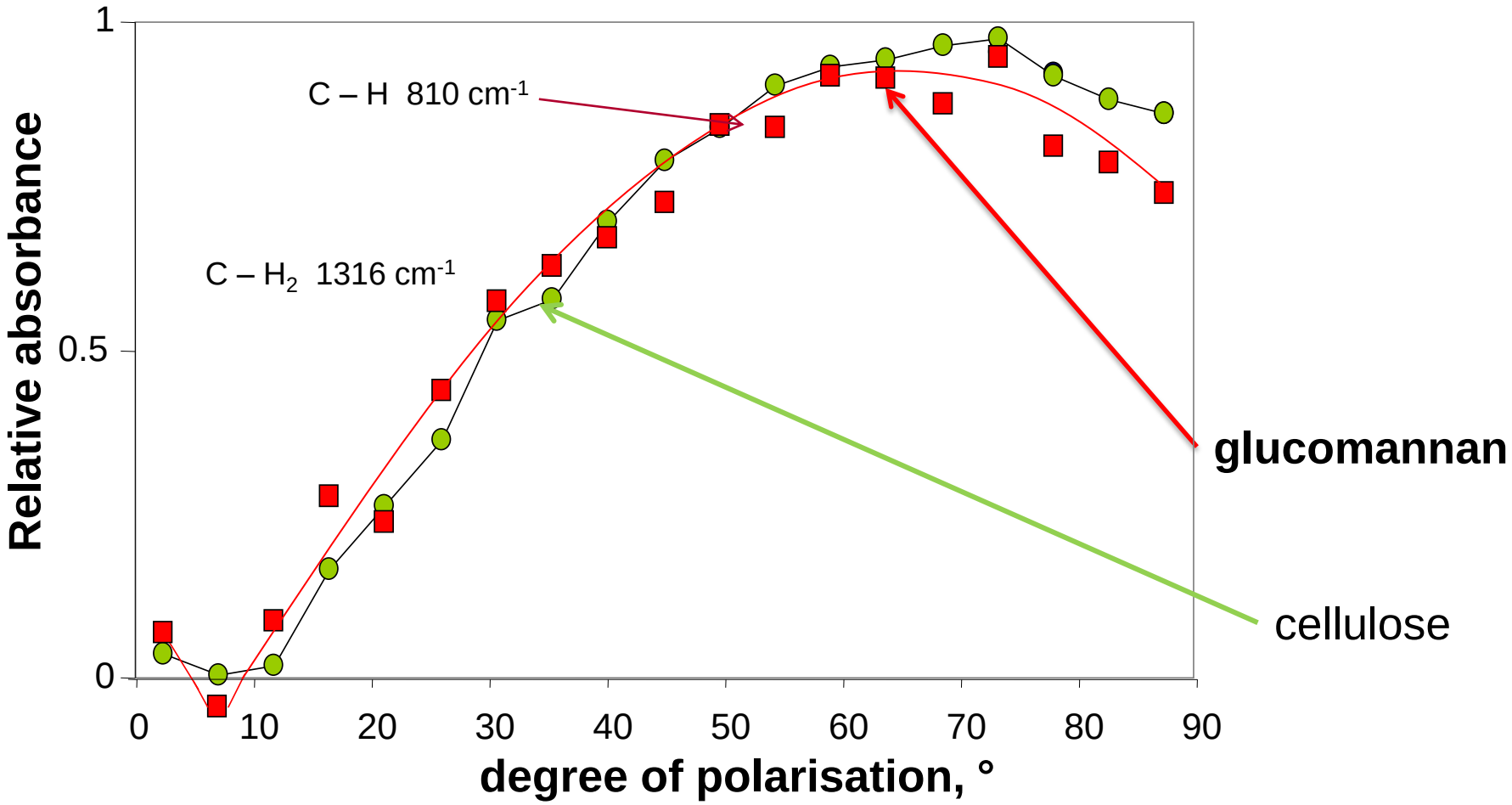


Glucomannan

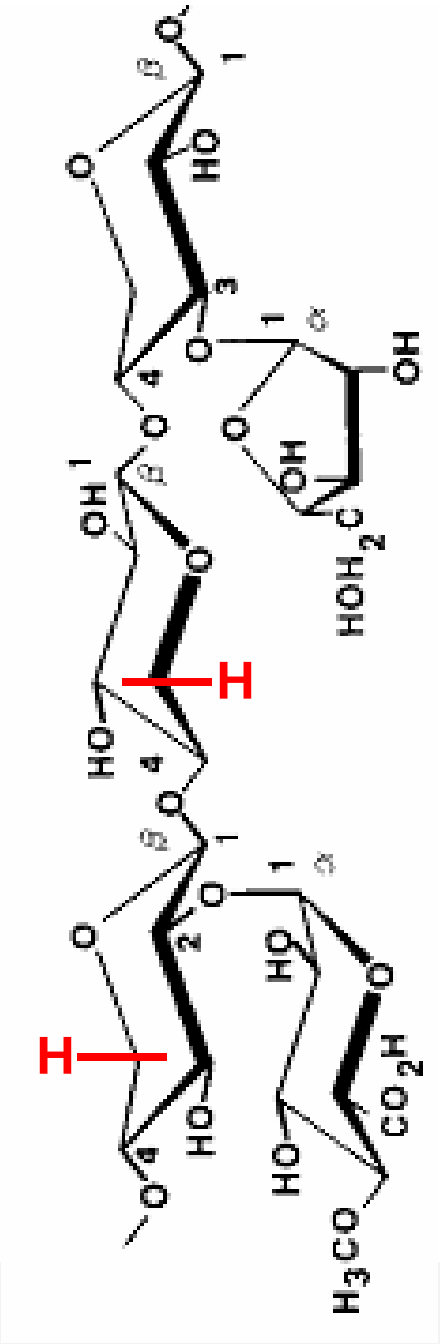
↔

810 cm^{-1}
equatorially aligned H vibration in mannose units

Orientation of glucomannan groups in softwood



Polarisation FTIR for molecular orientation



Xylan

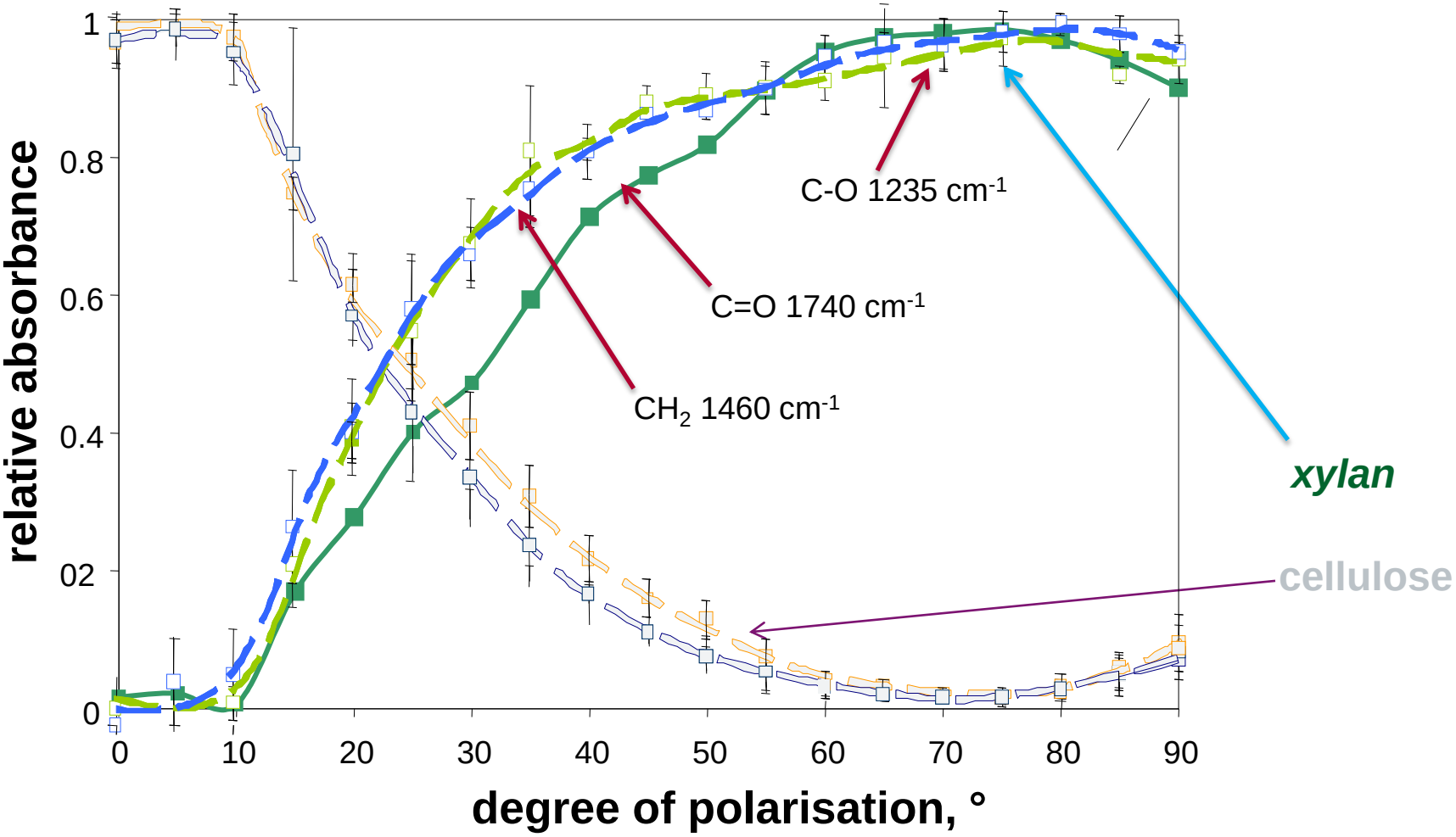
↔ **1460 cm^{-1}**
CH_2 symmetric bending on xylose units

