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Copper Sulfide nanocrystals for efficient photothermal ablation of tumor cells

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Abstract

The unique properties of nanomaterials (e.g., novel optical, electronic and structural properties) provide new opportunities to approach current obstacles in medicine. One of the key aspects of the 'nanophenomenon' that potentially benefits biomedical research and nanomedicine is quantum size confinement, by which the absorption coefficient can be improved and absorption band can be selected at nanoscales. Nanomaterials as photothermal ablation (PTA) agents, which convert optical energy into thermal energy, are desired for cancer therapy especially at near-infrared (NIR, λ = 700–1100 nm) wavelength. In this study, we developed a process for rapid synthesis of CuS nanocrystals coated with starch for PTA. The thickness and width of nanocrystals were controlled by synthesis temperature, concentration of the precursors, i.e. $CuCl_2$ and $(NH_4)_2S$. Typically, the CuS nanocrystal is 1 nm in thickness, 10 nm in width and the starch coating of 1 nm (measured by atomic force microscopy and transmission electron microscopy). The starch acted as a protecting agent, preventing the aggregation and providing reaction sites for following modification of specific recognition agents. At low concentration of precursors, uniform nanocrystals were hardly achieved even with excess of starch (CuS_LPHS, Figure 1a). In contrast, monodispersed nanocrystals were obtained when the concentration of precursors increased (CuS_HPLS, Figure 1b). Moreover, with a same concentration of copper ions, CuS_HPLS has higher absorptions in NIR region owing to the smaller average size of CuS_HPLS than CuS_LPHS (Figure 1c). Treated with CuS_HPLS (conc. =4.4 μg/ml) and a 808-nm NIR laser at 38 W/cm^2 for 2 minutes, human prostate cancer PC-3 cells showed a 36% inhibition of growth compared to those without CuS_HPLS (n=3, p=0.03). Owing to the unique optical properties, small size, low cost of production and low cytotoxicity, CuS nanocrystals are a promising nanomaterial for cancer PTA therapy.

Image

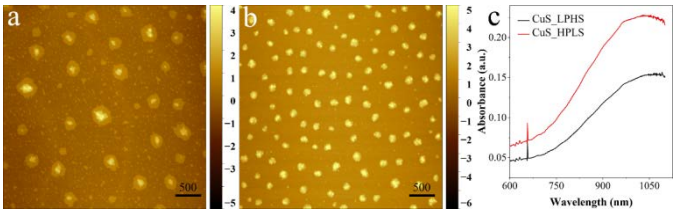

Figure 1 Atomic force microscopy image of CuS_LPHS (a) and CuS_HPLS (b) and corresponding UV-Vis spectroscopy at same Copper ion concentration (c). Unit: nm.

Recent Publications

1. Zejie W, Zhiyong Z, Suqi Z, Shuiliang C, Feng Z (2015) Carbonized textile with free-standing threads as an efficient anode material for bioelectrochemical systems. Journal of Power Sources 287(0):269-275.
2. Yue Z, Chao W, Zhiyong Z, Jing C, Yong X, Zhaohui Y, Feng Z (2014) Ameliorating acidic soil using bioelectrochemistry systems. RSC Advances 4(107):62544-62549
3. Huan D, Zhiyong Z, Feng Z (2015) Biosynthesis of selemium nanobars by *Shewallena oneidensis* MR-1. Acta Microbiologica Sinica 8:016.
4. Xiaochun T, Feng Z, Lexing Y, Xuee W, Zhiyong Z, Ranran W, Yanxia J, Shigang S (2015) Interaction between *in vivo* bioluminescence and extracellular electron transfer in *Shewanella woodyi* via charge and discharge. Physical Chemistry Chemical Physics 19(3):1746-1750
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Biography

Zhiyong Zheng is a PhD student at NanoChemistry group, Department of Chemistry, Technical University of Denmark. He specializes in the electrochemical analysis, nanochemistry, and materials characterization, for example, atomic force microscope, scanning electron microscope, transmission electron microscope, X-ray powder diffraction. With the background of environment science, he is focusing on the extracellular electron transfer, the application of nanomaterials in environment, medicine and energy.

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Notes/Comments: