Polysarcosine brushes stabilized gold nanorods for in vivo near-infrared photothermal tumor therapy

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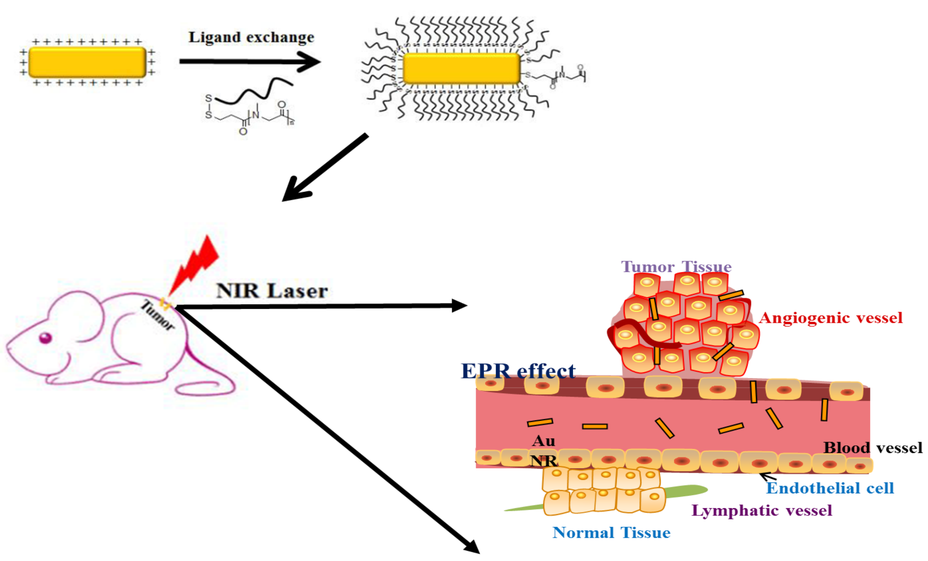
Gold nanorods (AuNRs) are suitable candidates for in vivo photothermal therapy of cancer, because of their strong absorption of near-infrared (NIR) light. Polysarcosine with optimized molecular weight was synthesized and used to cap AuNRs by traditional ligand exchange. The polysarcosine coated AuNRs (Au@PS) showed good stabilities in wide pH range and simulated physiological buffer with the ligand competition of dithiothreitol (DTT). The Au@PS NRs had very low cytotoxicity and showed high efficacy for the ablation of cancer cells in vitro. In vivo photothermal therapy showed that tumors were completely cured without reoccurrence by one-time irradiation of NIR laser after a single injection of the polysarcosine modified AuNRs.



Scheme 1. Schematic illustration of surface modification of CTAB capped AuNRs with thiol/disulfide functionalized polysarcosine.

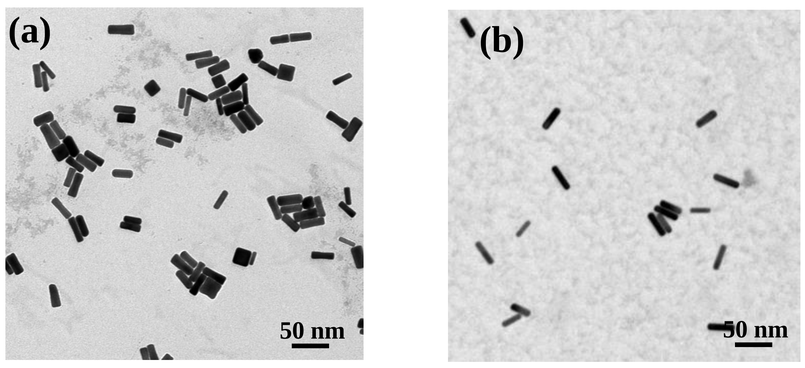


Figure 1. TEM images of (a) Au@PEG NRs and (b) Au@PS NRs, respectively. (c) FT-IR spectra of different AuNRs.