↔ **1240 cm^{-1}**
C-O stretching in carboxylic group

↔ **1734 cm^{-1} , 54º**
C=O stretching in carbonyl group

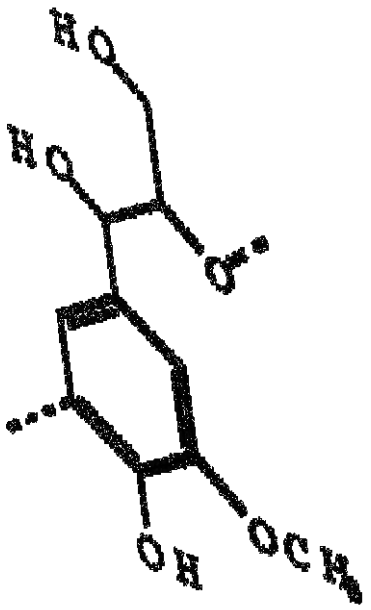
INNVENTIA

Orientation of xylan groups in poplar



INNVENTIA

Polarisation FTIR for molecular orientation



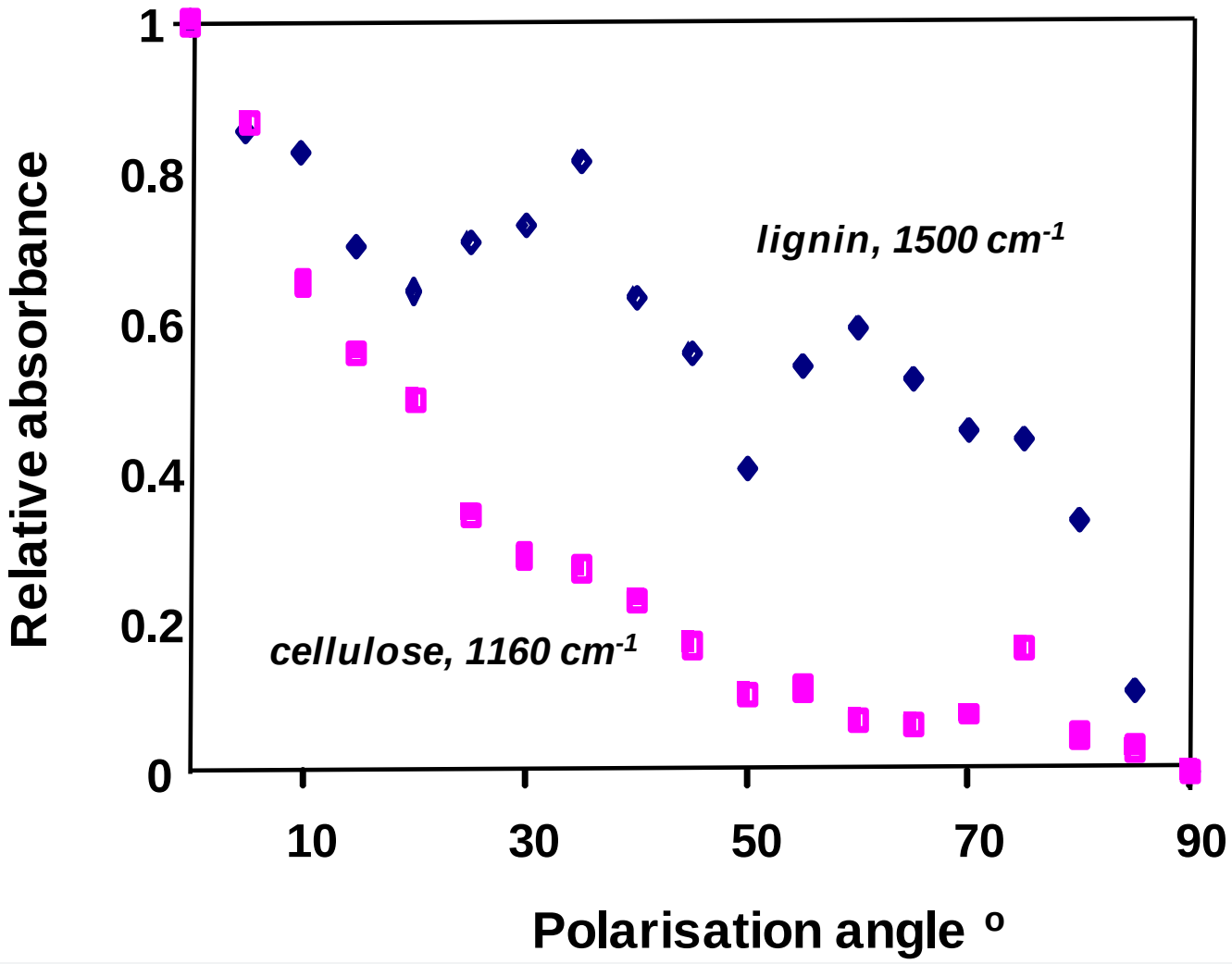
Lignin

1508 cm^{-1}
aromatic ring vibration

1600 cm^{-1}
aromatic ring + C - O stretch

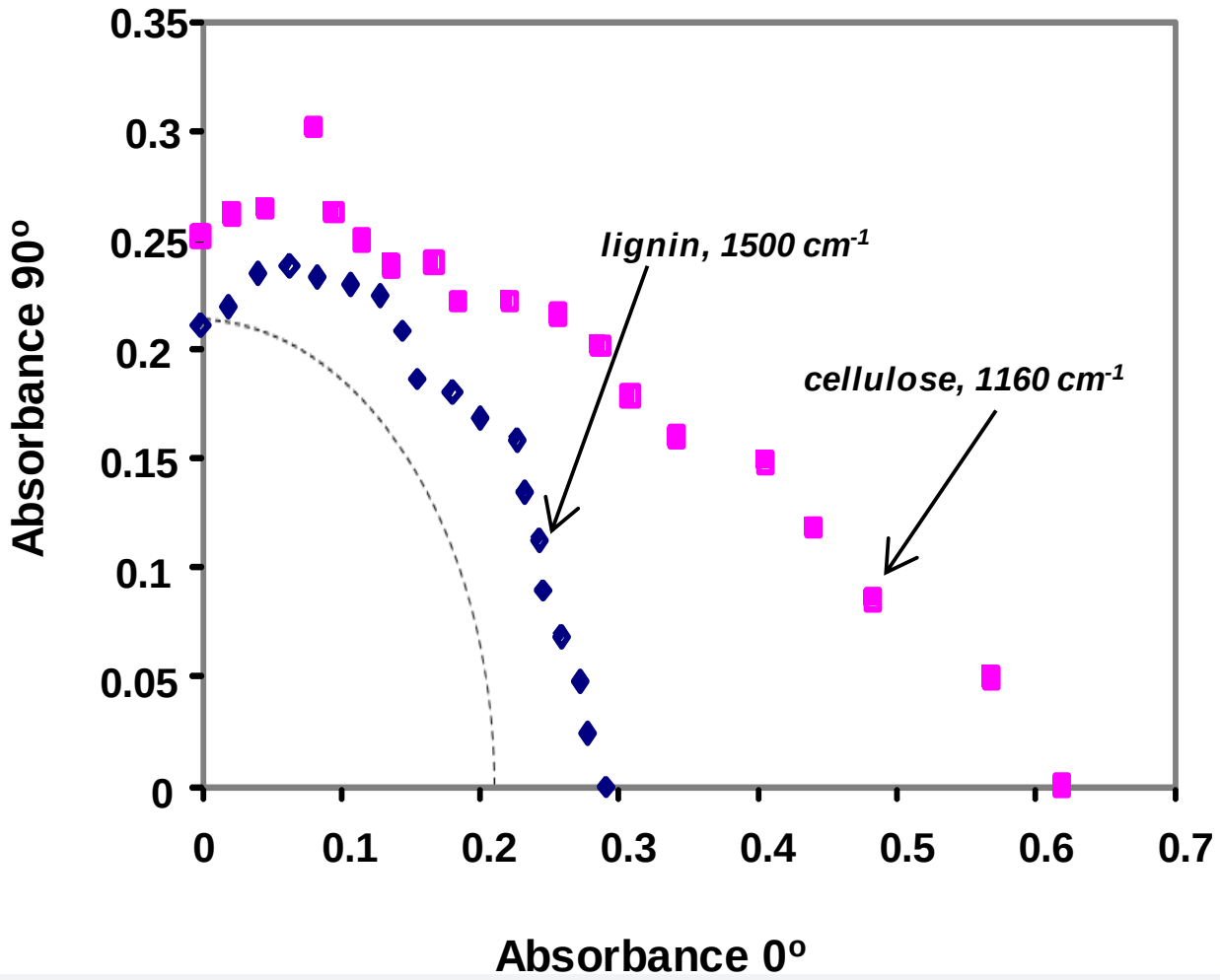
INNVENTIA

Orientation of lignin groups in softwood – S_2



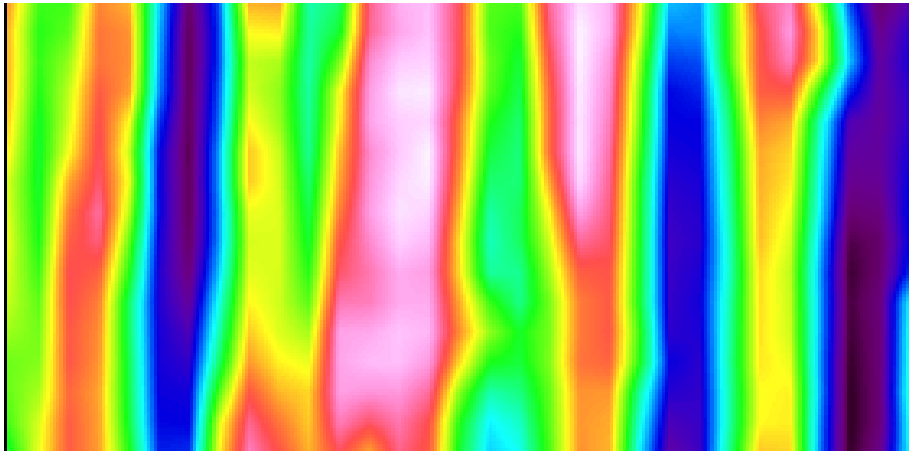
INNVENTIA

Absolute absorbance – polar diagram, spruce - S_2

