

## Supporting Information

### Multifunctionalized flower-like gold nanoparticles with high chemiluminescence for label-free sensing of hepatitis C virus core protein

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## 1. The deconvolution of N 1s, O 1s, and Co 2p spectra

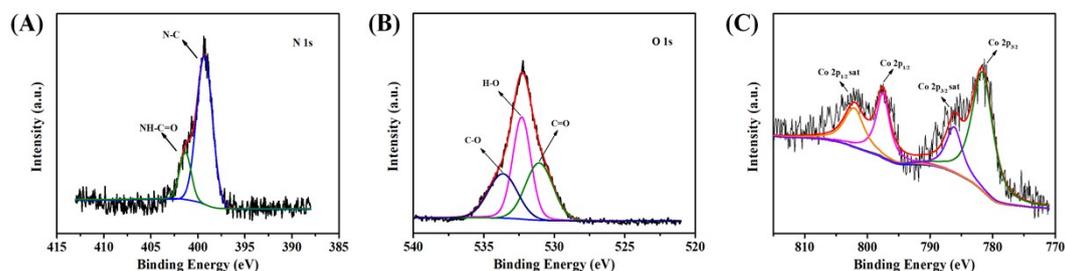


Fig. S1 The deconvolution of (A) N 1s, (B) O 1s, and (C) Co 2p spectra of Co<sup>2+</sup>/CS/Lum/AuNFs.

## 2. UV-visible spectra of the prepared materials

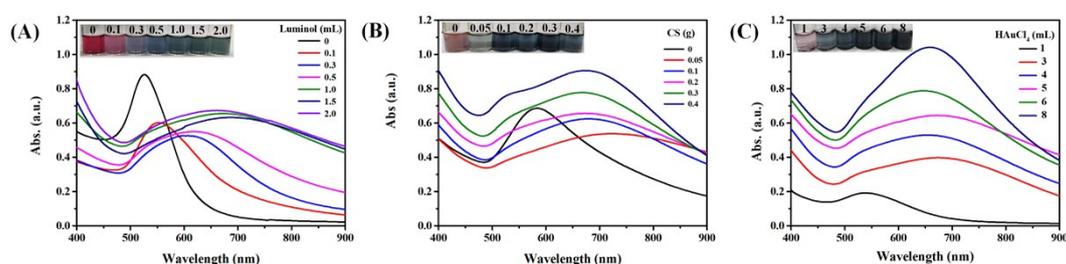


Fig. S2 (A) UV-visible spectra of the materials were prepared by varying the volumes of luminol (10 mM) in the presence of 0.2 g CS and 5.0 mL HAuCl<sub>4</sub> (0.2%). (B) UV-visible spectra of the materials were prepared by varying the amounts of CS added in the presence of luminol (1.0 mL, 10 mM) and 5.0 mL HAuCl<sub>4</sub> (0.2%). (C) UV-visible spectra of the materials were prepared by varying the volumes of HAuCl<sub>4</sub> (0.2%) in the presence of luminol (1.0 mL, 10 mM) and 0.2 g CS. The insets are the corresponding photographic images.

## 3. CL intensities of the prepared materials

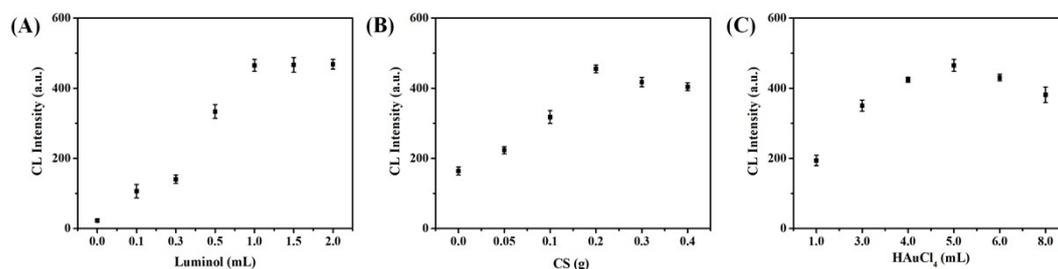


Fig. S3 (A) CL intensities of the materials were prepared by varying the volumes of luminol (10 mM) in the presence of 0.2 g CS and 5.0 mL HAuCl<sub>4</sub> (0.2%). (B) CL intensities of the materials were prepared by varying the amount of CS added in the presence of luminol (1.0 mL, 10 mM) and 5.0 mL HAuCl<sub>4</sub> (0.2%). (C) CL intensities of the materials were prepared by varying the volumes of HAuCl<sub>4</sub> (0.2%) in the presence of luminol (1.0 mL, 10 mM) and 0.2 g CS. Reaction conditions: 100 mM H<sub>2</sub>O<sub>2</sub> (pH 13) and PMT voltage: -600 V.

