Supplementary Information

Preparation of gold@europium-based coordination polymer nanocomposite structures with excellent photothermal properties and its four-mode imaging technique

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Calculation of the photothermal conversion efficiency

Following literature report [1] , the total energy balance for the system is

$$\sum_i m_i C_{p,i} \frac{dT}{dt} = Q_{NPs} + Q_S - Q_{loss} \qquad (1)$$

where m and Cp are the mass and heat capacity, respectively. The suffix "i" of m and Cp refers to solvent(water) or dispersed matter (nanoprods). T is the solution temperature. Q_{NRs} is the photothermal energy absorbed by GNRs@EuCP NPs per second:

$$Q_{NRs} = I\left(1 - 10^{-A_{980}}\right)\eta \qquad (2)$$

where I is the laser power, Aλ is the absorbance of GNRs@EuCP at the wavelength of 980 nm in aqueous solution, and η is the photothermal conversion efficiency of GNRs@EuCP NRs which means the ratio of absorbed light energy converting to thermal energy.

Q_{loss} is thermal energy lost to the surroundings:

$$Q_{loss} = hA\Delta T \qquad (3)$$

Where h is the heat transfer coefficient, A is the surface area of the container, and ΔT is the changed temperature, which is referred to T-T_{surr} (T and T_{surr} are the solution temperature and ambient temperature of the surrounding, respectively).

Qs is the heat associated with the light absorbed by solvent per second. In the situation of heating pure water, the heat input is equal to the heat output at the maximum steady-statue temperature, so the equation can be:

$$Q_S = Q_{loss} = hA\Delta T_{max,H_2O} \qquad (4)$$

Where $\Delta T_{max,H2O}$ is the temperature change of water at the maximum steady-state temperature.

As it to the experiment of GNRs@EuCP NRs dispersion, the heat inputs are the heat generated by Nanoparticles (QNRs) and the heat generated by water (Qs), which is equal to the heat out put at the maximum steady-statue temperature, so the equation can be:

$$Q_{NPs} + Q_s = Q_{loss} = hA\Delta T_{max,mix} \qquad (5)$$

Where $\Delta T_{max,mix}$is the temperature change of the GNRs@EuCP NRs dispersion at the maximum steady state temperature. According to the equation (2), (4) and (5), the photothermal conversion efficiency (η) can be expressed as following:

$$\eta = \frac{hA\Delta T_{max,mix} - hA\Delta T_{max,H_2O}}{I\left(1 - 10^{-A_{980}}\right)} = \frac{hA(\Delta T_{max,mix} - \Delta T_{max,H_2O})}{I(1 - 10^{-A_{980}})}$$

(6)

In this equation, only hA is unknown. In order to get the hA, we introduce θ , which is defined as the ratio of ΔT to ΔT_{max} :

$$\theta = \frac{\Delta T}{\Delta T_{max}} \qquad (7)$$

Substituting equation (7) into equation (1):

$$\frac{d\theta}{dt} = \frac{hA}{\sum_i m_i C_{p,i}}[\frac{Q_{NPs} + Q_s}{hA\Delta T_{max}} - \theta] \qquad (8)$$

When the laser was shut off, the Q_{NPs} + Q_s=0, equation (8) could be expressed to:

$$dt = -\frac{\sum_i m_i C_{p,i}}{hA}\frac{d\theta}{\theta} \quad (9)$$

Equation (9) changes the expression:

$$t = -\frac{\sum_i m_i C_{p,i}}{hA} ln\theta \quad (10)$$

Where $\frac{\sum_i m_i C_{p,i}}{hA}$ can be calculated by linear relationship of time versus -ln(θ). As the m_{H_20} was 2 g. $Cp,_{H_20}$ was 4.2 $J^{-1}g^{-1}$. So we can get *hA* equals 0.0295.

According to equation (6), ΔTmax,mix was 50°C. ΔTmax,$_{H_20}$ is 12°C. *I* was 1.57 W where the area of light spot was 3.14 cm^2. A_{980} was 1.365 Thus, the photothermal conversion efficiency (η) of GNRs@EuCP NRs could be calculated to be 74.6%.

