# Supporting Information

## Accurate intracellular and in vivo temperature sensing based on $CuInS_2$/ZnS QD micelles

Hui Zhang[a,†], Youshen Wu[b,†], Zhenhai Gan[a], Yuexuan Yang[a], Yiming Liu[a], Peng Tang[a], Daocheng Wu[a]*

[a] *Key Laboratory of Biomedical Information Engineering of Education Ministry, School of Life Science and Technology, Xi'an Jiaotong University, Xi'an 710049, P. R. China*

[b] *Department of Chemistry, School of Science, Xi'an Jiaotong University, Xi'an 710049, P. R. China*

* Corresponding author: Tel/Fex: +86 029 82663941 E-mail: wudaocheng@mail.xjtu.edu.cn (Daocheng Wu)

† These authors contributed equally to this work.

## 1.Preparation of $CuInS_2$/ZnS QDs

Briefly, we mixed 0.4 mmol of indium acetate and 0.4mmol of CuI in a 50 mL three-necked flask, then added 1.0 mL of DDT and 10 mL of ODE with continuous $N_2$ flow. The soulution was heated to 80 °C, magnetically stirred for 1 h, then raised the temperature to 210 °C. After maintaining the mixture at 210 °C for 30 min, the reaction solution was cooled at room temperature. The $CuInS_2$ QDs cores were separated by added excess acetone and 5 min of centrifugation at 8500 rpm. After discarding the supernatant, repeat the washing and centrifugation three times. The precipitate was then separated in n-hexane for further use or dried in the form of powder for characterization.

To prepare core/shell $CuInS_2$/ZnS QDs, the temperature of the $CuInS_2$ core solution was heated to 80 °C. Then, zinc stearate (0.8 mM) were sufficient mixed with 3.2 mL of ODE and 0.8 mL of oleylamine, injected into the flask containing core. The mixture was then heated to 210 °C maintained 30 min to grow the shells. Core/shell QDs were purified through the same process as QD cores.

## 2.Preparation of micelle-encapsulated $CuInS_2$/ZnS QDs.

The resulting core/shell QDs could be successfully transferred into water through well-established preparation protocols.[1-3] In a typical experiment, 250 μL of 1 $mg \cdot mL^{-1}$ $CuInS_2$/ZnS QD chloroform solution and 50.0 mg of PS were dispersed in a round-bottomed flask by 2.0 mL of chloroform. PS is a cheap amphiphilic stearate derivative with a long PEG tail that is structurally similar to PEG-DSPE. To prepare the QD–micelles, we evaporated the chloroform in vacuum drying oven for 30 min. The obtained thin film was heated over a water bath for 2 min at 70 ℃ and mixed with 5.0

mL of water. After ultrasonicated for 1 min repeated three times, the QD-micelles solution was obtained. The resulting QD–micelles were filtered through a 0.22 μm membrane filter for further use.

## 3.Figures

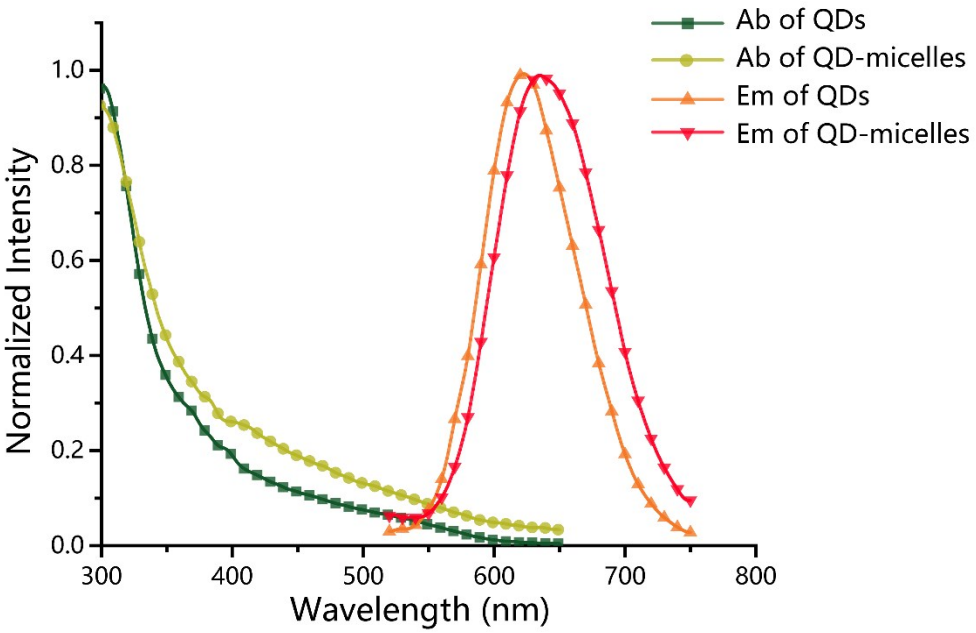
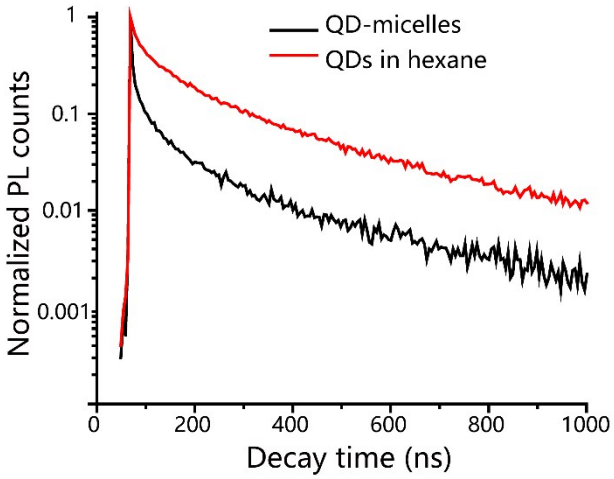



**Figure S1** Absorption (Ab) and emission (Em) spectra of $CuInS_2$ QDs dispersed in n-hexane (as synthesized) or water (after PS micelle-encapsulation). Both of QDs and QD-micelles were excited at 488nm.




| Sample | $A_1$ | $\tau_1$ (ns) | $A_2$ | $\tau_2$ (ns) | $A_3$ | $\tau_3$ (ns) | $\tau$ (ns) |
|---|---|---|---|---|---|---|---|
| **QDs in hexane** | 3386.42 | 31.01 | 2846.37 | 156.26 | 623.1 | 504.03 | 267.49 |
| **QD-micelle** | 3133.56 | 10.13 | 976.78 | 83.44 | 172.93 | 426.02 | 206.01 |

**Figure S2** PL decay curves of the $CuInS_2/ZnS$ QDs in hexane and QD-micelles in PBS of the PL peak at 645 nm. The excitation wavelength was 488 nm. The obtained decay parameters were also given in table below.

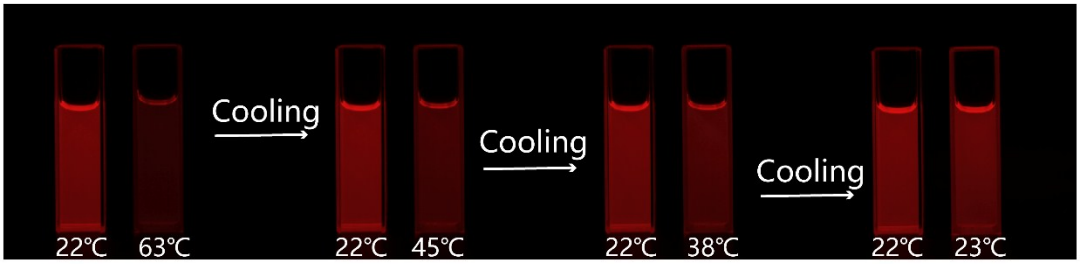



**Figure S3** Fluorescence differences of the heated QD-micelles solution sample (right) and the control (left) as it cooled from 63 °C to 23 °C, under 365 nm UV illumination.

