Electronic Supplementary Information

Liquid Crystals-Mediated Self Assembly of Copper Nanoclusters with Induced Circular Dichroism and Amplified Circularly Polarized Luminescence

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1 Experimental Section

1.1 Materials

For the synthesis of G-SH-Cu NCs, we referenced the Andrey L. Rogach synthetic route[1]. Polyvinyl Pyrrolidone (PVP), and copper sulfate ($CuSO_4$) were bought from Kermel Chemical Reagent Co. L-ascorbic acid (AA), and L-glutathione reduced (G-SH) were obtained from Sinopharm Chemical Reagent Co. TX-100 was purchased from Sigma. All of the reagents purchased have not been further purified. The ultra-pure water used in the experiment was all ion-exchanged by ultrapure water plants (Ulupure, China).

1.2 Preparation of Chiral Liquid Crystals

The mass of the G-SH-Cu NCs was fixed and the added volume was 2 mL, different qualities of achiral TX-100 were added to G-SH-Cu NCs solution with stirring. After the samples were placed for 24 hours at 20^{o}C, the polarization appeared and the chiral liquid crystals were prepared. The concentration of G-SH-Cu NCs is 28 mg·mL^{-1}, according to the concentration we selected, the appropriate volume of G-SH-Cu NCs solution was selected and diluted with water, then add TX-100 with a weight percentage of 50%.

1.3 Instruments

Fluorescence data are tested by FLS920 luminescence spectrometer system (Edinburgh Instruments, United Kingdom, Xenon lamp, 450 W). Fourier transform infrared (FT-IR) spectra were measured on a Tensor II spectrophotometer (Bruker, Germany). POM observations were performed using an AXIOSKOP 40/40 FL (ZEISS, Germany) microscope. Rheological measurements were proceeded on a HAAKE RS6000 rheometer (Thermo Fisher Scientific, Germany) with a cone-plate system (Material: Ti, oscillatory mode, diameter: 35 mm; cone angle: 1º). The frequency scan was confirmed to be performed in the linear viscoelastic region, as the stress scan have been performed at a fixed 1 Hz before frequency scan measurement. The temperature of characterization and measurements were 25.0 ± 0.5 ºC, unless otherwise specified. Circular dichroism (CD) information and Circularly polarized luminescence (CPL) data were recorded on a Chirascan V100 circular dichroism spectrometer (Applied Photophysics, British), and the values of g_{lum} were averaged from the instrumental measurements at 455 nm to 465 nm. The UV-vis spectra were recorded on a Hitachi UV-vis 4100 spectrophotometer. Thermal gravity analysis (TGA) measurement was performed on a TGA5500 (TA, USA) at a scanning speed of 10 ºC min^{-1} in the temperature range of 30 to 700 ºC under a nitrogen flow. ^1H NMR spectra were measured on a Bruker AVANCE III HD 400 MHz spectrometer (USA) at room temperature with tetramethylsilane (TMS) as reference. Small angle X-Ray scattering (SAXS) measurements were performed on the SAXSess mc2 system (Anton Paar, Austria) with Ni-filtered Cu Kα radiation (1.54 Å) at 40 kV and 40 mA.

2 Additional Figures

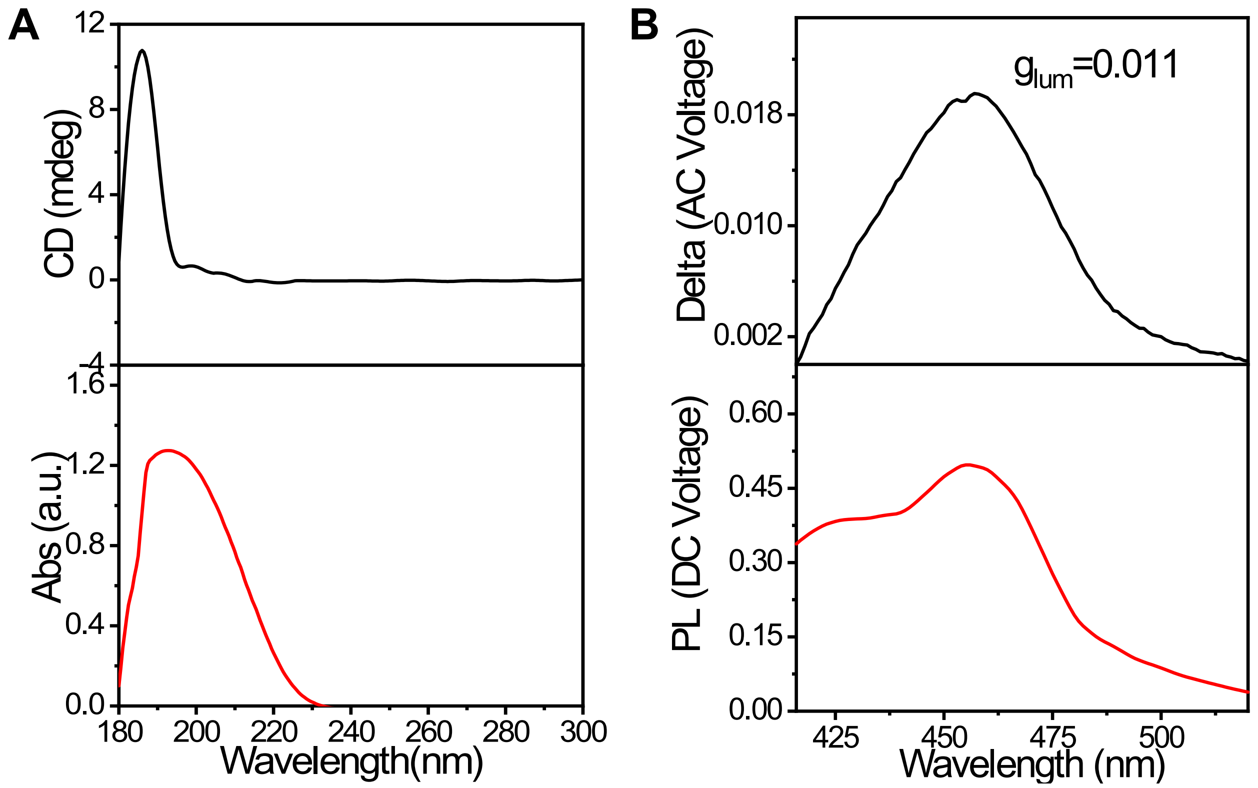

Figure S1 Chiral properties of G-SH-Cu NCs: **A)** CD (top) spectra and absorbance (bottom) of G-SH-Cu NCs. **B)** CPL (top) and luminescence spectra (bottom) of G-SH-Cu NCs, λ_{ex} =385 nm.

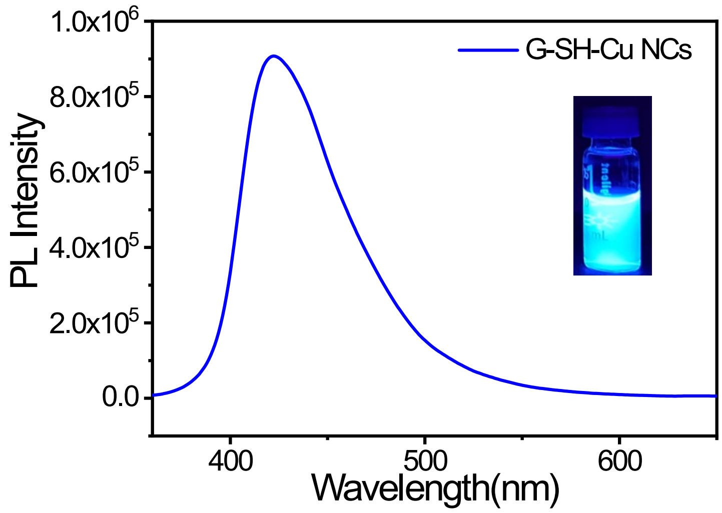

Figure S2 PL (excitation wavelength 335 nm) spectra of G-SH-Cu NCs.

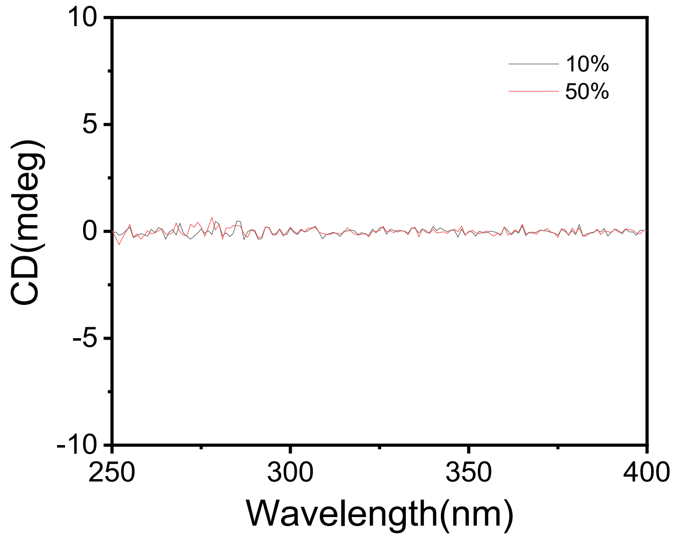

Figure S3 The CD spectra of TX-100 in water.

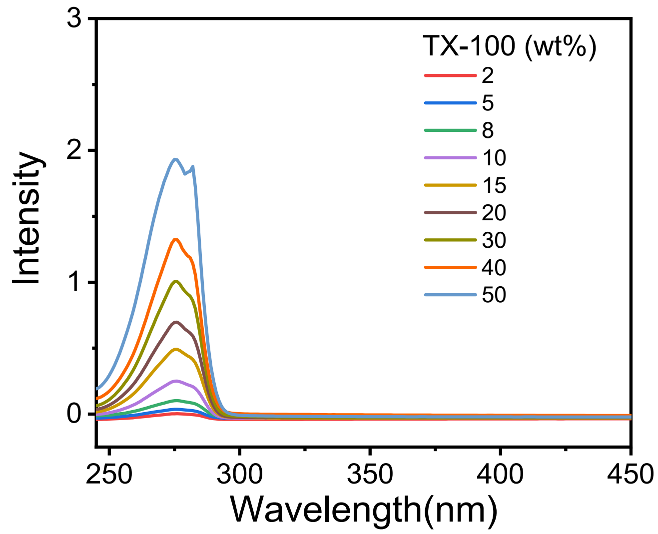

Figure S4 UV-visible absorption spectra of different mass ratios of TX-100 (wt%) in water.

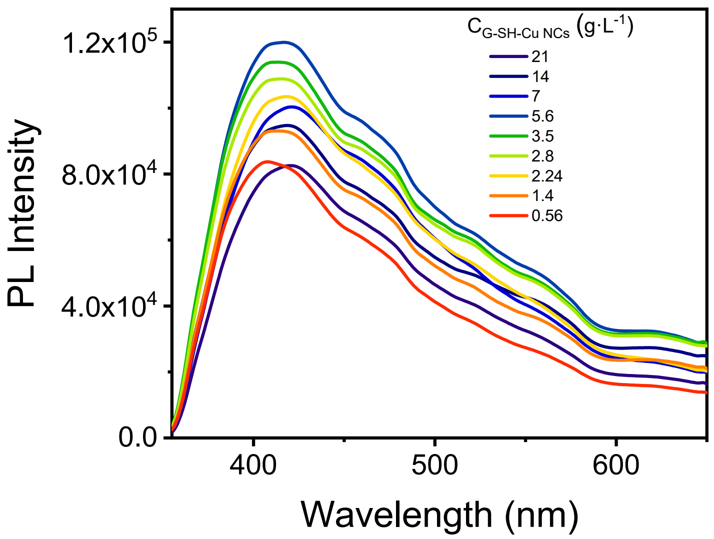

Figure S5 Fluorescent spectra of G-SH-Cu NCs/TX-100 system (λex =335 nm) at different concentrations of G-SH-Cu NCs (mg/mL).

