Methods for the Structural Characterisation of Cigarette Paper

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- Paper Porosity - Mercury Porosimetry
  Gas Adsorption
- Scanning Electron Microscopy
- Fibre Quality Analysis

Routine Paper Characterisation

- Air permeability, basis weight, % filler, % burn additive, strength and stretch, opacity

Why study structure ?

- Info on paper strength
- Info on optical properties
- Info on SBR and smoke deliveries

Porosity

- Different to Air permeability (CU) which involves measuring the air flow rate resulting from applying a known pressure difference across a specified area of paper sample
- Porosity gives an accurate description of the the paper structure on a microscopic scale.
- Papers can have the same air permeability but different porosities.

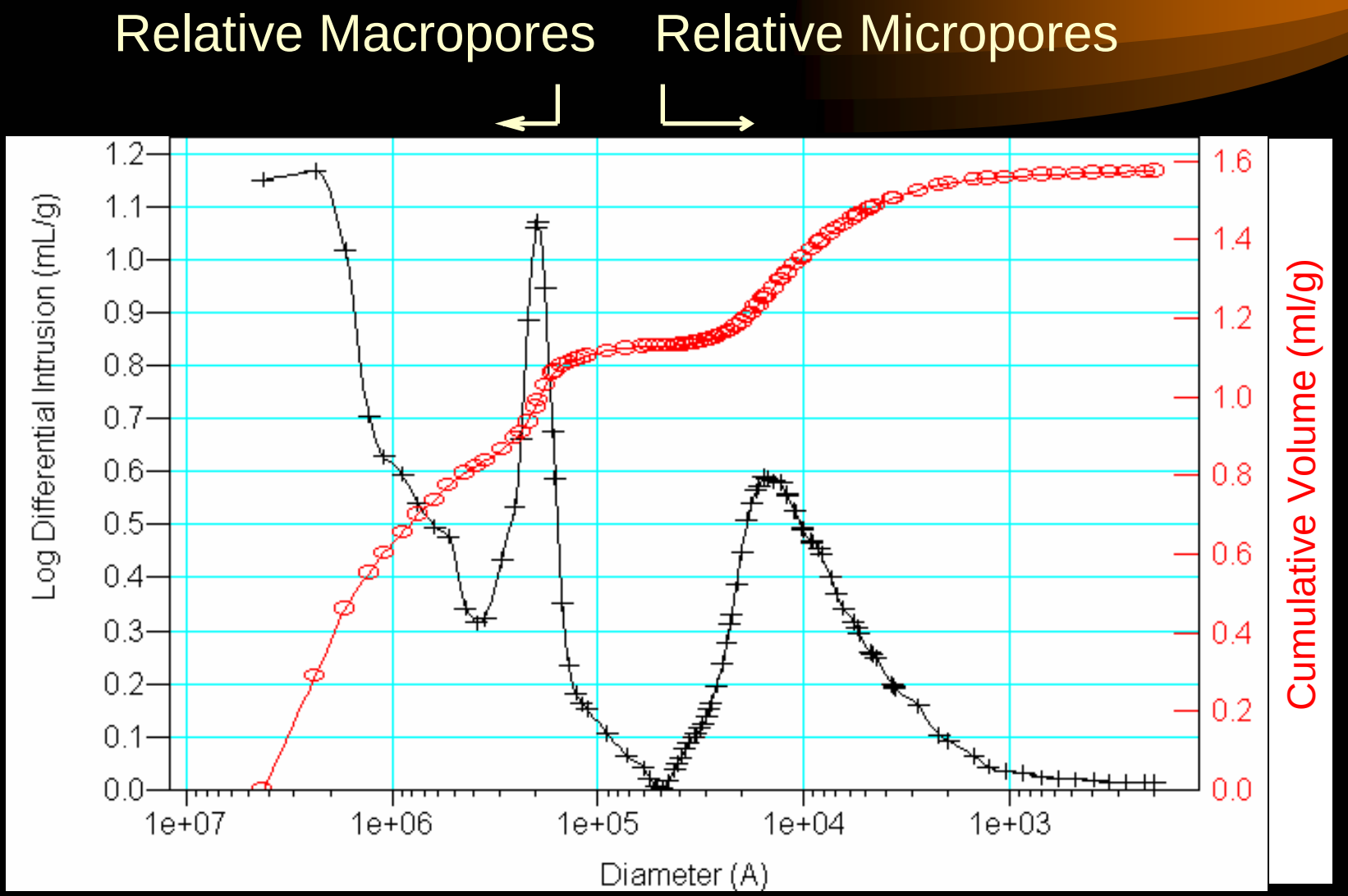
Mercury Porosimetry

- Measures pore sizes and pore size distributions in the range ca 30nm to 360μm
- Measures pore volumes
- Measures bulk and skeletal densities
- Very reproducible and accurate
- Relatively fast
- Uses mercury
- Destructive technique

Principles of Mercury Porosimetry

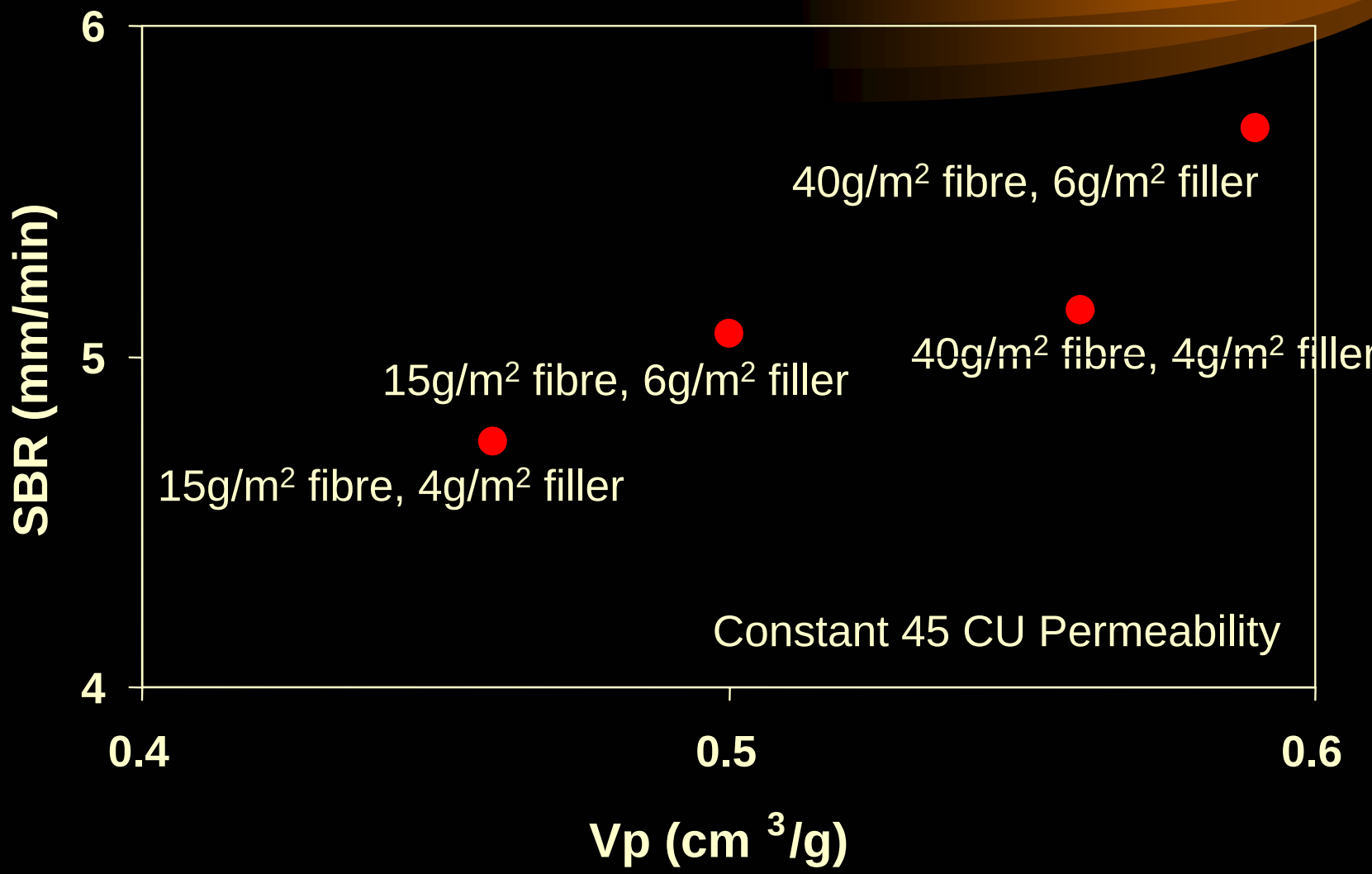
- No pores are penetrated by mercury unless a force is applied
- $D=-4\gamma\cos\theta/P$ $(D \propto 1/P)$ Washburn equation
- Can measure pore diameters from ca 30nm-360μm
- Data can be used to predict Static Burn Rates