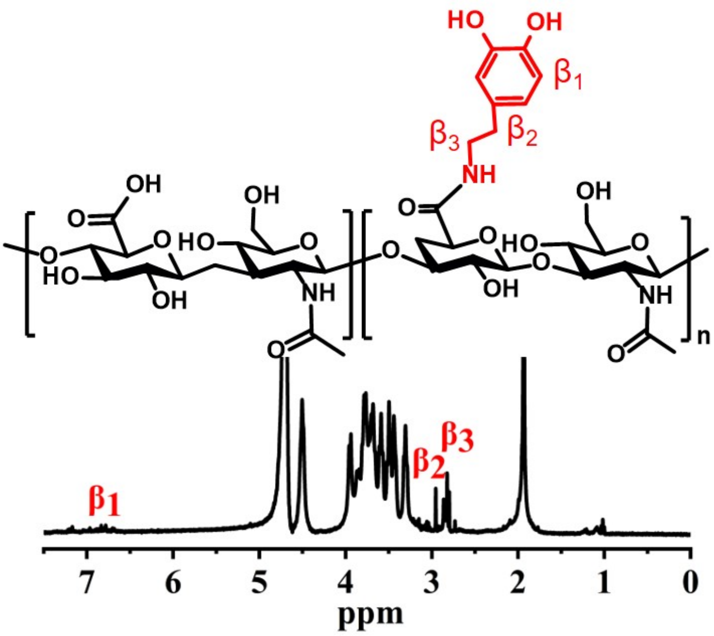


Fig. S1 1HNMR spectra of HA1.

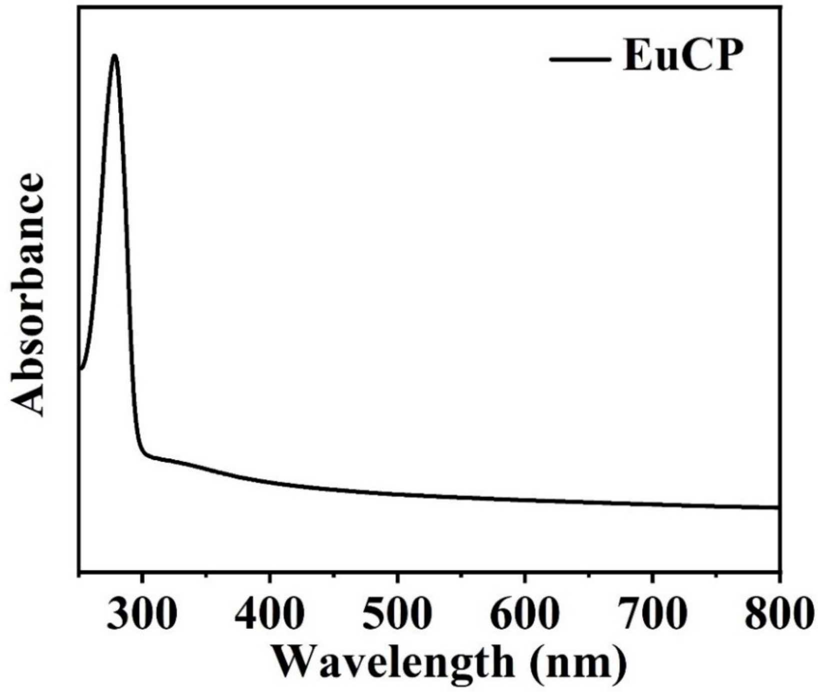
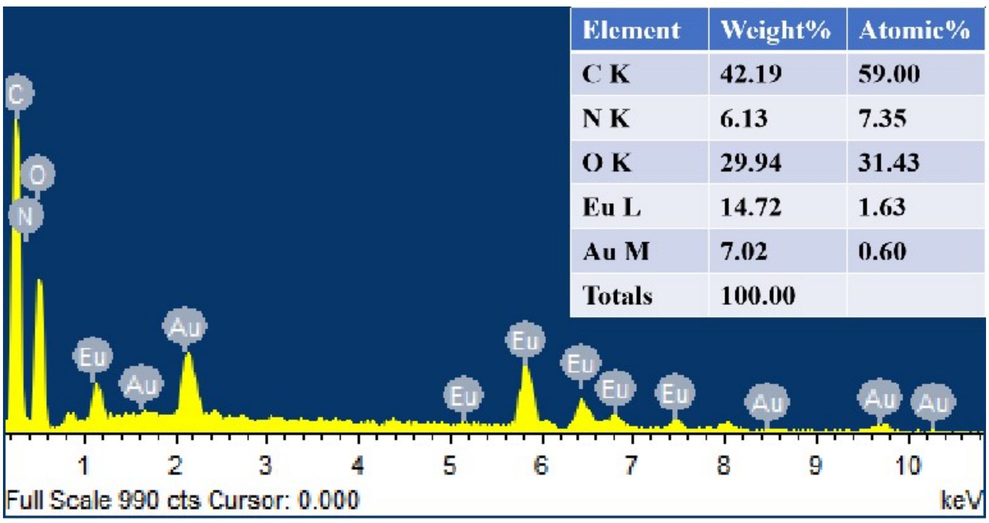


Fig. S2 UV−vis−NIR spectra of EuCP.



Element	Weight%	Atomic%
C K	42.19	59.00
N K	6.13	7.35
O K	29.94	31.43
Eu L	14.72	1.63
Au M	7.02	0.60
Totals	100.00	

Fig. S3 EDS spectra of GNRs@EuCP.