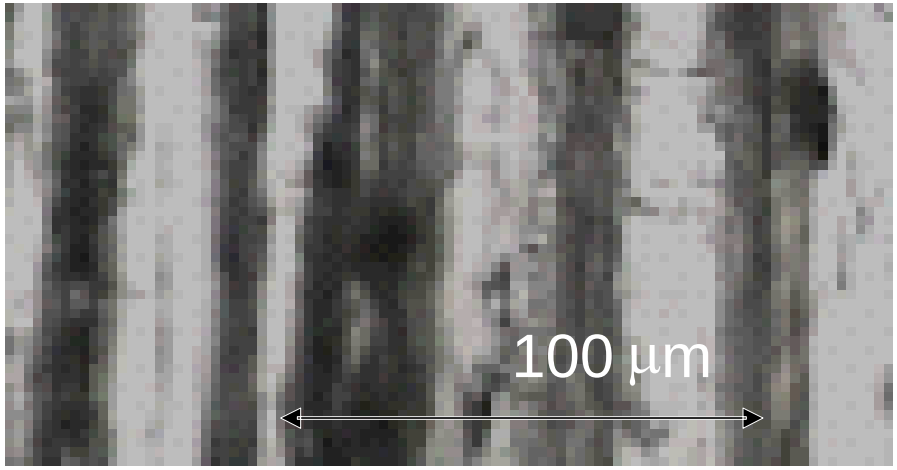


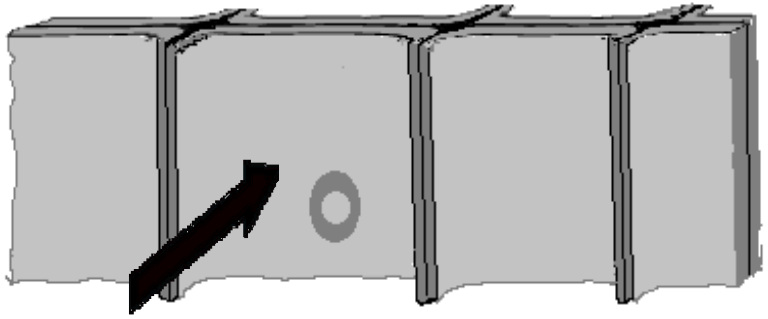
INNVENTIA

Radially cut cross section of spruce



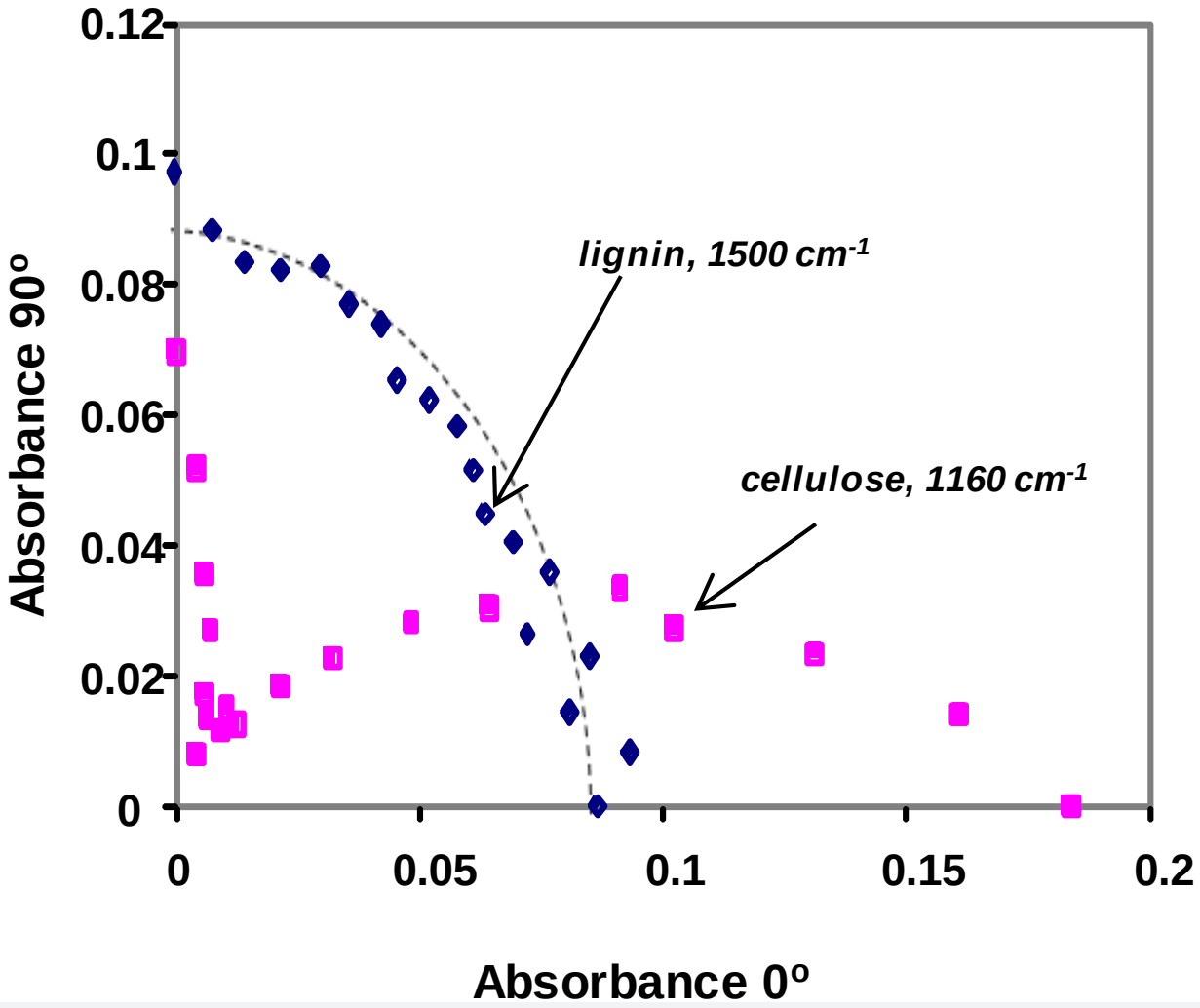
increased absorbance, arbitrary scale





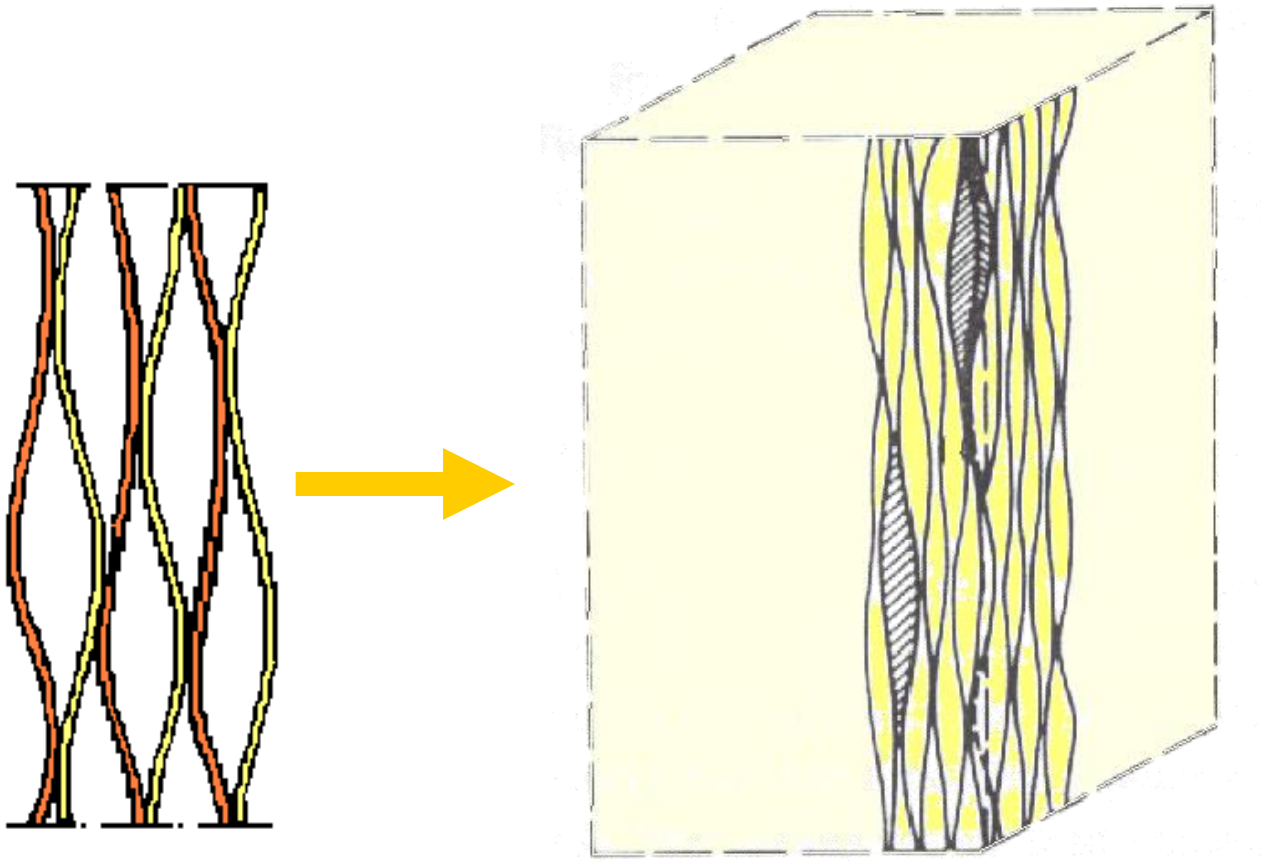
IR-radiation

Absolute absorbance – polar diagram, spruce - ML

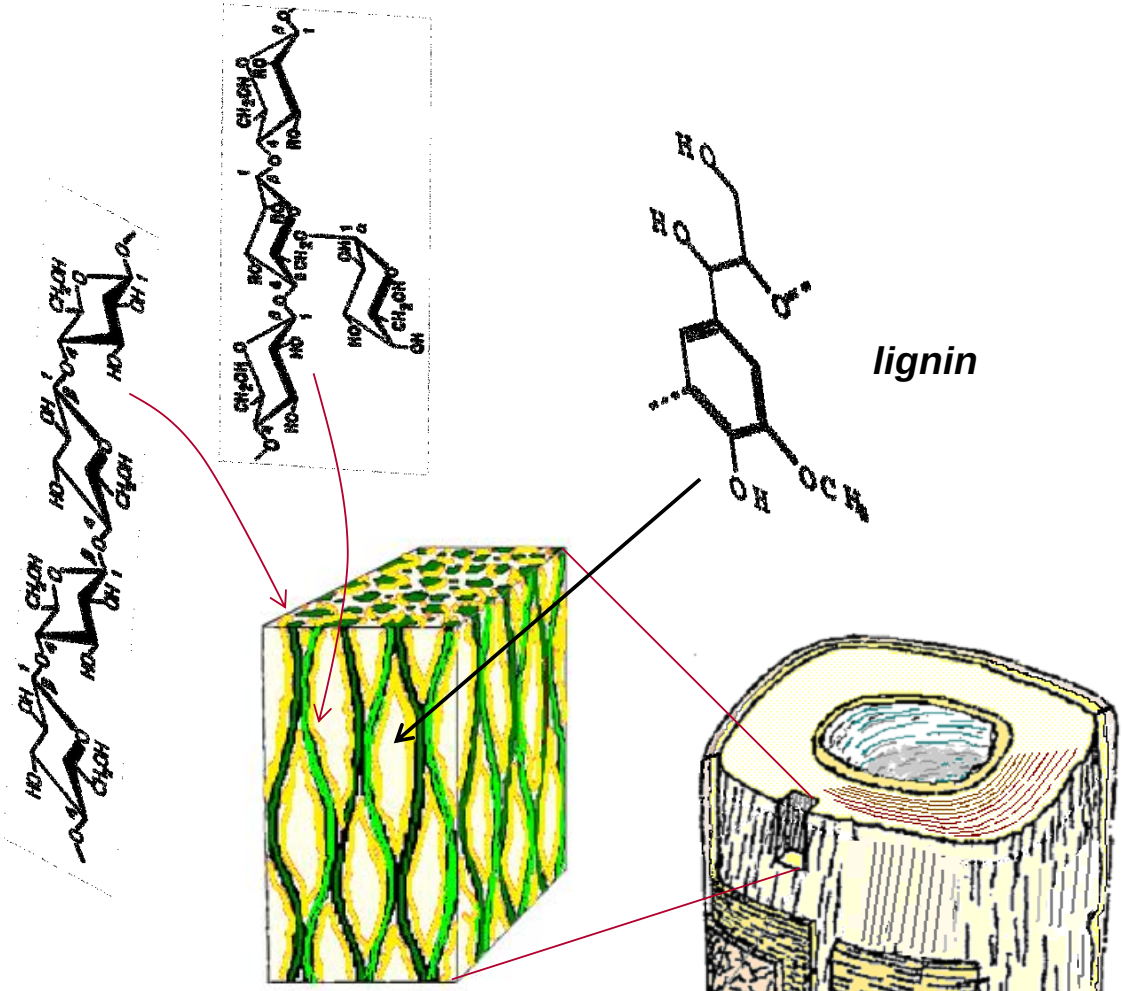


INNVENTIA

Three-dimensional lenticular structure of cell wall



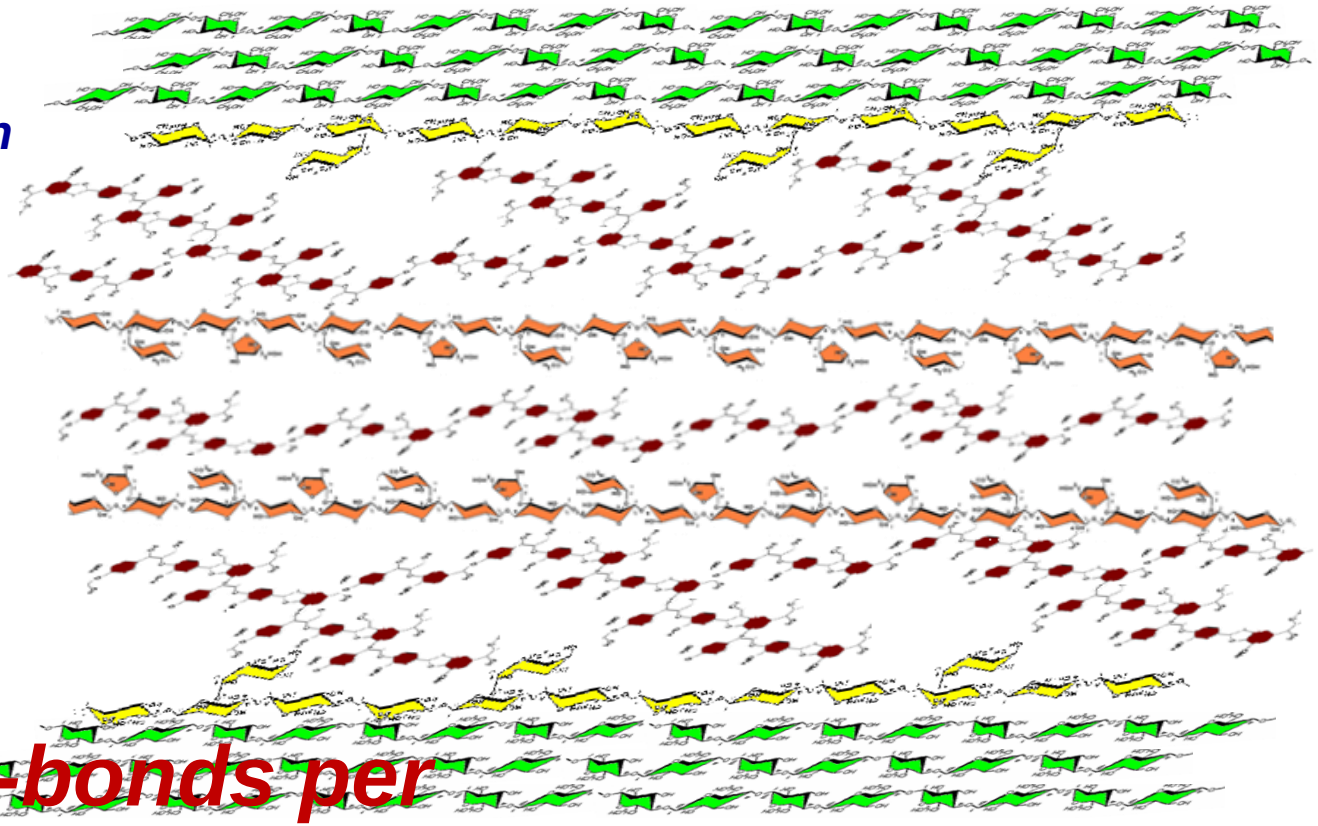
Space restrictions for lignin deposition



lignin

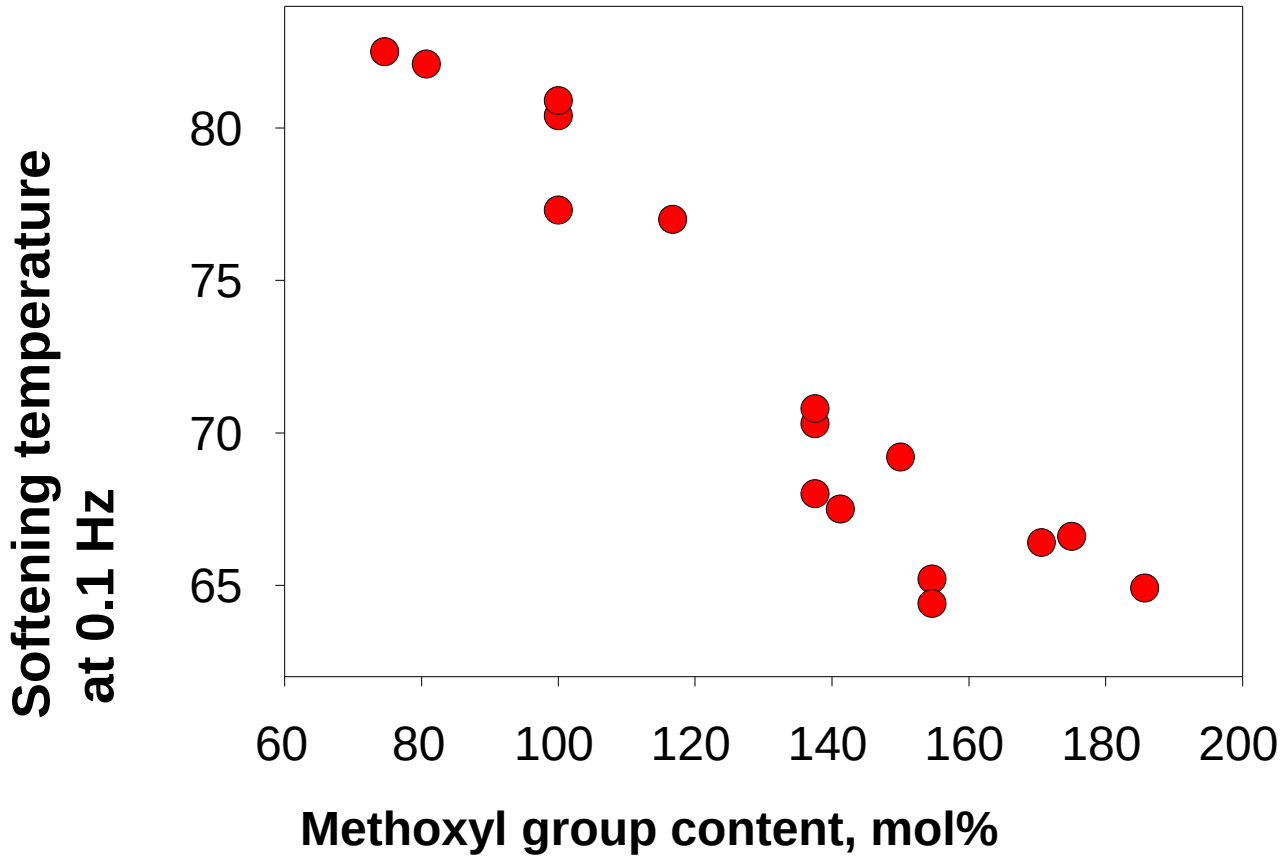
cellulose/hemicellulose
undulating structure

Different types of secondary wall lignins

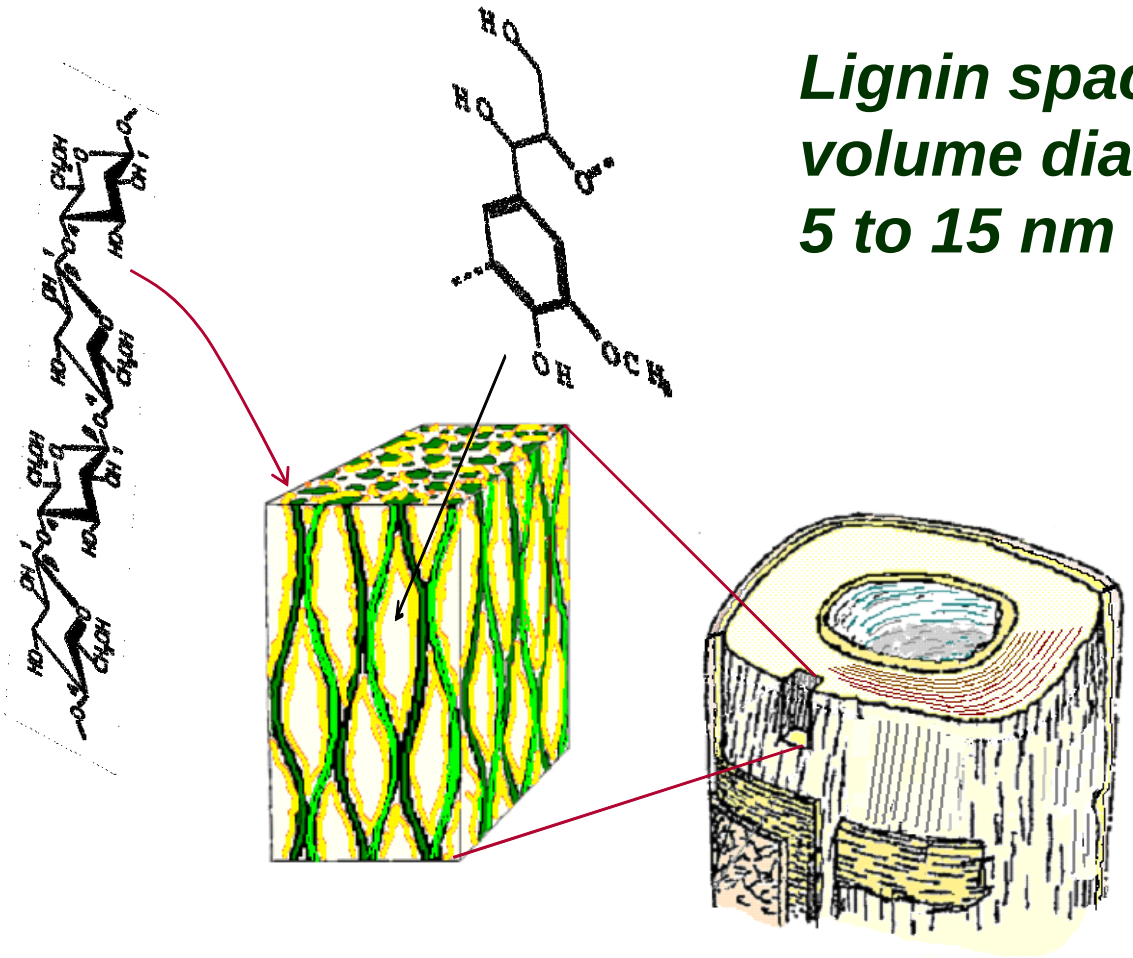


1.6 LCC-bonds per hemicellulose chain

Softening temperature of different wood species



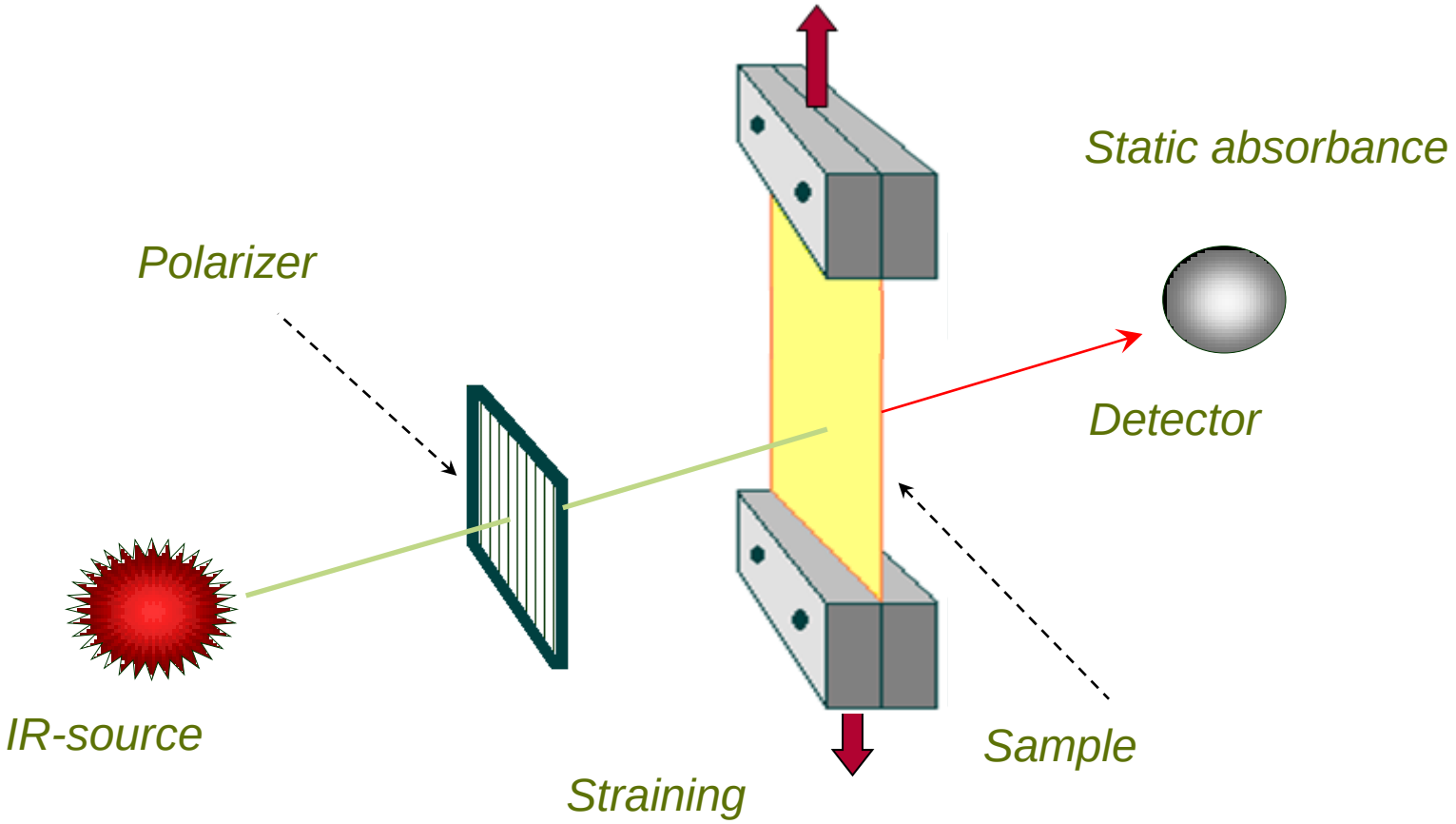
Lignin space



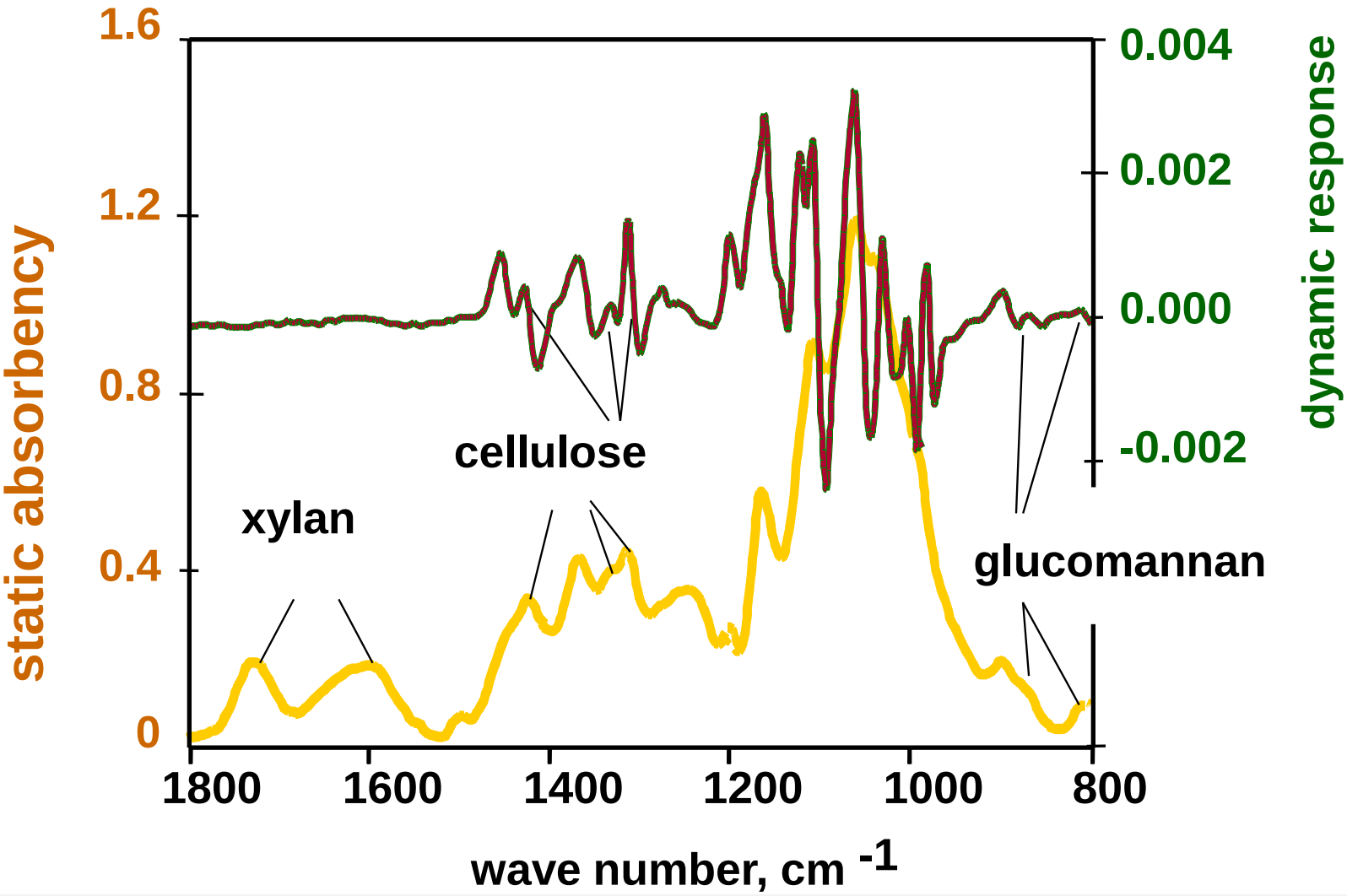
Lignin space volume diameter 5 to 15 nm

INNVENTIA

Polymer interaction - FT-IR spectroscopy

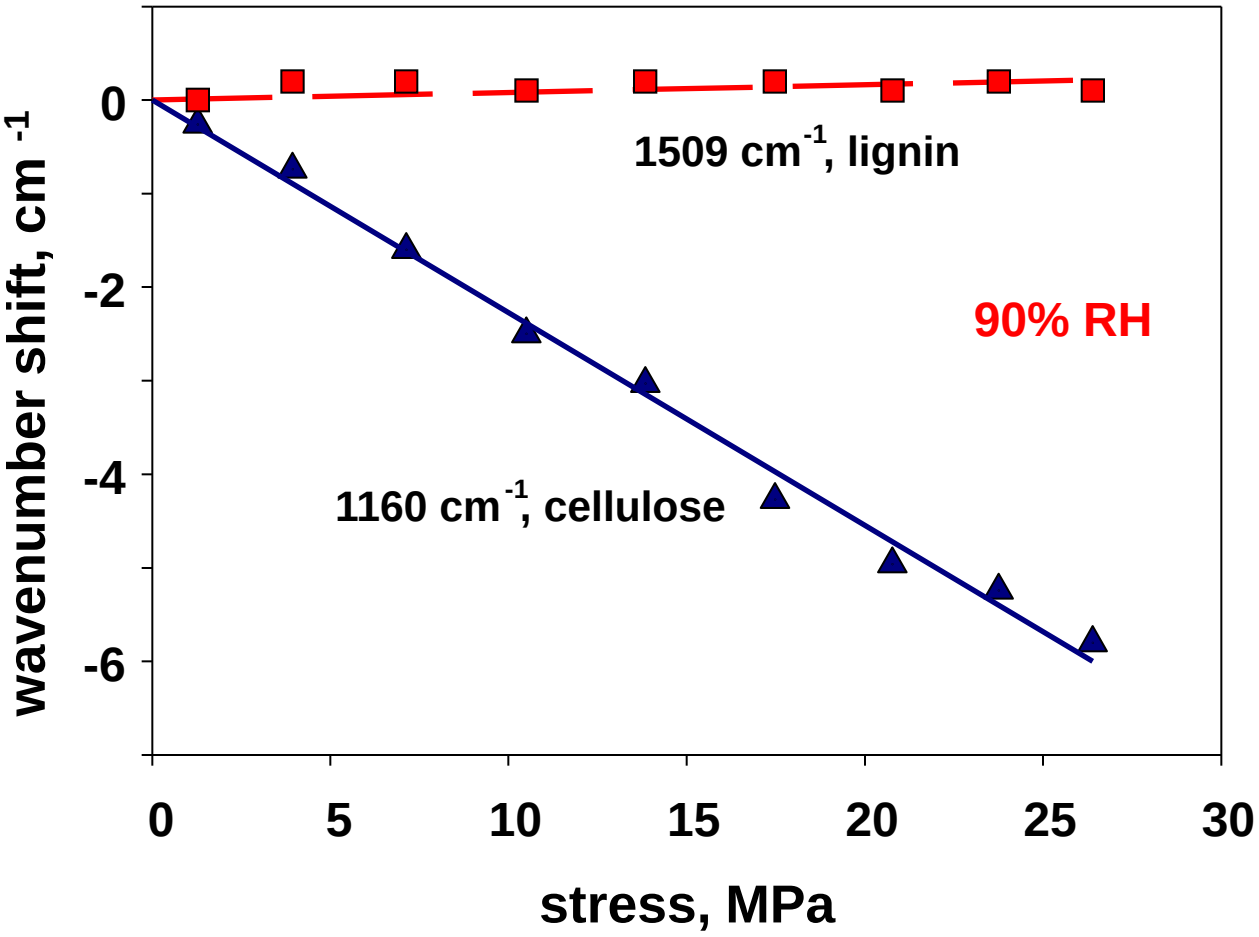


Dynamic FTIR -spectra



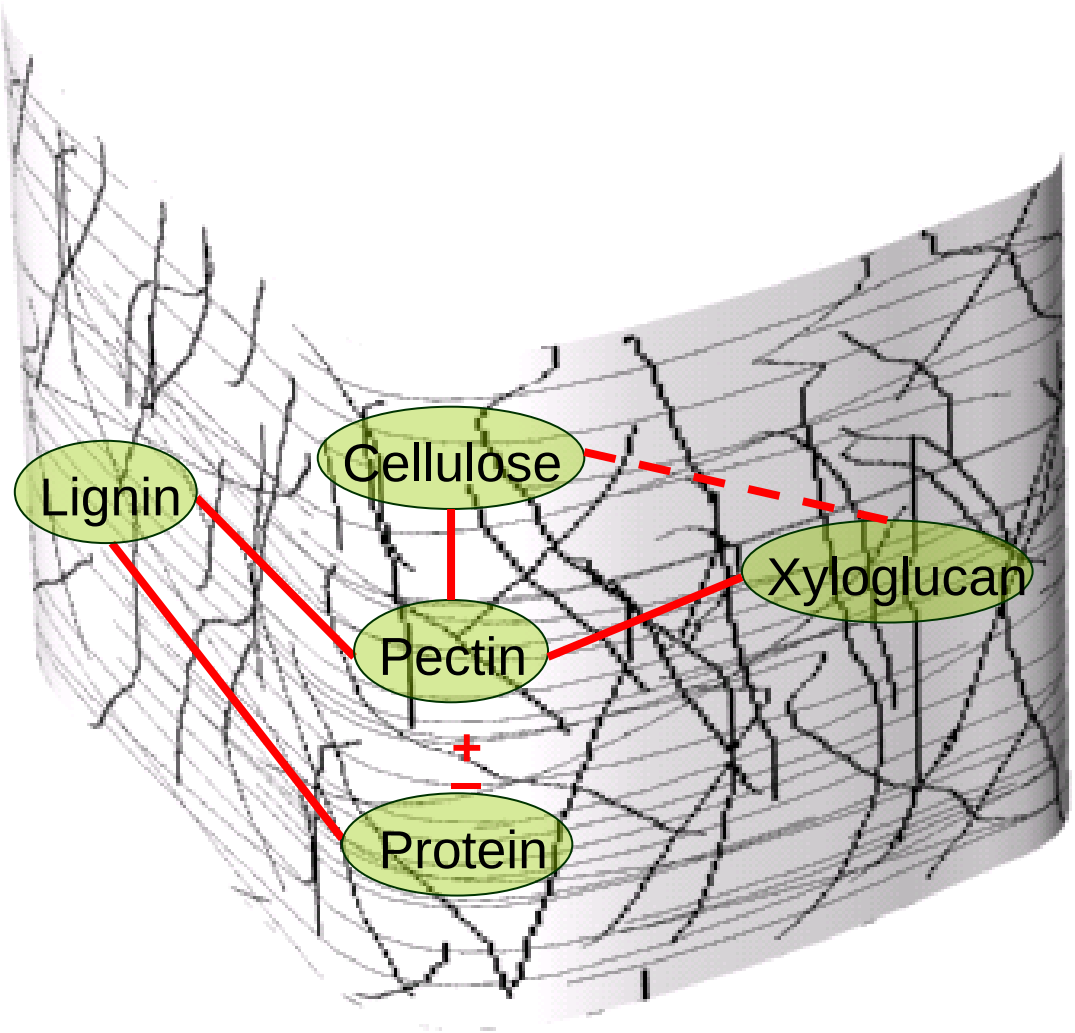
INNVENTIA

Wood – cellulose, lignin deformation

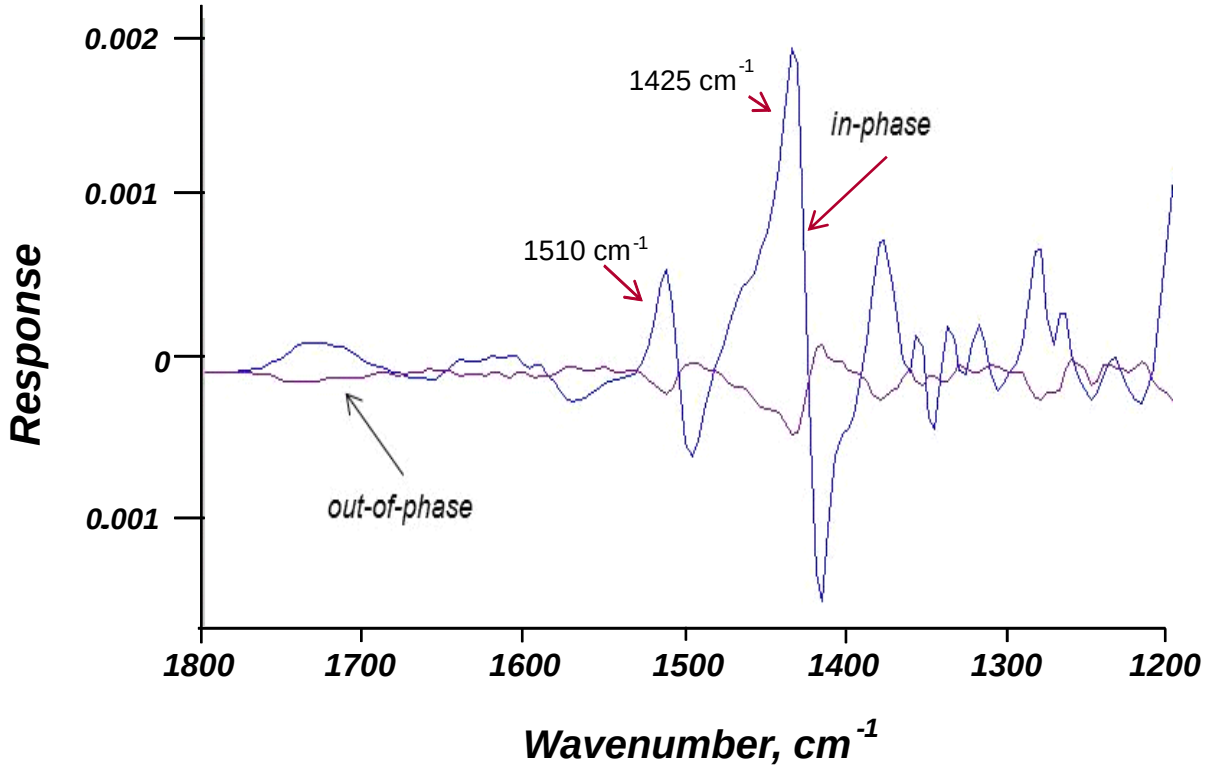


INNVENTIA

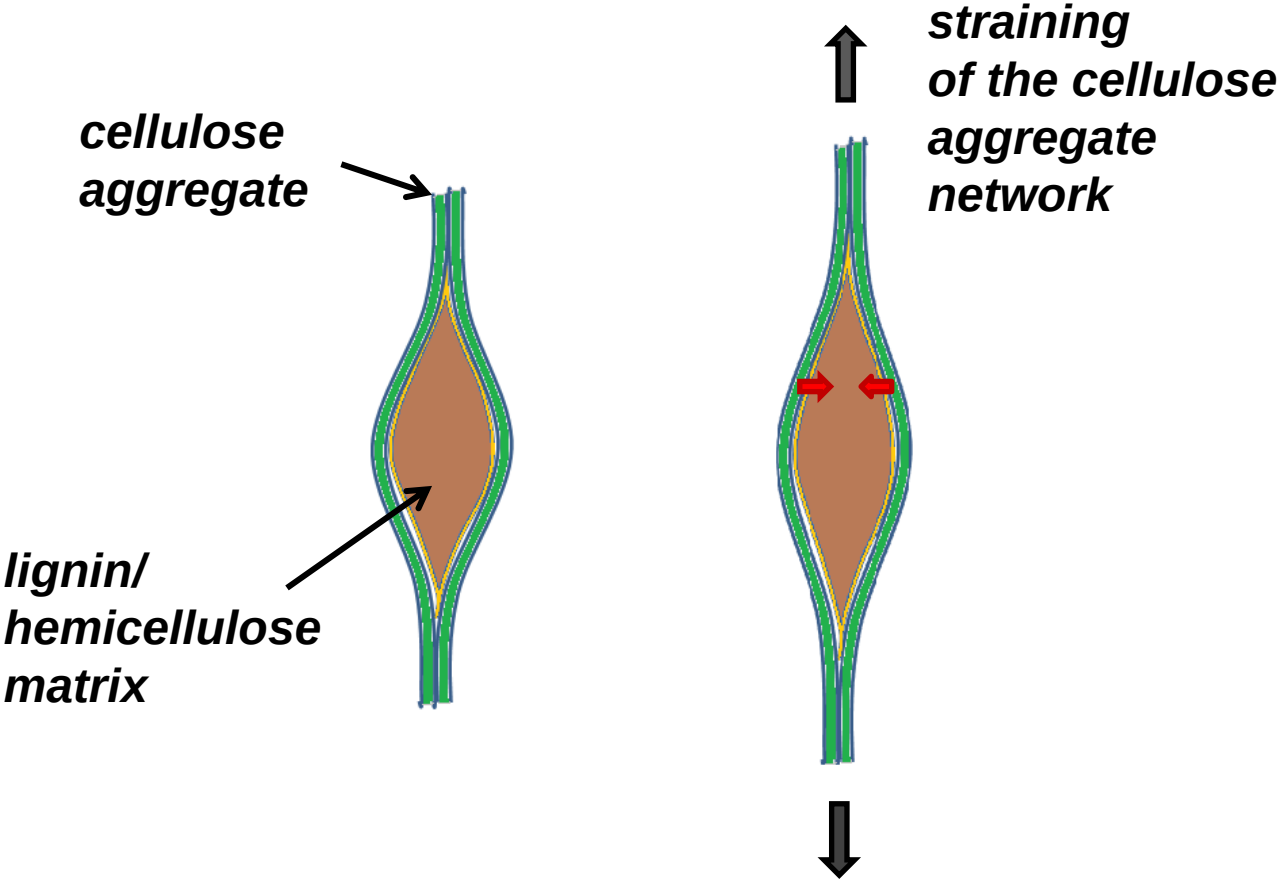
Interactions in the primary cell-wall



Deformation of primary wall

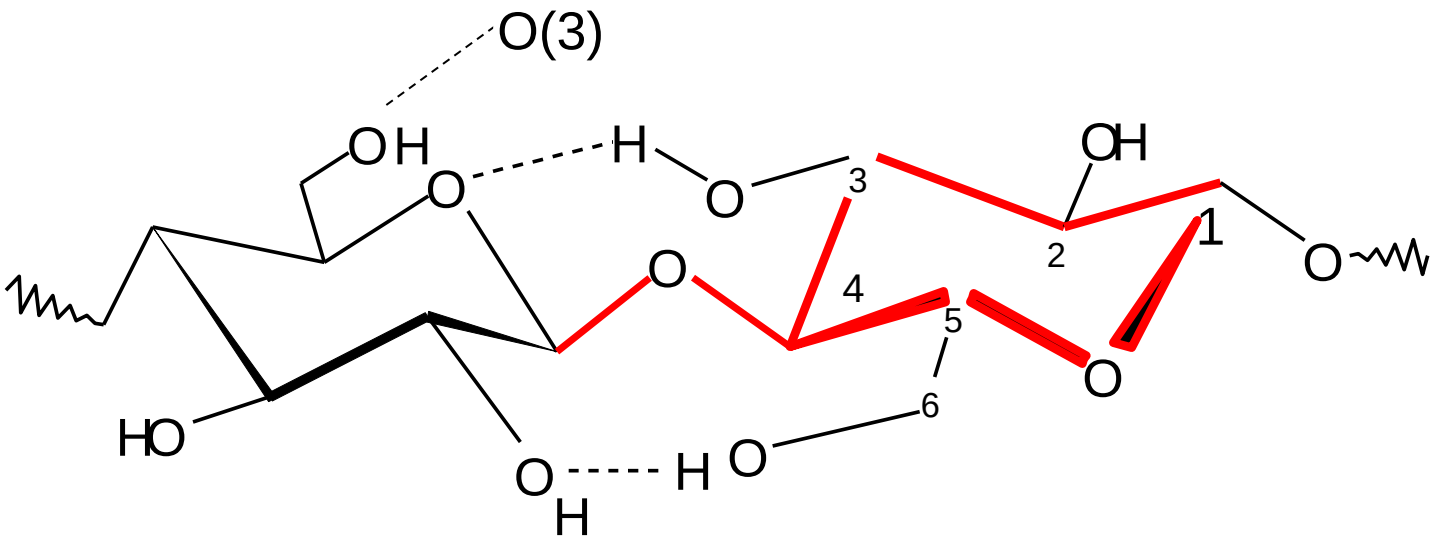


Lignin deformation in secondary wall



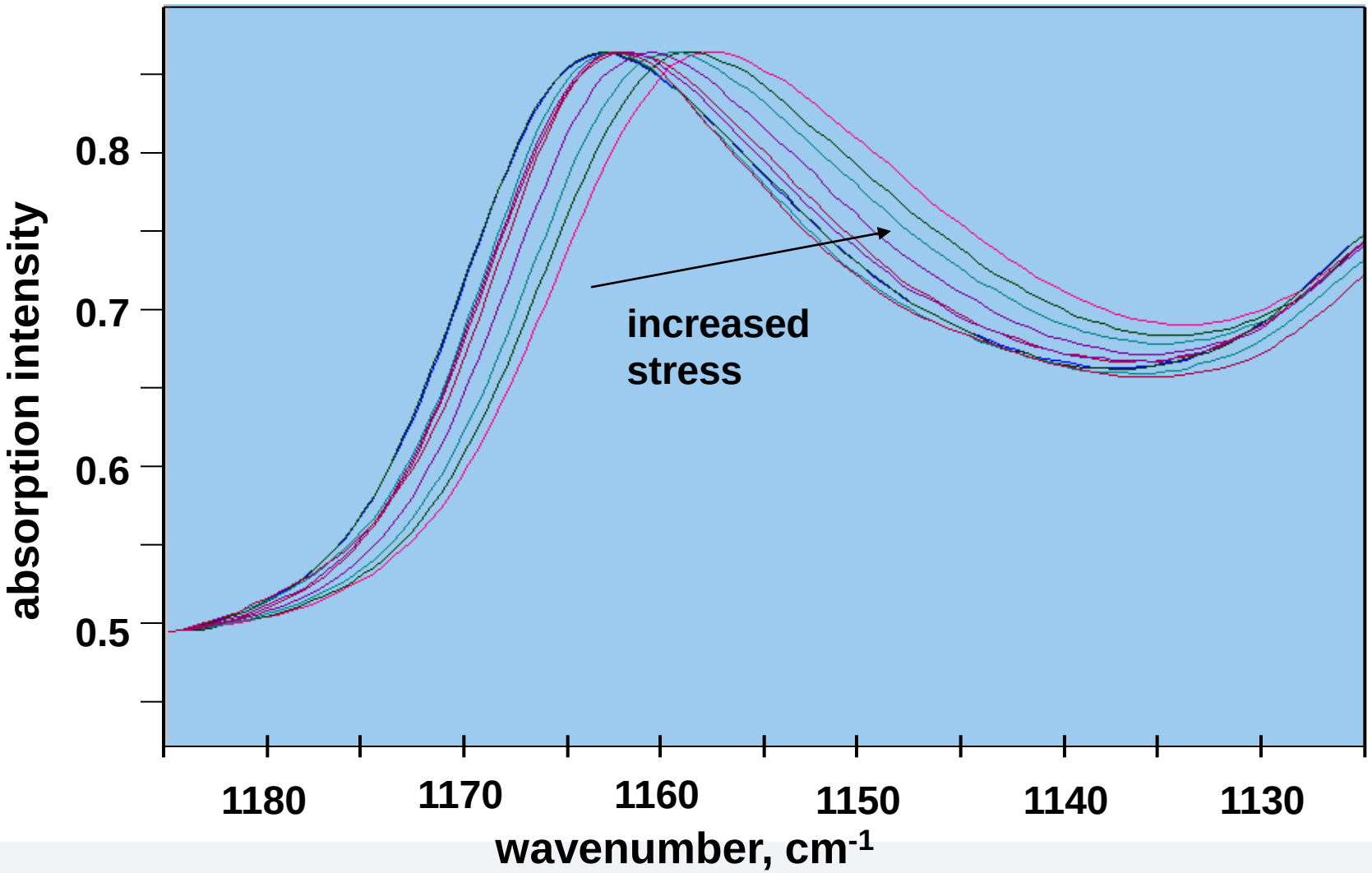
Cellulose – molecular deformation

1160 cm^{-1} deformation

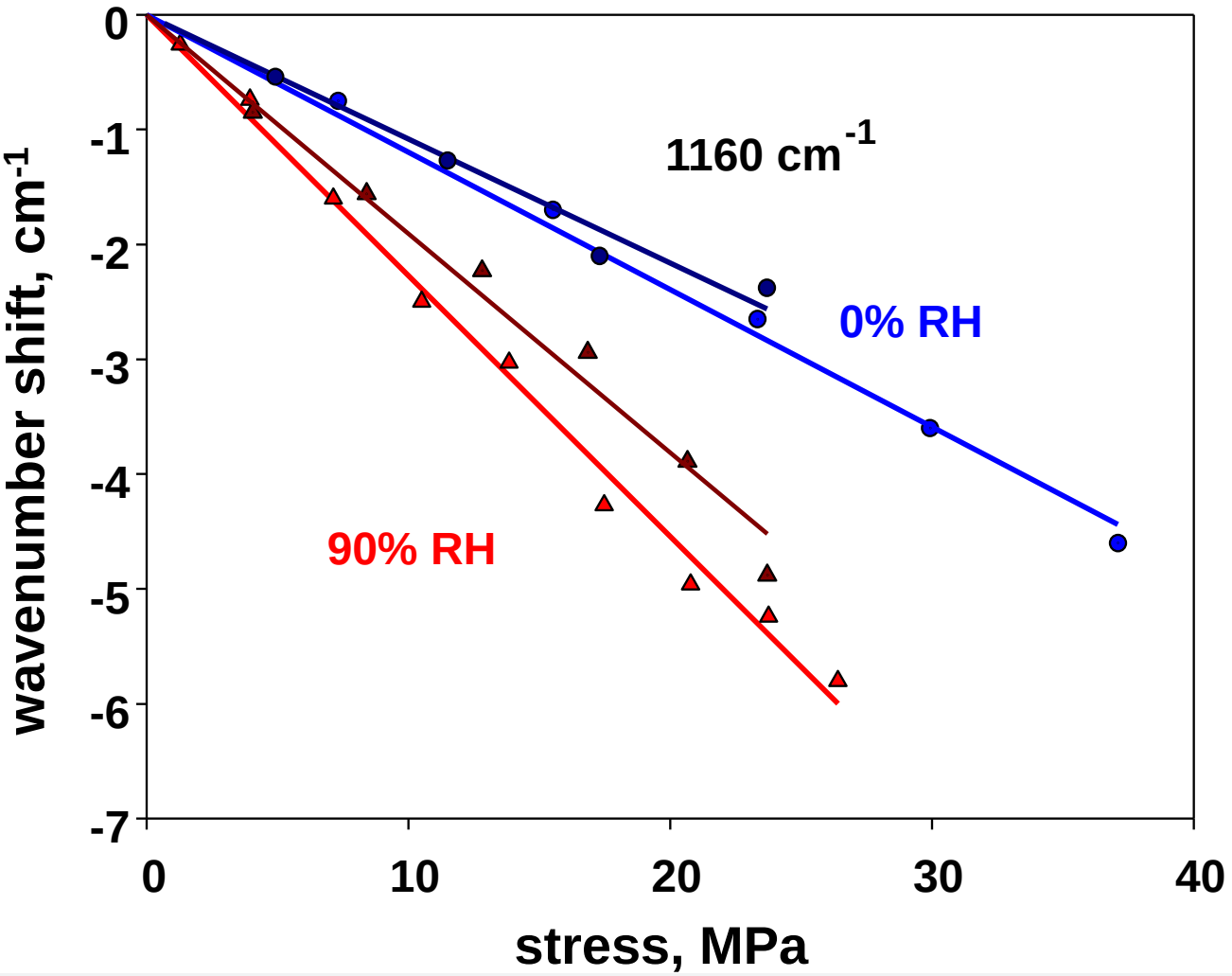


INNVENTIA

Cellulose main chain vibration, 1160 cm^{-1}

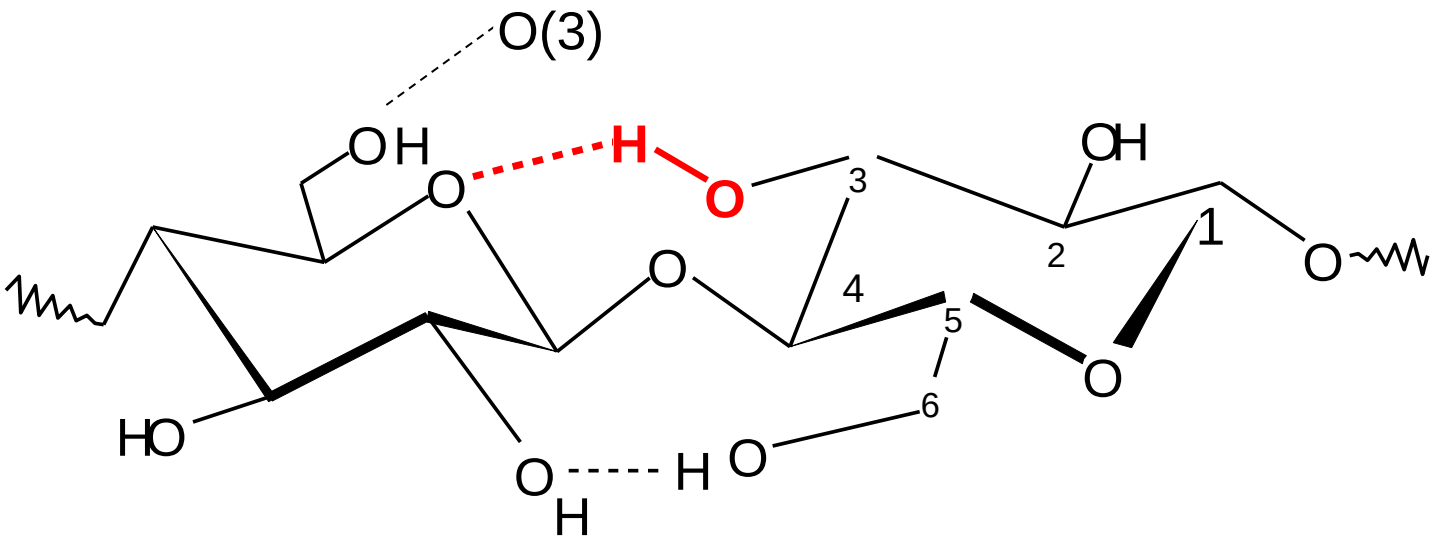


Cellulose chain deformation

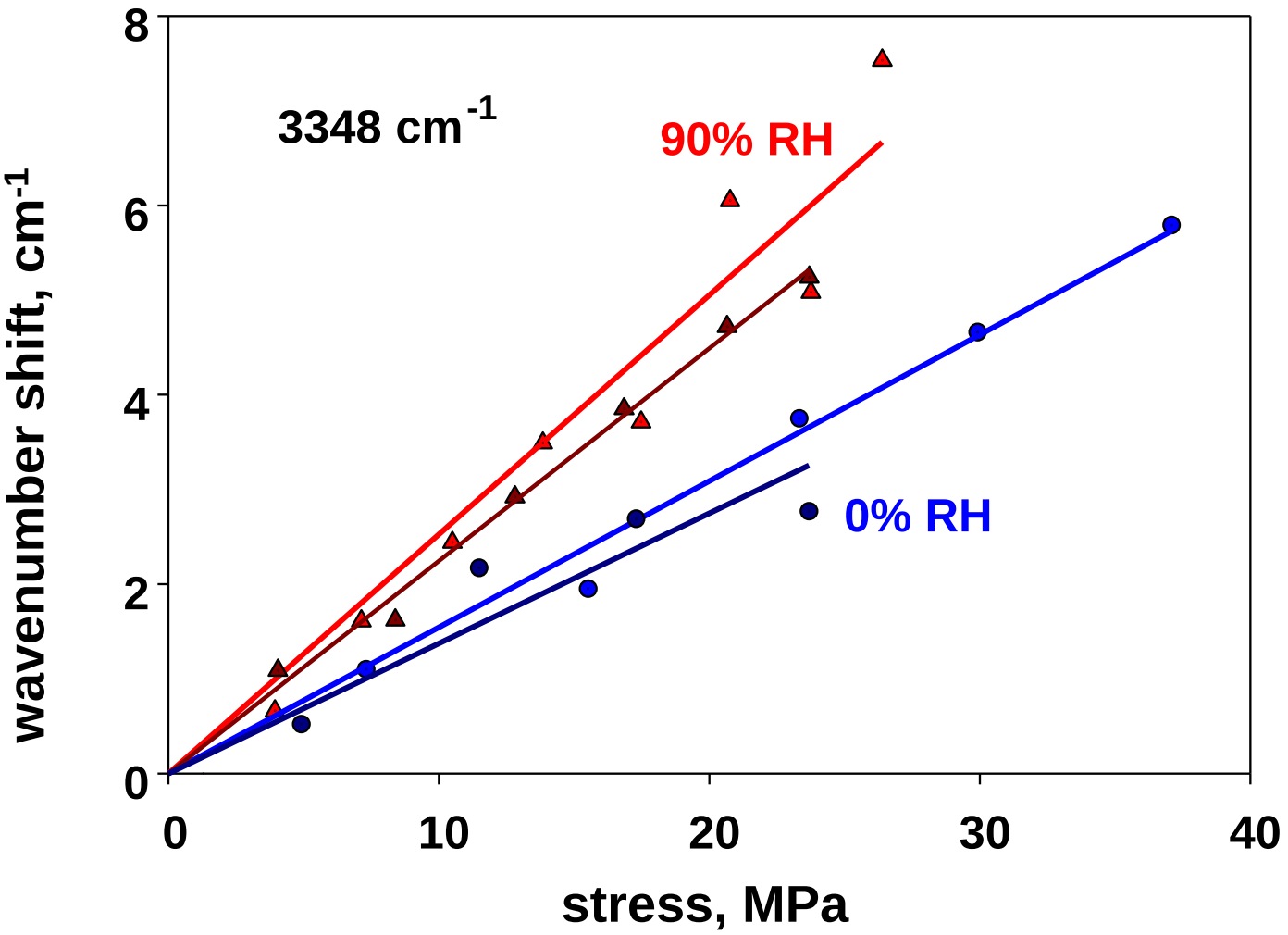