#### 4. Effect of size of CS/Lum/AuNFs on CL intensity

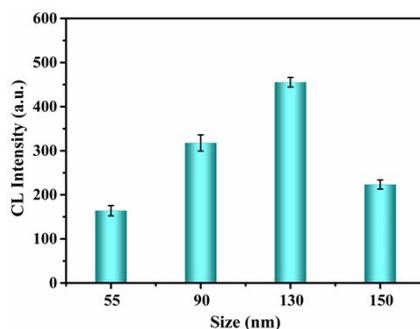


Fig. S4 Effect of the size of CS/Lum/AuNFs on CL intensity. Reaction conditions: 20  $\mu\text{L}$   $\text{H}_2\text{O}_2$  (50 mM; pH 13) was injected into 200  $\mu\text{L}$  of CS/Lum/AuNFs.

#### 5. Optimizations of experimental conditions

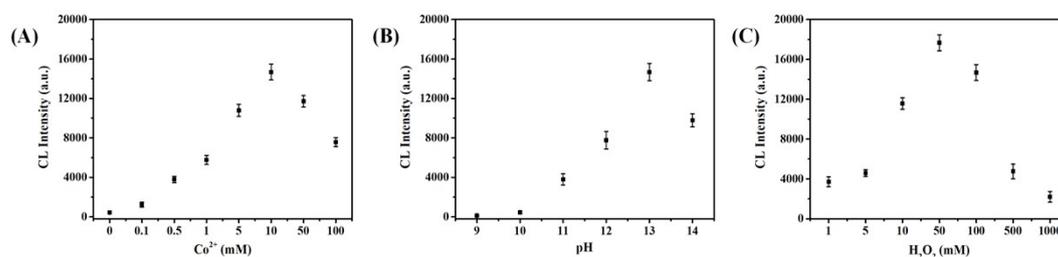


Fig. S5 (A) Optimization of  $\text{Co}^{2+}$  concentration, add 200  $\mu\text{L}$  different concentrations of cobalt acetate to 4.8 mL of CS/Lum/AuNFs to obtain a final concentration (0, 0.1, 0.5, 1, 5, 10, 50, 100 mM). Reaction conditions: 100 mM  $\text{H}_2\text{O}_2$  (pH 13). (B) Optimization of pH. Reaction conditions: 100 mM  $\text{H}_2\text{O}_2$  with different pH, 0.5 mg/mL  $\text{Co}^{2+}$ /CS/Lum/AuNFs. (C) Optimization of  $\text{H}_2\text{O}_2$  concentration. Reaction conditions:  $\text{H}_2\text{O}_2$  (pH 13) of different concentrations, 0.5 mg/mL  $\text{Co}^{2+}$ /CS/Lum/AuNFs. PMT voltage:  $-600$  V.

#### 6. Effect of different concentrations of HCVcp-apt on CL intensity

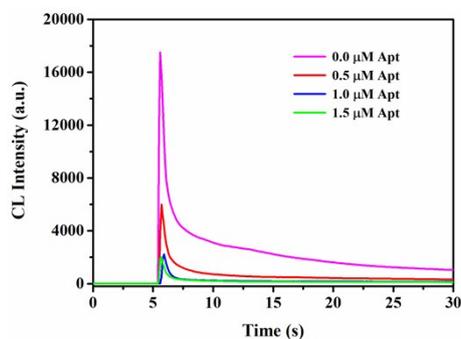


Fig. S6 CL kinetic curves of  $\text{Co}^{2+}$ /CS/Lum/AuNFs at different concentrations of HCVcp-apt.  $\text{Co}^{2+}$ /CS/Lum/AuNFs (0.5 mg/mL, 180  $\mu\text{L}$ ) + 20  $\mu\text{L}$  HCVcp-apt of different concentrations. The final concentrations of the HCVcp-apt: 0.0, 0.5, 1.0, and 1.5  $\mu\text{M}$ . Reaction conditions: 50 mM  $\text{H}_2\text{O}_2$  (pH 13) and PMT voltage:  $-600$  V.

## 7. The loading amount of the HCVcp-apt

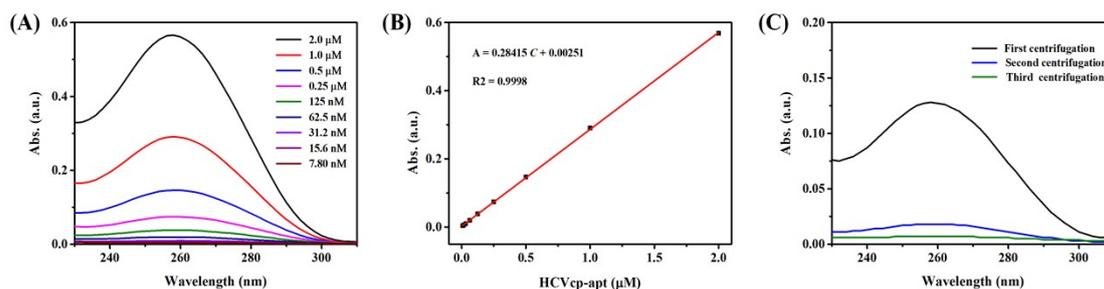


Fig. S7 (A) UV-vis absorption spectra and (B) corresponding calibration curve of HCVcp-apt solution concentration. (C) UV-vis absorption spectra of supernatant after three centrifugations.

## 8. Effect of dissolved oxygen, thiourea, and SOD on the CL intensity

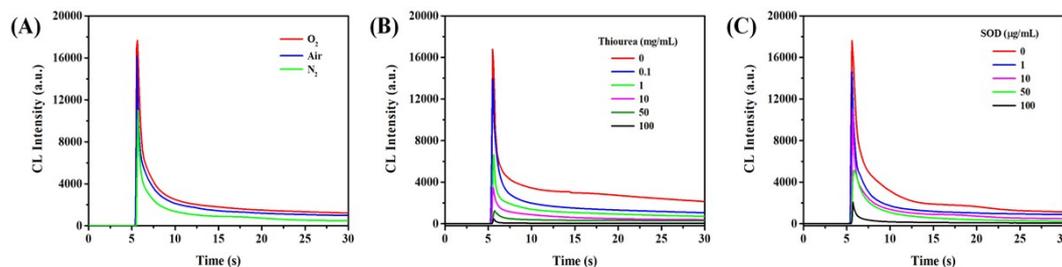


Fig. S8 (A) CL kinetic curves of  $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$  in oxygen-saturated (red), air-saturated (blue), and nitrogen-saturated (green) solutions, respectively. (B) CL kinetic curves of  $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$  in the absence and the presence of different final concentrations of thiourea: 0–100 mg/mL. (C) CL kinetic curves of  $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$  in the absence and the presence of different final concentrations of SOD: 0–100 μg/mL. Reaction conditions: 50 mM  $\text{H}_2\text{O}_2$  (pH 13) and PMT voltage: –600 V.

## 9. The original Zeta curves of CS/Lum/AuNFs

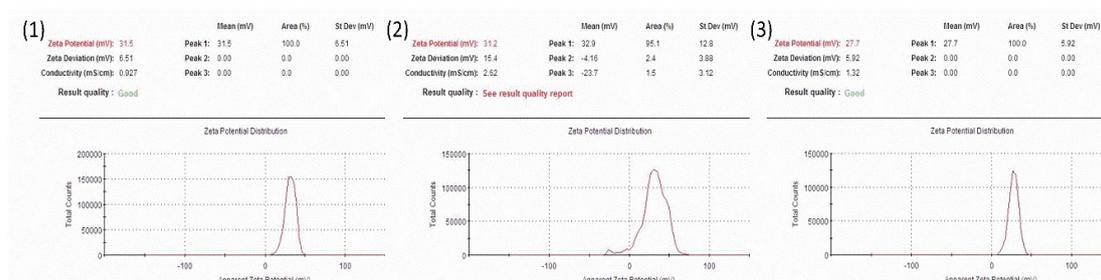


Fig. S9 The original Zeta curves of CS/Lum/AuNFs (three of measurements).