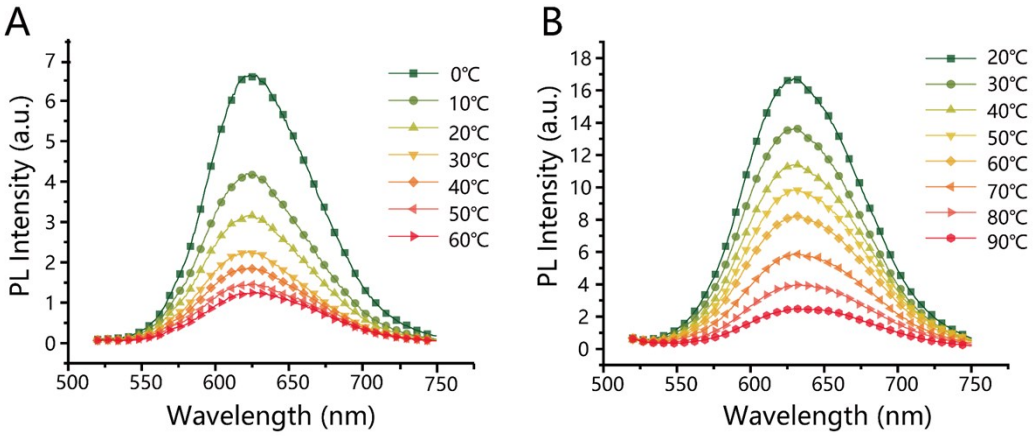



**Figure S4** Temperature-dependent PL emission spectra of $CuInS_2$/ZnS QDs in hexane (A) and in octadecene (B).

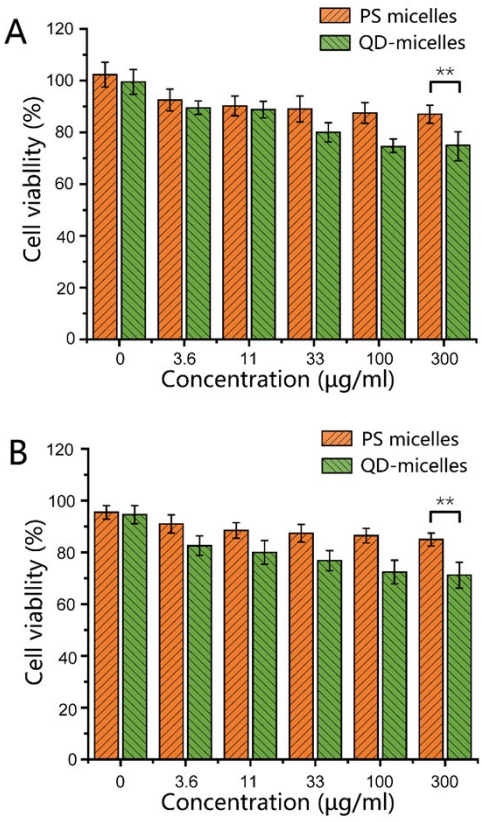



**Figure S5** MTT assay on Hela (A) and PC-3 (B) cells exposed to QD-micelles and PS micelles at different concentrations from 0 to 300 $\mu g \cdot mL^{-1}$ for 24 h. Data represent mean ± SD of six determinations. A T-test was performed; **$p < 0.01$ compared with PS micelles-treated cells.

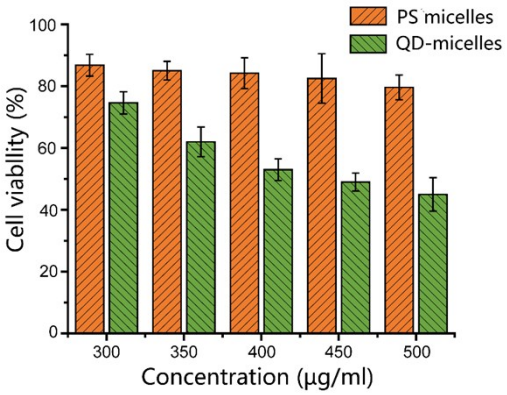



**Figure S6** MTT assay on Hela cells exposed to QD-micelles and PS micelles at different concentrations from 300 to 500 $\mu g \cdot mL^{-1}$ for 24 h.