Stretching of the hydrogen bond

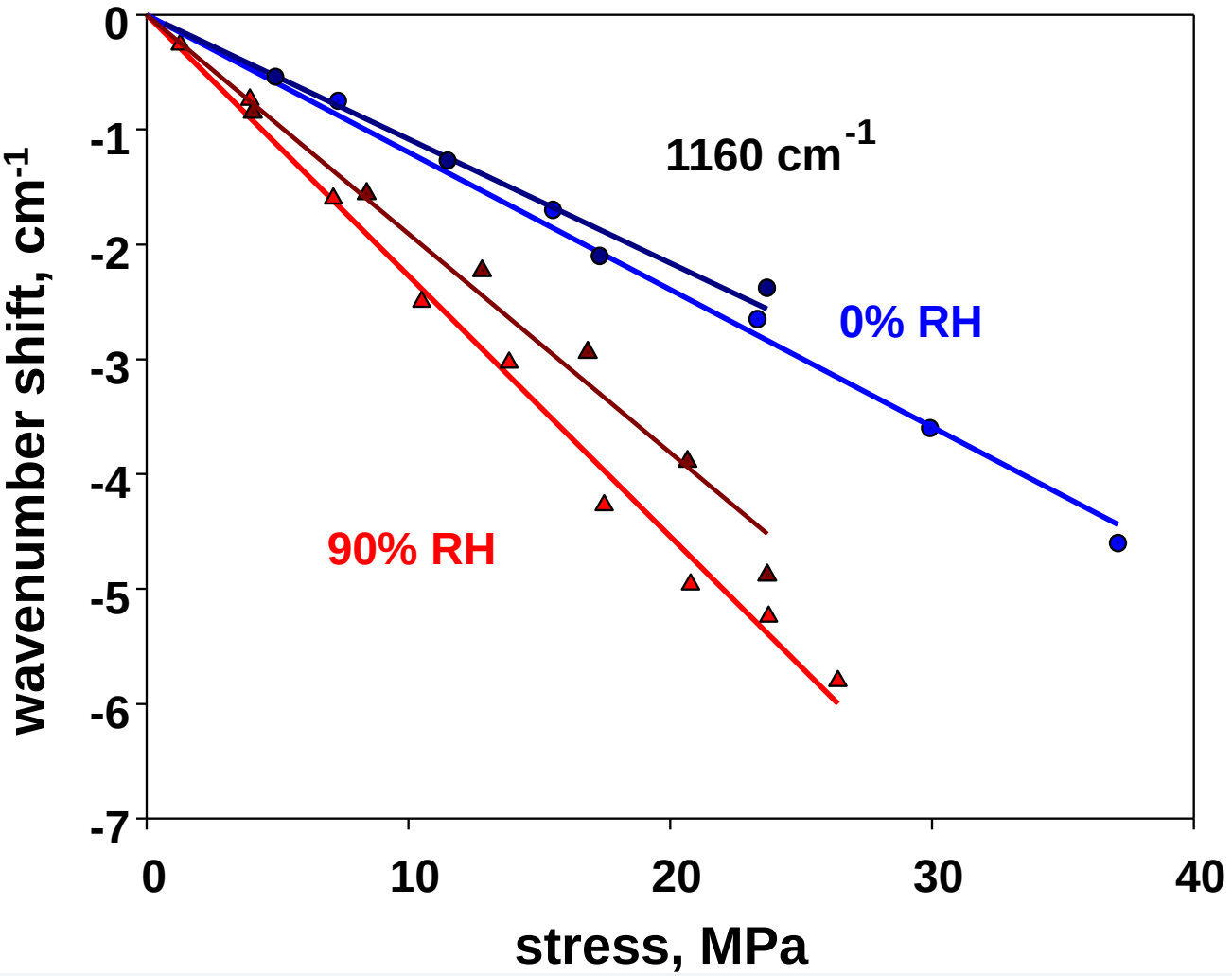
3348 cm^{-1} deformation



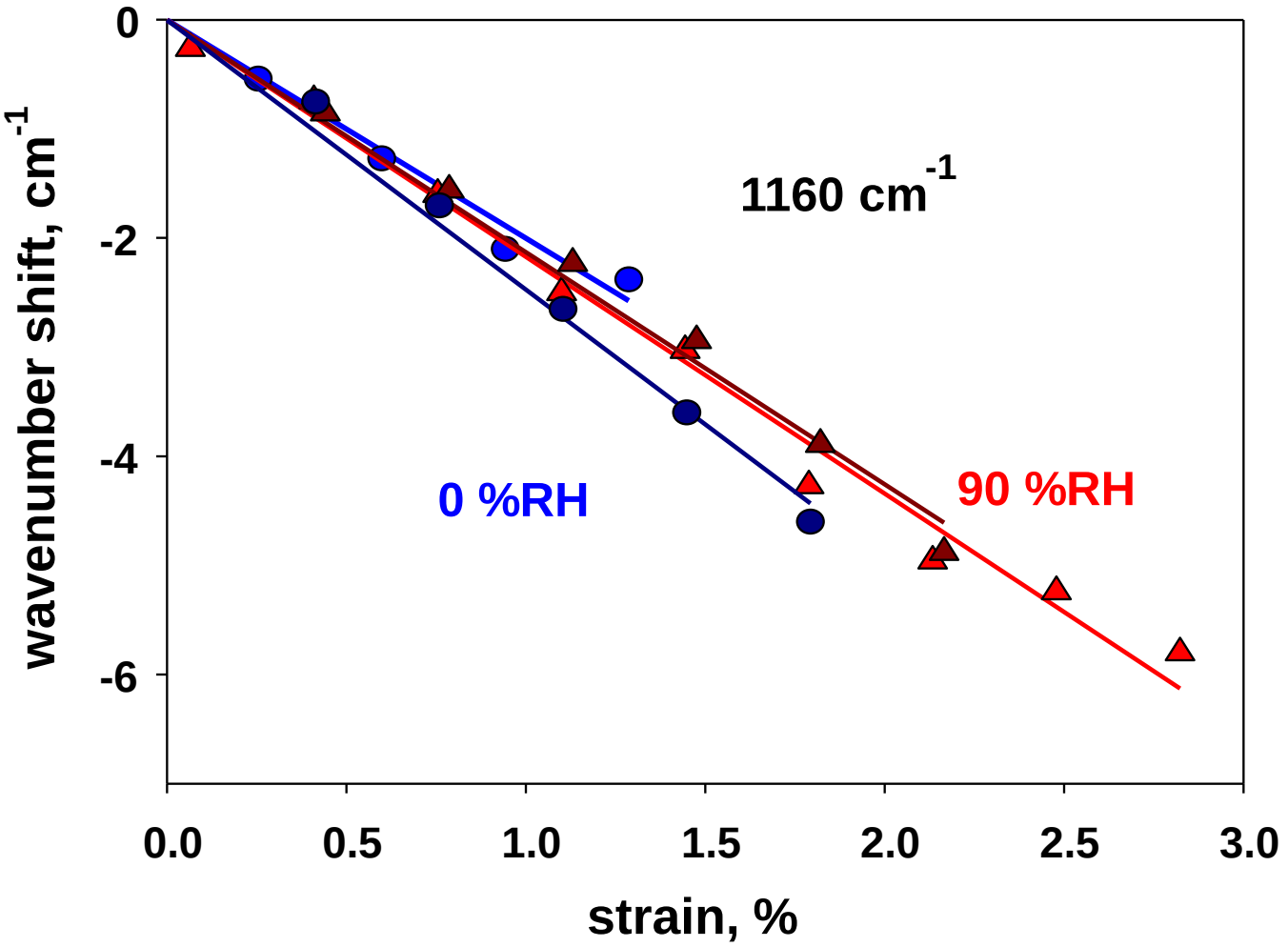
Deformation - OH



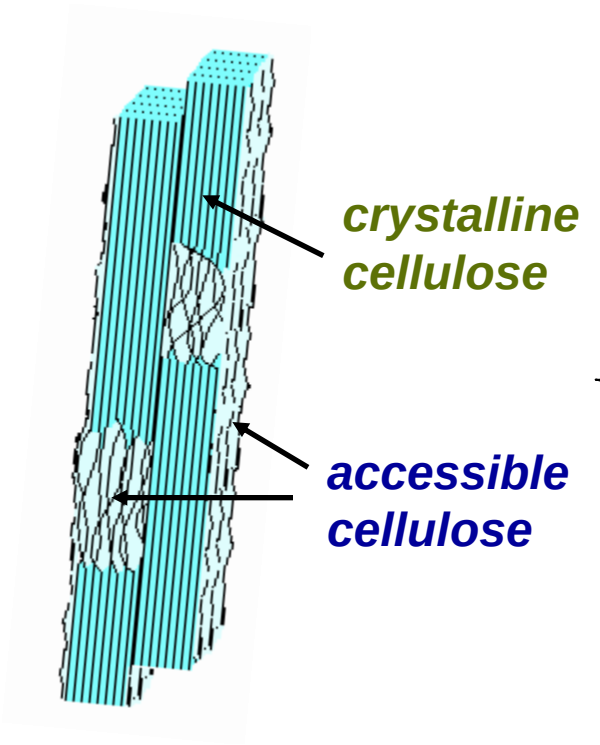
Cellulose chain deformation



Relation to strain



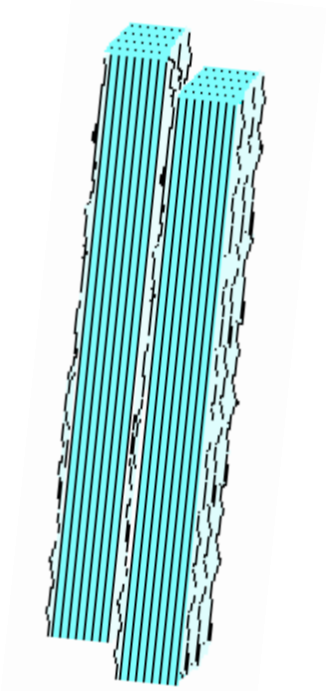
Accessible regions more or less arranged parallel to the cellulose crystalls



