Cell wall accessibility

Callum Hill

Centre for Timber Engineering

Edinburgh Napier University

ERPem

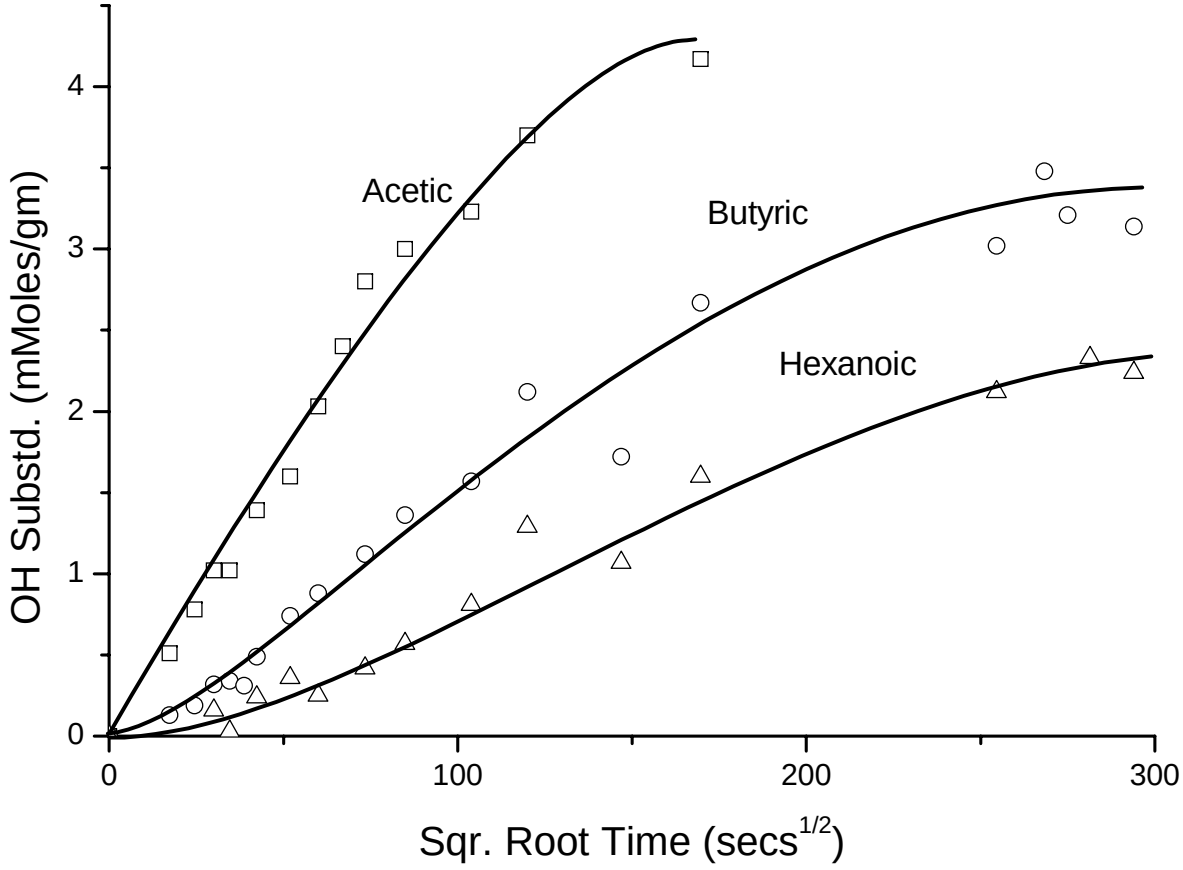
Edinburgh Research Partnership in Engineering and Mathematics

