

Supplementary Information for

Sprayed Water-Based Lignin Colloidal Nanoparticle-Cellulose Nanofibril Hybrid Films with UV-Blocking Ability

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GISAXS parameters

a) Set-up of CLP 20P and CLP/H₂O 20P:

The sample-to-detector distance (SDD) was kept at 6195 mm in GISAXS. The energy of X-ray was 11.9 keV ($\lambda=1.044$ Å) with a beam center X = 848 [pixel], Y = 222 [pixel]. One beam stop was used to shield the specular reflected beam. The incident angle α_i was set at 0.32° for GISAXS. 2D GISAXS data were collected by a PILATUS 2M detector (Dectris Ltd., Switzerland) with a pixel size of 172×172 μm^2 .

b) Set-up of CLP on CNF 20P and CLP/CNF 20P:

The sample-to-detector distance (SDD) was kept at 3602.99 mm in GISAXS. The energy of X-ray was 11.8 keV ($\lambda=1.041$ Å) with a beam center X 880 [pixel], Y 301 [pixel]. One beam stop was used to shield the specular reflected beam. The incident angle α_i was set at 0.4° for GISAXS. 2D GISAXS data were collected by a PILATUS 2M detector (Dectris Ltd., Switzerland) with a pixel size of 172×172 μm^2 .

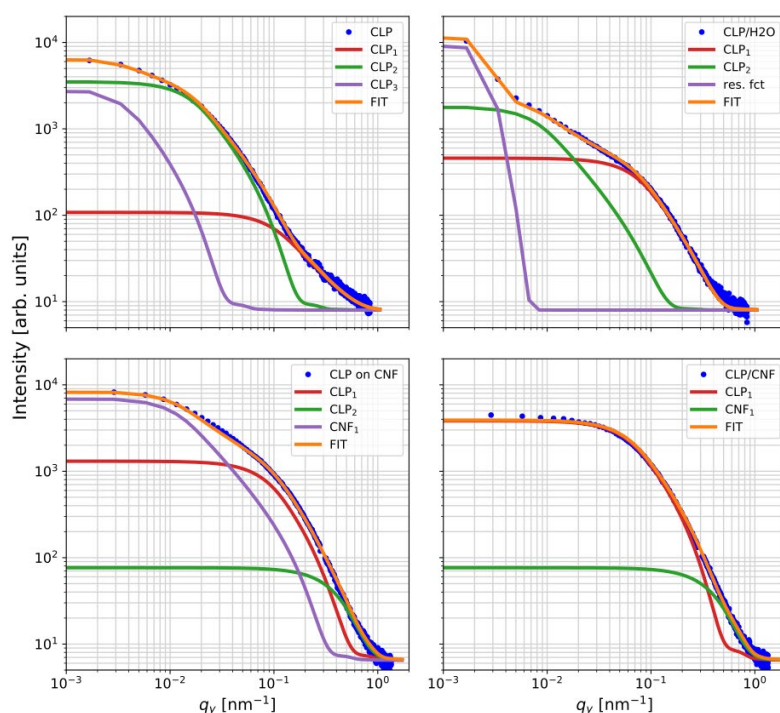


Fig. S1 Fitted horizontal line cuts data from the 2D GISAXS data. CLP 20P sample have three lignin nanostructure CLP₁, CLP₂, CLP₃ detected, which have a different diameter and distribution. CLP/H₂O 20P sample have two lignin nanostructures. CLP on CNF 20P sample have the similar two lignin nanostructure with CLP/H₂O samples detected, but also one CNF structure CNF₁. CLP/CNF 20P sample have only one lignin nanostructure and one CNF nanostructure, because of the homogeneity of the nanoparticles and their distribution. The resolution function was only detected in CLP/H₂O 20P sample as res. fct, that due to the very high roughness of lignin samples and the resolution function was mixed into nanostructure signal in other three samples.

Table S1. Diameter and polydispersity of different structures in the CLP-based samples from Fig. 1.

| | CLP 20P | CLP/H ₂ O 20P | CLP on CNF 20P | CLP/CNF 20P |
|-----------------------|-----------|--------------------------|----------------|-------------|
| Diameter [nm] 1st | 30 ± 10 | 44 ± 3 | 38 ± 25 | 52 ± 1 |
| Polydispersity 1st | 0.8 ± 0.3 | 0.7 ± 0.1 | 0.8 ± 0.9 | 0.7 ± 0.1 |
| Diameter [nm] 2nd | 190 ± 16 | 360 ± 9 | 10 ± 55 | 10 ± 3 |
| Polydispersity 2nd | 0.8 ± 0.1 | 0.9 ± 0.1 | 0.4 ± 5.0 | 0.4 ± 0.8 |
| Diameter [nm] 3rd | 850 ± 60 | None | 240 ± 9 | None |
| Polydispersity 3rd | 0.8 ± 0.1 | None | 0.9 ± 0.1 | None |

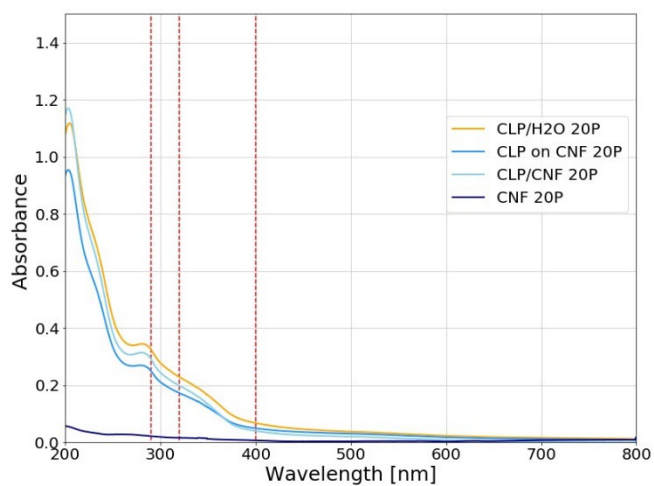


Fig. S2 UV-Vis Absorbance of CNF 20P, CLP/H₂O 20P, CLP on CNF 20P and CLP/CNF 20P samples.