

Supporting Information

Metal-Ion Induced Transition from Multi- to Single-Bilayer Tubes in Histidine Bearing Lipids and Formation of Monodisperse Au Nanoparticles

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Synthesis of cationic lipid HisL

3,5-Bis-dodecyloxy benzonitrile 1:

A solution of 3,5-dihydroxybenzonitrile (5.19g, 38.4mmol), 1-bromododecane (23.93g, 96.0mmol) and K_2CO_3 (26.5g, 192.0mmol) were stirred at 80°C in dry DMF for 12h under a nitrogen atmosphere. The reaction mixture was cooled to room temperature, 10mL of water was added and aqueous layer was extracted with dichloromethane. Organic layer was washed with brine and water, dried over $MgSO_4$, filtered. The solvent was removed *in vacuo*. The Product was isolated by chromatography on silica gel using 1:1 dichloromethane - Hexane as eluant. The product was white powder (17.8g, 98%). 1H -NMR ($CDCl_3$, 500 MHz, δ ppm): 0.88 (t, J = 6.5, 6H, CH_2CH_3); 1.26-1.47 (m, 35H, CH_2 (dodecyloxy)), 1.77 (m, 4H, OCH_2CH_2), 3.93 (t, J = 6.5, 4H, OCH_2CH_2), 6.64 (s, 1H, ArH), 6.73 (s, 2H, ArH)

3,5-Bis-dodecyloxy benzylamine 2:

Prepared a suspension of $LiAlH_4$ (0.406g, 10.7mmol) in 20 mL of dry Diethyl ether. Stirred at 0°C. Added a solution of 1 (2.0g, 4.2mmol) in 25 mL of Diethyl ether. After addition the reaction mixture was stirred at room temperature for 5 h under a nitrogen atmosphere. The reaction mixture was then cooled to 0°C and quenched by the sequential addition of 0.4 mL of H_2O , 0.4 mL of 15w/v% aq. NaOH and 1.2mL of H_2O . The mixture was then poured into 50 mL of dichloromethane and stirred for 30 min. The insoluble material was removed by filtration through Celite and the solvent was removed from the filtrate by rotary evaporation. The product was isolated by flash chromatography on silica gel using 10:1 dichloromethane-methanol as eluant. The product was white powder (1.76g, 88%). 1H -NMR ($CDCl_3$, 500 MHz, δ ppm): 0.88 (t, J = 6.5, 6H, CH_2CH_3); 1.26-1.47 (m, 35H, CH_2 (dodecyloxy)), 1.76 (m, 4H, OCH_2CH_2), 3.79 (s, 2H, $ArCH_2$), 3.93 (t, J = 6.5, 4H, OCH_2CH_2), 6.34 (s, 1H, ArH), 6.44 (s, 2H, ArH)

[1-(3,5-Bis-dodecyloxy benzylcarbamoyl)-2-(1H-imidazol-4-yl)-ethyl]-carbamic acid tert-butyl ester 3:

To a mixture of 2 (1.65g, 3.48 mmol) and L-Boc-Histidine (0.99g, 4.35mmol) in 10mL of dry chloroform, HOBT- H_2O (0.65g, 4.81mmol) and EDC-HCl (0.92g, 4.81mmol) in 10mL of chloroform were added. After stirred at room temperature for 40h, the reaction mixture was poured into 10% citric acid and extracted with dichloromethane. The organic layer was washed with sat. aq. $NaHCO_3$, brine, and water, dried over $MgSO_4$ and filtered. The solvent was removed by rotary evaporation. The product was isolated by flash chromatography on silica gel using 10:1 dichloromethane -methanol as eluant. The product was viscous oil (1.12g, 45%). 1H -NMR ($CDCl_3$, 500 MHz, δ ppm): 0.88 (t, J = 6.5, 6H, CH_2CH_3); 1.26-1.39 (m, 35H, CH_2