CTE

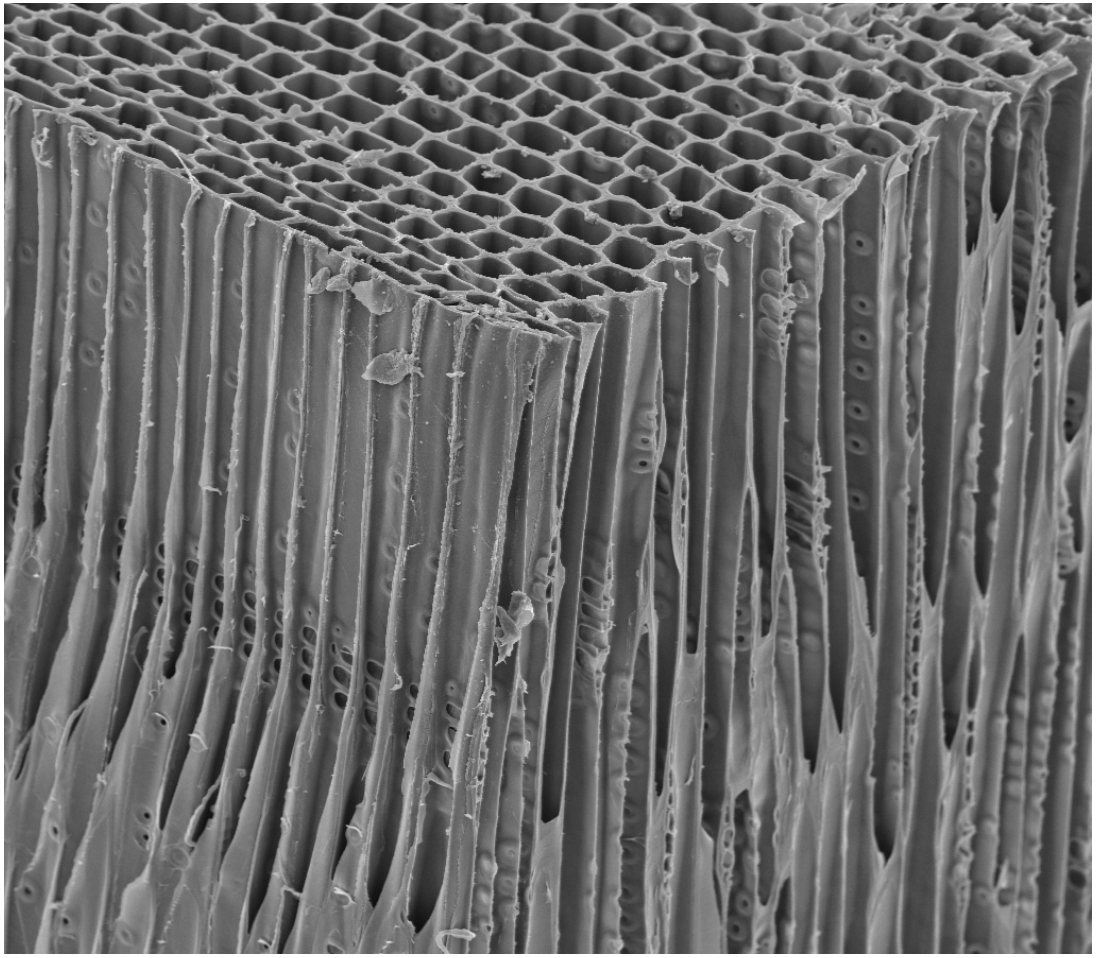
THE CENTRE FOR TIMBER ENGINEERING

Edinburgh Napier UNIVERSITY

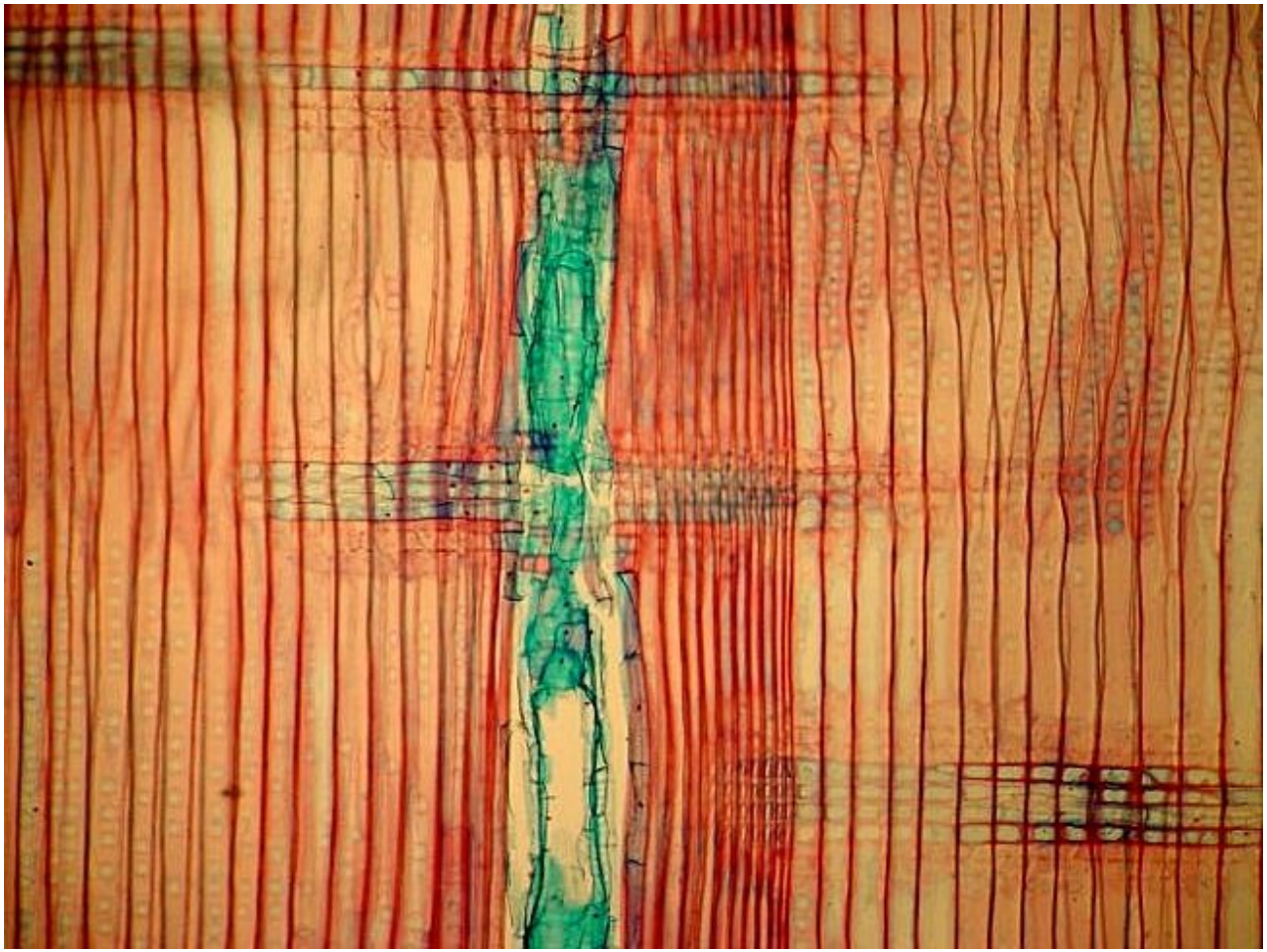
25 hours' reaction

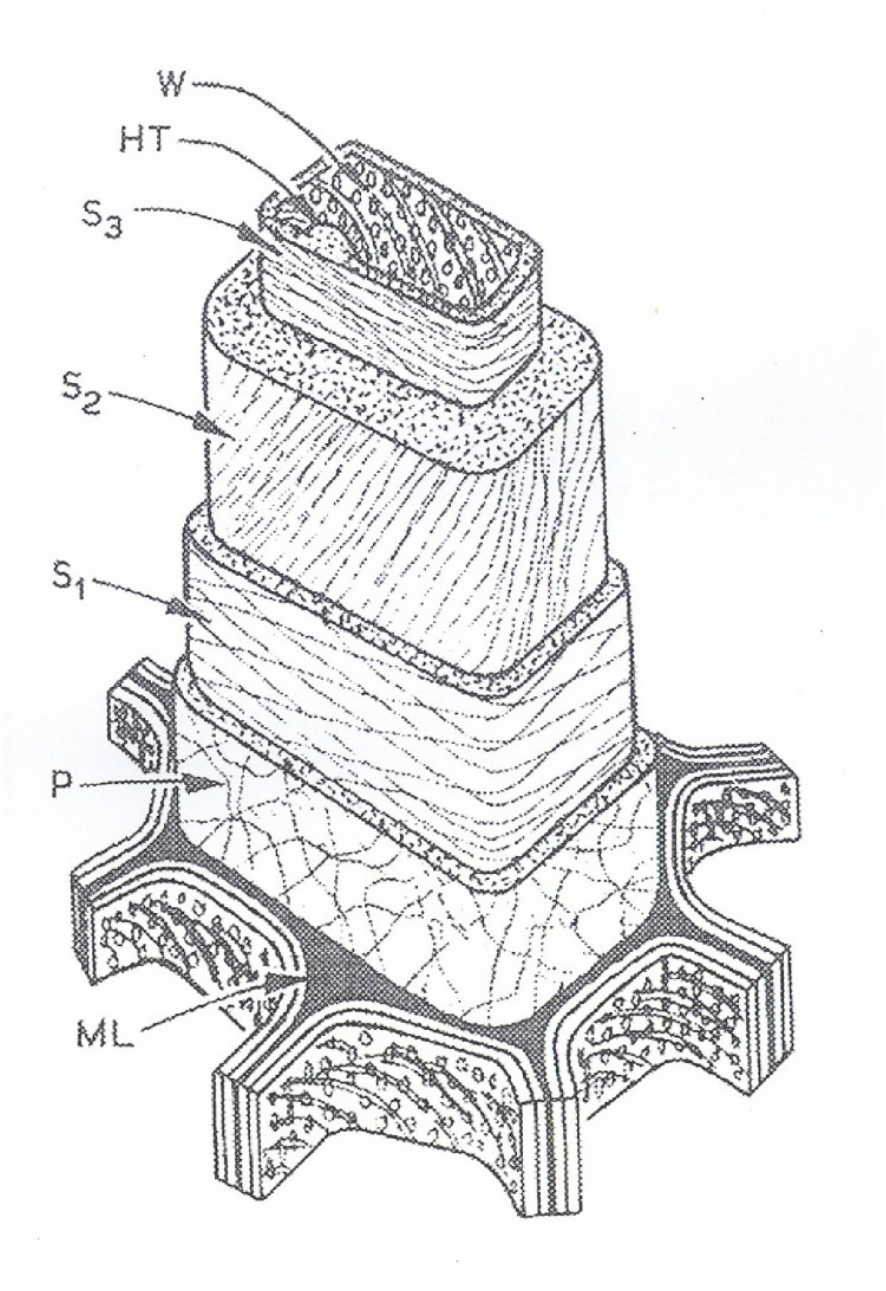


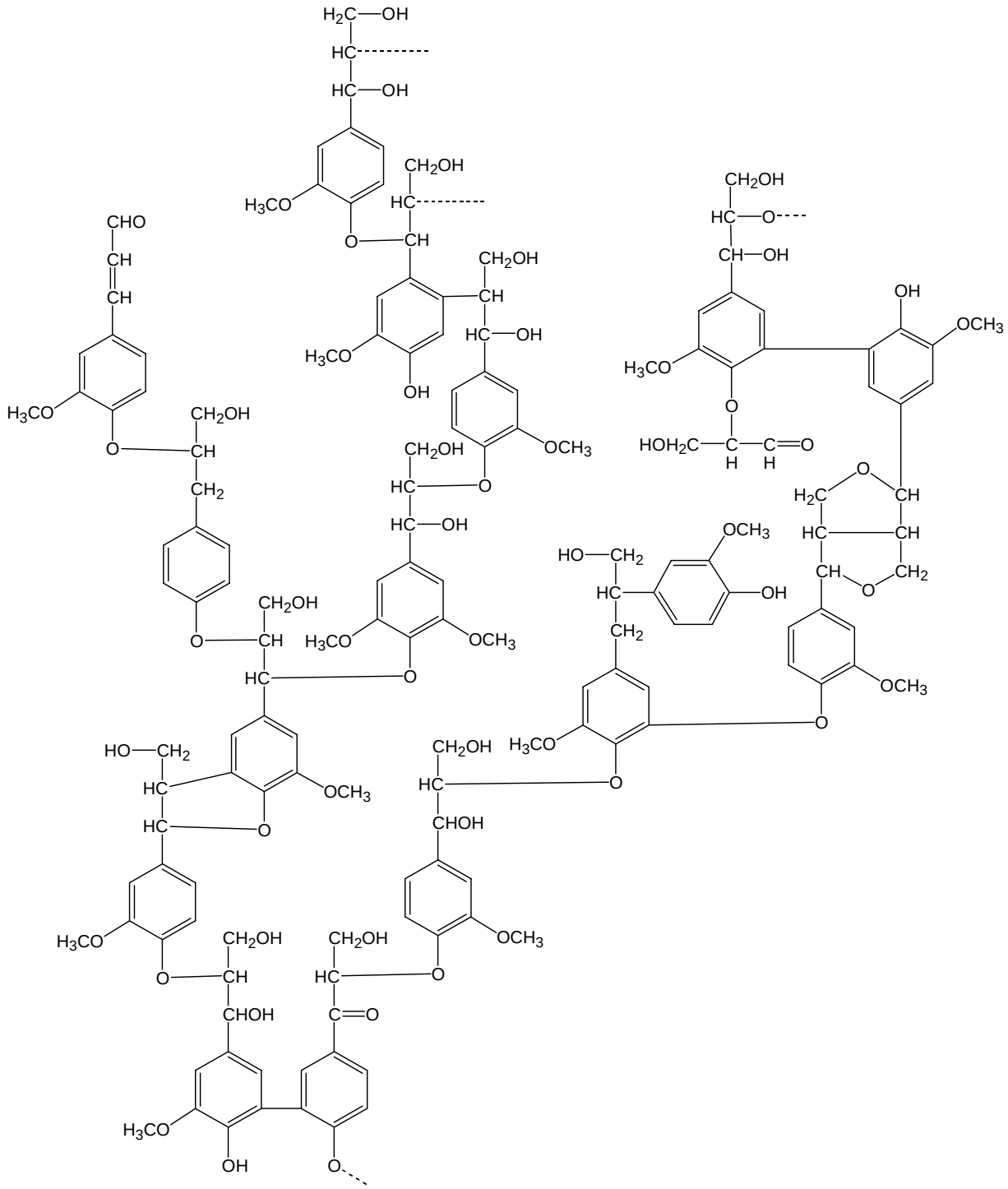
Pinus sylvestris

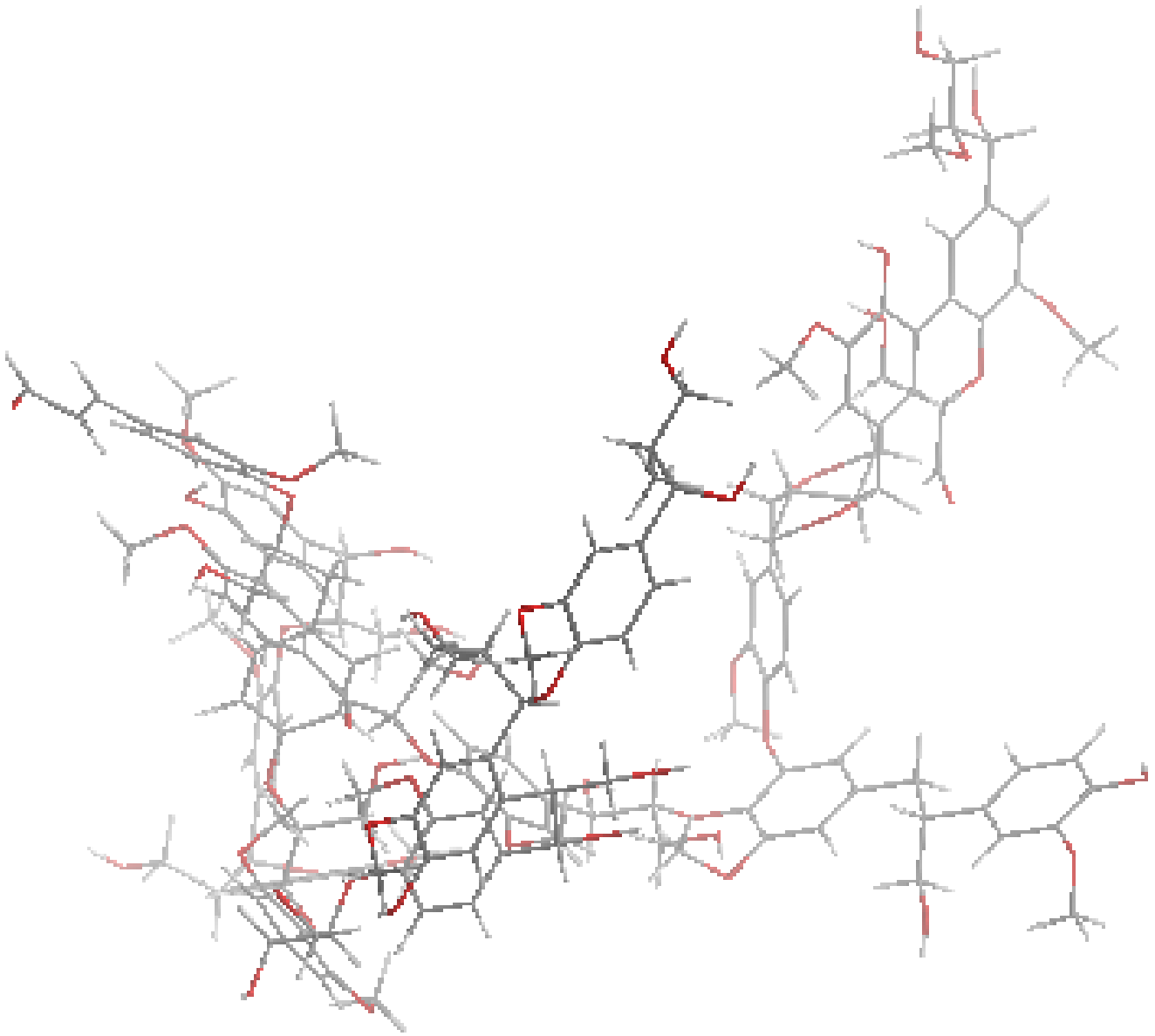


Pinus sylvestris

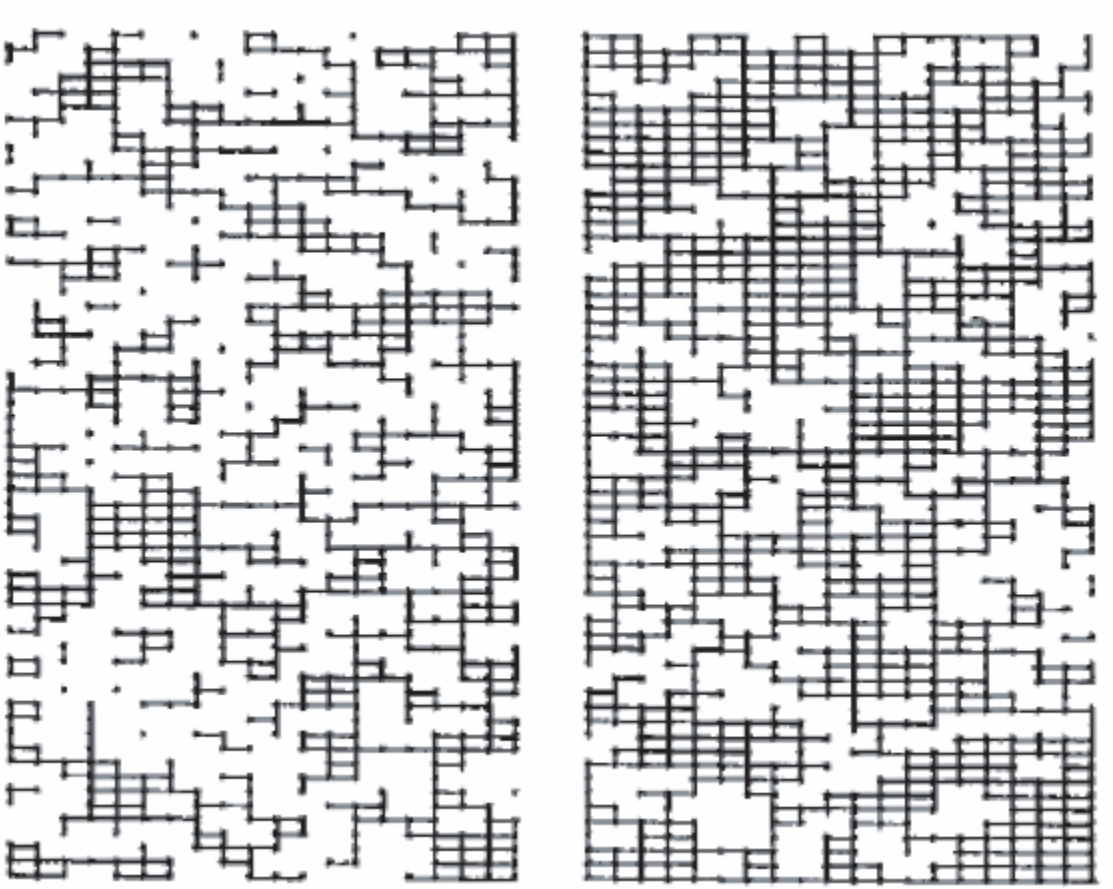



W
HT
S3
S2
S1
P
ML

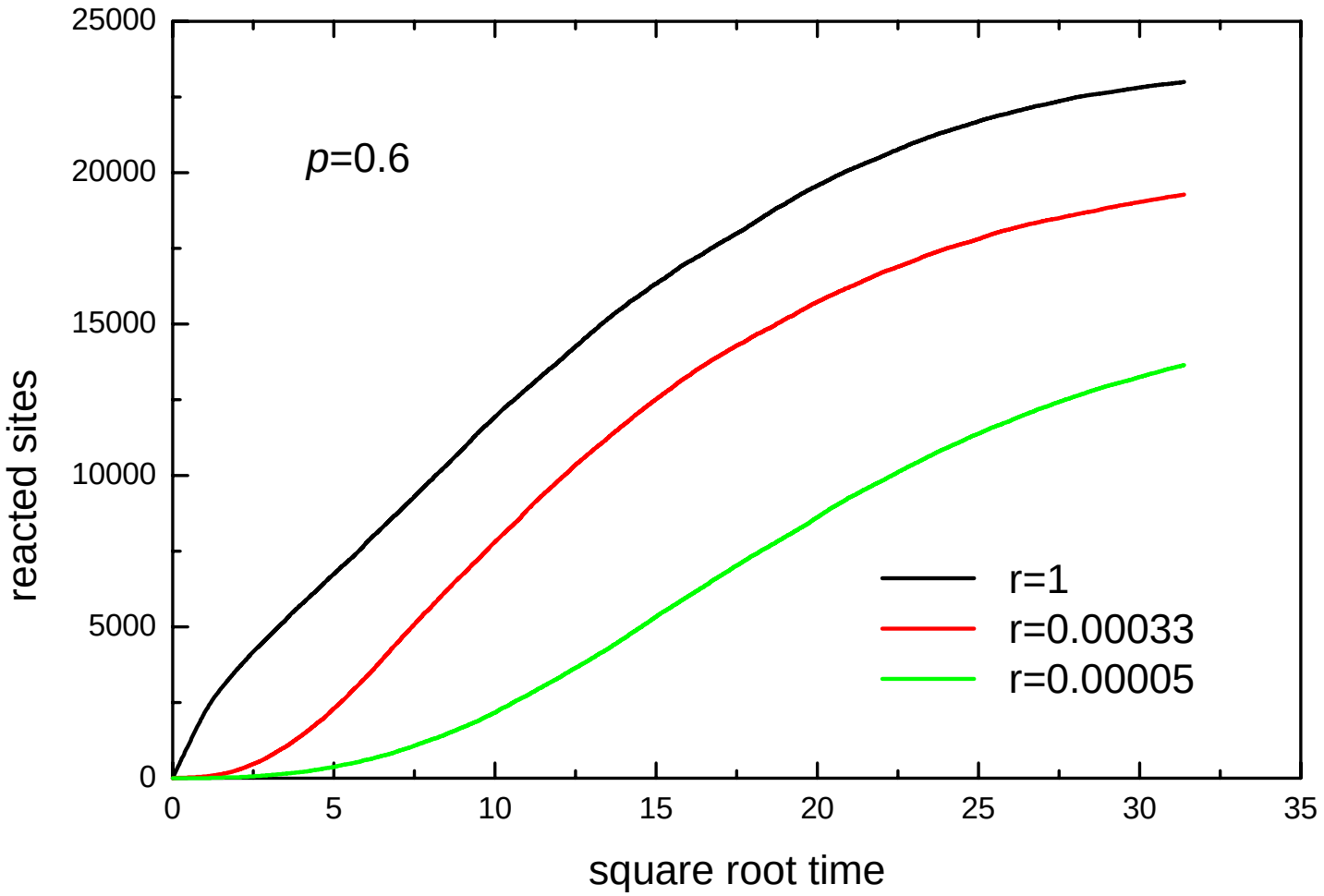




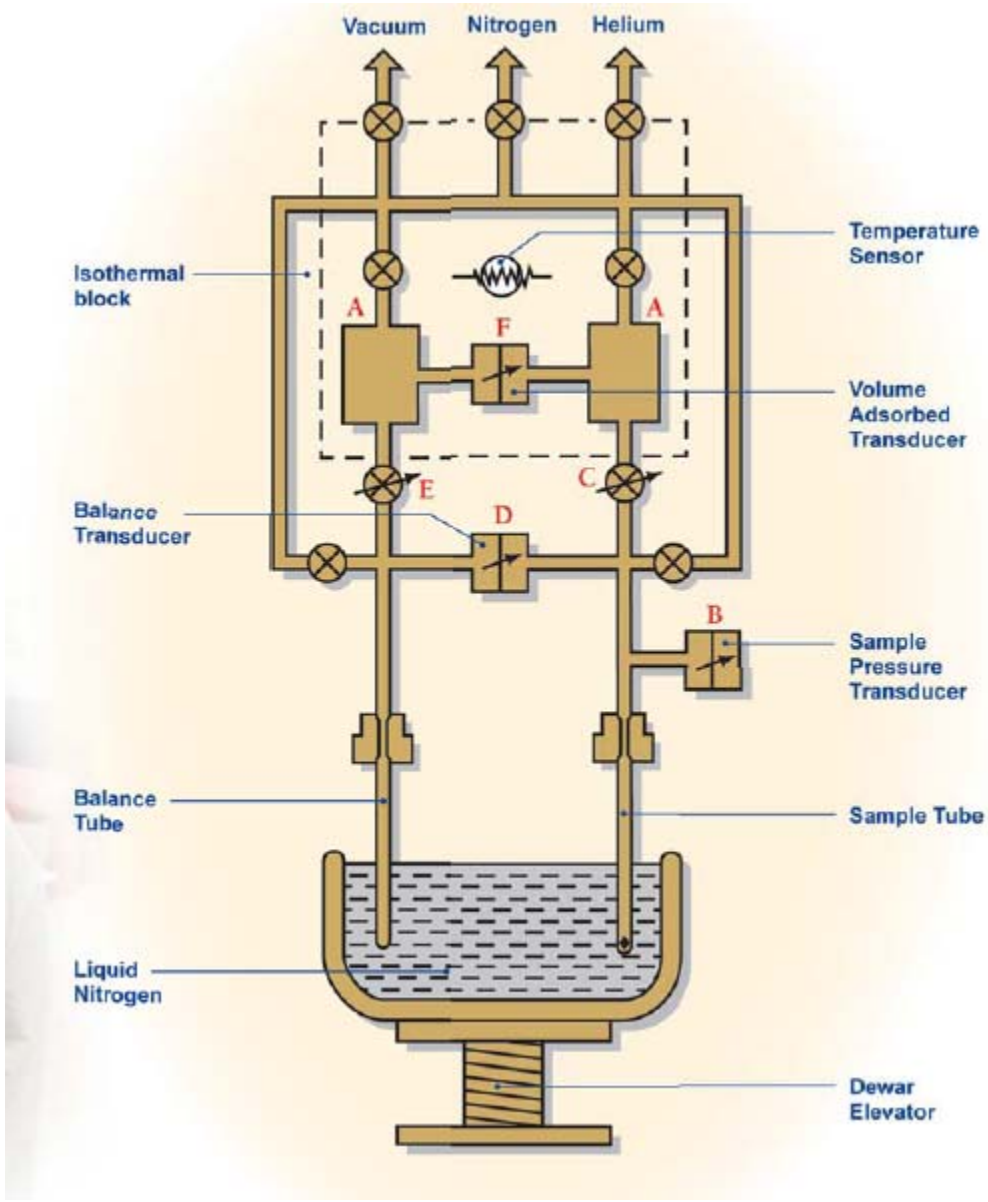