## 10. The original Zeta curves of $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$

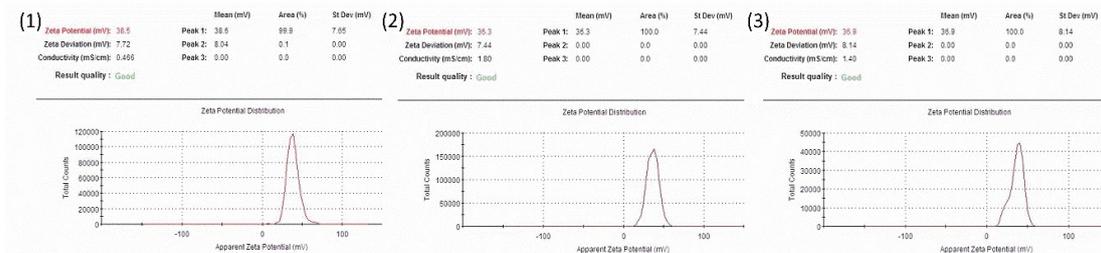


Fig. S10 The original Zeta curves of Co<sup>2+</sup>/CS/Lum/AuNFs (three of measurements).

### 11. The original Zeta curves of HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs

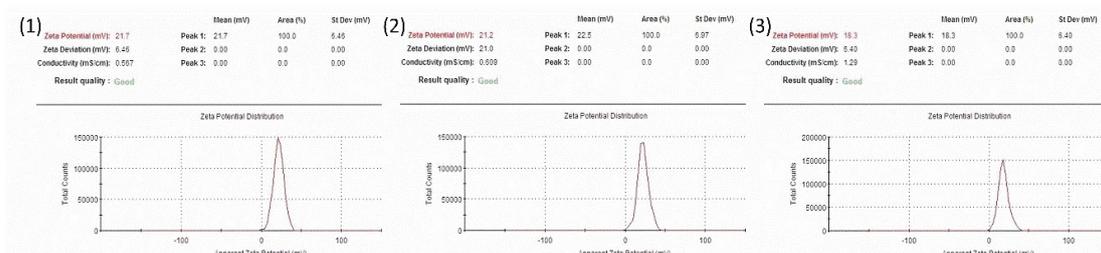


Fig. S11 The original Zeta curves of HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs (three of measurements).

### 12. The original Zeta curves of HCVcp (0.01 μg/mL) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs

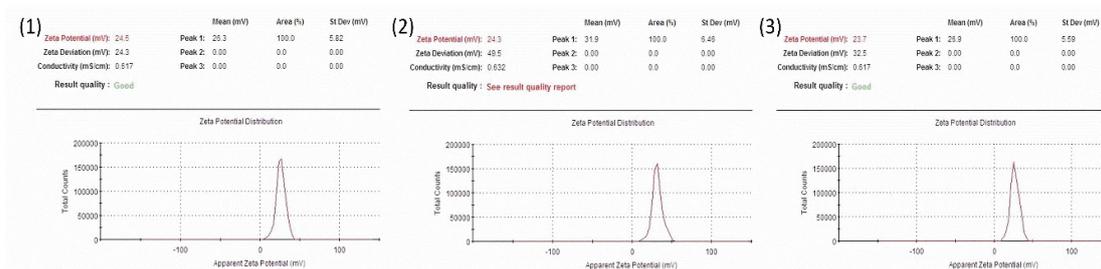


Fig. S12 The original Zeta curves of HCVcp (0.01 μg/mL) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs (three of measurements).

### 13. The original Zeta curves of HCVcp (0.10 μg/mL) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs:



Fig. S13 The original Zeta curves of HCVcp (0.10 μg/mL) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs (three of measurements).

### 14. The original Zeta curves of HCVcp (1.00 μg/mL) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs:

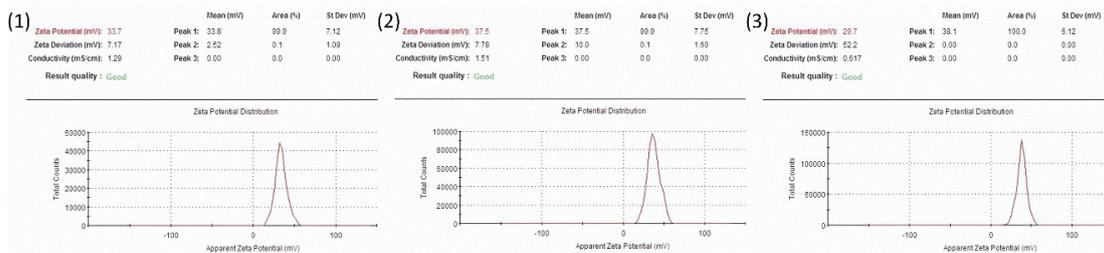


Fig. S14 The original Zeta curves of HCVcp (1.00  $\mu\text{g}/\text{mL}$ ) + HCVcp-apt/Co<sup>2+</sup>/CS/Lum/AuNFs (three of measurements).

