

Super-stable, Solvent-resistant and Uniform Lignin Nanorods and Nanospheres with a High Yield in a Mild and Facile Process

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Figures



Figure. S1 Lignosulfonate from the spent liquor (red liquor) of the sulfite pulping process and its structure.

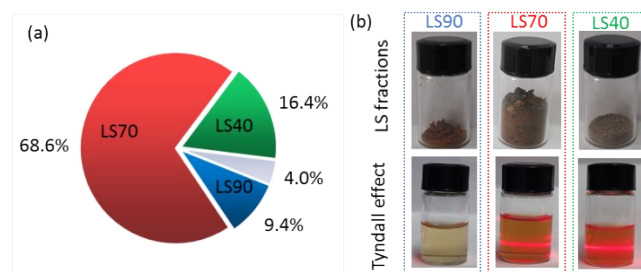


Figure S2 (a) The yield of each LS fraction. (b) The color of three fractions (top images) and the Tyndall effect photographs of three stable dispersions in ethanol (bottom images).

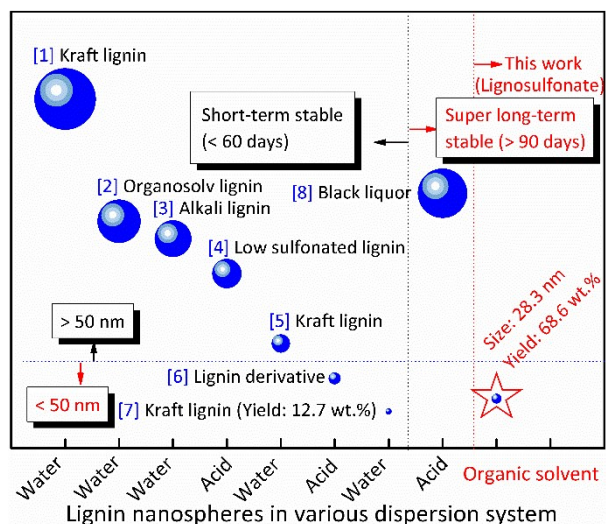


Figure. S3 Comparison of the raw material, size and stability of lignin nanospheres from this study and those reported in the literature.

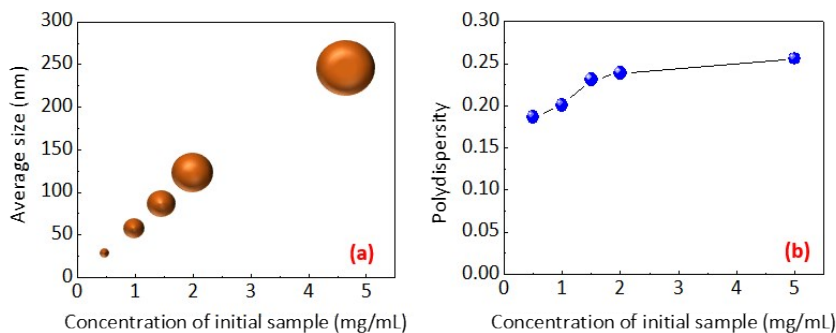


Figure S4 The average size distributions and polydispersity of lignin nanospheres obtained from LS70 using different initial concentrations.