Percolation theory

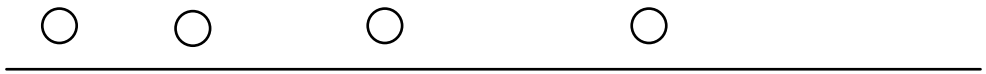


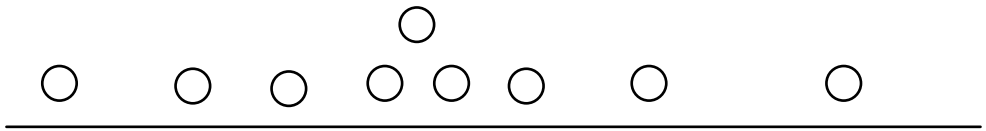
Results from model

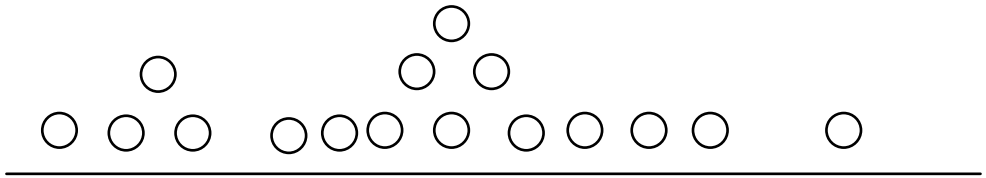


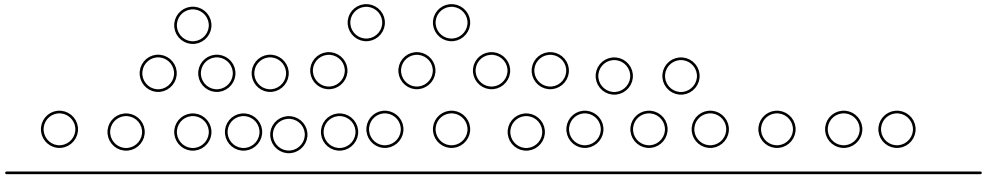
Nitrogen sorption

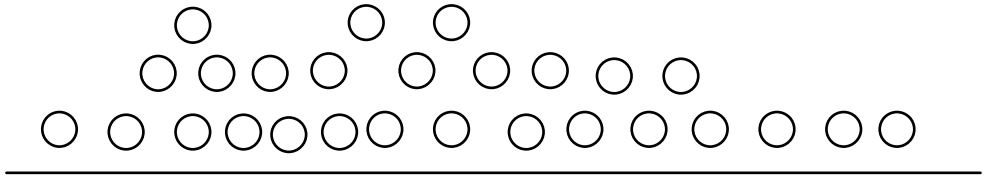

Vacuum
Nitrogen
Helium
Temperature Sensor
Isothermal block
A
F
A
Volume Adsorbed Transducer
E
C
Balance Transducer
D
B
Sample Pressure Transducer
Balance Tube
Sample Tube
Liquid Nitrogen
Dewar Elevator