### 15. CL reproducibility of the sensing platform

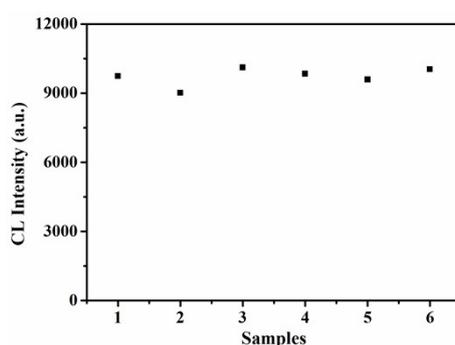


Fig. S15 CL reproducibility of the sensing platform. Six samples contain the same amount of HCVcp (100 ng/mL). Reaction conditions: 50 mM H<sub>2</sub>O<sub>2</sub> (pH 13) and PMT voltage: -600 V.

### 16. Effect of serum on CL signal

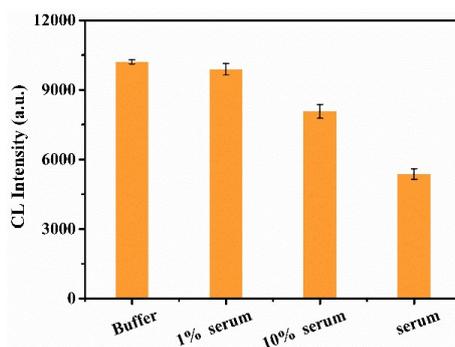


Fig. S16 Effect of undiluted serum samples and diluted serum samples with different dilution levels on CL signal. The concentration of HCVcp is 100 ng/mL. The error bar represents the standard deviation of three parallel measurements.

### 17. CL kinetic curves for HCVcp in healthy human serum samples

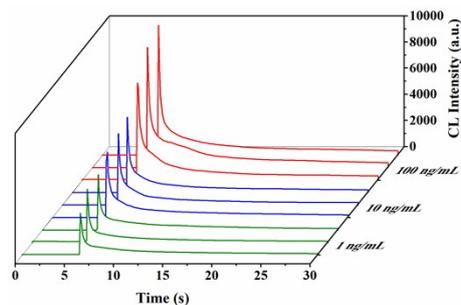


Fig. S17 CL kinetic curves of  $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$  for different final concentrations of HCVcp (1.00, 10.0, and 100 ng/mL) in human serum samples. Reaction conditions: 50 mM  $\text{H}_2\text{O}_2$  (pH 13) and PMT voltage:  $-600$  V.

**18. Table S1 Zeta potentials of CS/Lum/AuNFs,  $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$ , HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$ , HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$  in the presence of HCVcp.**

Sample	Zeta potential (mV)
CS/Lum/AuNFs	+30.1
$\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$	+37.2
HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$	+20.4
HCVcp (0.01 $\mu\text{g}/\text{mL}$ ) + HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$	+24.2
HCVcp (0.10 $\mu\text{g}/\text{mL}$ ) + HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$	+27.9
HCVcp (1.00 $\mu\text{g}/\text{mL}$ ) + HCVcp-apt/ $\text{Co}^{2+}/\text{CS}/\text{Lum}/\text{AuNFs}$	+33.6

**19. Table S2 Comparison of different methods for the detection of HCVcp**

Detection method	Material	Linear range	LOD	Ref.
ELISA	–	–	32 nM	30
ELISA	–	–	267.4 pg/mL	43
Colorimetric	lateral flow strip	–	10 pg/mL	32
Electrochemistry	GQD	10–70 pg/mL	3.30 pg/mL	44
Electrochemistry	AuNPs/ $\text{SiO}_2$ CN	2.0–512 ng/mL	0.17 ng/mL	45

Chemiluminescence	Co <sup>2+</sup> /CS/Lum/AuNFs	0.5–1000 ng/mL	0.16 ng/mL	This work
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**20. Table S3 Determination of HCVcp in healthy human serum samples**

Sample	Added (ng/mL)	Detected (ng/mL)	Recovery (%)	RSD (%)
1	1.00	1.08	108	3.26
2	10.0	10.5	105	6.18
3	100	99.1	99.1	1.56