(dodecyloxy), 1.42 (m, 9H, OC(CH₃)₃), 1.74 (m, 4H, OCH₂CH₂), 2.96-3.20 (m, 2H, ArCH₂NH), 3.88 (t, J = 6.5, 4H, OCH₂CH₂), 4.22-4.36 (m, 2H, CH₂CHNHCO), 4.46 (s, 1H, CH₂CHNHCO), 6.24 (s, 2H, ArH), 6.32 (s, 1H, ArH), 6.79 (s, 1H, C=CHNH), 7.49 (s, 1H, NHCHN)

2-Amino-N-(3,5-bis-dodecyloxy-benzyl)-3-(1H-imidazol-4-yl)-propionamide (HisL):

To a solution of 3 (1.14g, 1.57mmol) in 2mL of dichloromethane, a total of 10 mL of TFA was added. The mixture was stirred for 30 min at room temperature. The solvent was removed by rotary evaporation. To the residue, a total of 5 mL of dichloromethane was added with stirring and was evaporated. This was repeated to yield 940 mg (1.53 mmol, 97%) of HisL as pale yellow oil. ¹H-NMR (CDCl₃, 500 MHz, δ ppm): 0.87 (t, J = 6.8, 6H, CH₂CH₃); 1.26-1.40 (m, 35H, CH₂(dodecyloxy)), 1.74 (m, 4H, OCH₂CH₂), 3.24-3.41 (m, 2H, ArCH₂NH), 3.83 (t, J = 6.5, 4H, OCH₂CH₂), 4.13-4.31 (m, 2H, CH₂CHNHCO), 4.48 (s, 1H, CH₂CHNHCO), 6.29 (s, 2H, ArH), 6.31 (s, 1H, ArH), 7.16 (s, 1H, C=CHNH), 8.29 (s, 1H, NHCHN)

Fig. S1

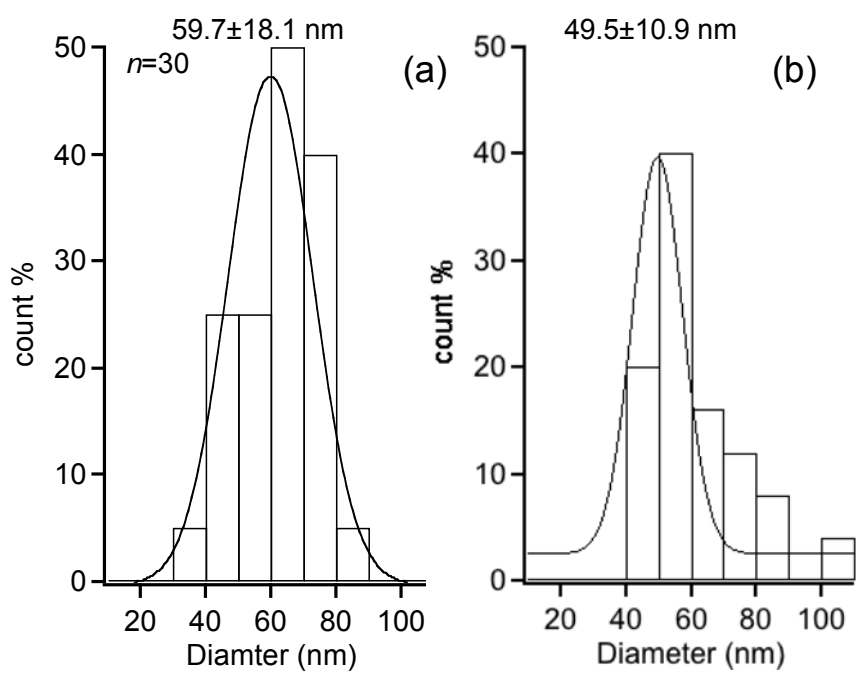


Fig. S1 The size distributions of HiL nanotube (a) and metal ion/HisL nanotube

Fig. S2

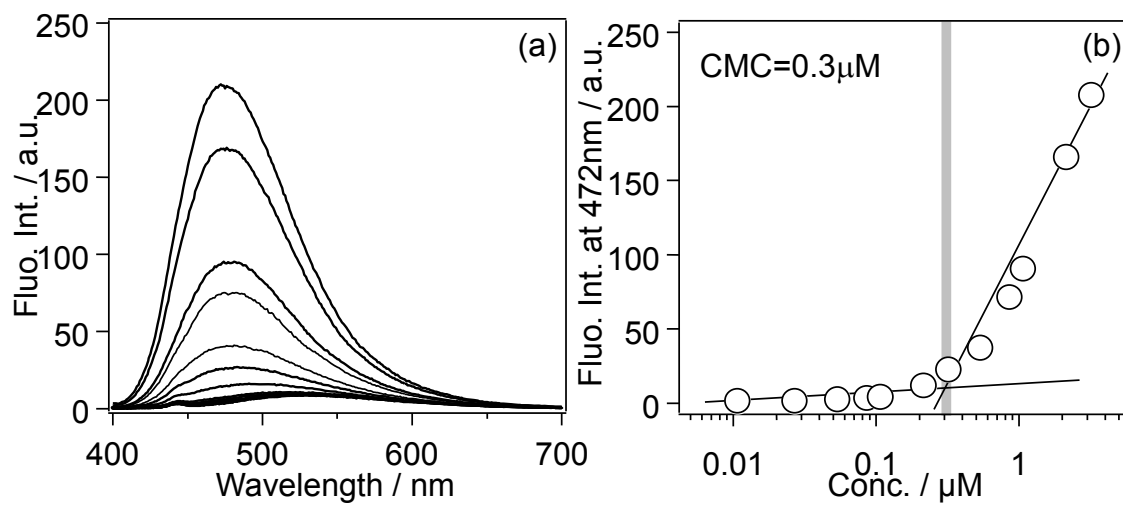


Fig. S2 (a) Fluorescence spectra of ANS in water at various concentrations of HisL, (b) Plots of fluorescence intensity at 472 nm versus concentration of HisL.

Fig. S3

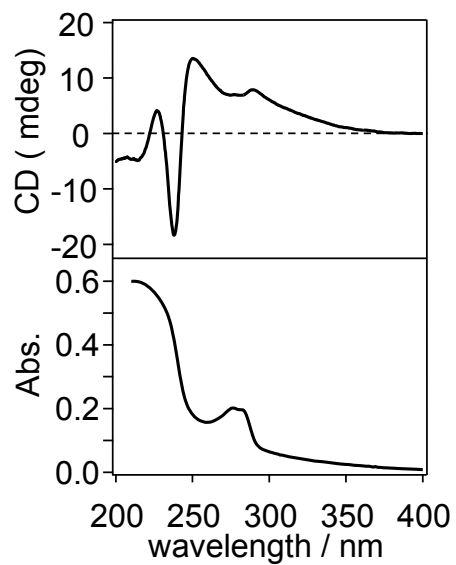


Fig. S3 CD and UV spectra for HisL (0.1mM)