Porosimetry Plot for a Standard $CaCO_3$ Cigarette Paper

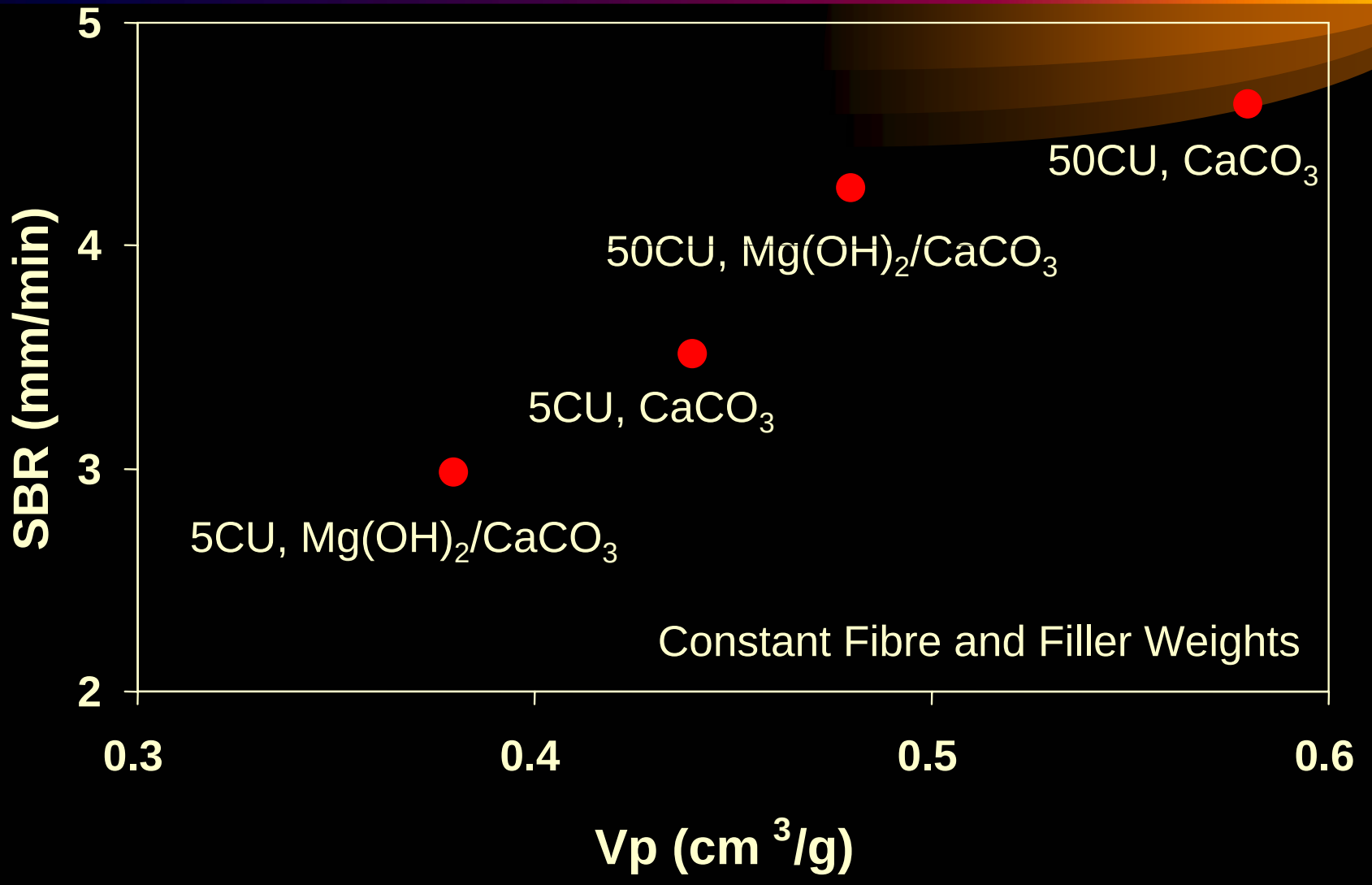


Effect of Microstructure Pore Volume (Vp) on the Static Burn Rate