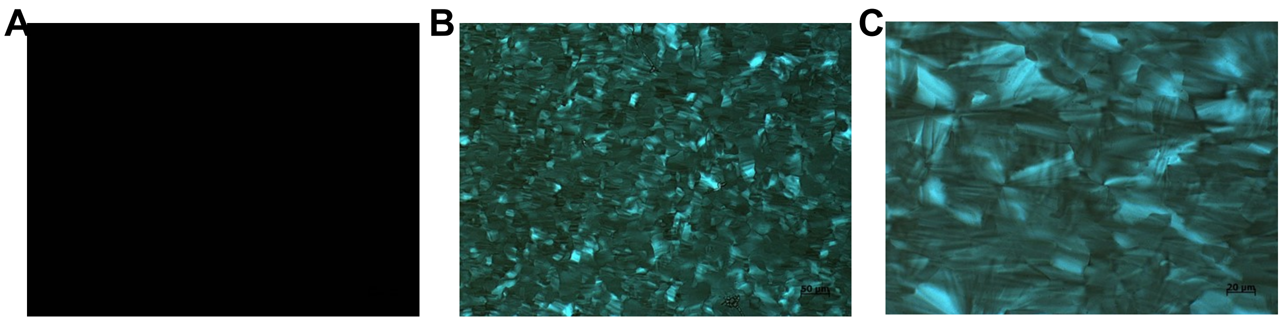

Figure S6 POM images of **A)** 40wt% TX-100 and **B) C)** 50wt% TX-100 in water.

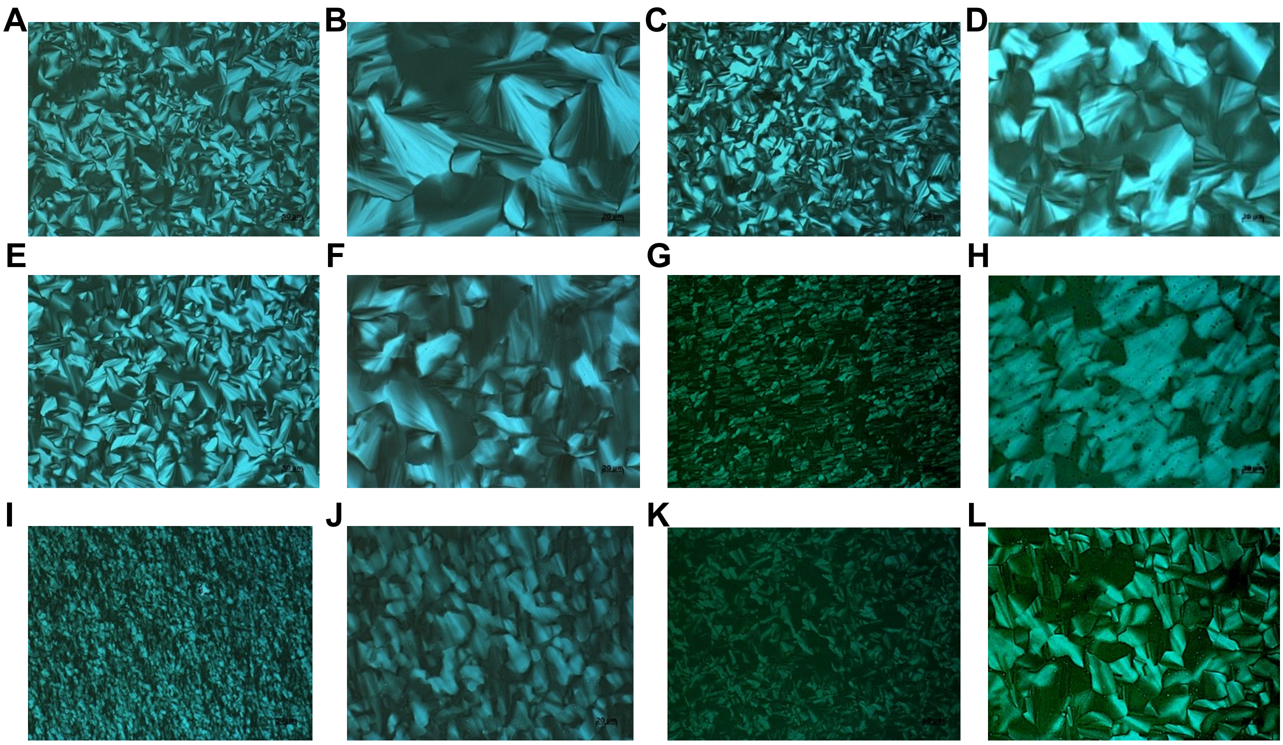

Figure S7 POM photos of different concentrations of G-SH-Cu NCs combinated with TX-100: **A) B)** 0.56 g·L^{-1} G-SH-Cu NCs/50 wt% TX-100; **C) D)** 1.4 g·L^{-1} G-SH-Cu NCs/50 wt% TX-100; **E) F)** 2.8 g·L^{-1} G-SH-Cu NCs/50 wt% TX-100; **G) H)** 7 g·L^{-1} G-SH-Cu NCs/50 wt% TX-100; **I) J)** 14 g·L^{-1} G-SH-Cu NCs/50 wt% TX-100; **L) L)** 21 g·L^{-1} G-SH-Cu NCs/ 50 wt% TX-100.

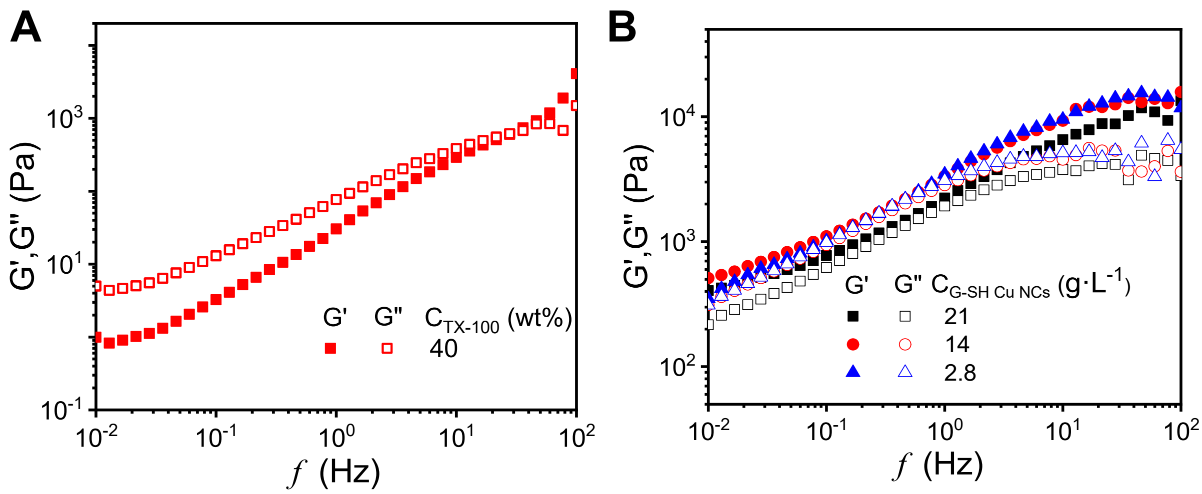

Figure S8 G 'and G "as a function of frequency: **A)** 28 g·L^{-1}G-SH-Cu NCs/40 wt% TX-100 systems; **B)** G-SH-Cu NCs/50 wt% TX-100 systems at different $c_{\text{G-SH-Cu NCs}}$ (g·L^{-1}).

