Supplementary information

Foam-formed biocomposites based on cellulose products and lignin

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Abstract Foam-formed cellulose biocomposites are a promising technology for developing lightweight and sustainable packaging materials. In this work, we produce and characterize biocomposite foams based on methylcellulose (MC), cellulose fibers (CF), and lignin (LN). The results indicate that adding organosolv lignin to a foam prepared using MC and CF moderately increases Young's modulus, protects the foam from the growth of *Escherichia coli* bacteria, and improves the hydrophobicity of the foam surface. This article concludes that organosolv lignin enhances many properties of cellulose biocomposite foams that are required in applications such as insulation, packaging, and cushioning. The optimization of the foam composition offers research directions toward the upscaling of the material solution to the industrial scale.

Graphic abstract

1 Automatic computation of the Young's modulus and yield point

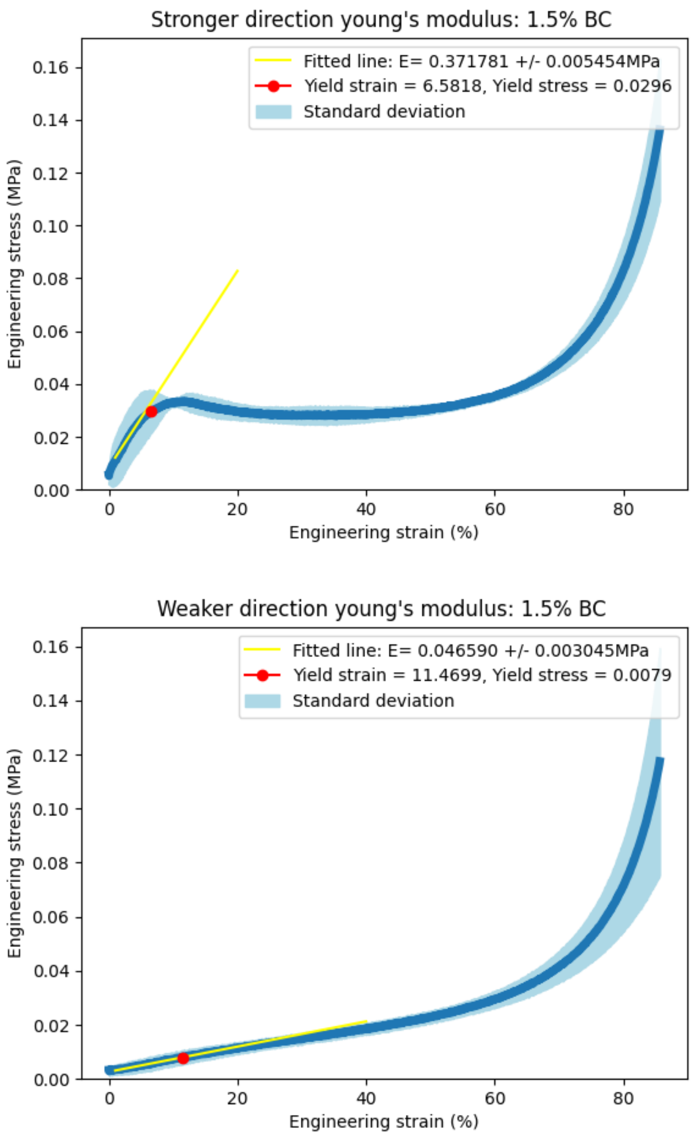

Figure S1: Calculation of the Young's modulus and yield point for the y-direction (i.e., stronger direction) and z-direction (weaker direction) of Foam-MC.