Effect of Fibre and Filler Level on Vp and SBR

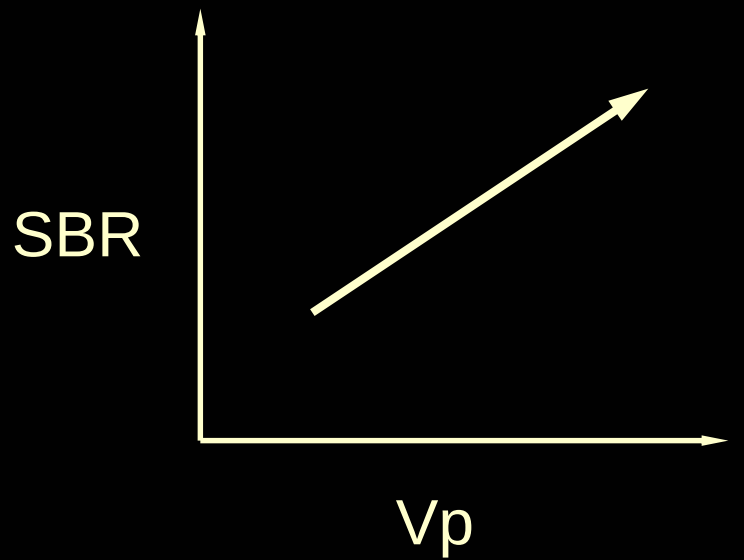


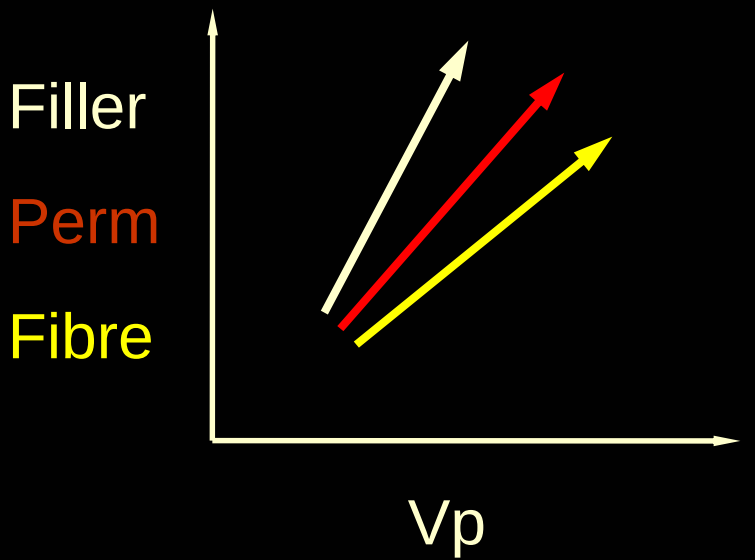
Effect of Permeability and Filler Type on Vp and SBR