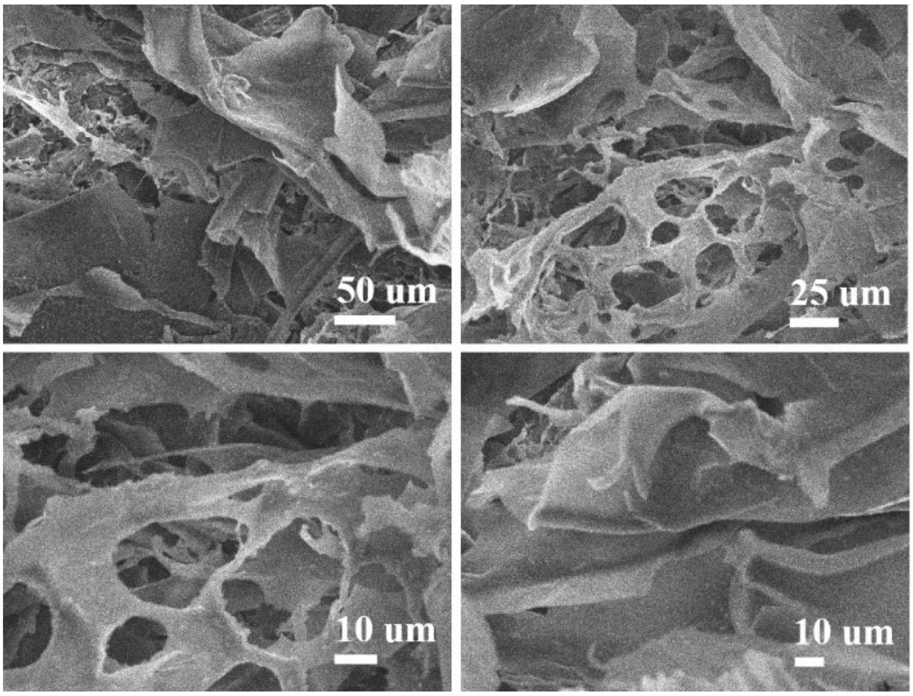


Fig. S4 SEM images of EuCP.

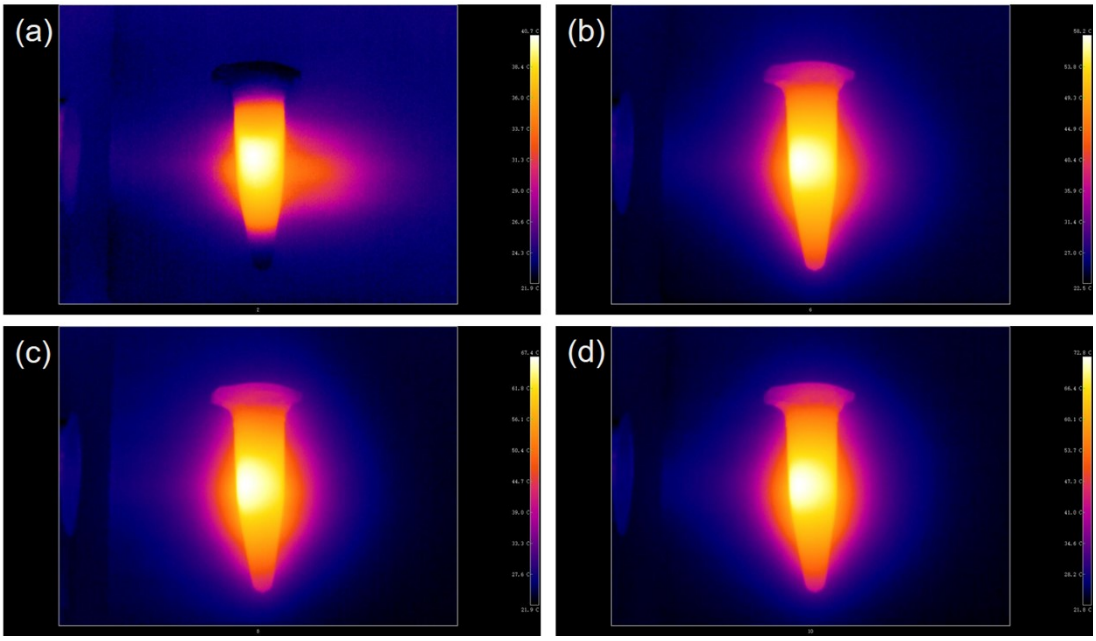


Fig. S5 (a, b, c, d). Corresponding infrared thermal images of GNRs@EuCP at 2, 6, 8 and 10 min intervals.

References

1. W. Ren, Y. Yan, L. Zeng, Z. Shi, A. Gong, P. Schaaf, D. Wang, J. Zhao, B. Zou, H. Yu, G. Chen, E. M. Brown and A. Wu, *Adv. Healthc. Mater.*, 2015, **4**, 1526-1536.