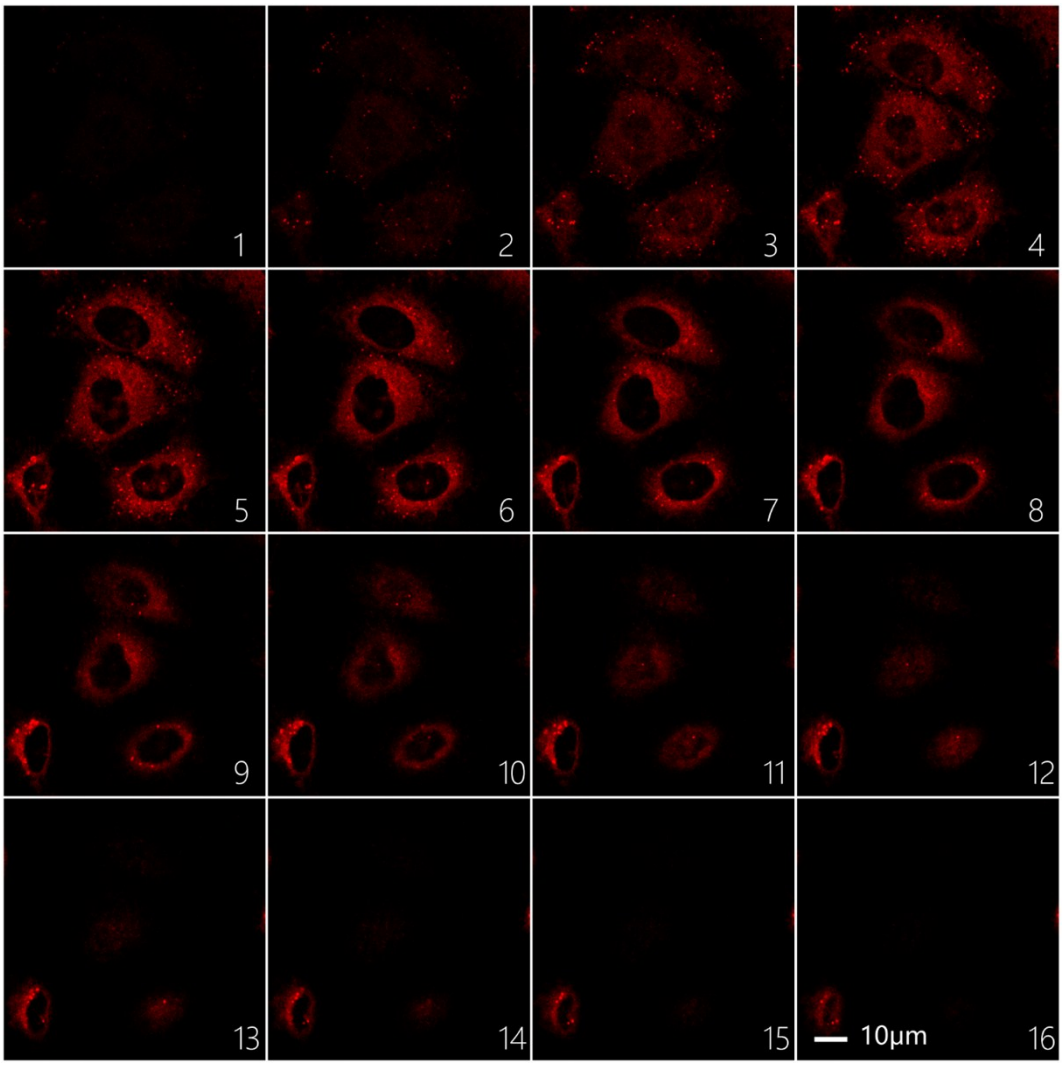



**Figure S7** Confocal fluorescence imaging (z stacking) in every 1 μm at a depth of 0 to 15 μm.

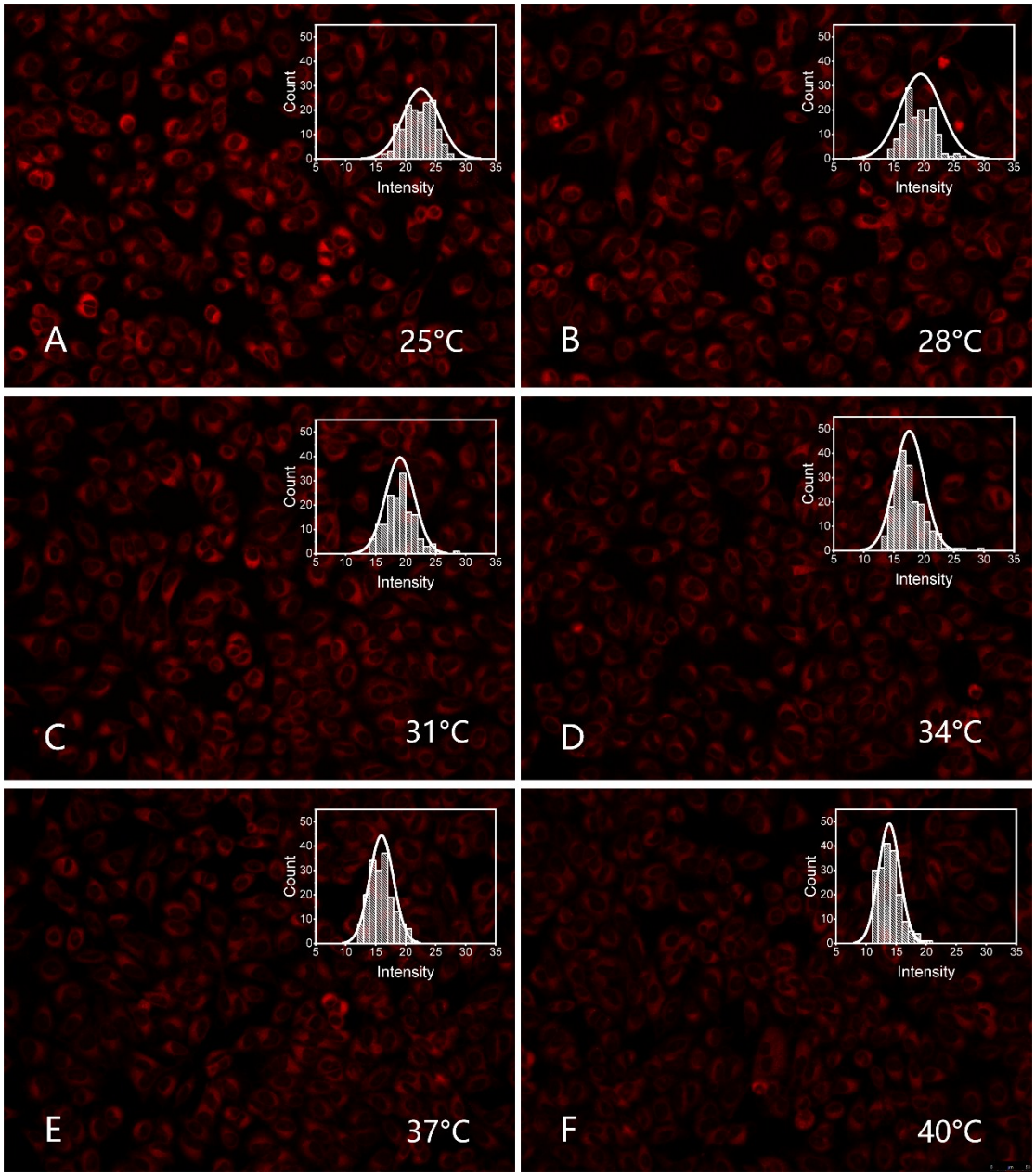



**Figure S8** (A)-(F) Fluorescence imaging of HeLa cells in temperature range of 25 °C, 28°C, 31°C, 34°C, 37°C and 40°C. The insets plot in every image displayed intensity distribution at respective temperature.