Summary of Results

Effect on SBR





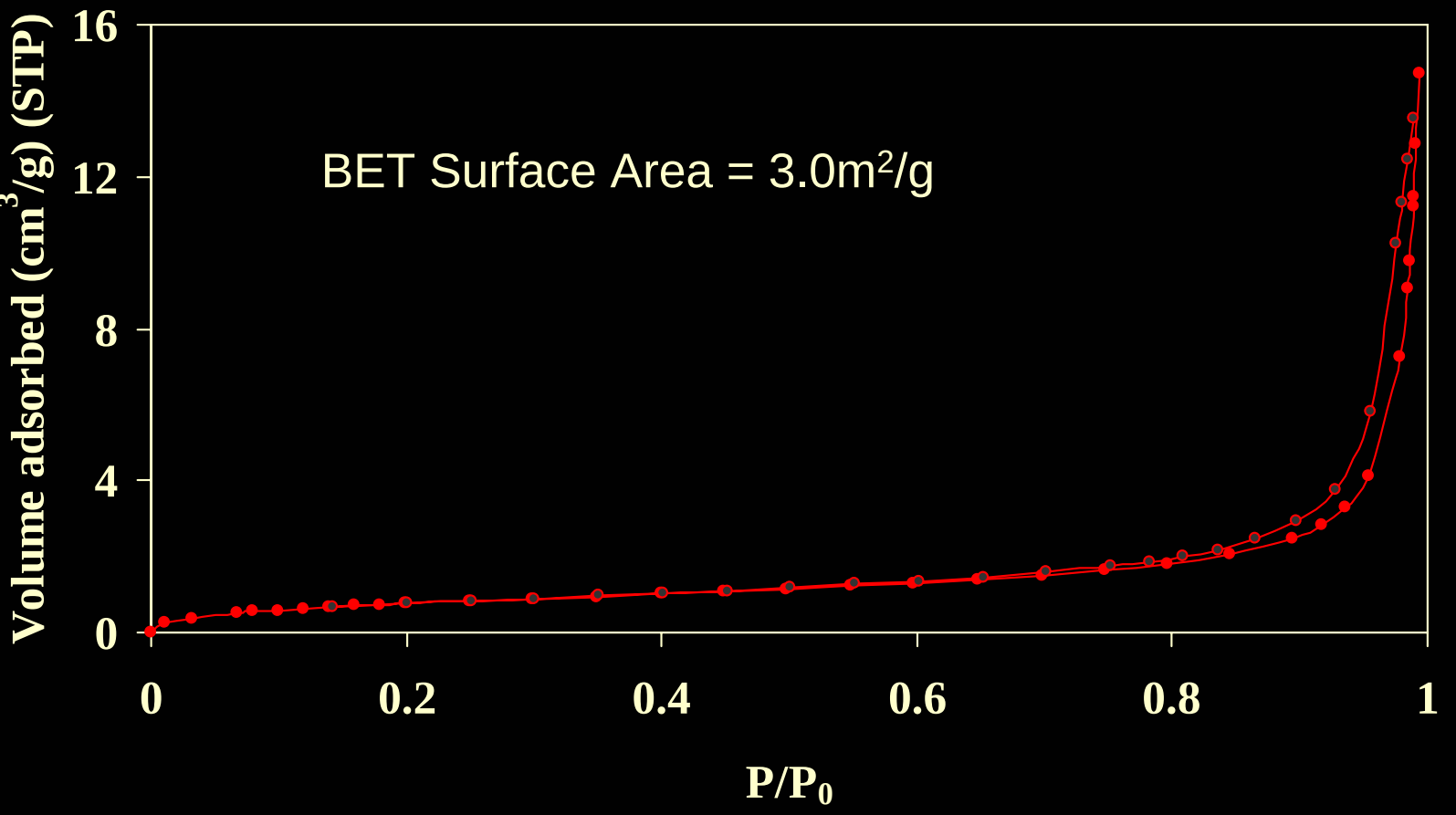
Nitrogen Adsorption

- Nitrogen adsorption at 77K gives info on
- Surface area