crystalline cellulose

accessible cellulose

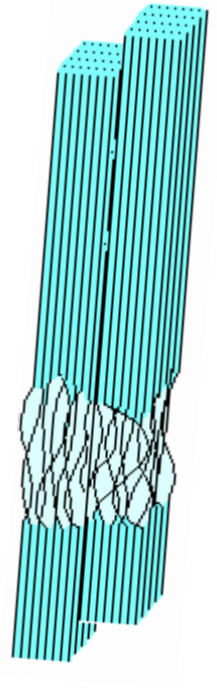
equal strain



parallel arrangement of cellulose structures

or

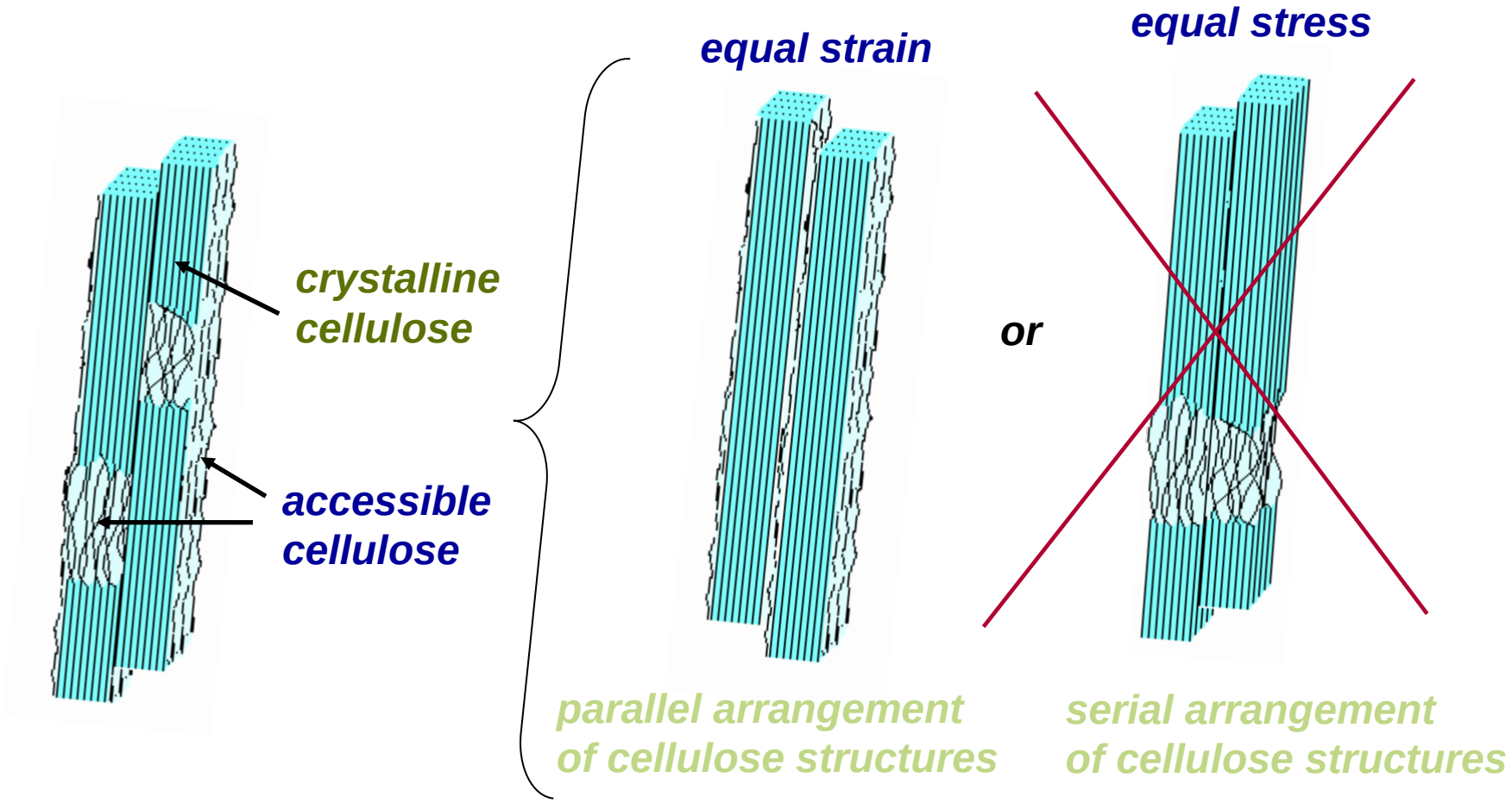
equal stress



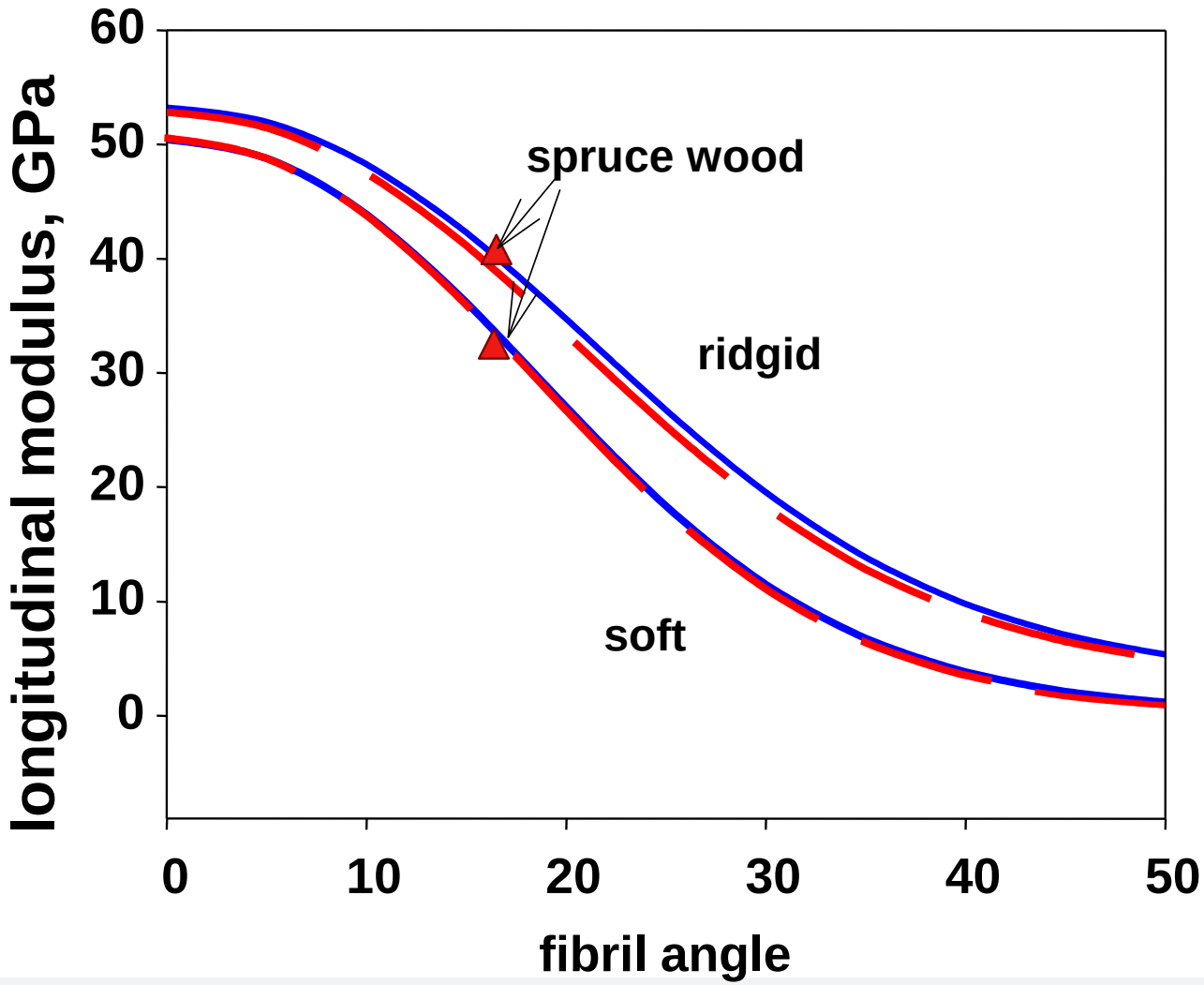
serial arrangement of cellulose structures

INNVENTIA

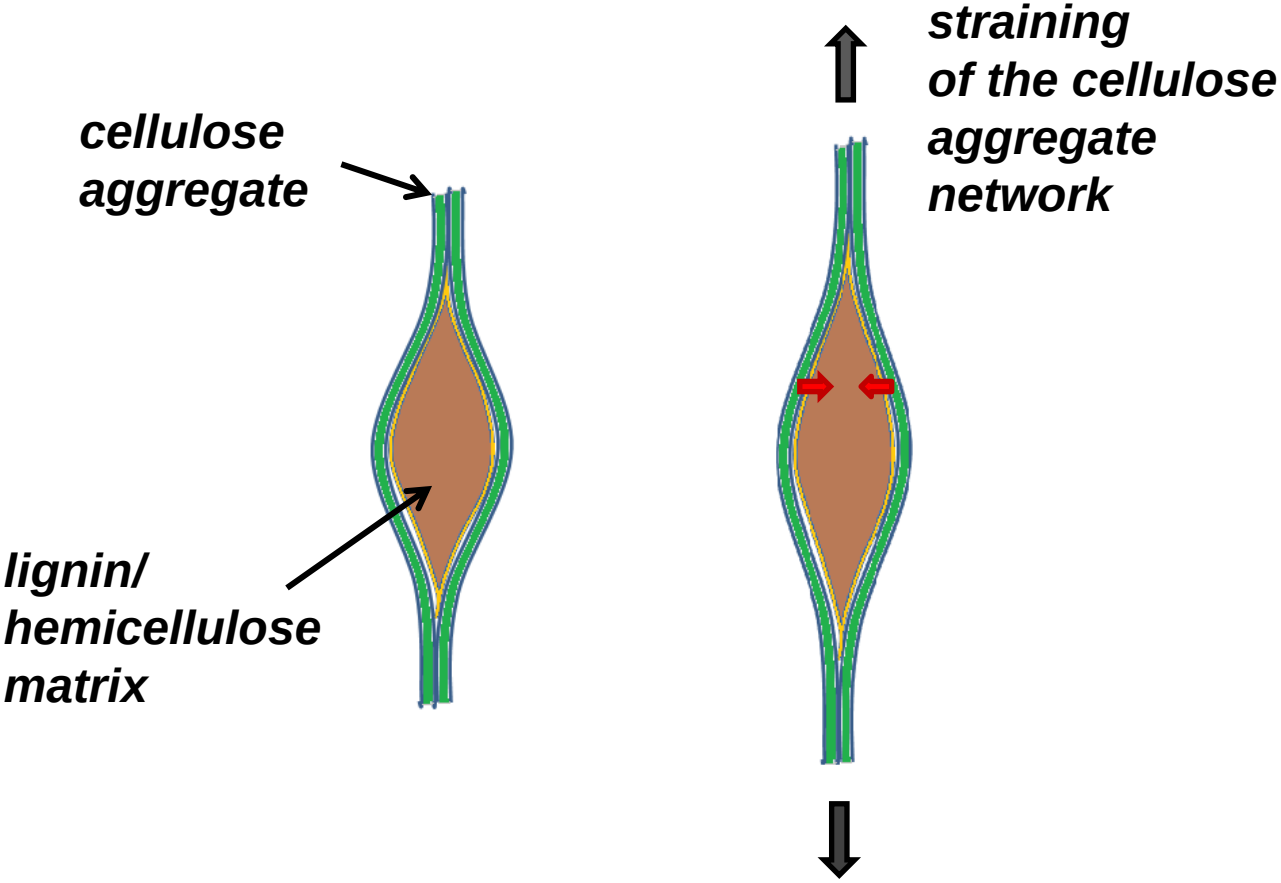
Accessible regions more or less arranged parallel to the cellulose crystalls



Softening in RH region



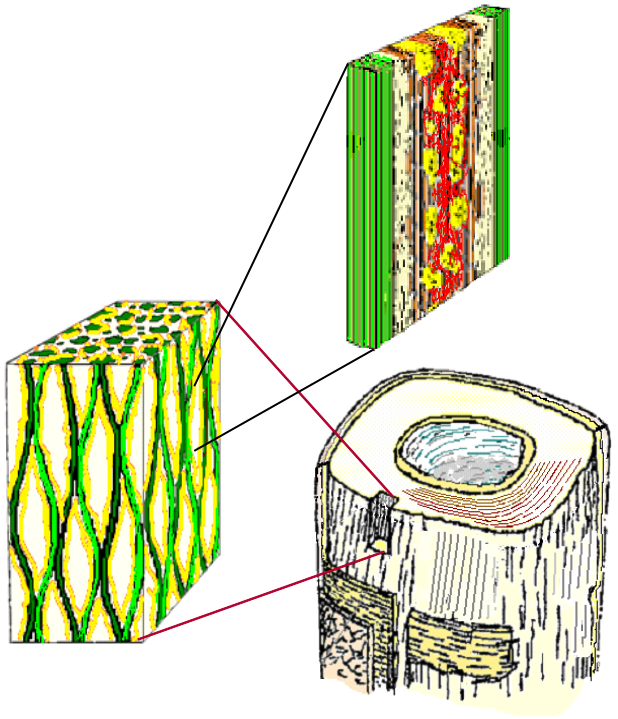
Cellulose – load bearing structure



Disintegration of cell wall

- ***Combination of;***
  - ***Chemical -***
  - ***Enzymatic -***
  - ***Mechanical -***

    approaches



INNVENTIA