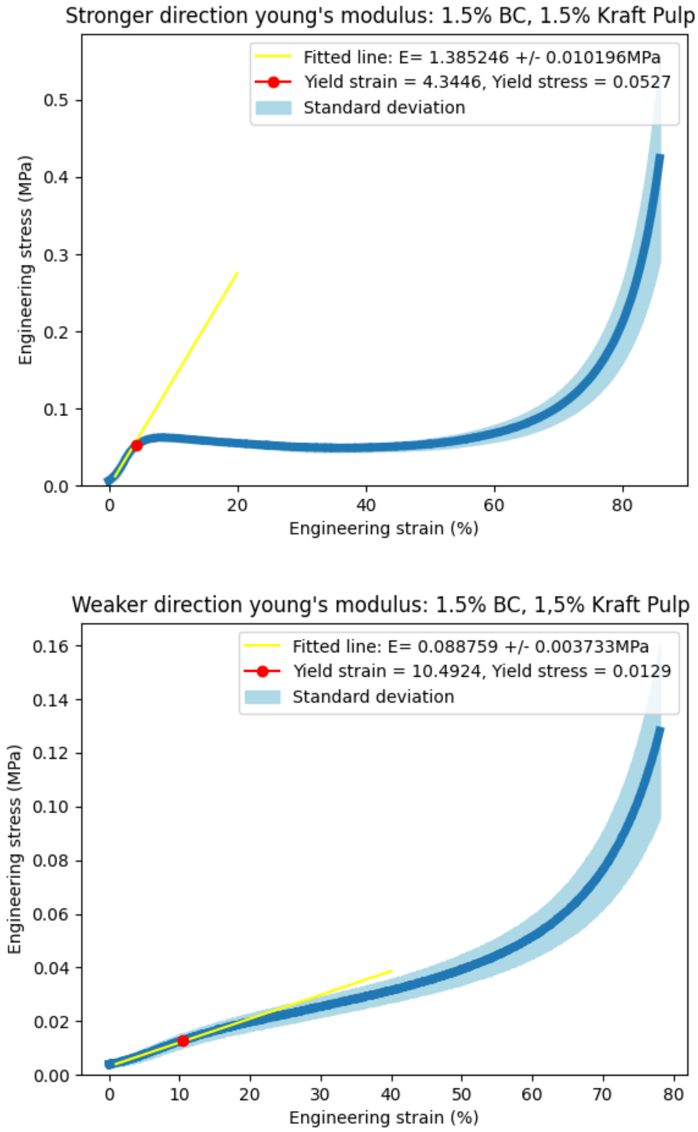

Figure S2: Calculation of the Young's modulus and yield point for the y-direction (i.e., stronger direction) and z-direction (weaker direction) of Foam-MCF.