- PSD from *ca* 1nm to 100nm
- Surface chemistry

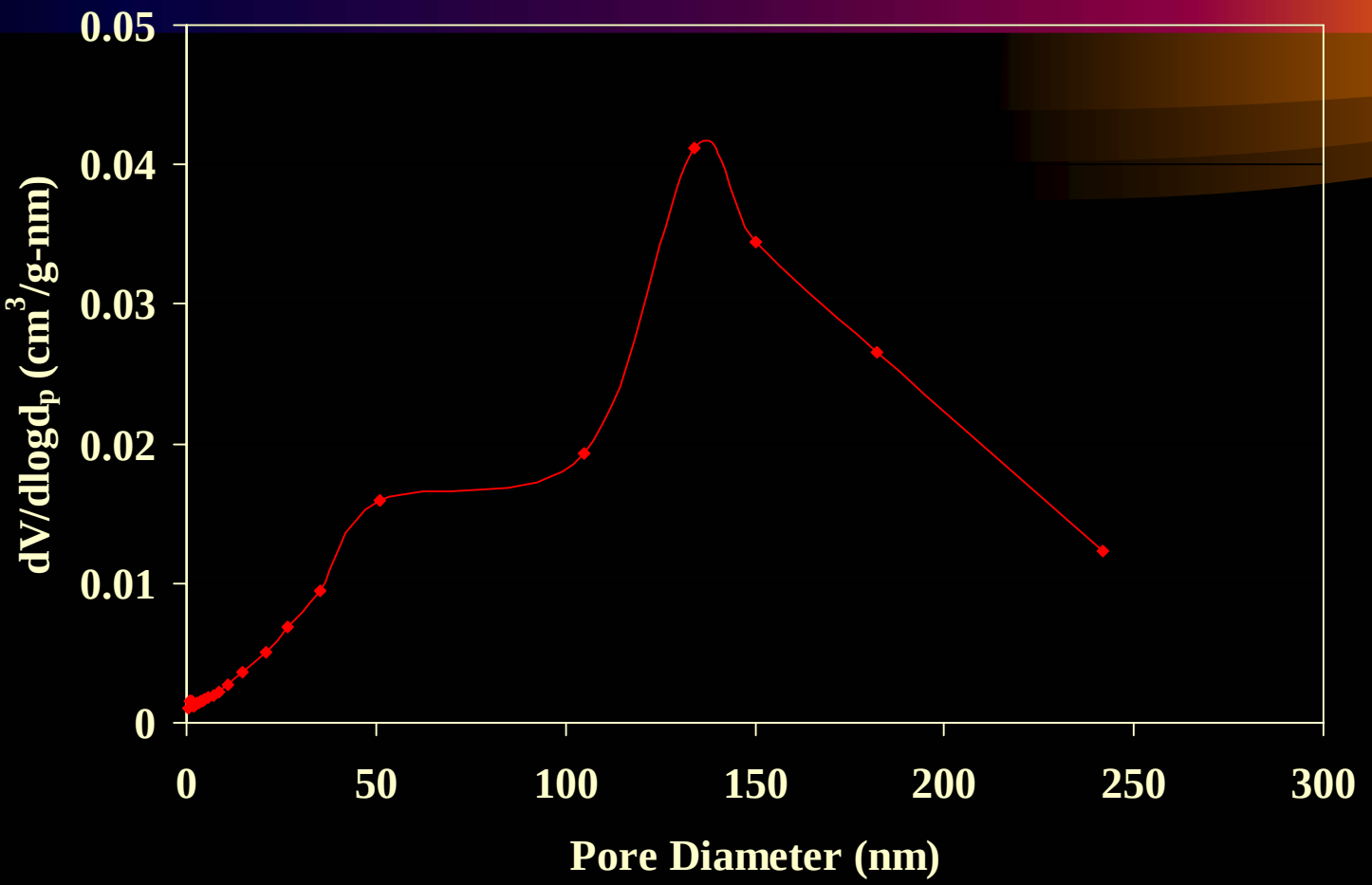
- Very reproducible and accurate
- Non destructive
- Samples can have long equilibrium times

