Supplementary Materials

Catechyl lignin enhances self-assembly for Pickering emulsion stabilization and the controlled-release application

Lingjuan Luo[ab], Ya Ma[ab], Dingfu Wang[ab], Fangfang Wang[ab], Zhicheng Jiang[abc*], Bi Shi[abc]

[a] College of Biomass Science and Engineering, Sichuan University, Chengdu 610065, PR China

[b] National Engineering Laboratory for Clean Technology of Leather Manufacture, Sichuan University, Chengdu 610065, PR China

[c] Key Laboratory of Leather Chemistry and Engineering (Sichuan University), Ministry of Education, Chengdu 610065, PR China

E-mail: zhichengjiang@scu.edu.cn

Materials and methods

1. Interfacial tension of oil and water with LNPs

The pendant drop method was used to measure the interfacial tension between LNPs aqueous dispersions and the oil phase. A series of LNPs aqueous dispersion samples with different concentrations were prepared. Soybean oil was injected into a transparent optical sample cell, and a syringe (connected to a flat-tipped needle) filled with the LNPs aqueous dispersion was immersed into the oil phase. A pendant drop (16 µL) was slowly formed by gently pushing the plunger. After the droplet reached equilibrium, the interfacial tension was recorded.

2. The stability of curcumin in Pickering emulsion

To evaluate the protective effect of the Pickering emulsion on curcumin, an accelerated degradation test was designed to compare the stability of curcumin in pure soybean oil and in Pickering emulsions stabilized by lignin nanoparticles (LNPs). A 0.05 mg/mL curcumin oil solution was prepared by dissolving curcumin in soybean oil. Equal volumes of this oil phase were used: one portion served as the control, while the other was used to prepare LNPs-stabilized Pickering emulsions. Both sample sets were then subjected to two stress conditions: ultraviolet (365 nm) irradiation and incubation at 40°C in the dark. At predetermined time points, 100 µL samples were taken, mixed with 400 µL methanol, and the supernatant was analyzed using a UV-vis spectrophotometer at 420 nm to measure the curcumin content.

Results and discussion

Table S1 Biomass structural composition.

	Lignin (wt %)	Cellulose (wt %)	Hemicellulose (wt %)	Others (wt %)
Birch wood	28.4	45.5	16.7	5.9
pine wood	28.2	51.3	14.6	9.4
pubescens	29.6	43.1	21.4	5.9
castor coats	27.9	55.6	12.2	4.3

Table S2 Contents of hydroxyl groups in the lignin oligomers determined by ^{31}P NMR.

Phenolic -OH (mmol g^{-1})	Aliphatic -OH (mmol g^{-1})	-COOH (mmol g^{-1})

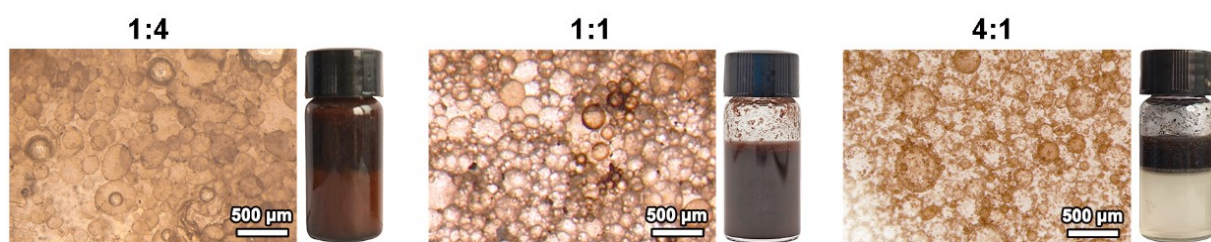|			
S-AL	2.43	1.78	0.14
G-AL	1.08	2.04	0.04
H-AL	5.82	1.88	0.73
C-AL	6.67	1.56	0.18
F1	2.24	1.23	0.06
F2	6.87	1.92	0.21

Fig. S1 Stereomicroscopic images of F2-0.5 at water-to-oil ratios of 1:4, 1:1, and 4:1, respectively.
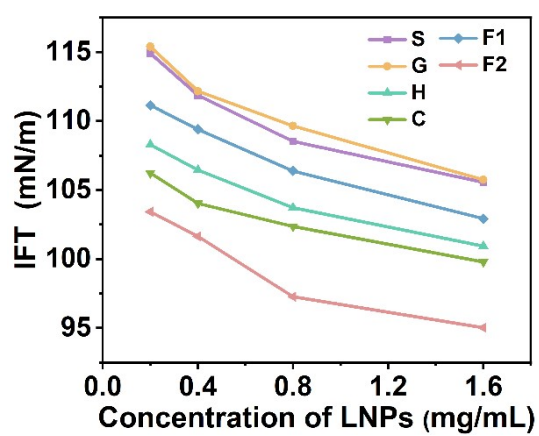

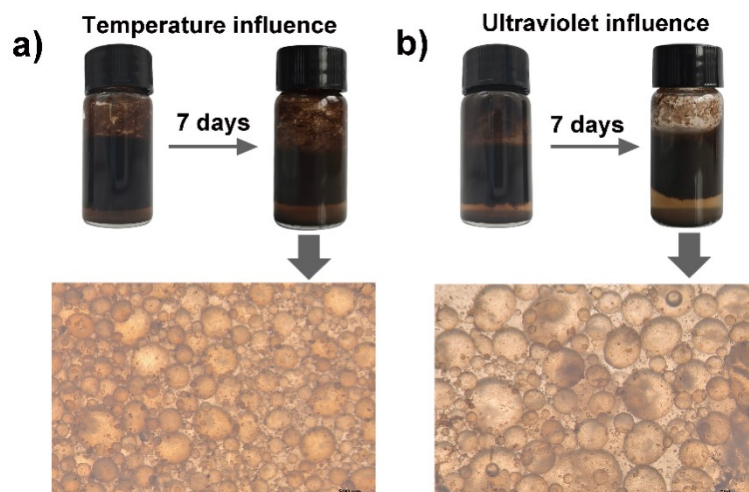**Fig. S2** The interfacial tension between LNPs' water dispersions and oil phase.

Fig. S3 a) F2-0.5 stored at 40°C for 7 days and the stereomicroscopic images; b) F2-0.5 stored for 7 days under the irradiation of 365 nm ultraviolet wavelength and the stereomicroscopic image.

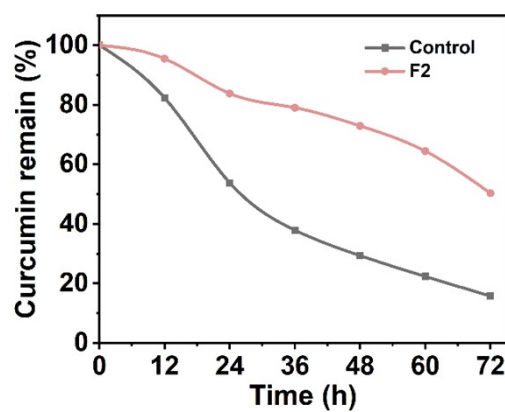**Fig. S4** The image of the F2-stablized Pickering emulsion stored over 500 days.

Fig. S5 Remaining rate of curcumin under the irradiation of 365 nm ultraviolet wavelength.