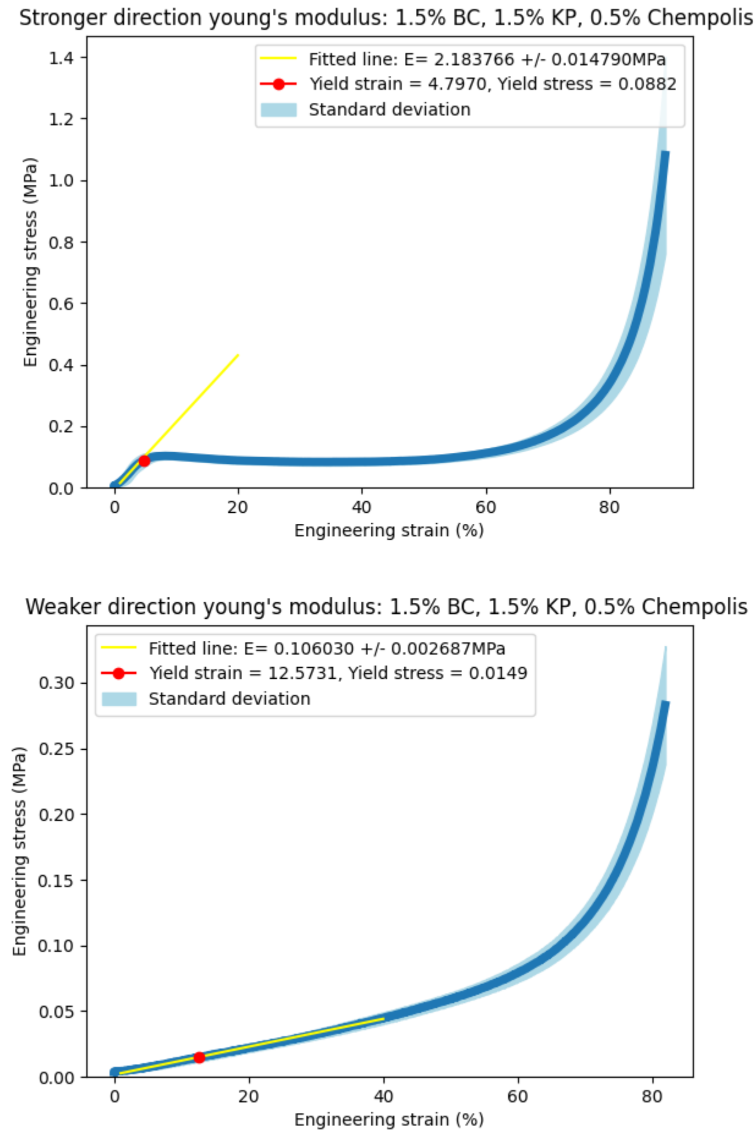

Figure S3: Calculation of the Young's modulus and yield point for the y-direction (i.e., stronger direction) and z-direction (weaker direction) of Foam-LN.

2 Scanning electron microscopy images of the biobased foams cross-section

Scanning electron microscopy (SEM) images taken at 50× magnification. Fig. S4 shows the cross-section of Foam-MC, while Fig. S5 and Fig. S6 depict the cross-section of Foam-CF and Foam-LN, respectively. In all of the cases, the images illustrate a bubble-like structure elongated toward the y-direction of the foams. To visualize the foams, the samples were held on carbon tape, and their surfaces were coated with a thin layer of Au/Pd 80/20. More information about the potential difference and the SEM signal can be found at the bottom of each figure.

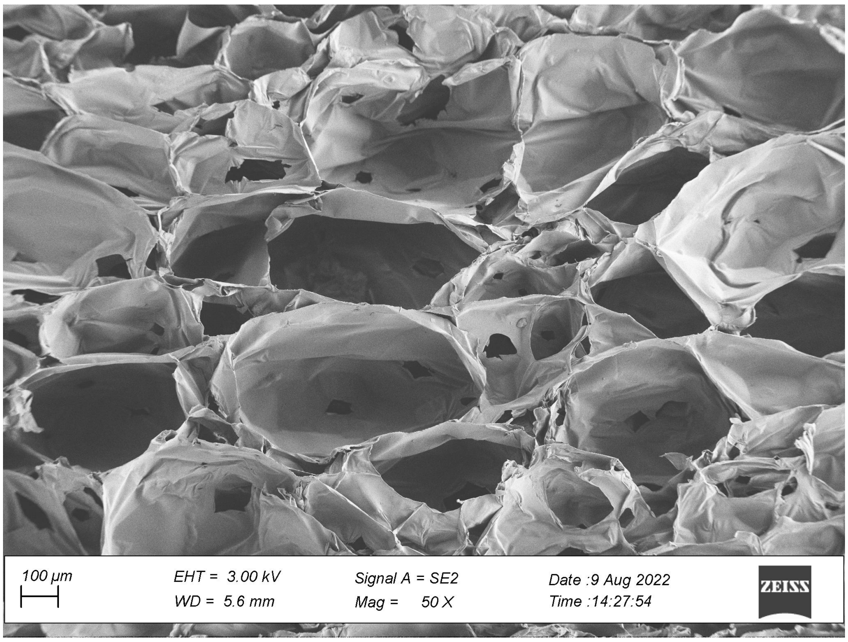

Figure S4: Scanning electron microscopy image of the cross-section of Foam-MC. The bubble elongation is oriented toward the y-direction of the foam.