Adsorption of Nitrogen at 77K

80 CU Flax Cigarette Paper



Paper Pore Size Distribution (BJH method)



1nm<Vp<100nm = 0.02cm^3/g

100nm<Vp<10,000nm = 0.35cm^3/g

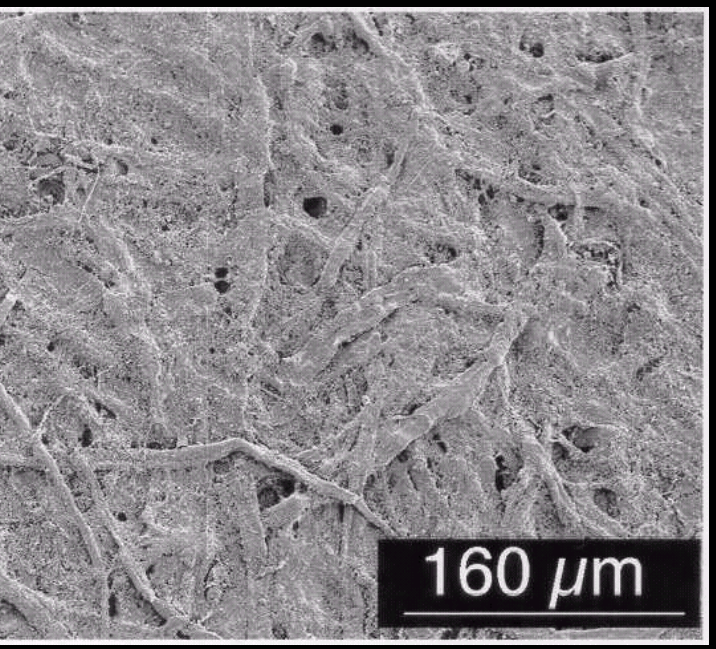
10,000nm<Vp<400,000nm = 1.45cm^3/g

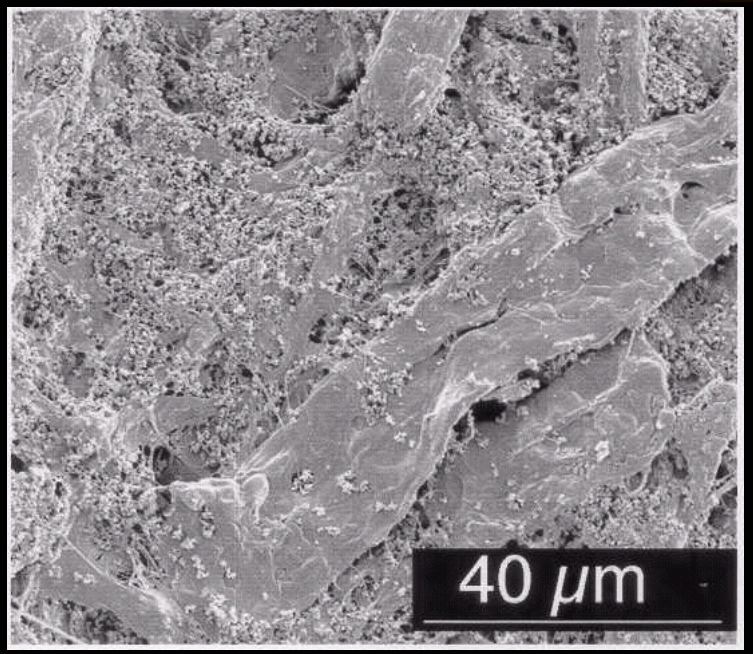
Scanning Electron Microscopy (SEM)

