Supplementary material for:

Microalgae *Chlorella vulgaris* and kraft lignin stabilized cellulosic wet foams for camouflage

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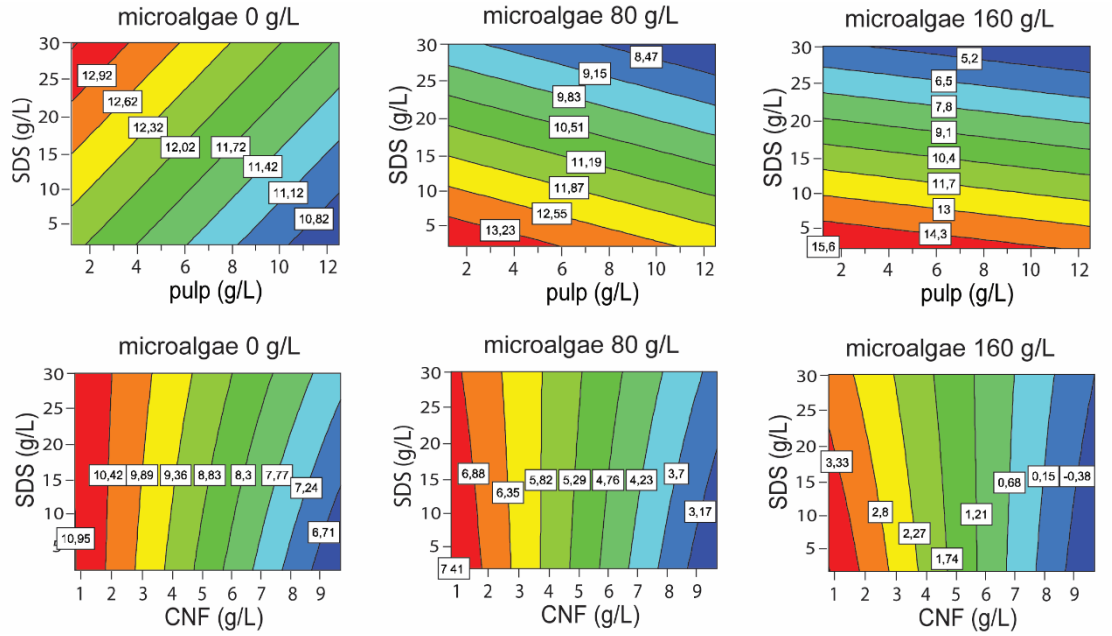

Fig. S1. The stability of foams containing bleached pulp (upper row) or cellulose nanofibril (CNF) (lower row) with and without microalgae 2 hours after foaming. The stability was investigated in terms of drained liquid (mL) using the response surfaces. The highest drainage volumes are marked with red and the lowest volumes with blue. The higher the microalgae content, the better the stability against drainage.

Fitting and validity of the model

The regression and other parameters for the foam optimization showed that the model fit was not great, and this was especially true for the CNF foams (Table S1). Reasons for the overall inferior fit include inaccuracies when transferring the foam from a cup into a measuring cylinder and obtaining a very exact reading of the foam volume. This was true especially for the drier foams with a higher dry mass content. The accuracy of the reading was in the range of 10 mL, but not 1 mL. Since some of the foams with higher dry mass content did not drain at all, even after 2 hours, that might have caused too large margins for the model. Using other concentration intervals could have helped, however, then any comparison with previous work would not be possible.

Nevertheless, despite these problems with the fit of the model, information about the behavior of the components and foams were gained and an optimized recipe for foams with a combination of maximum foam volume and minimum drainage was obtained for both pulp and CNF containing systems (Table S2). The software gave several options for the optimized foam composition, and the most fitting one containing microalgae was chosen according to maximized foam volume and minimum drainage. The concentration of microalgae was taken into account since the color was important. Especially for the pulp foam, there were options with very low microalgae content that would have given a higher foam volume and better stability, but not a sufficiently strong green color. The CNF concentration of the optimized CNF-microalgae foam is very low. There were options with higher CNF concentrations, but it was a deliberate decision to study a foam mostly consisting of microalgae to gain more information about the behavior of the microalgae. From an application perspective, the pulp is nevertheless more attractive than CNF due to its lower price.

Table S1. Regression parameters of the model foams.