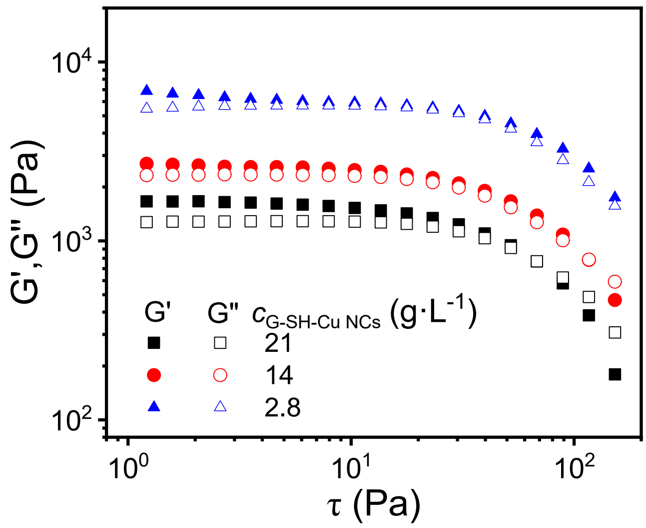

Figure S9 The change of elastic modulus (G') and viscous modulus (G '') with the stress (F =1 Hz, T=25℃) of G-SH-Cu NCs/50 wt% TX-100 systems at different $c_{\text{G-SH-Cu NCs}}$ (g·L^{-1}).

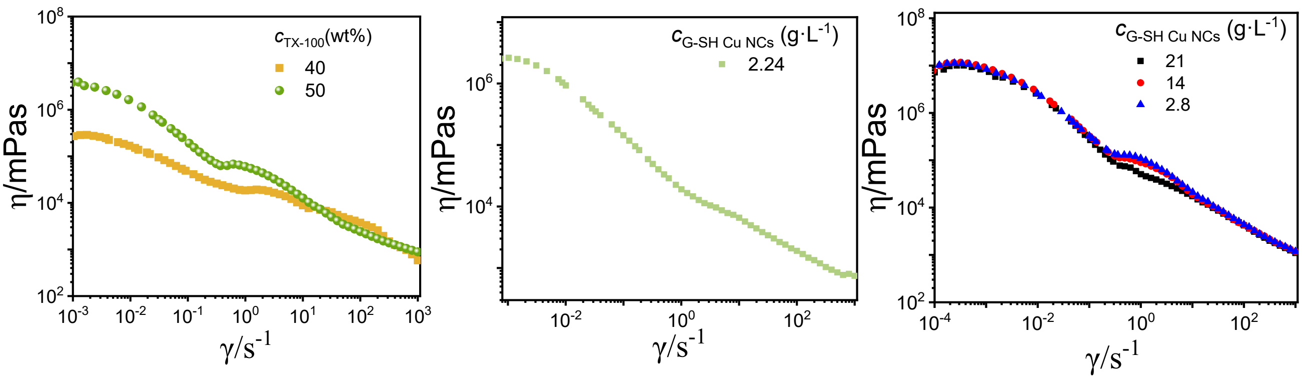

Figure S10 The change of shear viscosity with shear rate of G-SH-Cu NCs/TX-100 system.