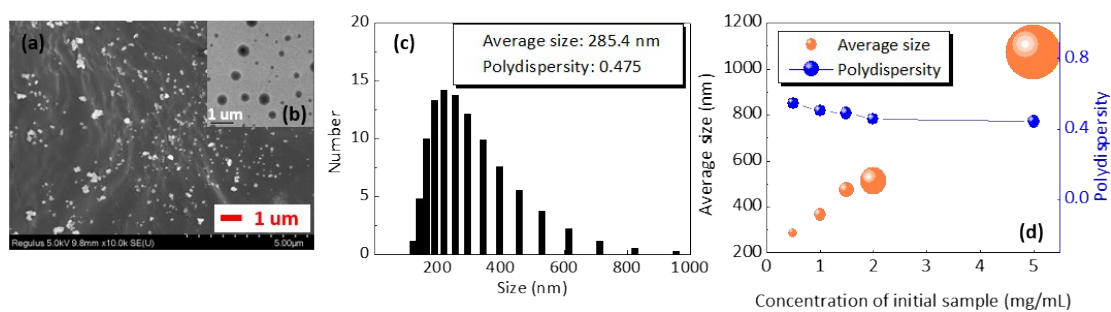


Figure S5 (a) SEM image, (b) TEM image and (c) average size distributions of the nanospheres obtained from original LS (The concentration of (a), (b) and (c) is 0.5 mg/mL). (d) Variations of size and polydispersity of lignin nanospheres obtained from different initial concentrations.

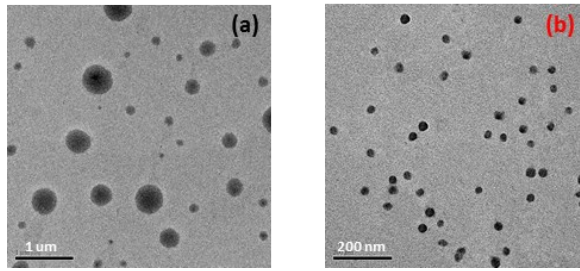


Figure S6 TEM image of (a) original LS nanospheres and (b) LS70 nanospheres. The initial concentration is 0.5 mg/mL.

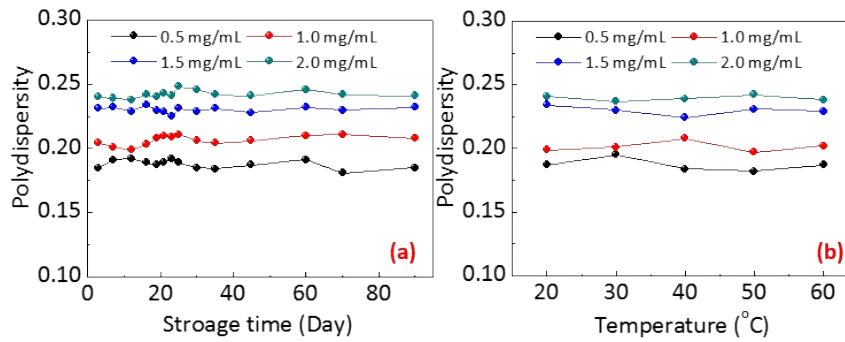


Figure S7 Long-term-stability in terms of the polydispersity of lignin nanospheres obtained from LS70. (a) 90 days of storage at room temperature ($\sim 25^\circ\text{C}$) in ethanol and (b) at temperature range of 20 \sim 60°C.

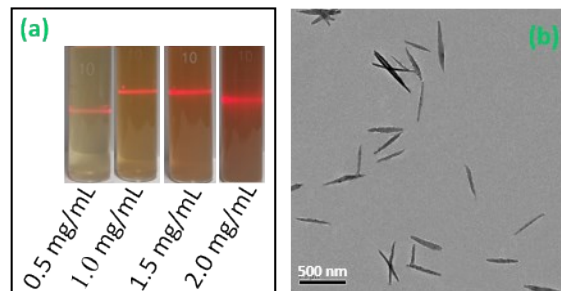


Figure S8 (a) Photographs (Tyndall effect) of stable dispersion of lignin nanorods obtained from LS40 for 90 days of storage at room temperature ($\sim 25^\circ\text{C}$). (b) The TEM image of lignin nanorods obtained from LS40 for 90 days of storage at room temperature ($\sim 25^\circ\text{C}$).