Foam/test	R2	Regression	Lack of fit	Q2
pulp-SDS-algae				
initial foam volume	0.738	0	0.116	0.659
5 min drainage	0.929	0	0.003	0.897
2 h drainage	0.825	0	0.164	0.696
CNF-SDS-algae				
initial foam volume	0.828	0	0.173	0.811
5 min drainage	0.580	0.001	0	0.379
2 h drainage	0.788	0	0	0.694

Table S2. Optimal parameters of the different constituents for creating maximum foam volume. Samples without algae are from[1].

Foam	Cellulose (g/L)	SDS (g/L)	Microalgae/Lignin (g/L)
Pulp-microalgae	12.65 (pulp)	30.0	121 (microalgae)
CNF-microalgae	0.1 (CNF)	30.0	132 (microalgae)
Pulp	7.0 (pulp)	21.6	0
CNF	10.4 (CNF)	30.0	0
Pulp-Lignin	6.1 (pulp)	22.4	160 (lignin)
CNF-Lignin	8.5 (CNF)	29.1	160 (lignin)

The optimal foam recipes of neat pulp and CNF were tested to validate their performance in practice. In Table S3, it can be seen that the experimental foam volume was around 10 mL higher than predicted one for both of the samples. The drainage at 5 minutes was as expected from the response surface experiments, but the drainage after 2 hours was greater than predicted.

Table S3. Validity of the model, with predicted and actual foam and drainage volume.

	Initial Foam Volume (mL)		Drainage 5 min (mL)		Drainage 2 h (mL)	
	predicted	actual	predicted	actual	predicted	actual
Pulp	63	76	<0	1	5.8	9.1
CNF	62	73	1.5	0.8	3.7	8.1

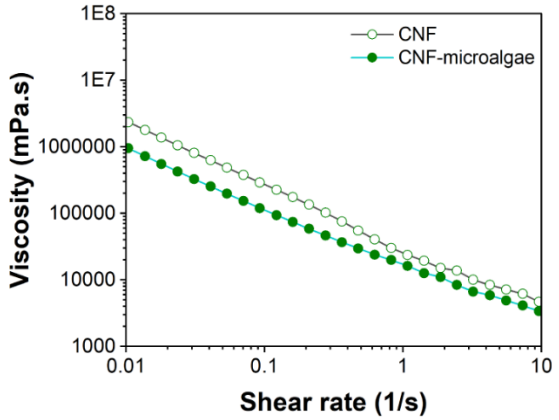

Fig. S2. The viscosity versus shear rate for neat CNF with a concentration of 10.4 g/L compared to CNF-microalgae with the same CNF content and microalgae concentration of 132 g/L.

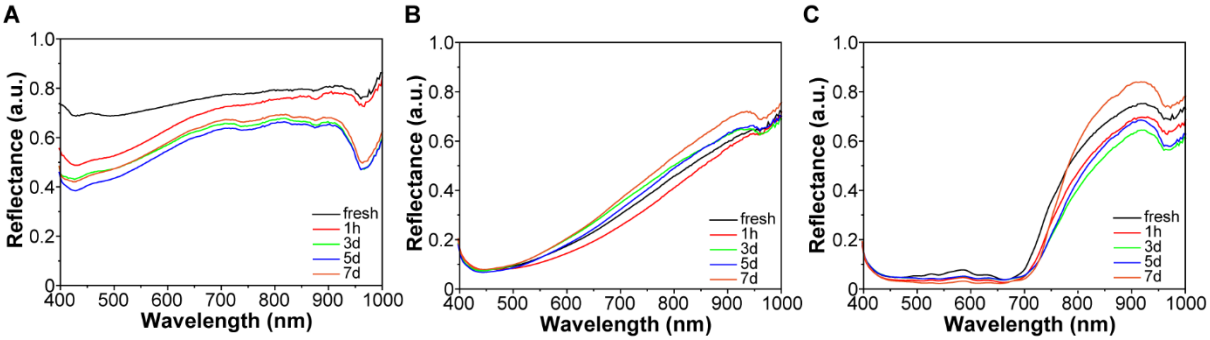

Fig. S3. The average reflectance spectra of pulp foams during the 7 days follow up. A) Neat pulp foams, B) pulp-lignin foams, and C) pulp-microalgae foams. The neat pulp exhibited the most drastic change in reflectance.

References

1 T. Lohtander, R. Herrala, P. Laaksonen, S. Franssila and M. Österberg, *Cellulose,* submitted.