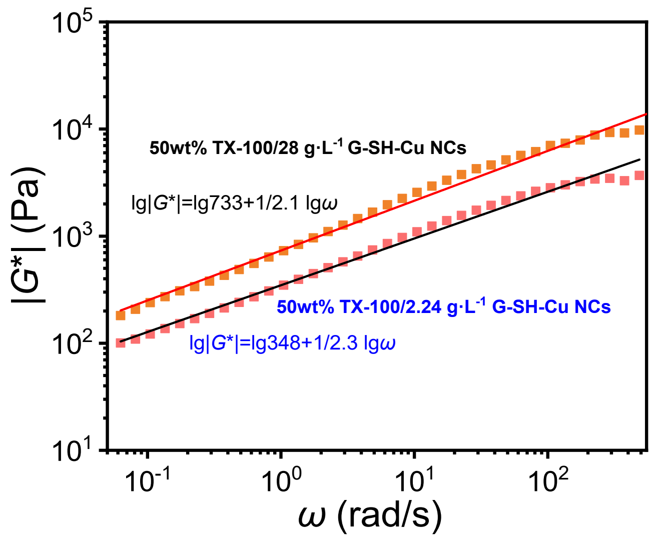

Figure S11 Complex modulus |G*| as a function of angular frequency (ω) of G-SH-Cu NCs/TX-100 system at different concentrations of G-SH-Cu NCs ($g \cdot L^{-1}$).