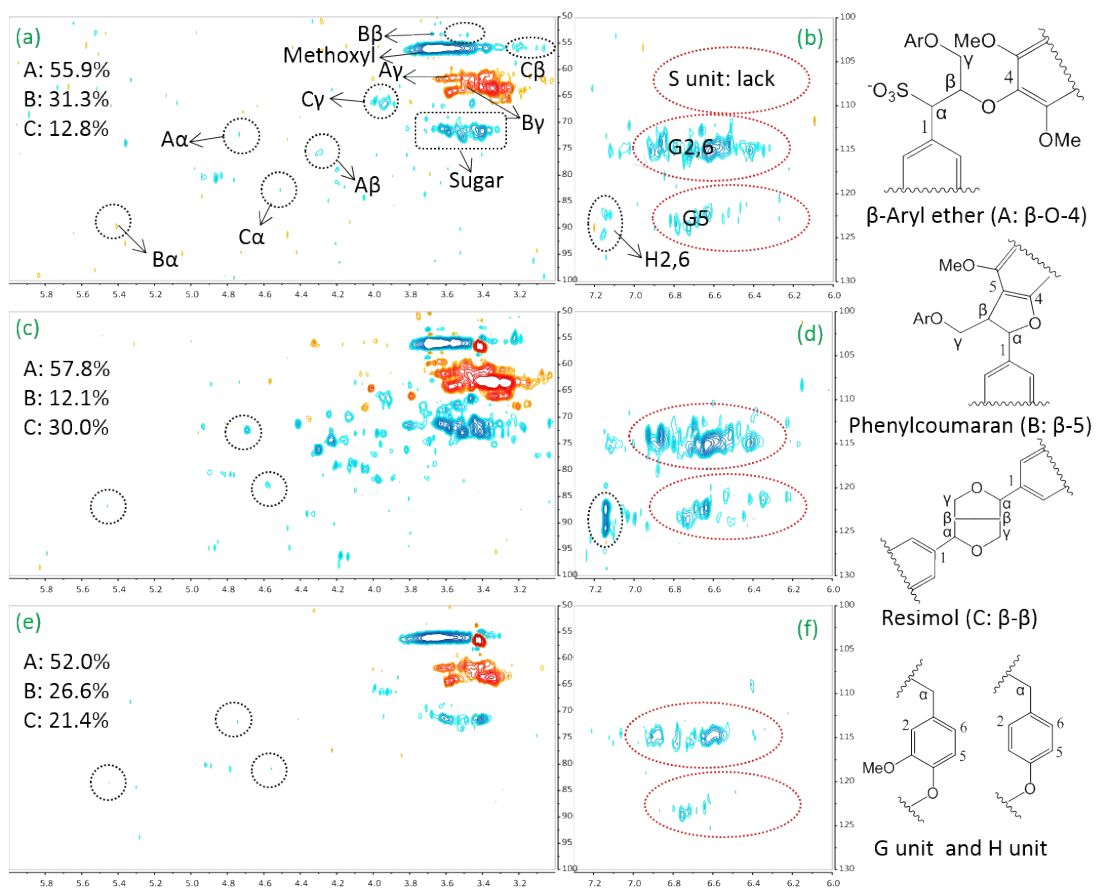


Figure S9 2D HSQC NMR spectra of the different LS fractions. LS: (a) and (b); LS70: (c) and (d); LS40: (e) and (f). (Left: Linkage region, $\delta C/\delta H$ 50-100/3.0-6.0 ppm; Right: Aromatic region, $\delta C/\delta H$ 100-130/6.0-7.3 ppm).

