Ni-Doped Carbon Dots Unlock Dual NIR-II Photothermal and Photodynamic Cancer Therapy

Jun Song [a,b,] Minghao Kang [a], Yongping Li [a,*], Jiaqing Guo [a], Huibo Wang [a], Liwei Liu [a,b], Junle Qu [a,b], Shuai Ye [a,b,*]

a State Key Laboratory of Radio Frequency Heterogeneous Integration（Shenzhen University); College of Physics and Optoelectronic Engineering, Key Laboratory of Optoelectronic Devices and Systems of Ministry of Education and Guangdong Province, Shenzhen University, Shenzhen 518060, P. R. China

b Medical Engineering and Technology College, Xinjiang Medical University, Urumqi 830011, P. R. China

E-mail addresses: liyongping2020@email.szu.edu.cn (Yongping Li), yes121@szu.edu.cn (Shuai Ye).

Detection of Photothermal Performance

The temperature changes of samples were measured and recorded using an infrared thermograph. Specifically, samples prepared under different conditions were dissolved in water to obtain CDs solutions, which were respectively irradiated with a 1064 nm laser (1 W/cm^2) for 5 min, followed by observation of temperature decrease within the next 5 min. The temperature changes of the solutions were recorded every 15 s. Temperature change curves were plotted to analyze the photothermal conversion performance.

The formula for calculating the photothermal conversion efficiency is as follows:

$$\eta = \frac{hs(T_{max} - T_{surr}) - Q_{dis}}{I\,(1 - 10^{-A_\lambda})}$$

where η is the photothermal conversion efficiency of Ni-CDs; h is the heat transfer coefficient of the container; s is the surface area of the container; Q_{dis} is the heat dissipation of the container system; T_{max} is the equilibrium temperature of the Ni-CDs solution after laser irradiation; T_{surr} is the ambient temperature; I is the laser power; and A_λ is the absorbance of the solution at λ nm (1064 nm in this case).

In addition, after determining the optimal preparation conditions, Ni-CDs solutions with different concentrations (40 $\mu g/mL$, 80 $\mu g/mL$, 120 $\mu g/mL$, 160 $\mu g/mL$, 200 $\mu g/mL$) were prepared, and the same experiment was conducted to investigate the maximum equilibrium temperature they could reach.
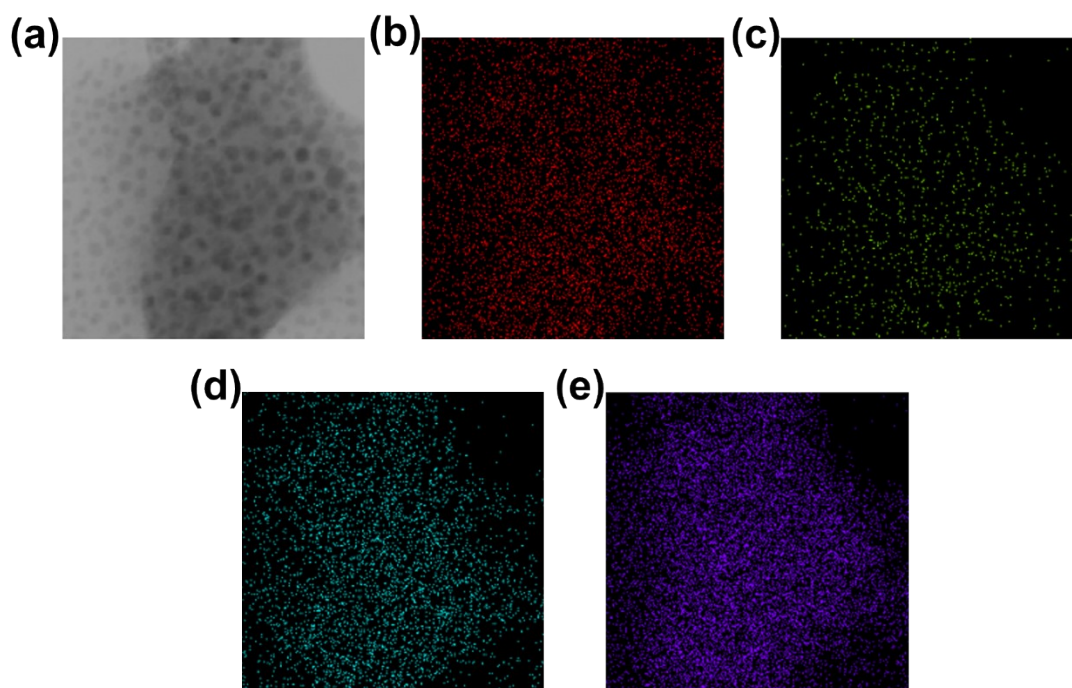
Figure S1. EDS Mapping images of Ni-CDs: bright-field image (a), C distribution image (b), N distribution image (c), O distribution image (d), Ni distribution image (e).
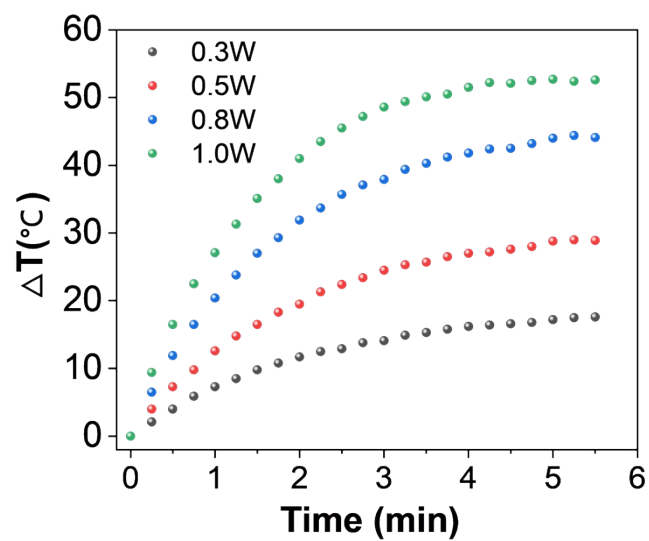

Figure S2. Temperature rise curves of Ni-CDs at the same concentration under irradiation with 1064 nm lasers of different power densities
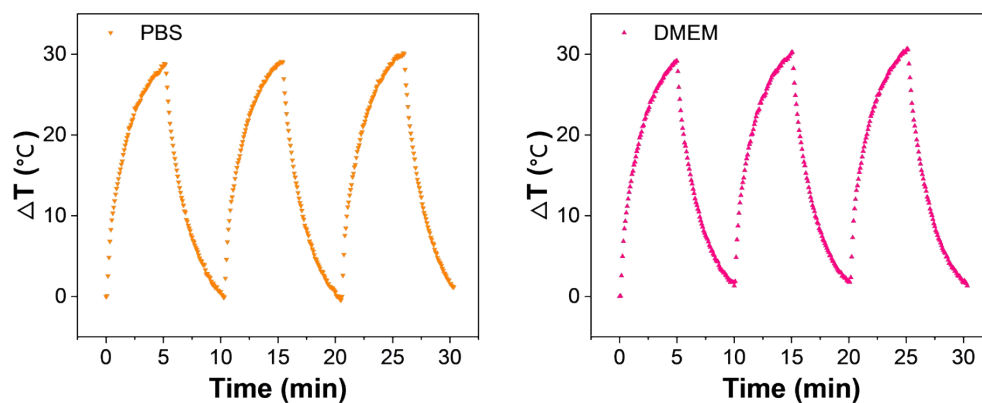
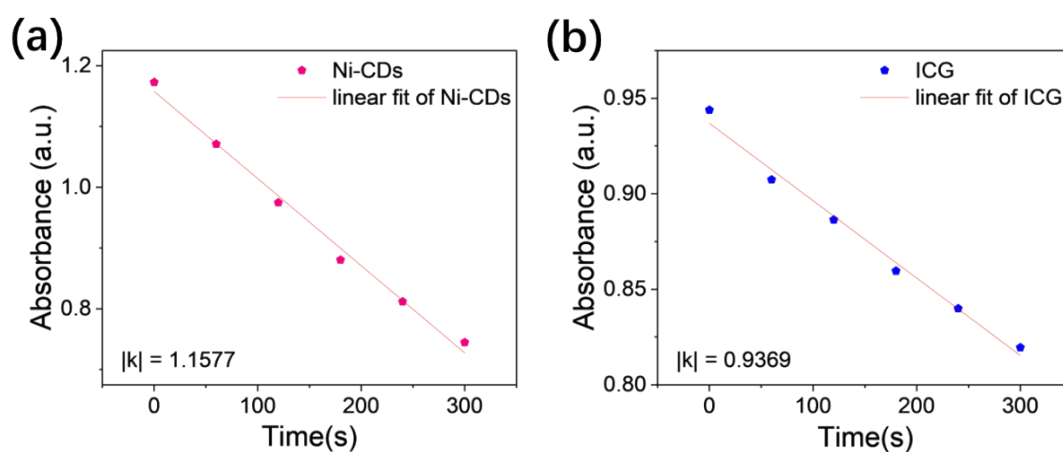Figure S3. Photothermal Stability of Ni-CDs in PBS and DMEM

Figure S4. Linear relationships between absorption rate changes and time for Ni-CDs (a) and ICG (b) within 300 s of 1064 nm laser irradiation.
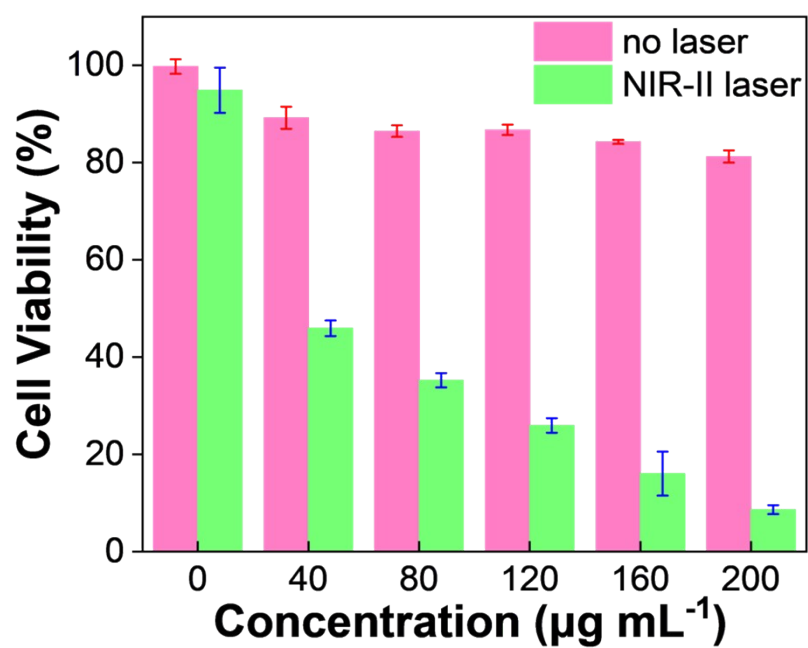
Figure S5. Cell viability at different Ni-CDs concentrations determined by the CCK-8 assay.
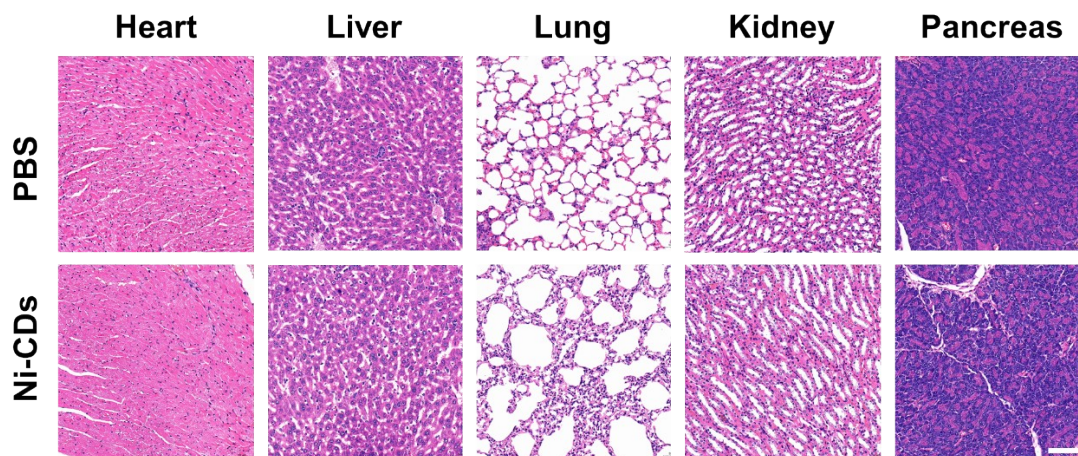

Figure S6. H&E staining images of major organs obtained after anatomical treatment of samples from different groups, with a scale bar of 100 μm.