Fig. S4

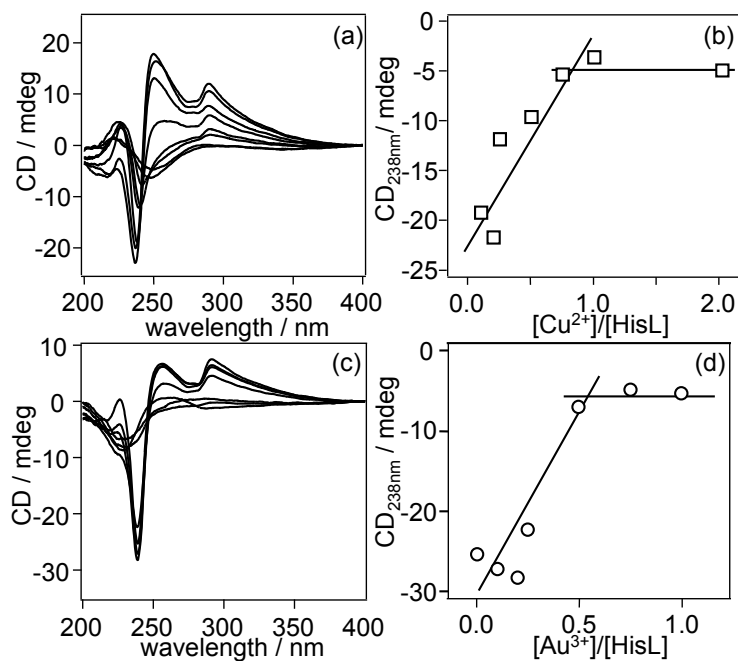


Fig. S4 Metal ions concentration dependence of the CD spectra of HisL in water and the difference of the CD spectra intensity at 238 nm plotted against molar ratio for Cu²⁺ / HisL (a), (b) and Au³⁺ / HisL (c), (d).

Fig. S5

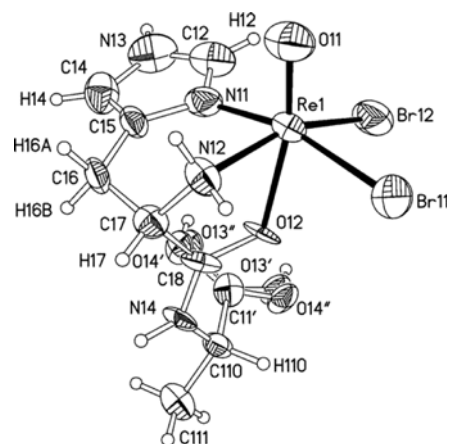


Fig. S5 Crystal structure of Ru⁵⁺/His-Ala complex.

Fig. S6

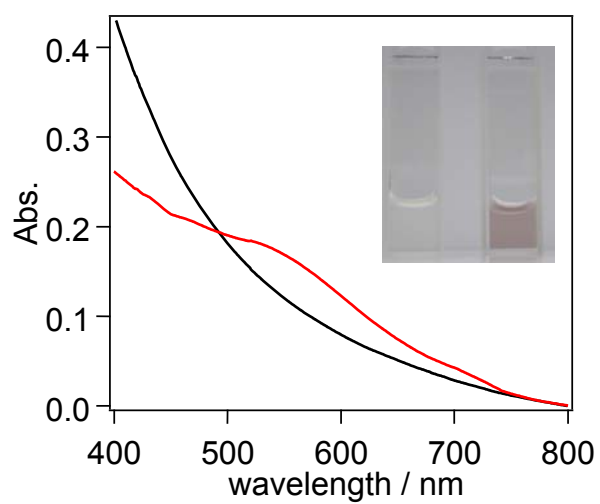


Fig. S6. UV-Vis absorption spectra of Au³⁺/HisL (black) and after reduction of Au³⁺/HisL (red)

Fig. S7

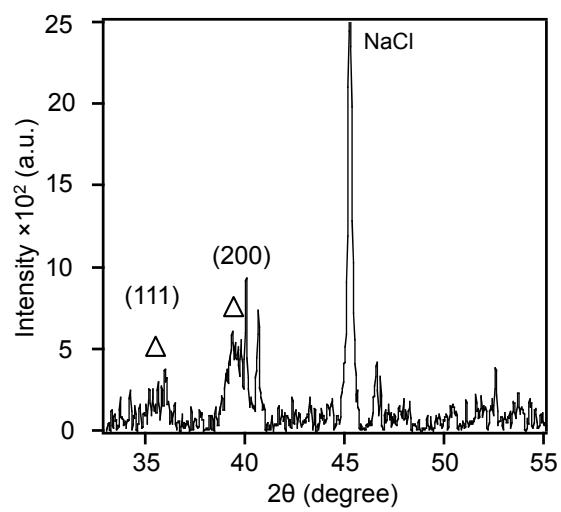


Fig. S7 XRD for Cu/HisL complex