

Measure of porosity in flax fibres reinforced polylactic acid biocomposites

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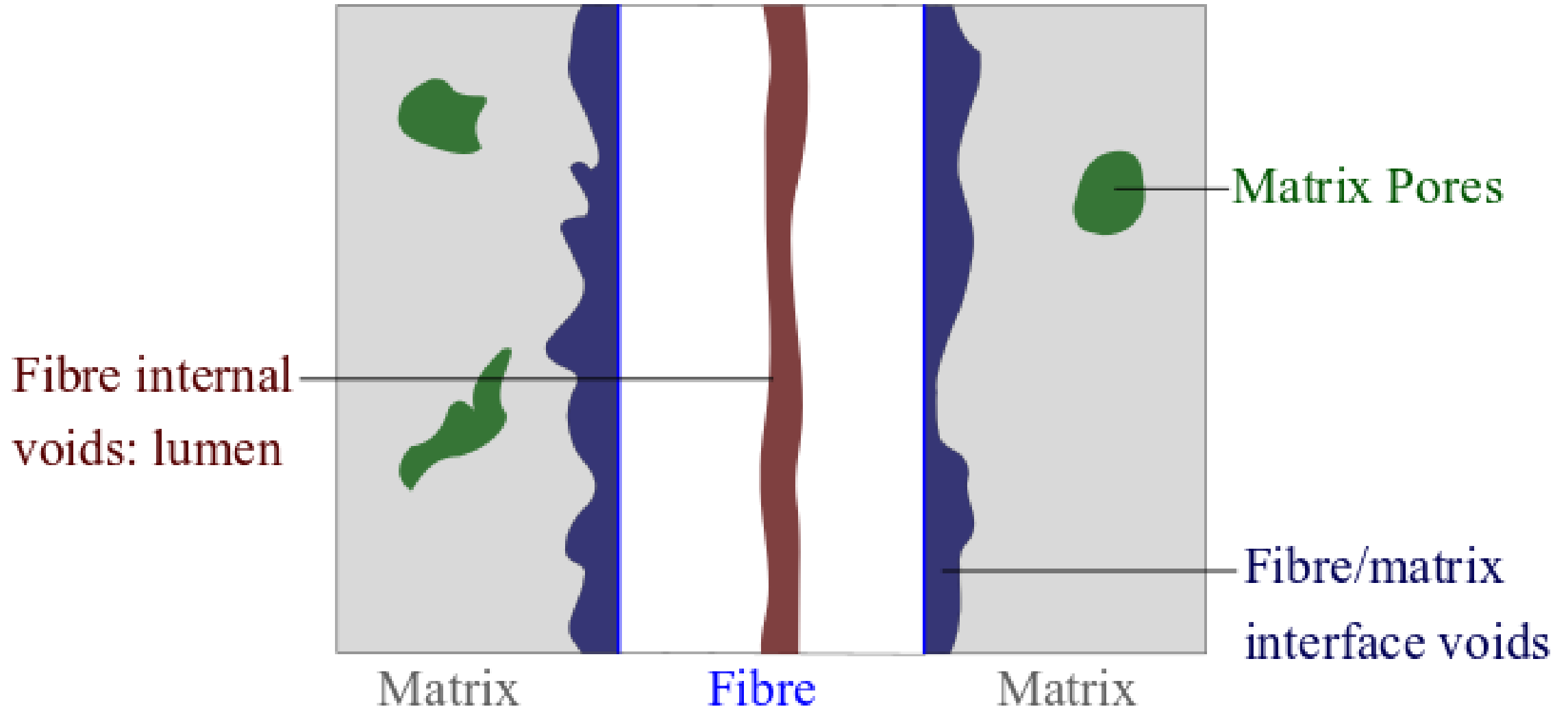
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In literature (flax fibre composite)

Porosity (%)	FVF (%)	Measurement	Production	Resin	Reference
8.3±2.3	53	Gravimetric Ethanol CT-scanner	Hot Press	PLA	Present Study
8.0	43	Gravimetric Ethanol SEM	Prepreg Autoclave	Epoxy	Panzera et al. [48]
4.9-8.6	46	Geometric Density Prior to manufacturing FVF	Hot Press	Epoxy	Berges et al. [46]
6.9±1.3	34	Gravimetric Ethanol	Hot Press	PP	Gager et al. [1]
3.8±1.0 7.7 ± 0.5	– 57-71	Gravimetric Water Digestion Xylene	Filament Winding	PP	Madsen et al. [12]
3.2±0.7	30	Geometric	3D Print	PLA	Le Duigou et al. [47]
0.02 - 0.34	45	Ultrasound (C-scan)	Prepreg Hot Press	Epoxy	Li et al. [20]
1.5±0.04 2.4 ± 0.1	– 45	Optical microscope	Prepreg Hot Press	Epoxy	Li et al. [20]
3.5±1.5 10.3 ± 3.6	– 37-55	Optical microscope	Prepreg Autoclave	Epoxy	Meredith et al. [25]