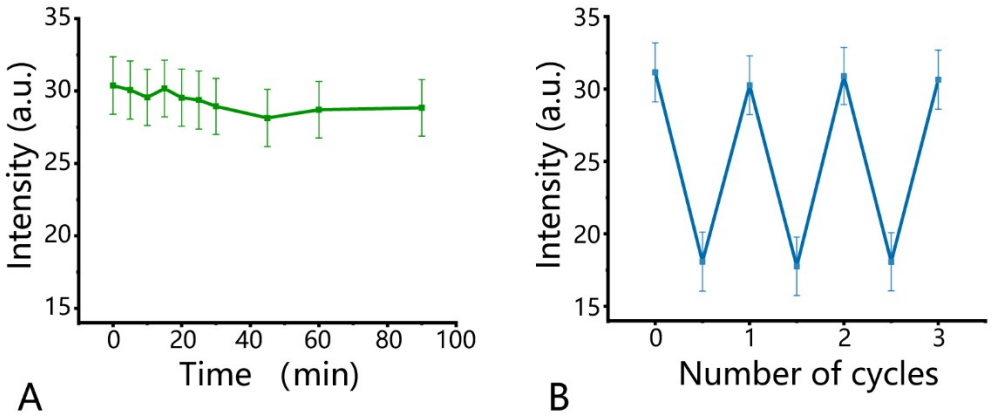



**Figure S9** (A) The average fluorescence intensity of cells during continuous incubation for 90 minutes. (B) The average fluorescence intensity of cells repeated heating and cooling from 0 °C-60 °C. Error bars, SD, n=3

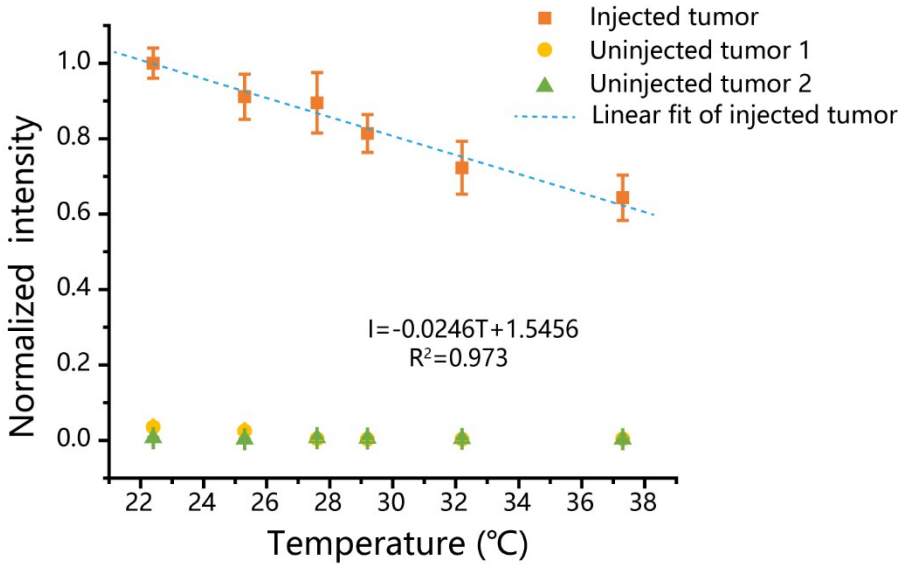



**Figure S10** PL intensity change at the ROIs (regions of interest) of QD-micelles injected tumor and non-injection tumor at different temperatures. Image analysis was performed using Image J software. Error bars, SD, n=3.