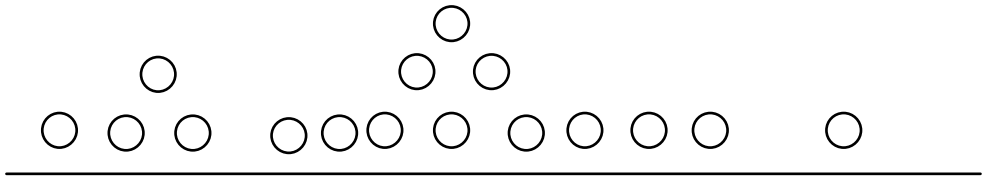


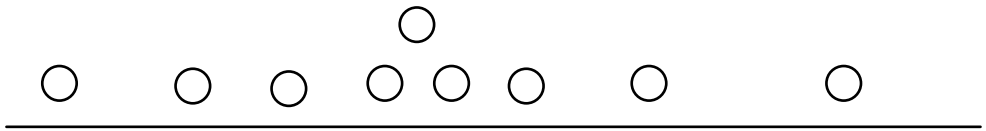


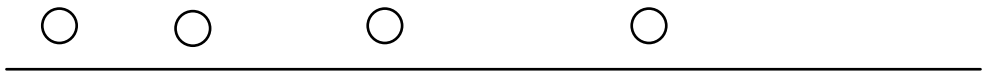




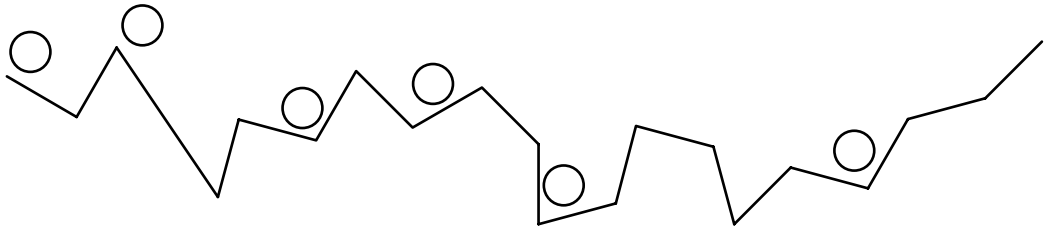


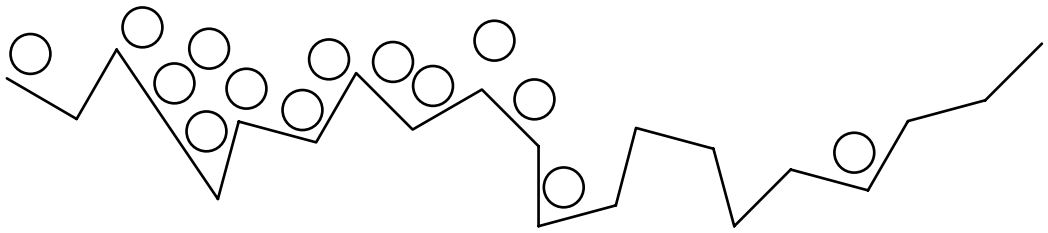


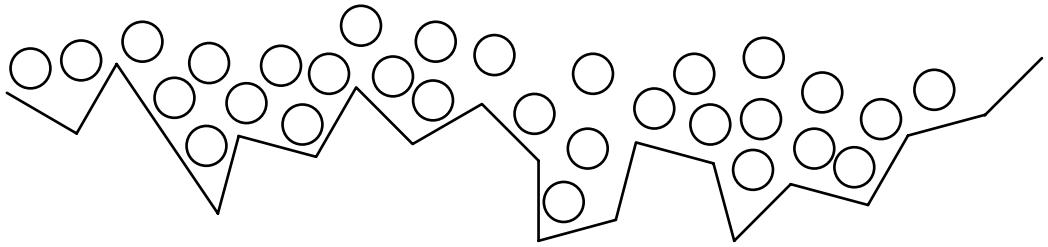




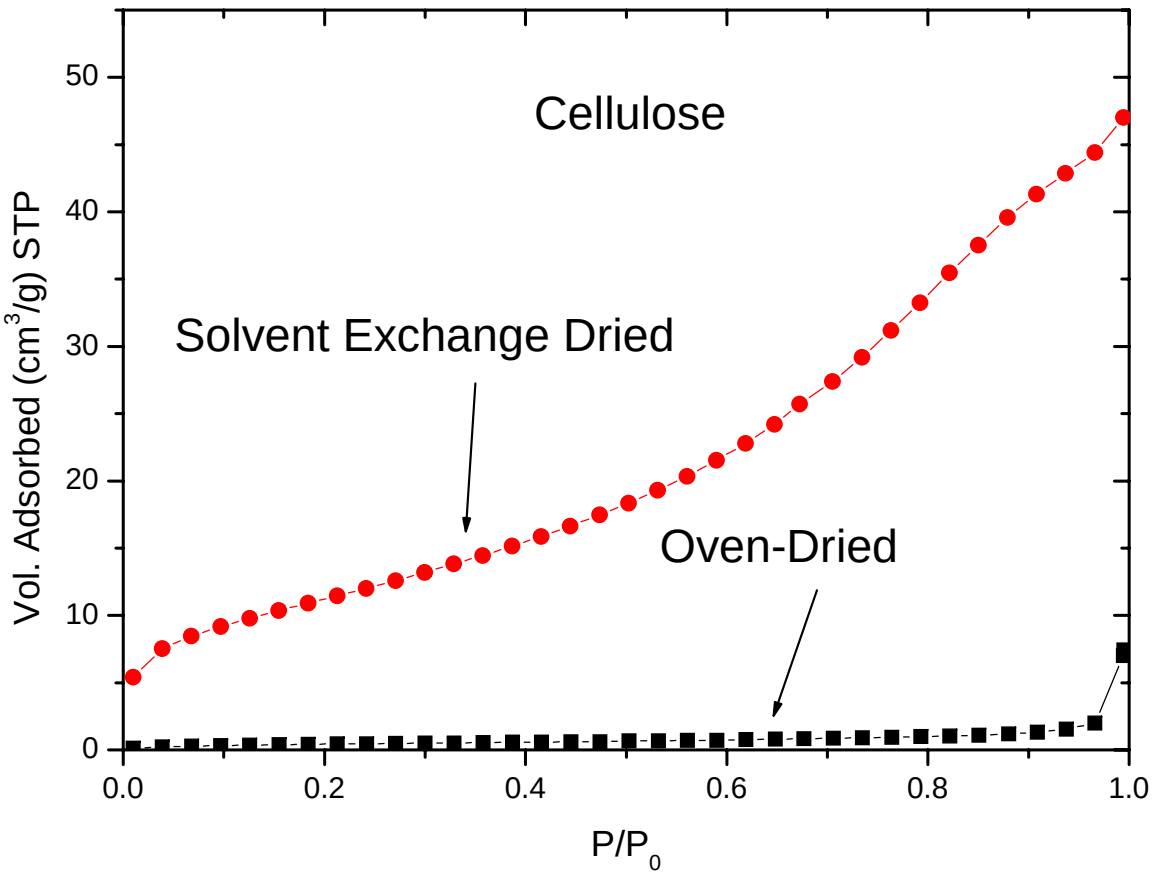
Rough Surface



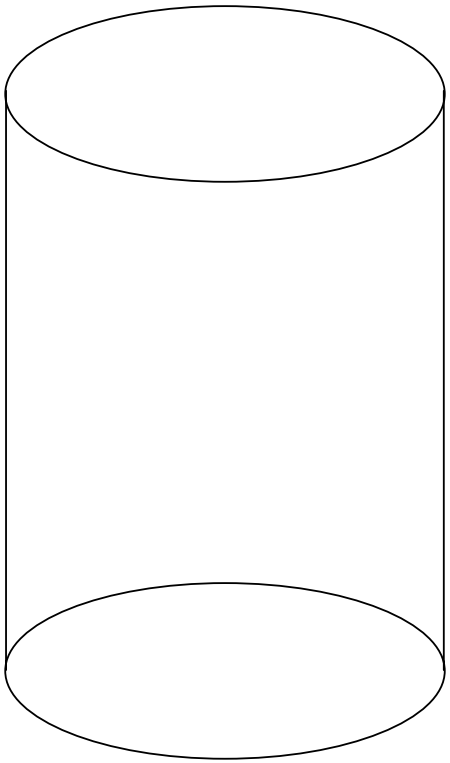


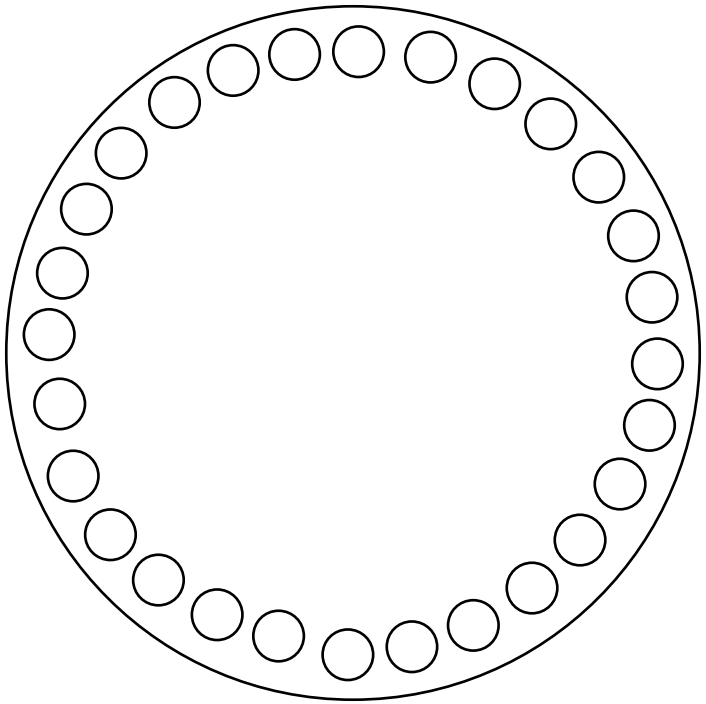


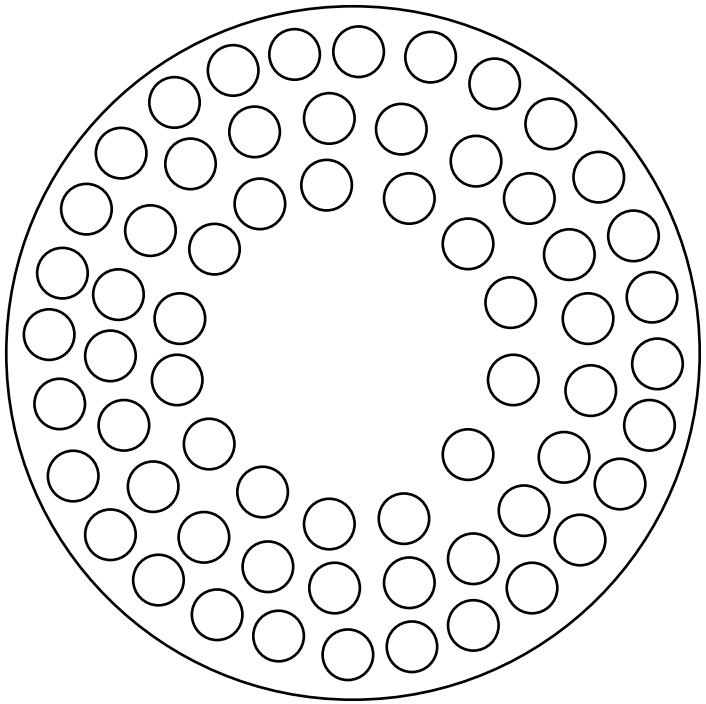
Effect of solvent exchange drying