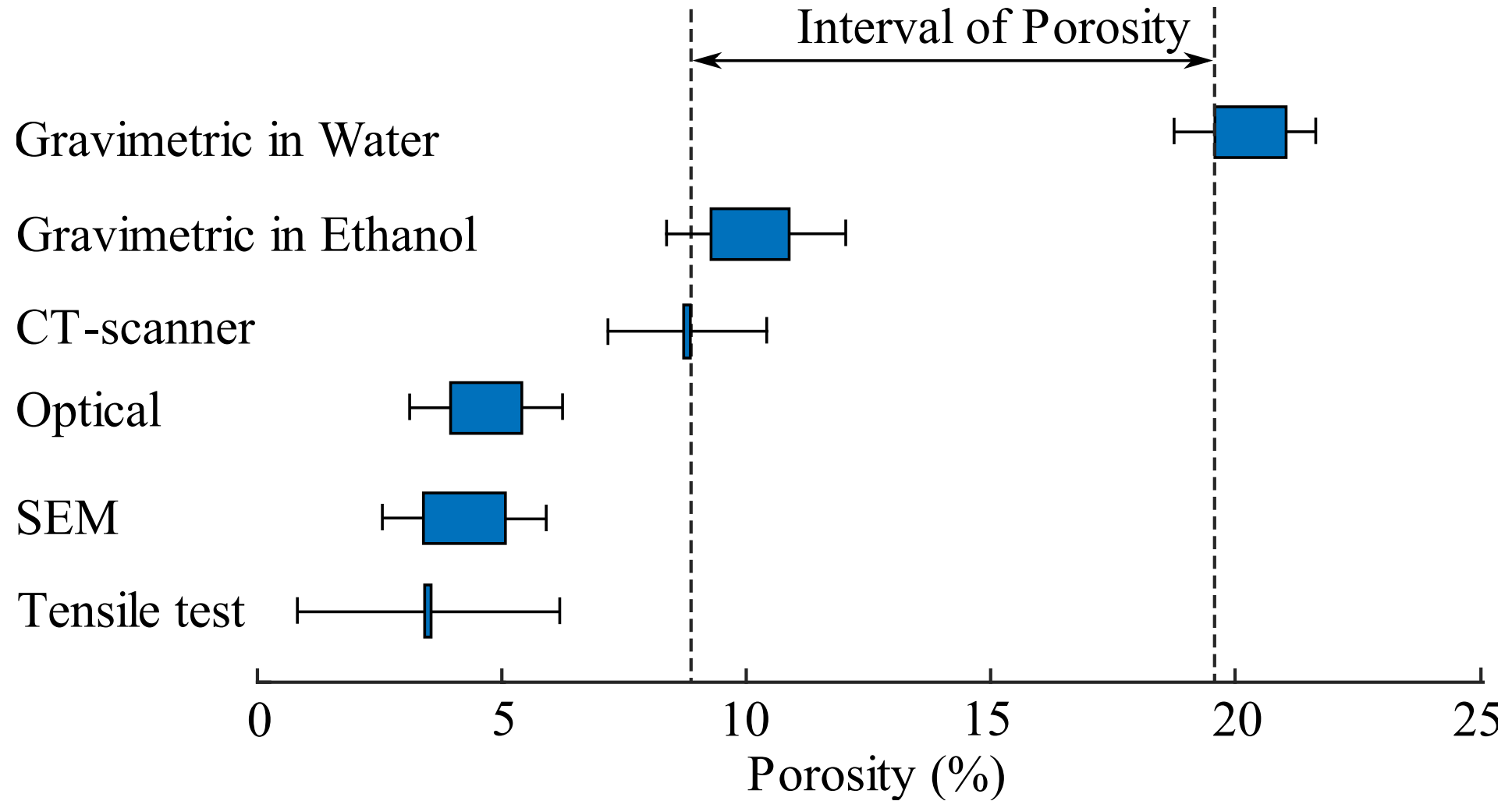
Porosity in Natural fibre Composite



Questions we wanted to solve

- 1- What is measured by the different technique?
- 2- How to adapt porosity measure to natural fibre composites?
- 3- To what extend can I trust the values obtained?

Porosity in Natural fibre Composite



1- Type of values:

- Overestimation
- Underestimation
- Approximation

2- Type of porosity:

- Fibre internal voids (Lumen)
- Matrix pores
- Fibre matrix interface voids

3- Size of pores:

- Select Technique
- Adapt it to materials

Conclusion

Technique	Advantages	Disadvantages
Gravimetric measurement in ethanol	Easy and inexpensive Quick Measure density Measure FVF Can approximate an underestimation of the "real" porosity	No void distribution or morphology Cannot distinguish between the porous features measured Uncertainty regarding measuring liquid and composite interaction
Gravimetric measurement in water	Easy and inexpensive Measure density Overestimate the "real" porosity	Long but not work intensive No void distribution or morphology Cannot distinguish between the porous features measured Uncertainty regarding measuring liquid and composite interaction
Optical microscope	Easy and inexpensive Void distribution and 2D morphology Can distinguish between the porous features measured Can account for the fibre internal voids (with high magnification)	Fairly long but not work intensive Difficult to obtain a representative surface of inspection Influenced by preparation process
SEM	Void distribution and 2D morphology Can distinguish between the porous features measured Can account for the fibre internal voids (with high magnification)	Fairly long but not work intensive Difficult to obtain a representative surface of inspection Cost increasing with accuracy Influenced by preparation process
CT-scanner	Quick 3D analysis Precise void distribution Can distinguish between the porous features measured Void shape Not influenced by preparation process Underestimate the "real" porosity Can account for the fibre internal voids (with high magnification)	Expensive Limited to small volumes
Tensile test	Measures mechanical properties	Costly Fairly long and work intensive No void distribution or morphology High uncertainty Cannot distinguish between the porous features measured Cannot account for the fibre internal voids

C. Kergariou, A. L. Duigou, V. Popineau, V. Gager, A. Kervoelen, A. Perriman, H. Saidani-Scott, G. Allegri, T. H. Panzera, and F. Scarpa, "Measure of porosity in flax fibres reinforced polylactic acid biocomposites," Composites Part A: Applied Science and Manufacturing, vol. 141, p. 106183, 11 2020

Thank you very much for your time

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