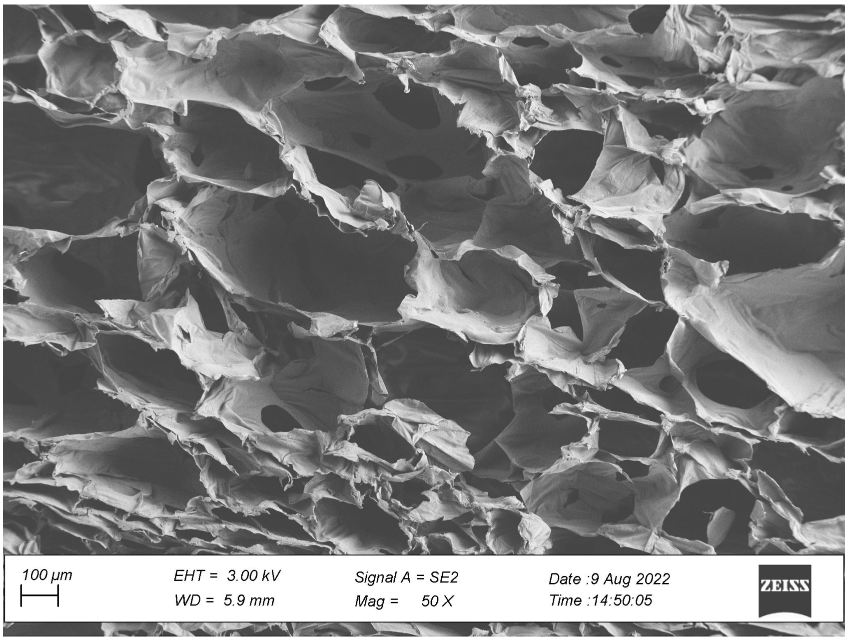

Figure S5: Scanning electron microscopy image of the cross-section of Foam-CF. The bubble elongation is oriented toward the y-direction of the foam.

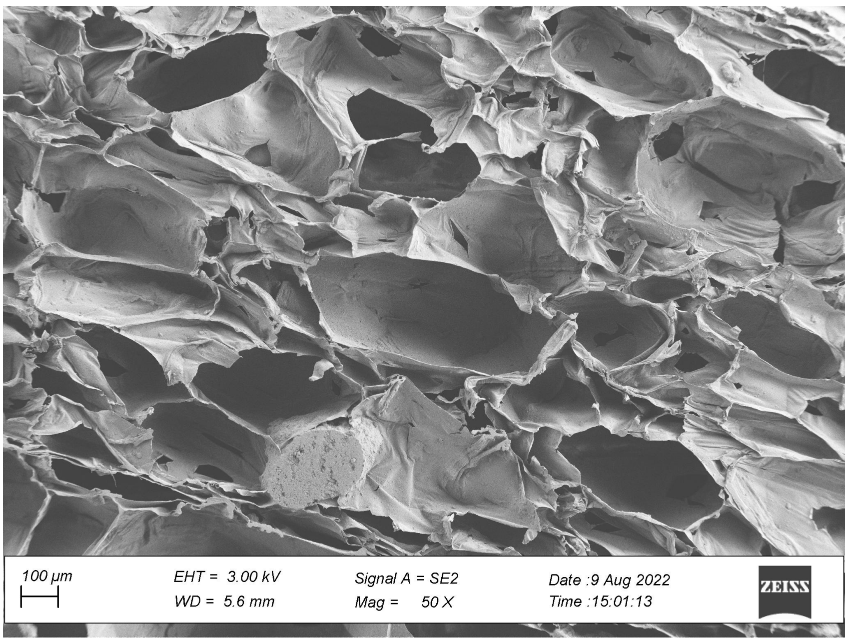

Figure S6: Scanning electron microscopy image of the cross-section of Foam-LN. The bubble elongation is oriented toward the y-direction of the foam.

3 Water contact angles of the biobased foams

Sessile drop goniometry tests performed on the flat surfaces of Foam-MC (Fig. S7), Foam-CF (Fig. S8), and Foam-LN (Fig. S9). The images show the initial contact angle after 2 seconds and then after 20 seconds.

Figure S7: Water test *CA* on Foam-MC. The drop on the left side shows the initial *CA* after two seconds, and the drop on the right shows the *CA* after 20 s.

Figure S8: Water test *CA* on Foam-CF. The drop on the left side shows the initial *CA* after two seconds, and the drop on the right shows the *CA* after 20 s.

Table S1: Water contact angles tested on foam surfaces. Measurements taken after 2 and 20 seconds.

Sample	*CA* 2s	*CA* 20 s
Foam-MC	$84° \pm 5°$	$79° \pm 4°$
Foam-CF	$100° \pm 3°$	$58° \pm 6°$
Foam-LN	$117° \pm 4°$	$115° \pm 5°$

Figure S9: Water test *CA* on Foam-LN. The drop on the left side shows the initial *CA* after two seconds, and the drop on the right shows the *CA* after 20 s.