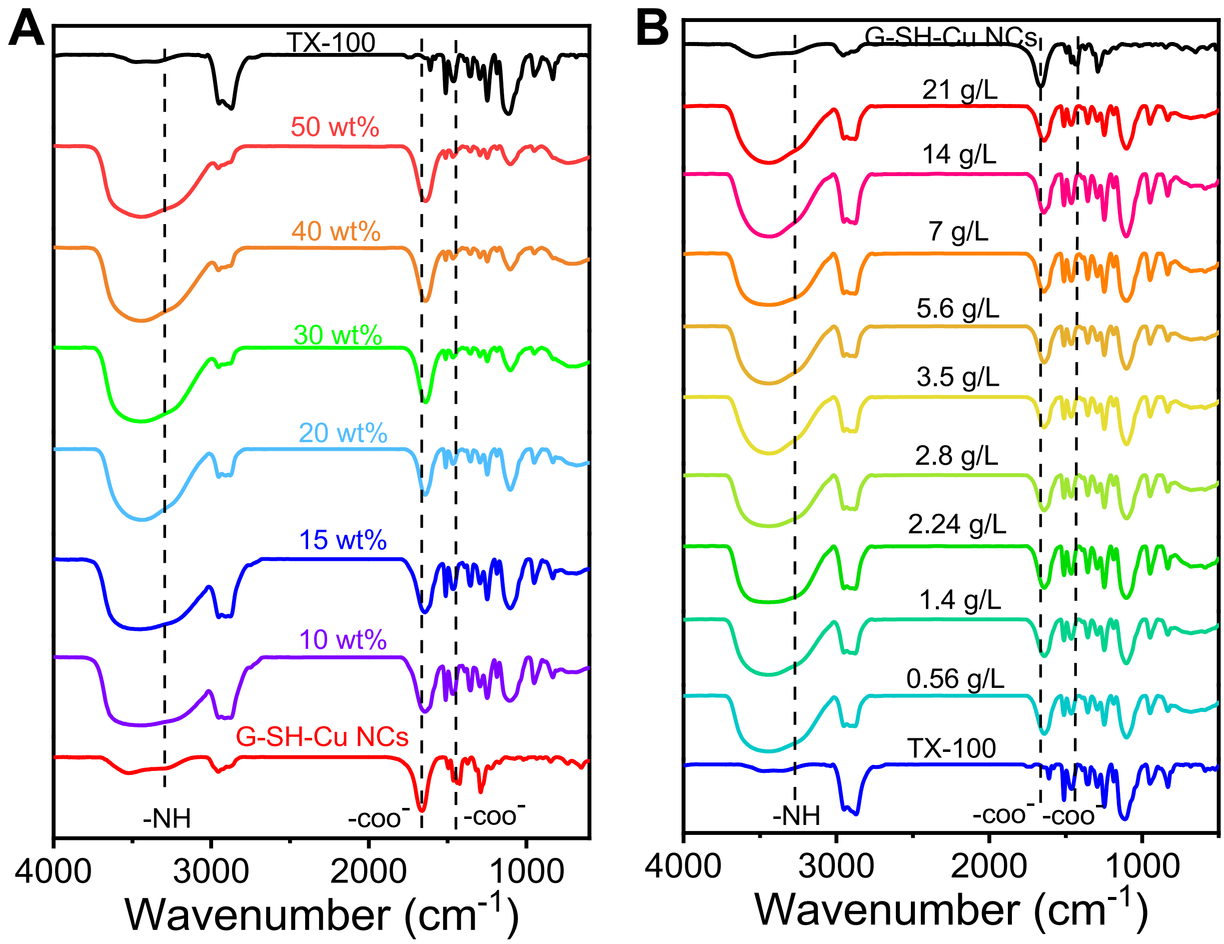

Figure S12 Fourier transform infrared spectra of G-SH-Cu NCs/TX-100 system.

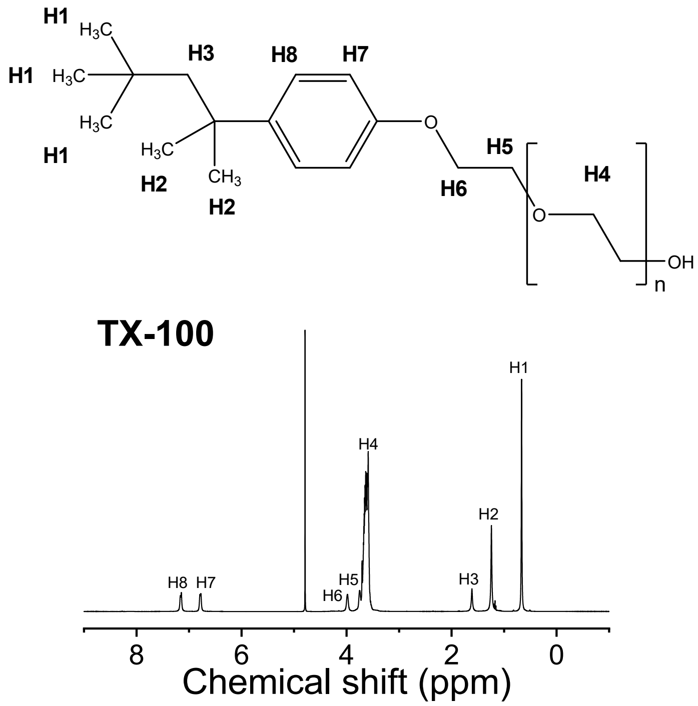

Figure S13 Chemical structure and [1]H NMR image of TX-100.

Table S1. The lattice parameters (D) for G-SH-Cu NCs/TX-100 hexagonal LCs at different concentrations of G-SH-Cu NCs ($g \cdot L^{-1}$)

samples	TX-100	28 $g \cdot L^{-1}$ G-SH-Cu NCs/50wt% TX-100	2.24 $g \cdot L^{-1}$ G-SH-Cu NCs/50wt% TX-100
q_1 (nm^{-1})	1.20	1.24	1.21
D (nm)	6.04	5.85	5.99

Calculation of the interaction strength parameter (A) between molecules in lyotropic liquid crystal (LLCs) based on the Bohlin cooperative flow theory

The quantitatively relationship between the microstructure of a flowing substance and its rheological properties could be determined by Bohlin cooperative flow theory which provides the link between the dynamic moduli and angular frequency (ω) concerning the interaction of molecules in LLCs by the following formula

$$|G^*| = \sqrt{G'^2 + G''^2} = A\omega^{\frac{1}{z}}$$

where |G*| is the complex modulus, A is defined as the interaction strength between molecules in LLCs, and z is a parameter considered as the “coordination number” of the interactive flow units.

References

[1] Z. Wang, A. S. Susha, B. Chen, C. Reckmeier, O. Tomanec, R. Zboril, H. Zhong, A. L. Rogach, *Nanoscale* **2016**, *8*, 7197-7202.