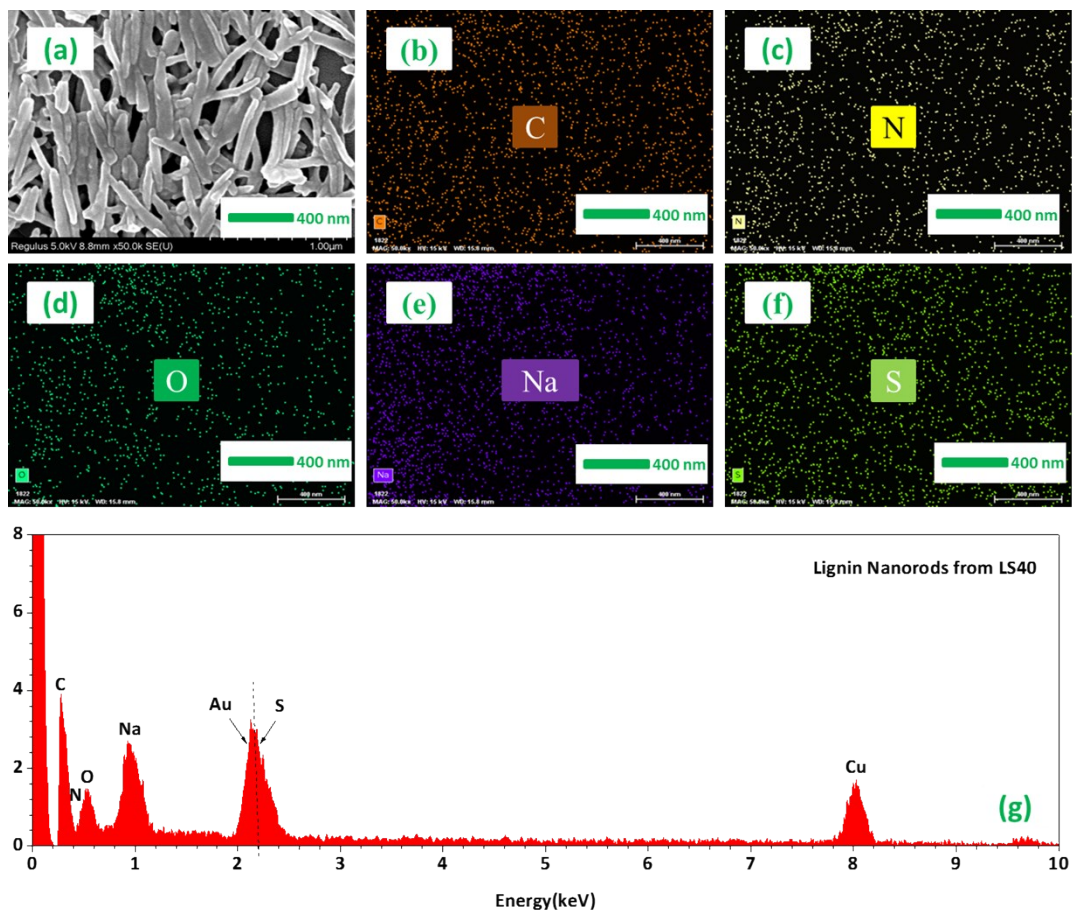


Figure S10 The energy-dispersive X-ray spectroscopies (EDS) of lignin nanorods. (a) The SEM image of lignin nanorods, (b) ~ (f) the elemental (C, N, O, Na and S) mapping of the lignin nanorod, (g) the corresponding EDS results of lignin nanorods.

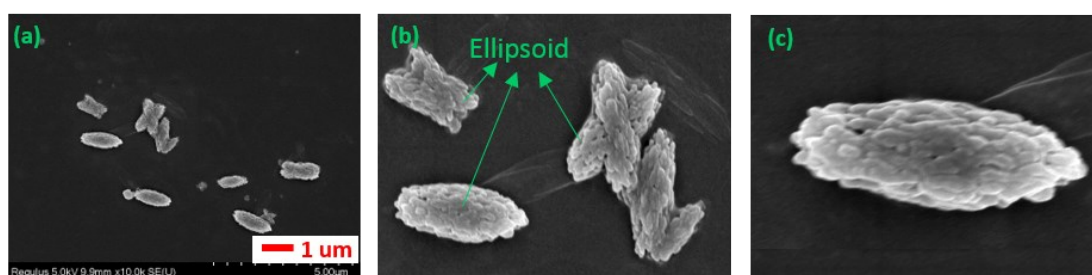


Figure S11 SEM images of nanorods before dialysis. (The initial concentration is 0.5 mg/mL).

Table

Table S1 Elemental analysis of three LS fractions (LS90, LS70 and LS40)

Sample	Elemental analysis (wt. %)				
	C	H	N	O	S
LS	42.8	4.7	1.0	37.1	6.7
LS90	41.8	5.3	1.8	41.5	4.1
LS70	46.2	5.3	0.8	38.8	5.2
LS40	34.8	4.2	0.7	41.6	9.2

References

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