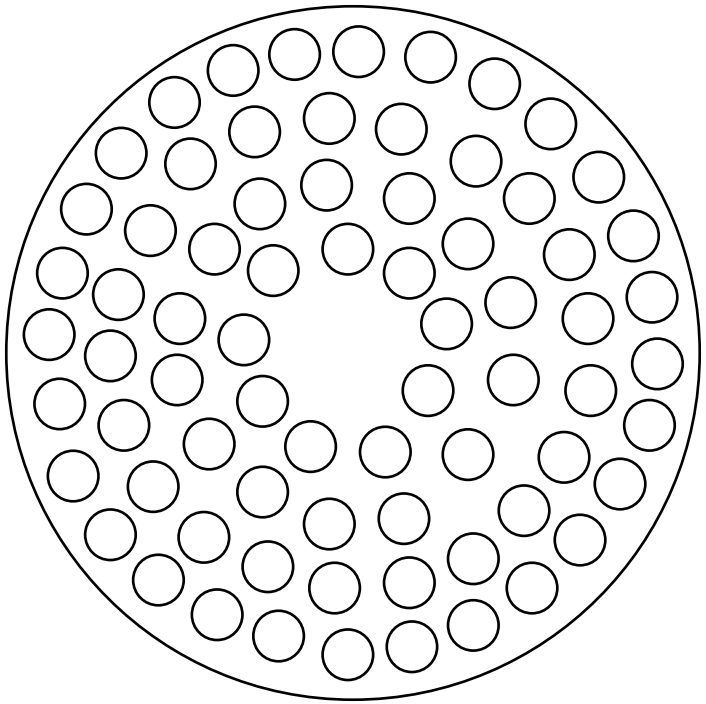


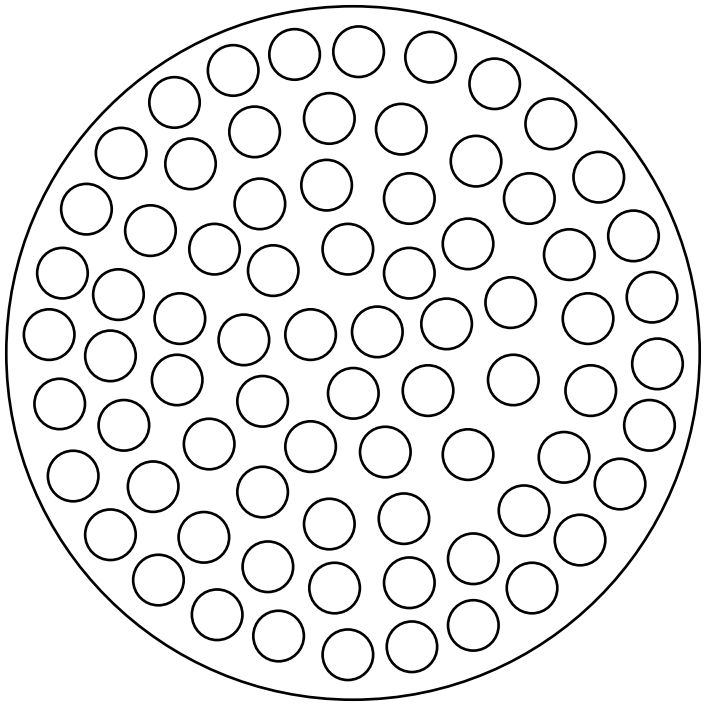
Hysteresis



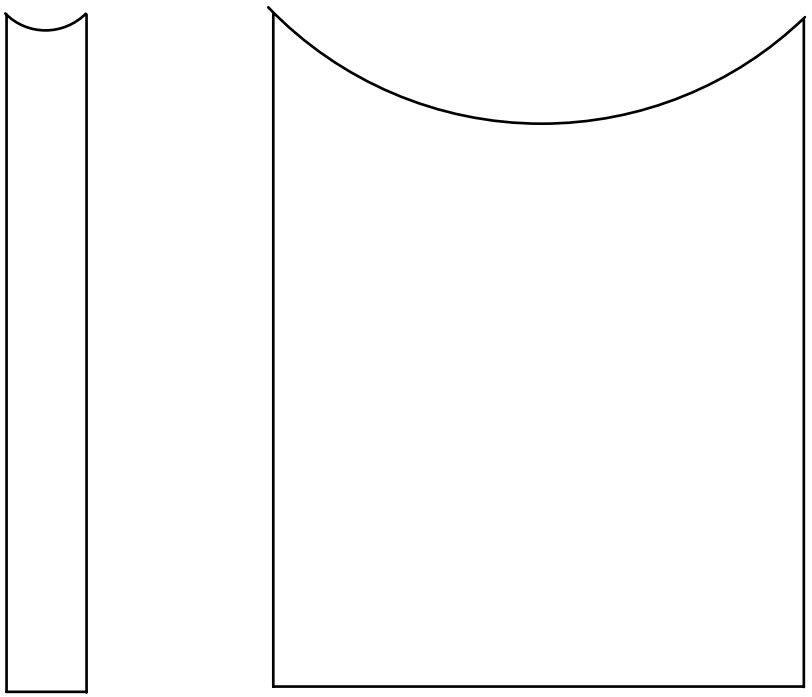




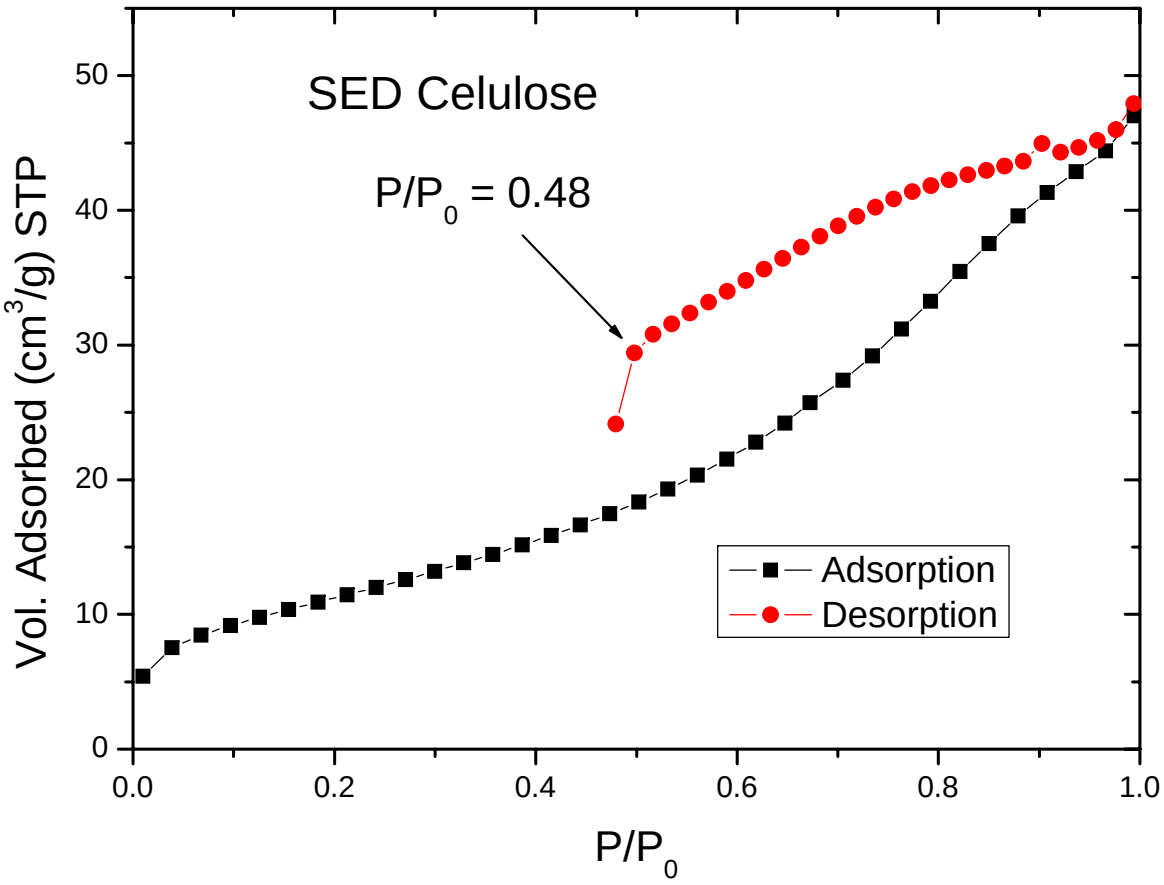


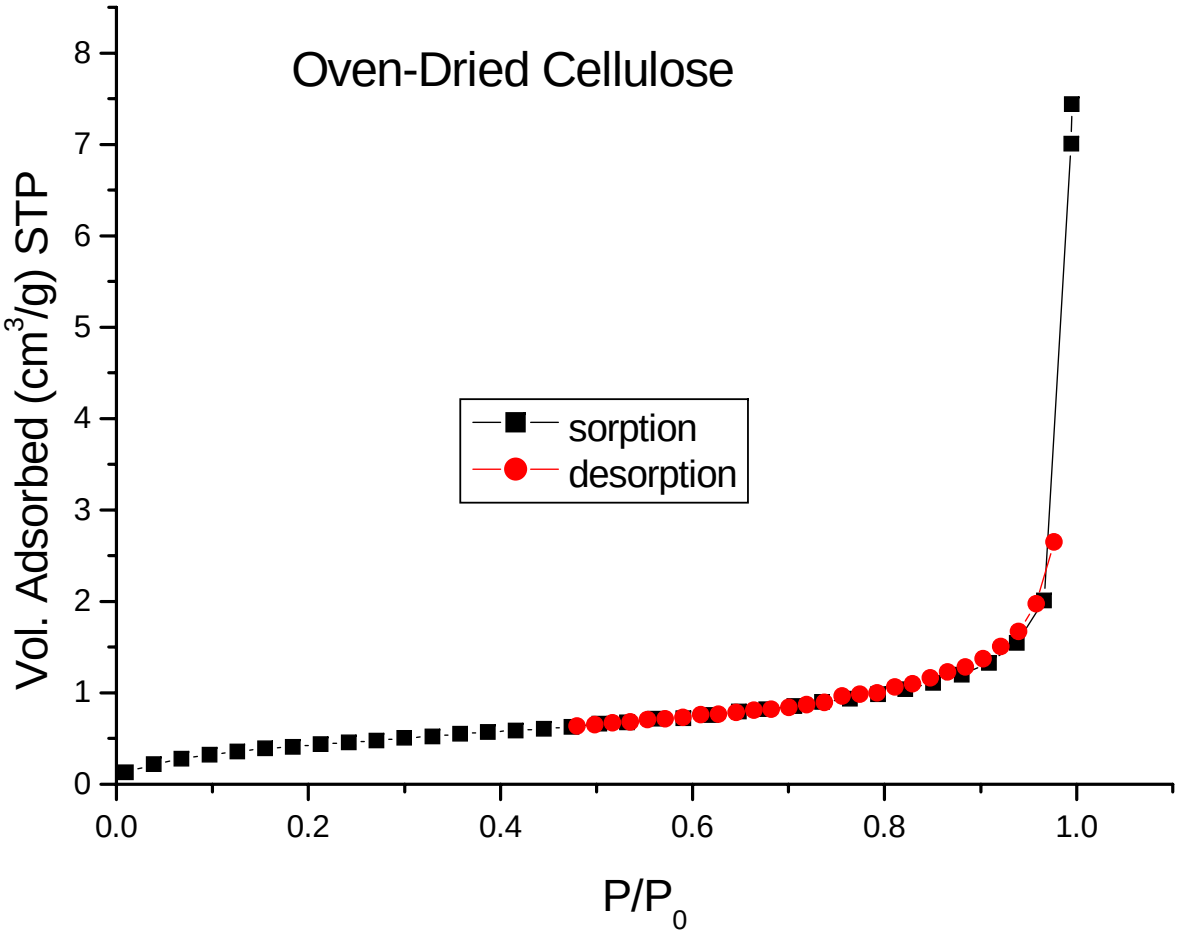


Desorption

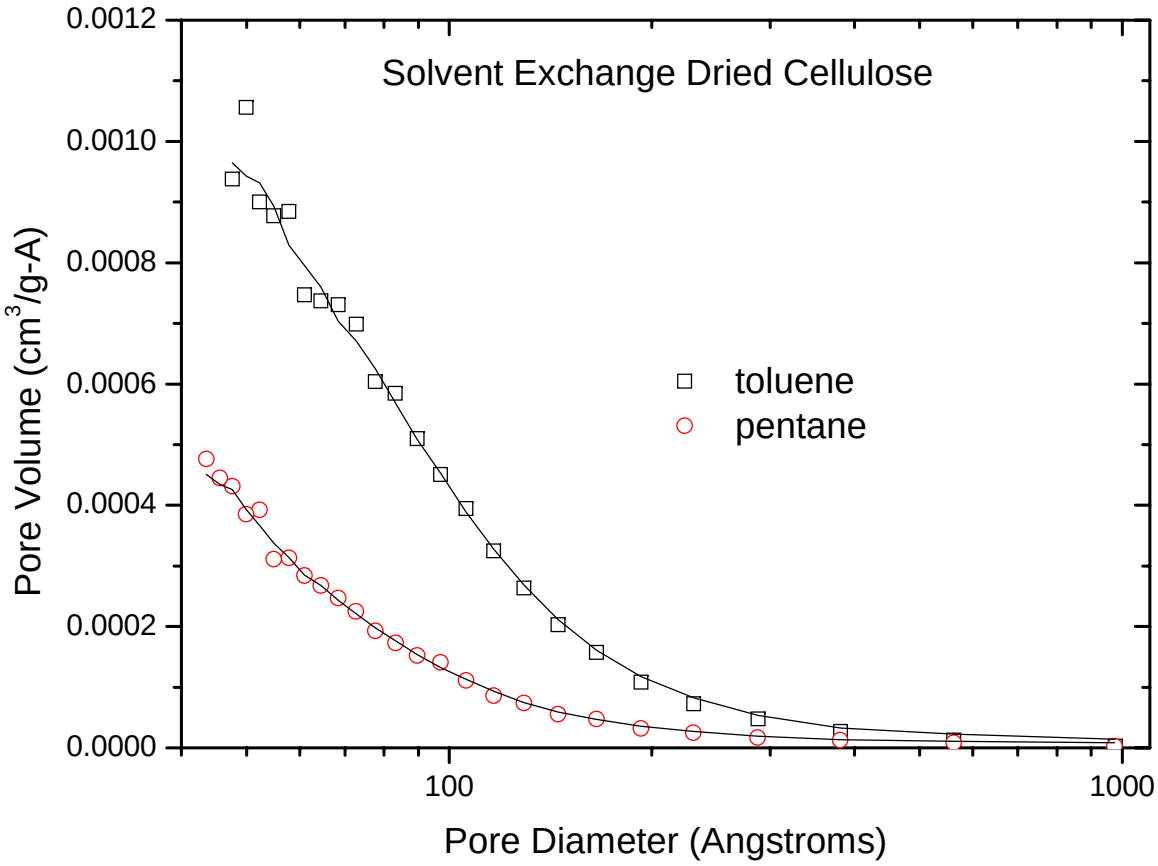


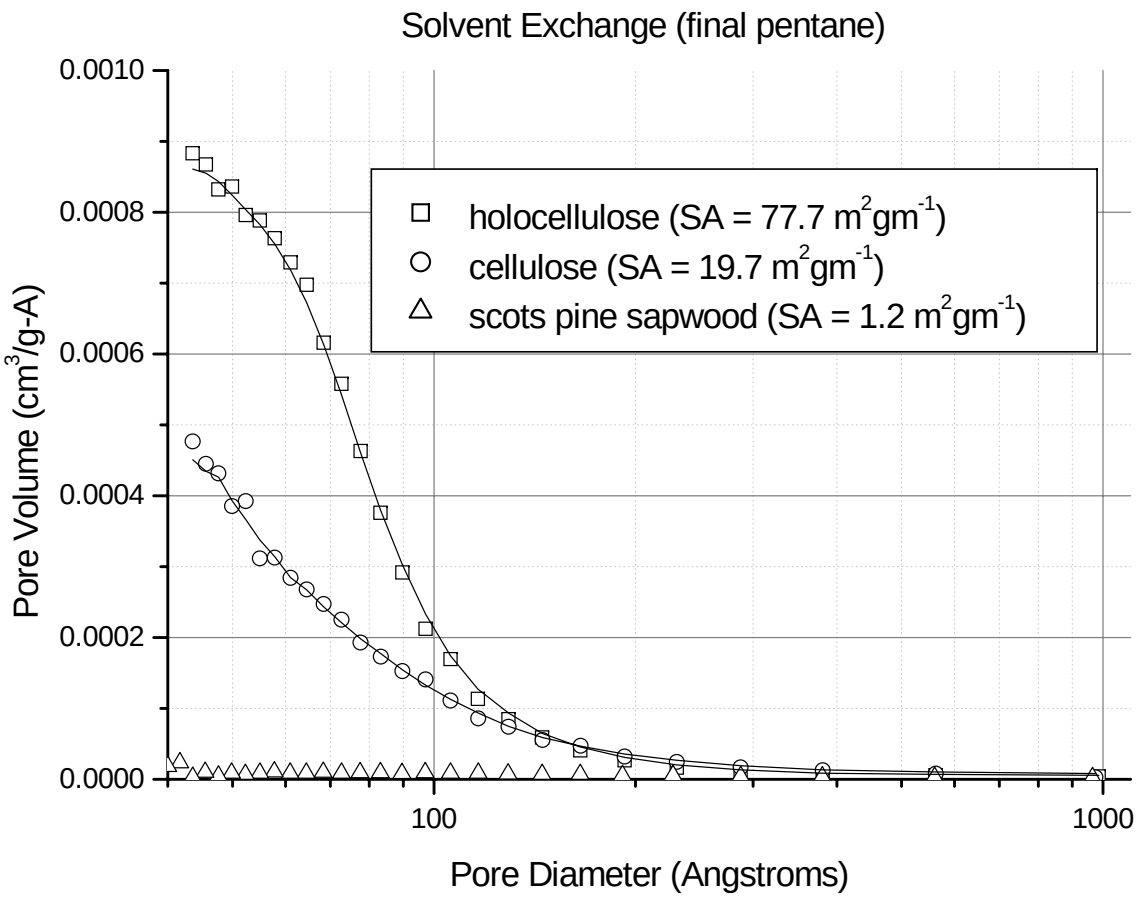
Effect of solvent-exchange drying




Oven-Dried Cellulose
Vol. Adsorbed (cm3/g) STP
P/P0
sorption
desorption
0
1
2
3
4
5
6
7
8
0.0
0.2
0.4
0.6
0.8
1.0

Solvent-exchange drying