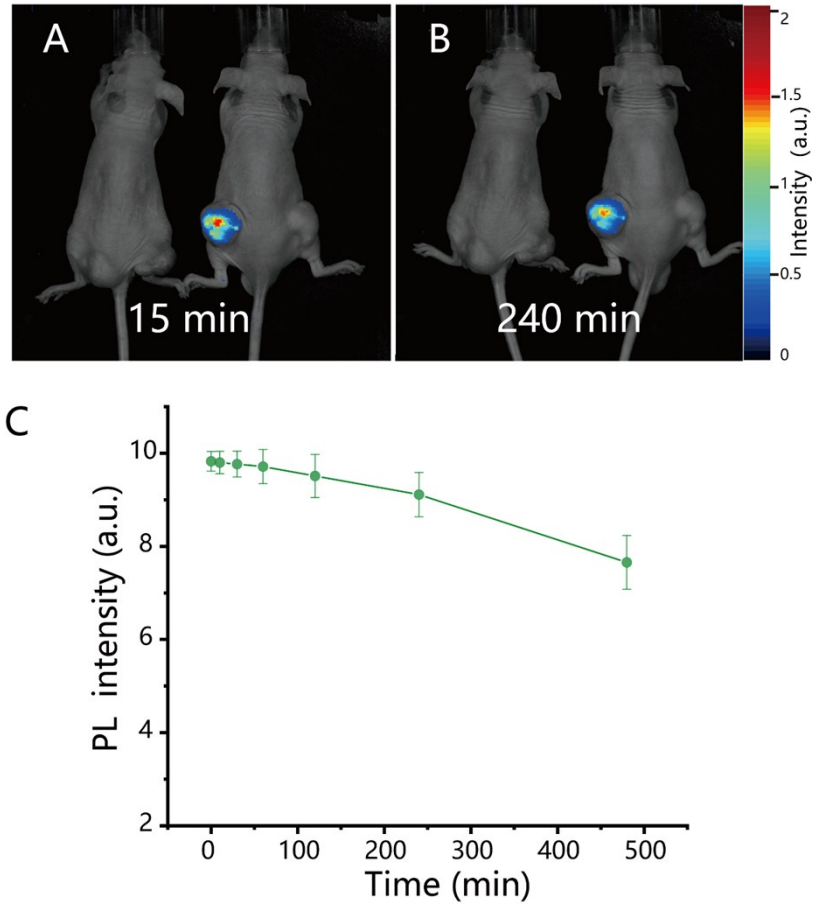



**Figure S11.** NIR fluorescence imaging of the tumor 15 min (A) and 240 min (B) after subcutaneous injection of 50 μL of QD–micelles in the concentration of 2 mg·mL$^{-1}$ into the right tumor. (C) Graph representing the variation of fluorescence intensity of tumor site from 0 to 480 minutes after injection of QD-micelles. Error bars, SD, n=3.

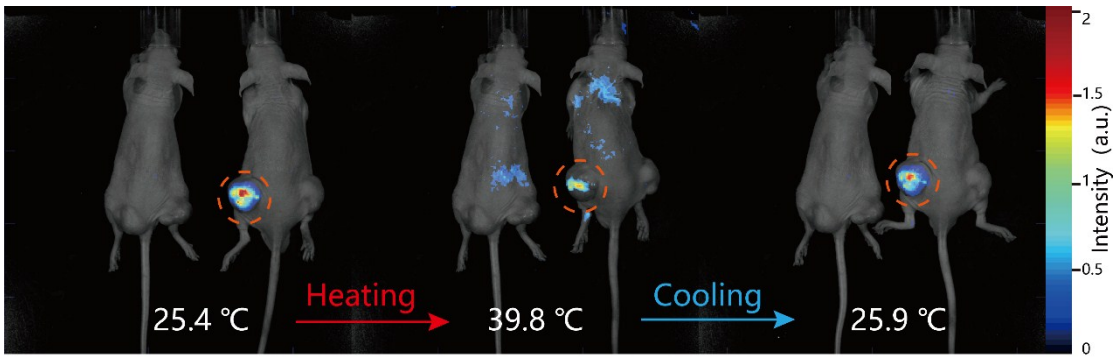



**Figure S12.** NIR fluorescence imaging of the tumor after subcutaneous injection of 50 μL of QD–micelles in the concentration of 2 mg·mL$^{-1}$ in a heating and cooling cycle.

**References:**


1. B. Dubertret, P. Skourides, D. J. Norris, V. Noireaux, A. H. Brivanlou and A. Libchaber, *Science*, 2002, **298**, 1759-1762.
2. O. Carion, B. Mahler, T. Pons and B. Dubertret, *Nat. Protoc.*, 2007, **2**, 2383-2390.
3. H. Y. Fan, E. W. Leve, C. Scullin, J. Gabaldon, D. Tallant, S. Bunge, T. Boyle, M. C. Wilson and C. J. Brinker, *Nano Lett.*, 2005, **5**, 645-648.