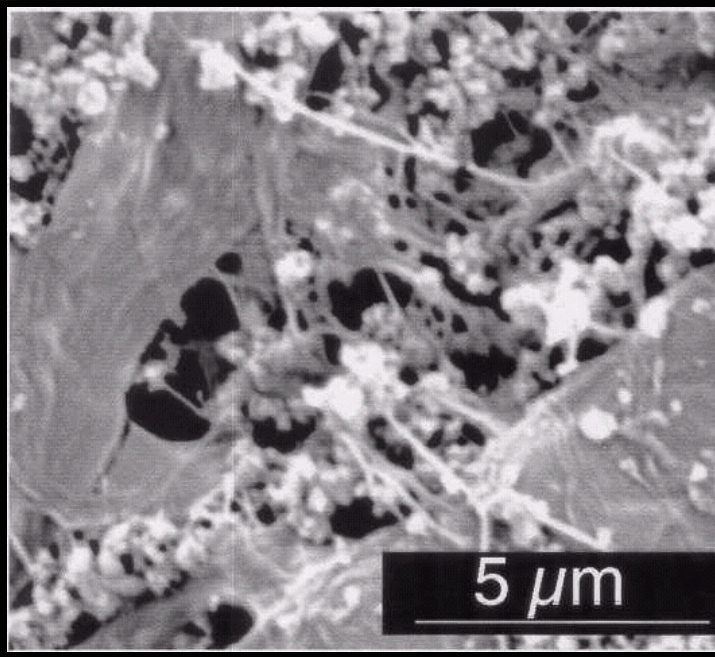
- Visible representation of the paper structure
- Info on fibre and filler particle size and distribution

- Very small sample size
- Very specialised/expensive equipment

SEM Images







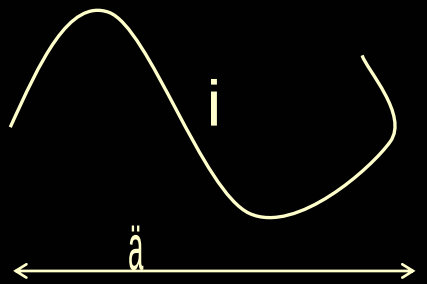
Fibre Quality Analysis

- Principles - A flow cell, light source with circular polarizing filters, a CCD camera and imaging software
- Measure paper fibre length, fines, curl and kink
- Quick and easy
- Uses a very small sample size (sample must therefore be homogenous)
- Equipment expensive

- Softwoods have long fibres, hardwoods have short fibres

  As fibre length ↑, tensile ↑, tear resistance ↑, formation ↓

- Fines (2º formed during refining) improve paper strength
- Curl



Curl Index = (L/l) -1

- Kink is the abrupt change in fibre curvature (defined using Kibblewhite's equation)

  As curl and kink ↑, strength ↓, tear resistance ↑, light scattering properties ↑

Example

Papers 1 and 2 made to identical specifications.

Paper	*Strength (N/15mm)*	*Opacity (%)*
1	20.8	74.1
2	18.0	76.6

Difference in optical properties due to (1) filler distribution within the paper and (2) fibre quality.

Paper	*Fibre length (mm)*	*Mean Curl*	*Kink (1/mm)*
1	0.70	0.056	1.19
2	0.64	0.087	1.57

Acknowledgements

- Papeteries De Mauduit
- Wattenspapier