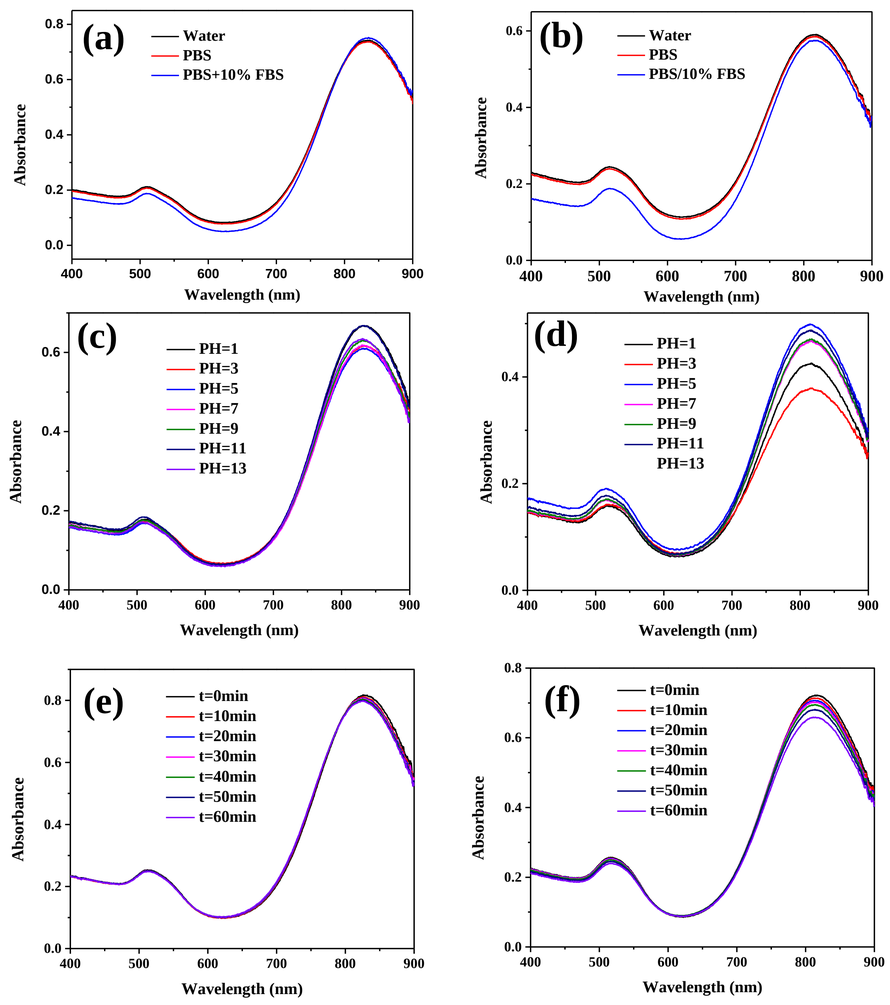


Figure 2. UV-vis spectra of (a) Au@PEG NRs, (b) Au@PS NRs dispersed in water, PBS or PBS/10% FBS solutions. UV-vis spectra of (c) Au@PEG NRs and (d) Au@PS NRs incubated in solutions with various pH. The AuNPs were treated under different conditions for 24 h. Time-dependent absorption spectra of (e) Au@PEG NRs and (f) Au@PS NRs in 150 mM DTT and 400 mM NaCl.

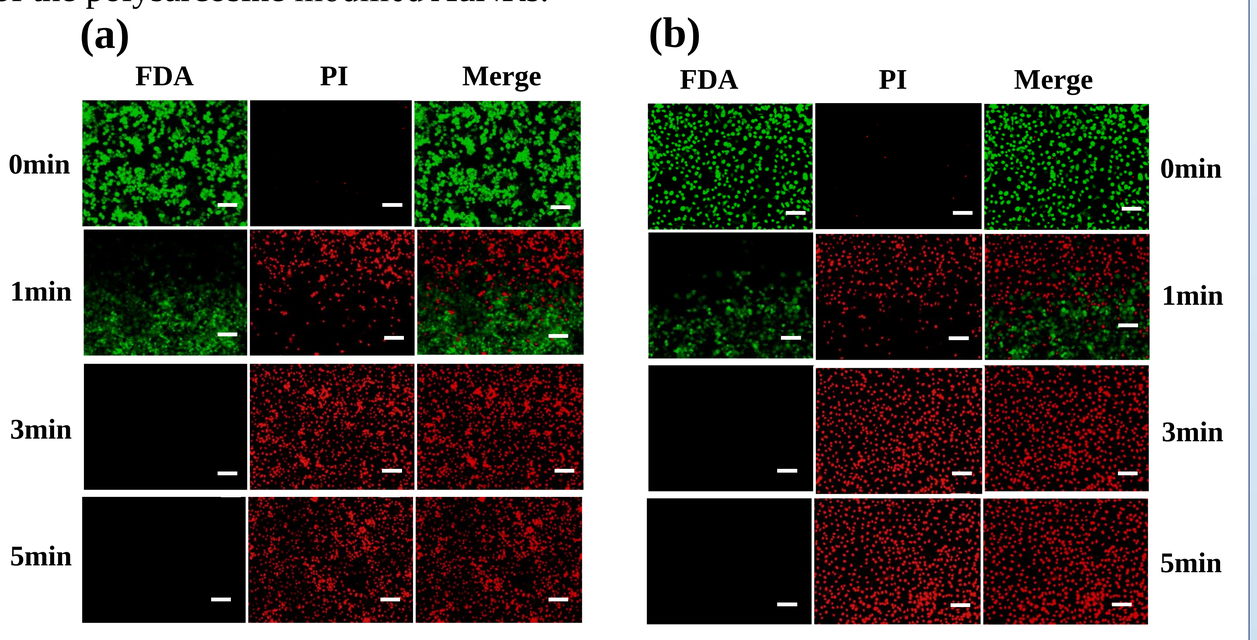


Figure 3. Dead/living staining of cells incubated with 50 μg/mL (a) Au@PEG or (b) Au@PS NRs of various concentrations for 24 h, and then irradiated under a 808 nm NIR laser for different duration. The cells were stained by a mixture solution of FDA and PI. Green and red colors are representing viable and dead cells, respectively.

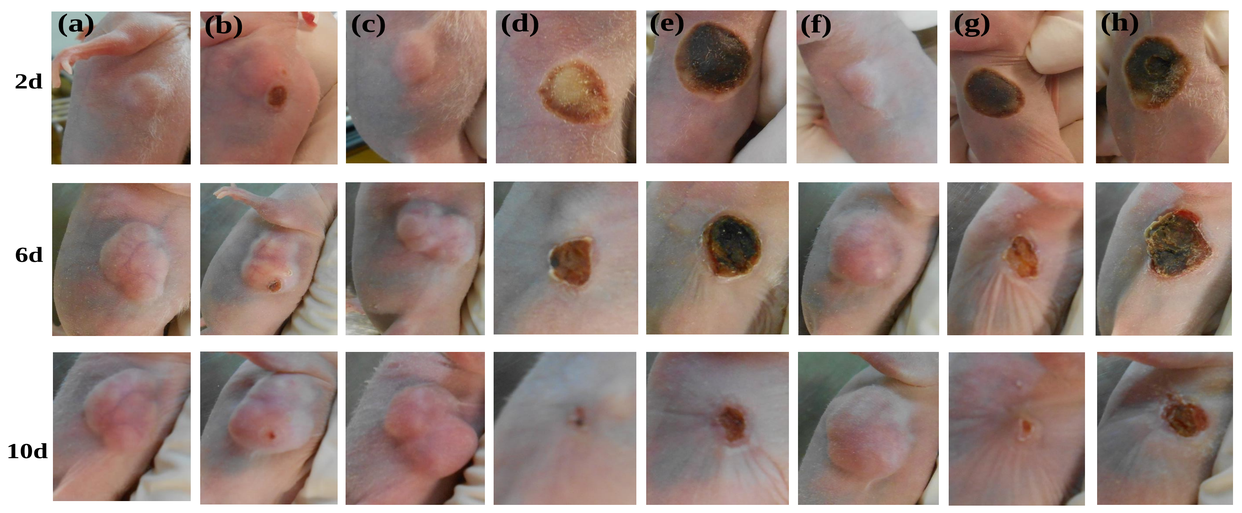


Figure 8. Representative digital photos of nude mice bearing xenograft tumors after injection of AuNRs and laser irradiation: (a) control, (b) saline + 2 min irradiation, (c) Au@PEG, (d) Au@PEG + 0.5 min irradiation, (e) Au@PEG + 2 min irradiation, (f) Au@PS, (g) Au@PS + 0.5 min irradiation, (h) Au@PS + 2 min irradiation. The 1-3 panels represented the mice 2 d, 6 d and 10 d after treatment, respectively.

Conclusion

In summary, we demonstrated that polysarcosine modified AuNRs can serve as an effective NIR photothermal agent for tumor ablation in vivo. These encouraging results suggest that polysarcosine modified AuNRs have great potential in serving as an effective photothermal agent for future clinical cancer therapy. It also strongly indicates that the polysarcosine could be widely used to stabilize various nanomaterials and successfully deliver them to disease sites, which is important for realizing the fascinating functions of nanomaterials for biomedical applications in vivo.

Acknowledgements

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References

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