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Assessing hemp fibre morphology and fibre/matrix interfaces using contact angle measurement technique

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ABSTRACT

This study is part of the SSUCHY-Next project. An initial investigation of fibre morphology revealed various cross-sectional shapes for hemp elementary fibres, with diameters ranging between 15–28 μm . Measurements of the contact angles (CA) between elementary fibres and four different testing liquids, using the Wilhelmy method, allowed the fibre surface energy components characterisation. The results show that the fibres are hydrophilic and possess mainly dispersive (γ^{LW}) and basic (γ^-) surface energy components.

The next step will be to correlate the surface properties derived from contact angles with inverse gas chromatography (IGC). This method is proposed because it enables the characterization of a large number of fibres simultaneously, making it highly time-efficient compared to the Wilhelmy method. Additionally, IGC allows for an increased number and complexity of probes, enabling a more detailed characterization of the fibre surface.

INTRODUCTION

Hemp fibres present an attractive alternative to flax, as they share many favourable properties, such as a high cellulose content (Liu et al., 2017) and a low microfibrillar angle (Placet et al., 2011), making them suitable for load-bearing applications.

A common method for investigating fibre surfaces is analysing the contact angles formed between the fibre and various testing liquids (Woigk et al., 2019). From these CA's, different interfacial parameters of the fibres, such as polarity and surface energy, can be determined. These interfacial parameters can be used for predicting the fibre-matrix adhesion and wetting.

RESULTS AND CONCLUSIONS

Figure 1a illustrates the cross-sections of both elementary fibres and technical fibre bundles. The elementary fibres exhibit various shapes (bean-like, elliptical, round, and hexagonal), with diameters ranging from $15 \pm 5 \mu\text{m}$ measured for the short side of an ellipse to $28 \pm 9 \mu\text{m}$ for the long end. Figure 1b shows a relatively rough fibre surface, which may influence contact angle measurements by increasing interactions between the liquid and solid.

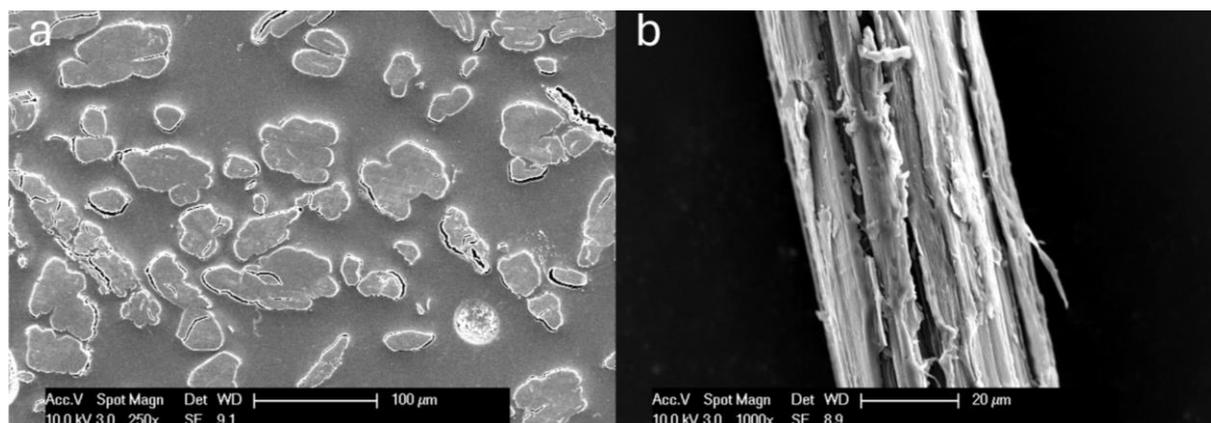


Fig. 1 Cross-sections of elementary and technical hemp-fibres (a) and fibre surface along its length (b)

Table 1 presents the CA's for the four different testing liquids. Due to the hydrophilic nature of these natural fibres, measuring receding angles proved to be difficult. Bromoform is proposed as an alternative to water in an attempt to measure receding CA more precisely. Finally, Table 2 summarises the results for the surface energy of the hemp fibres using the Van Oss model and a combination of the three different testing liquids. For both sets of testing liquids, the surface energies were determined using equilibrium contact angles.

Table 1 Advancing and receding contact angles of elementary hemp-fibres for different testing liquids

	CA_{adv} (°)	<i>Std. Dev.</i> (°)	CA_{rec} (°)	<i>Std. Dev.</i> (°)
Water (W)	70.83	4.74	/	/
Bromoform (BrF)	27.57	5.10	14.27	3.74
Ethylene Glycol (EG)	61.07	8.47	12.20	1.61
Bromonaphthalene (BrN)	40.37	5.18	22.13	1.64

Table 2 Surface energies for hemp-fibres based on Van Oss model and two sets of testing liquids with condition number of 3.305 and 3.775 respectively

	γ^{tot} (mJ/m ²)	γ^{LW} (mJ/m ²)	γ^{ab} (mJ/m ²)	γ^+ (mJ/m ²)	γ^- (mJ/m ²)
W/EG/BrN	39.74 ± 2.55	37.75 ± 1.43	1.99 ± 2.11	0.06 ± 0.13	16.49 ± 2.05
BrF/EG/BrN	39.49 ± 1.62	37.75 ± 1.43	1.74 ± 0.76	0.36 ± 0.30	2.08 ± 0.57

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