Solvent Exchange (final pentane)
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Pore Volume (cm3/g-A)
100
1000
Pore Diameter (Angstroms)
holocellulose (SA = 77.7 m2gm-1)
cellulose (SA = 19.7 m2gm-1)
scots pine sapwood (SA = 1.2 m2gm-1)

SED vs SC CO_2

- Water saturated then exchanged with methanol then acetone:

  Surface area = 13.6 m^2 g^{-1}

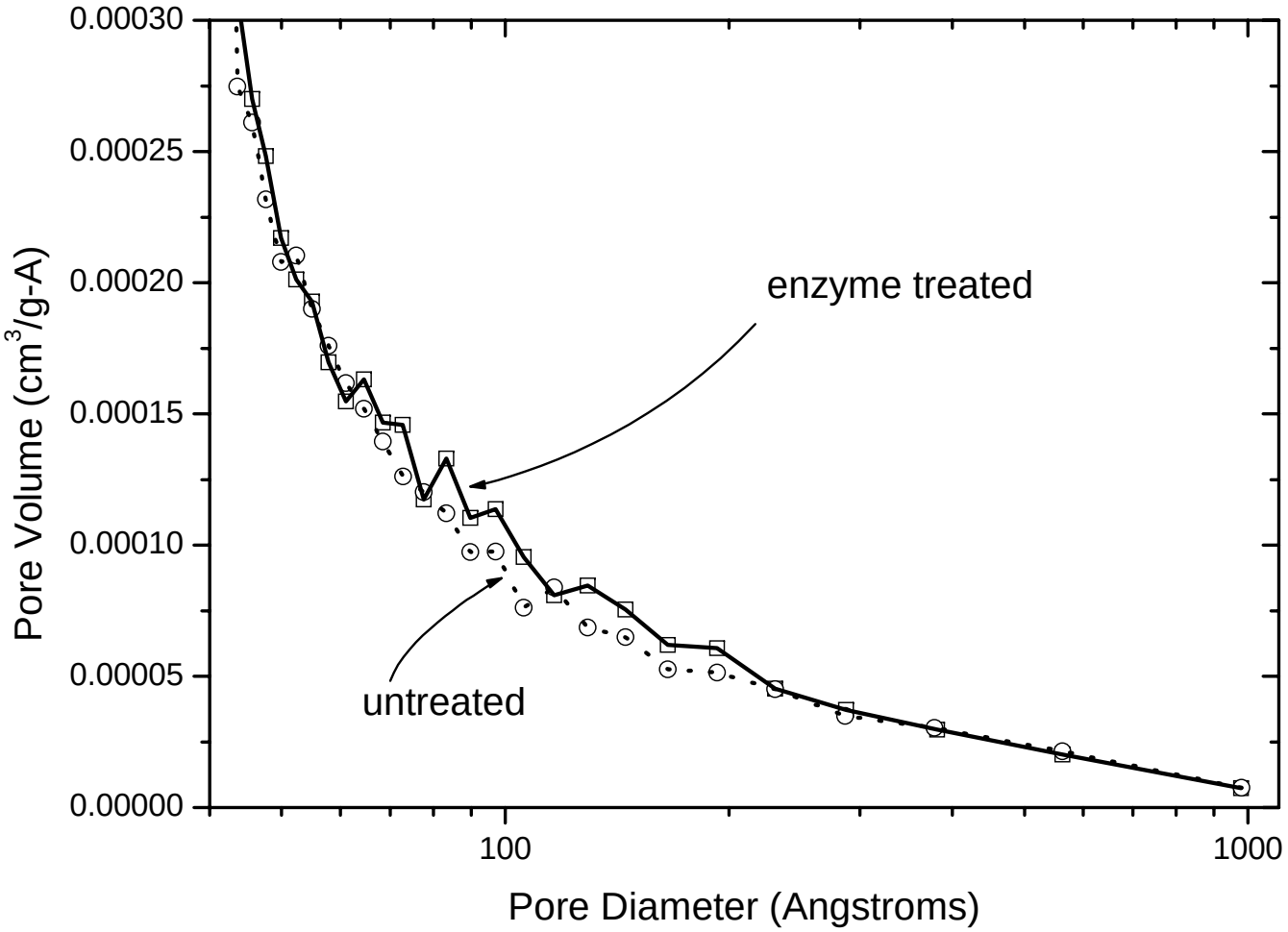
- Water saturated then exchanged with methanol then acetone then super-critical CO_2 dried:

  Surface area = 47.7 m^2 g^{-1}

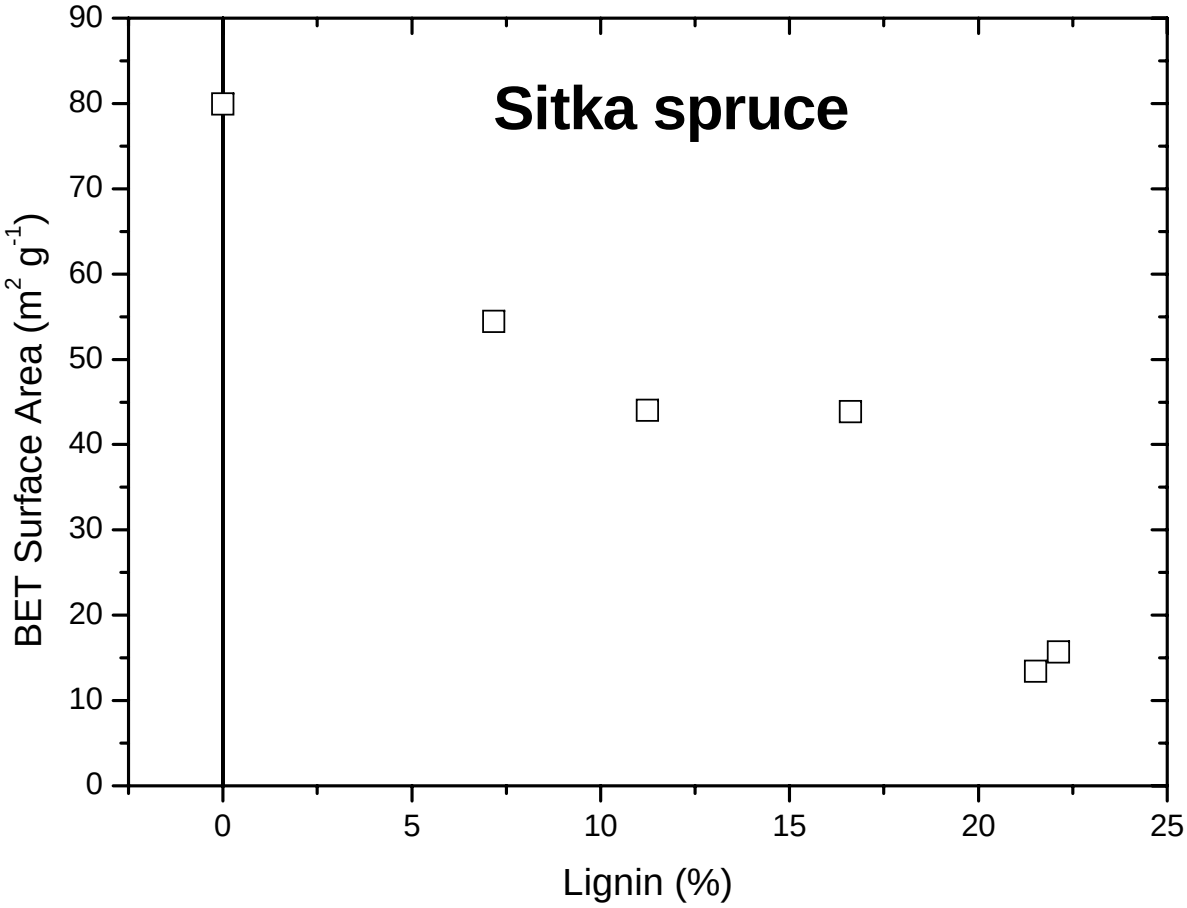
Effect of refining on surface area

Treatment	Surface area (m^2 g^{-1})
None	17.6
Refined	29.4

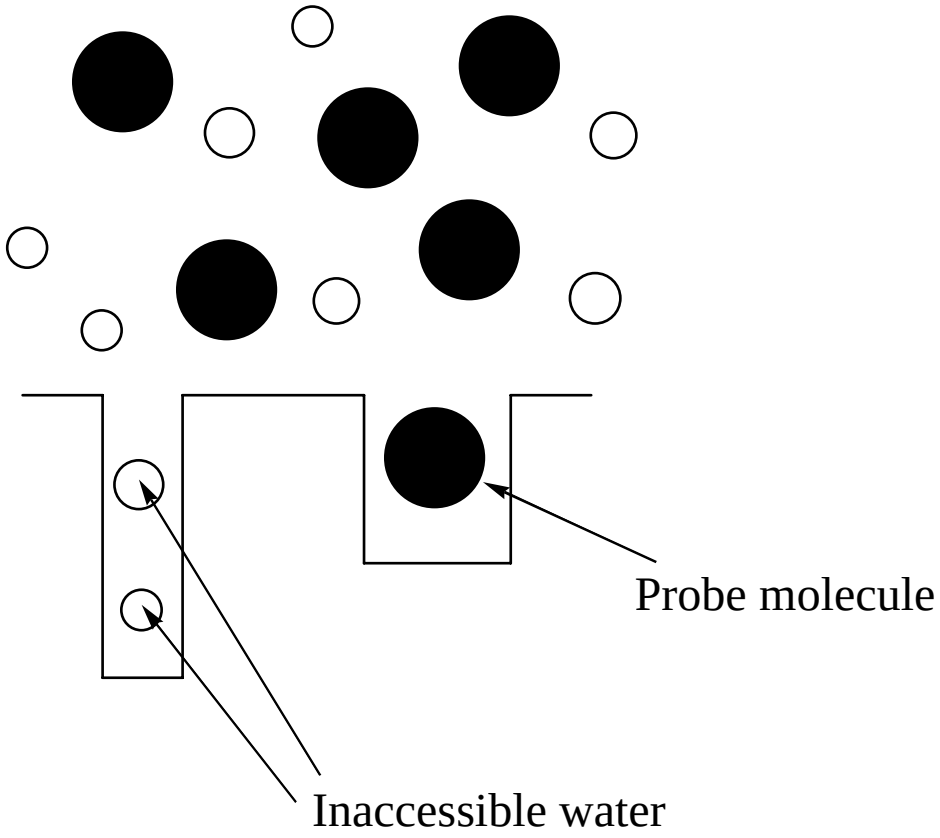
Enzyme treatment of pulp



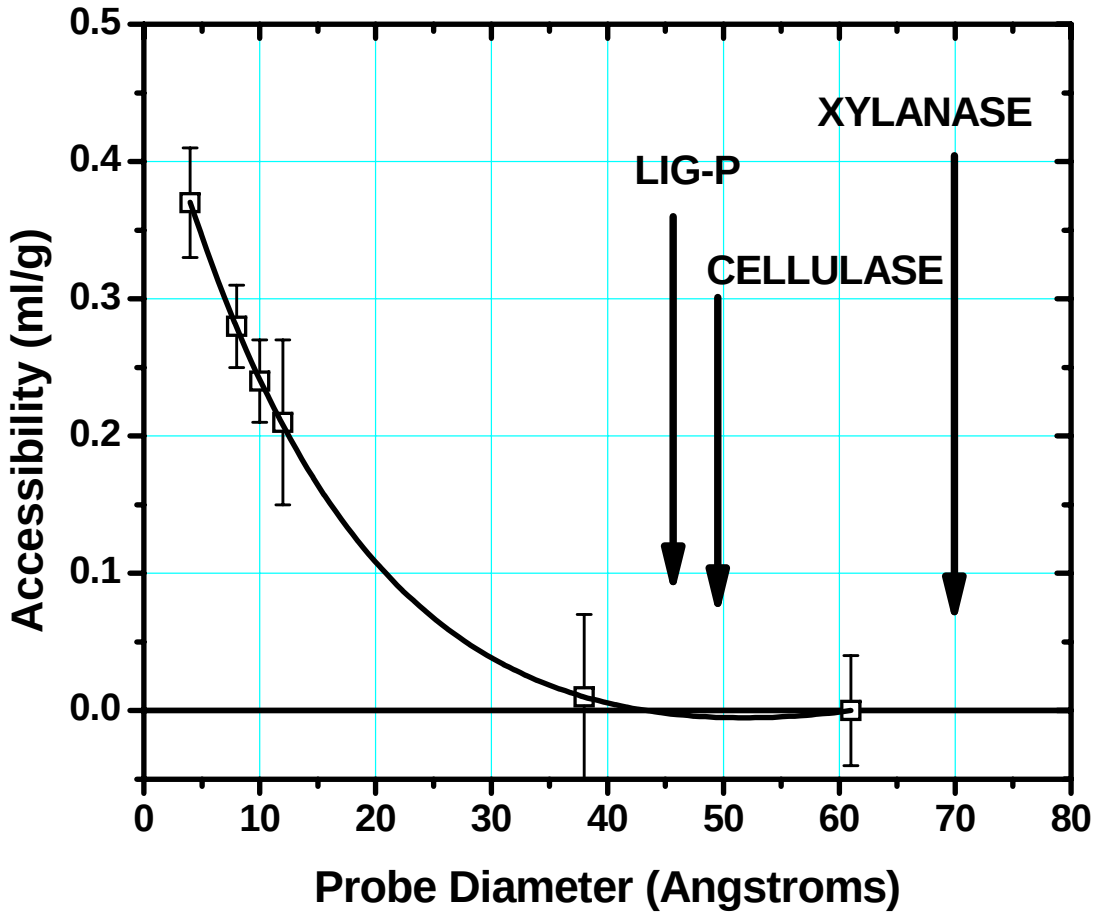
Critical point drying

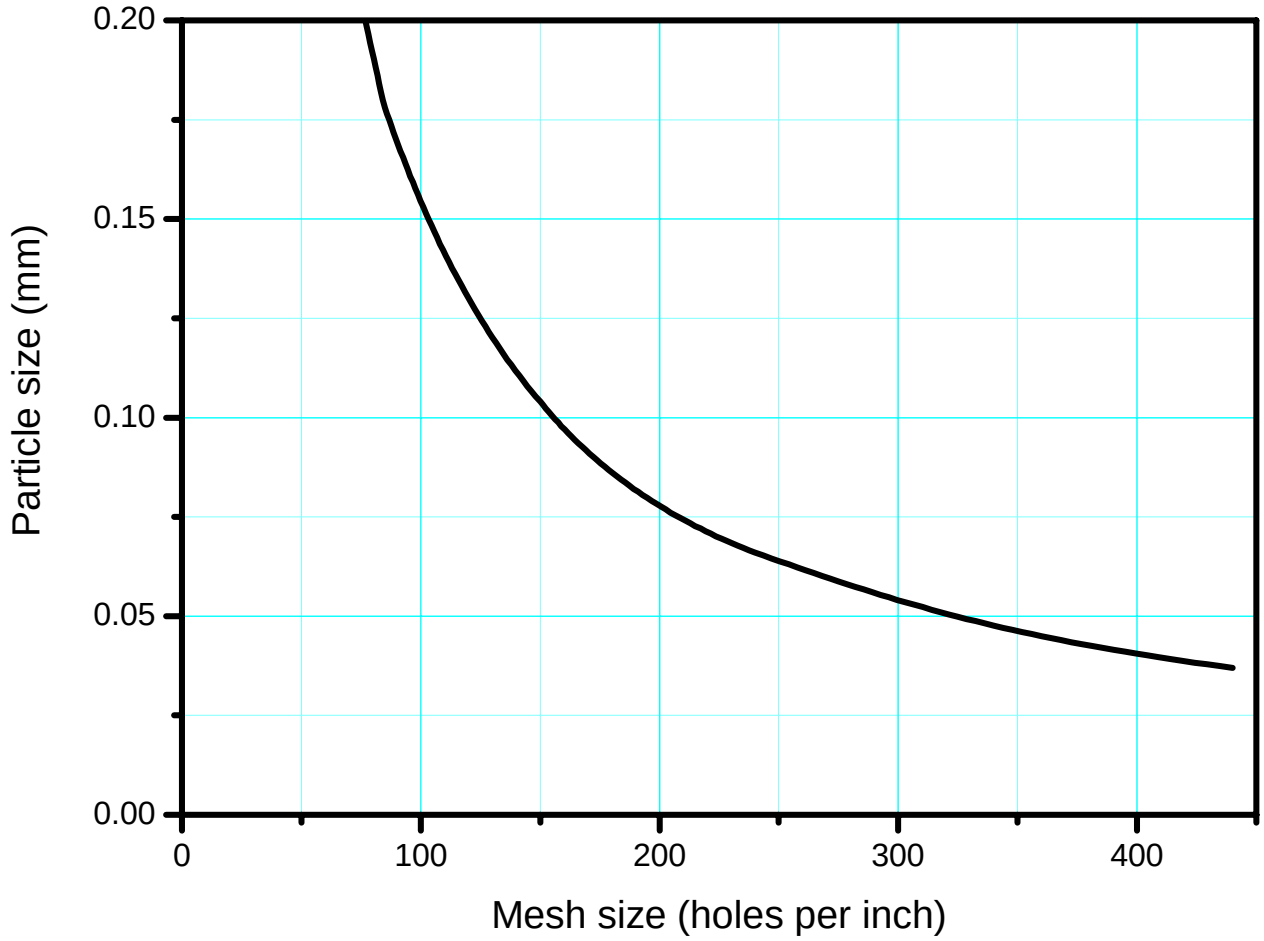


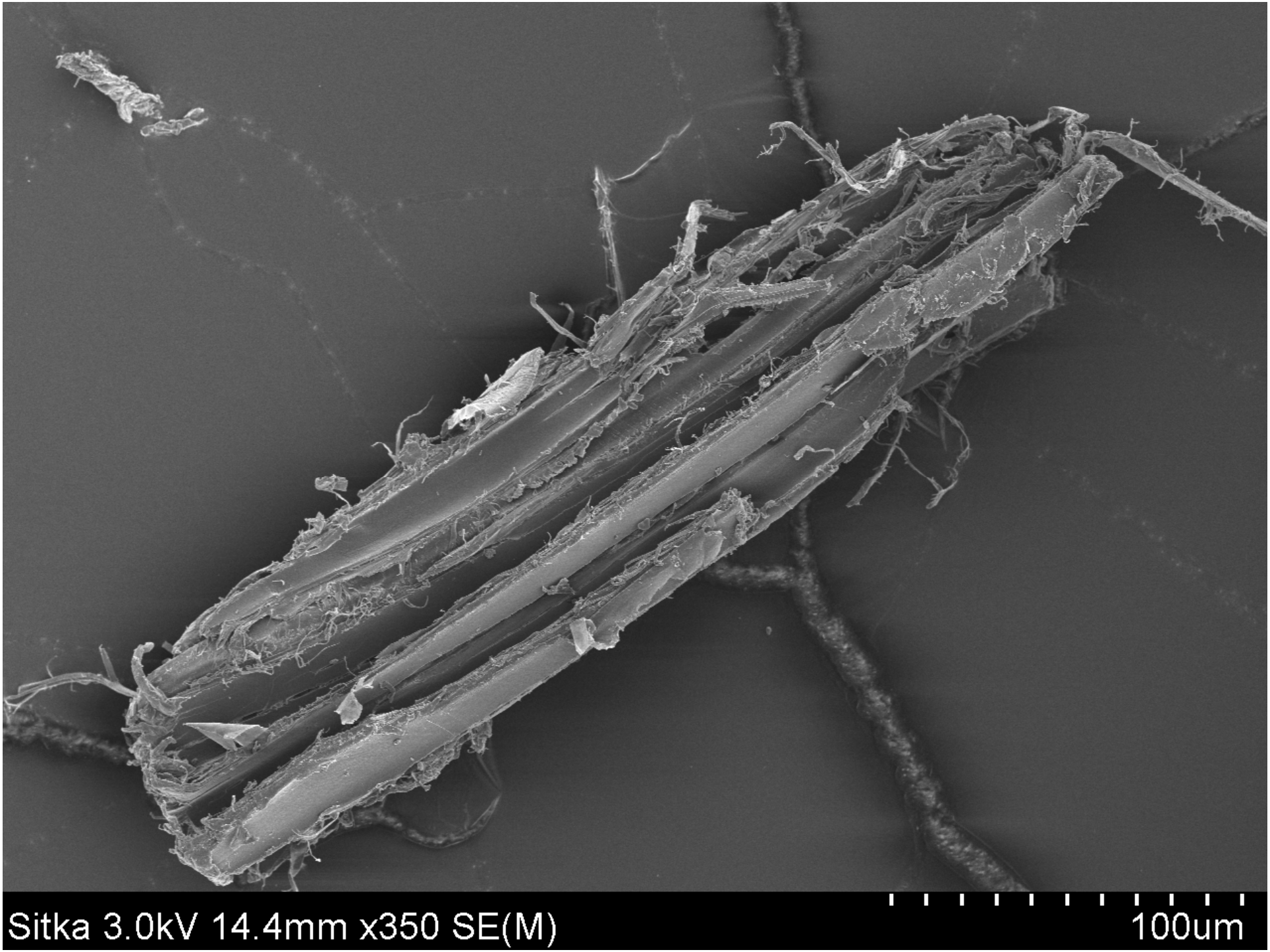
Solute exclusion

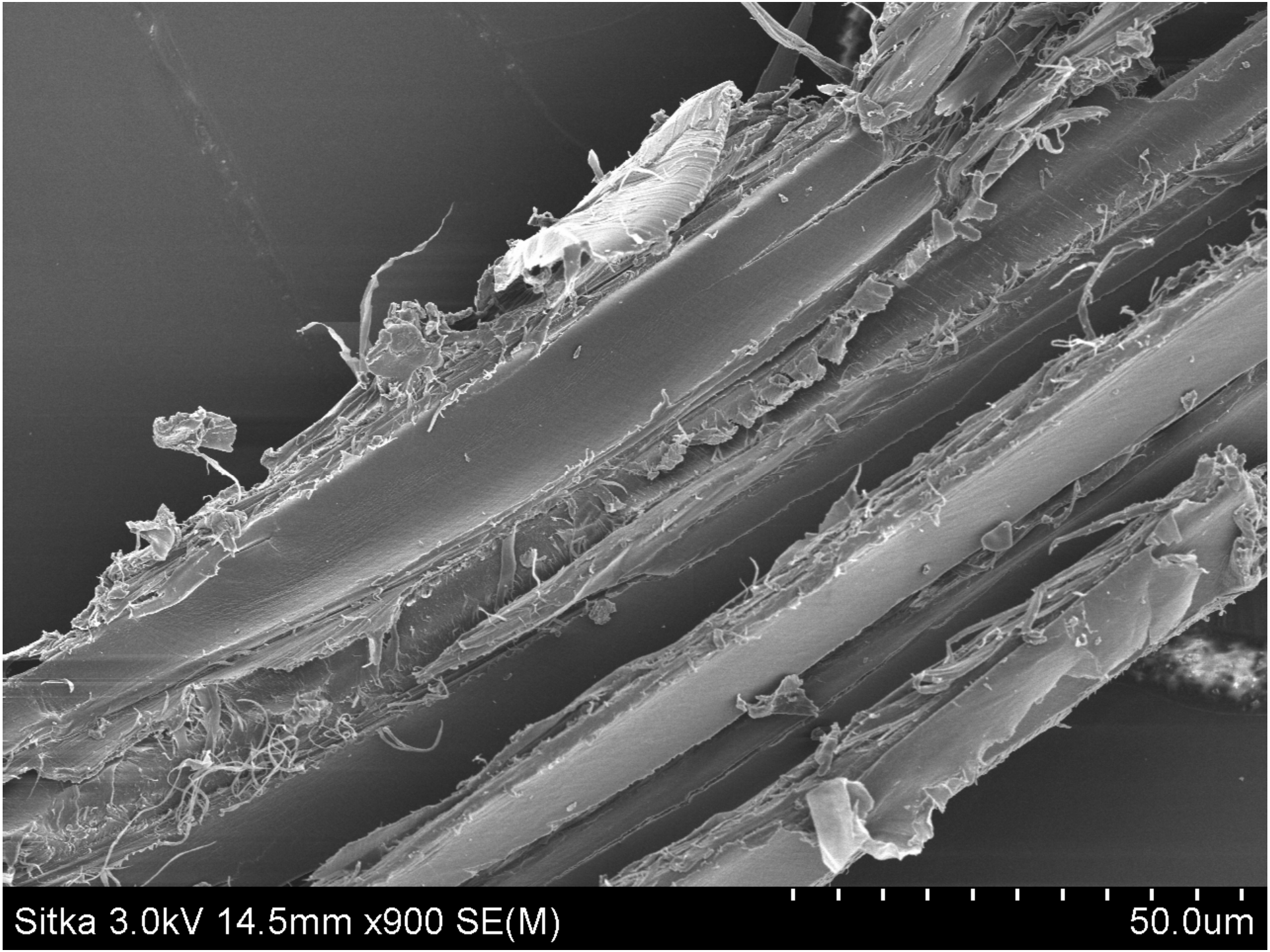


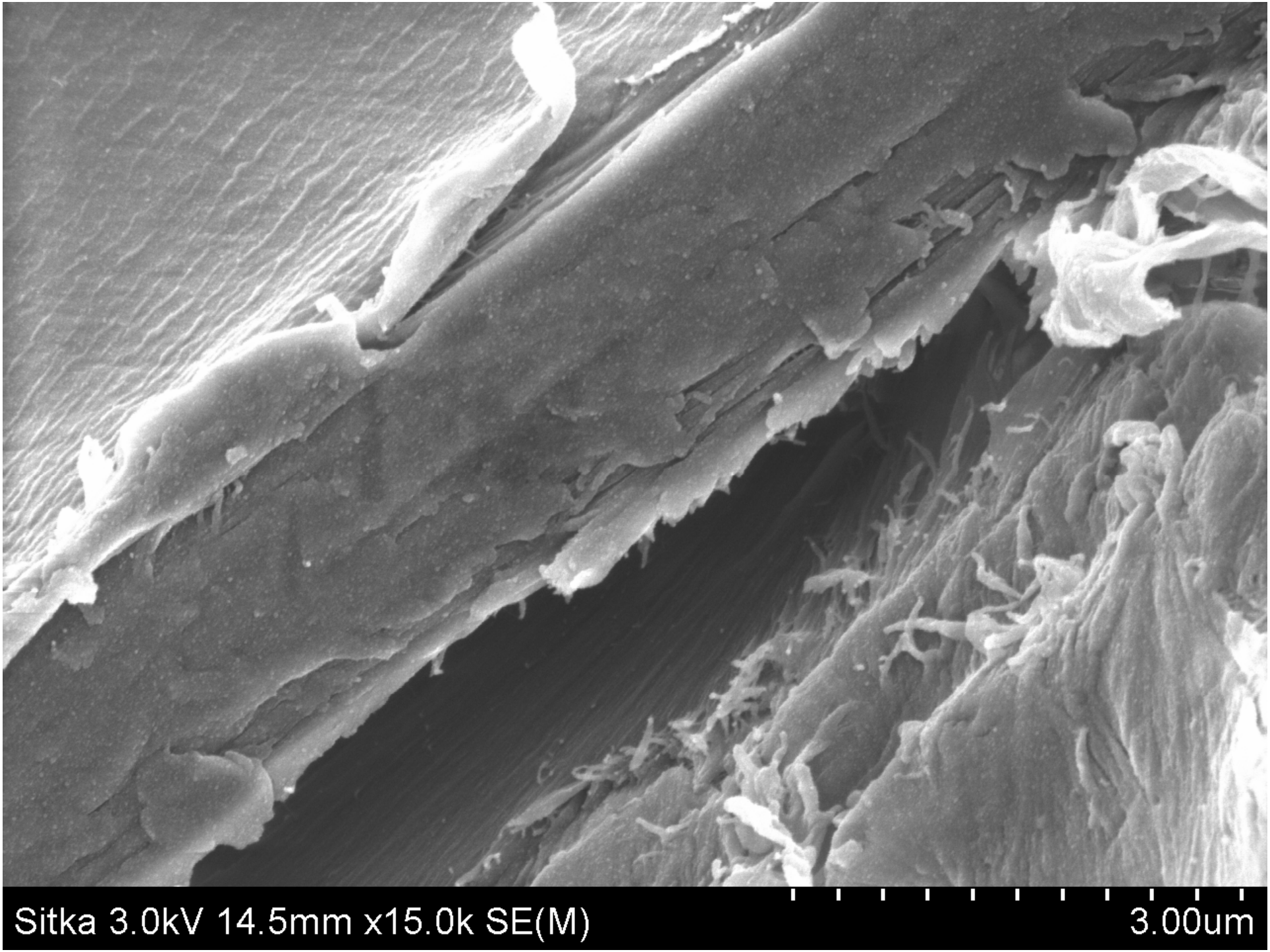
Enzyme accessibility




0.20
0.15
0.10
0.05
0.00
Particle size (mm)
0
100
200
300
400
Mesh size (holes per inch)


Sitka 3.0kV 14.4mm x350 SE(M)
100um


Sitka 3.0kV 14.5mm x900 SE(M)
50.0um


Sitka 3.0kV 14.5mm x15.0k SE(M)
3.00um

Conclusions

- Nitrogen sorption isotherm analysis of lignified material gives low surface areas
- Even SC CO_2 drying does not change this much
- Lignin acts to collapse cell wall nano-pores as well as acting as an occluding material
- Solute exclusion of lignified material reveals nano-pores of diameter not much greater than 2nm – enzymes cannot penetrate
- Grinding does not improve accessibility

Acknowledgements

- **Simon Curling, John Hillier**
- **Engineering and Physical Sciences Research Council:**
- **An investigation of the kinetics of the chemical modification of wood. A fractals approach (GR/L39596)**
- **The determination of the pore space geometry of wood (GR/M91709)**
- **Utilising timber residues as a source of process chemicals (SILVICHEM) (GR/S42620/01)**

- **Scottish Funding Council**