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Dual-faced nano-mushrooms for tri-functional single cell diagnosis and drug delivery

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Here we introduce a monodispersed mushroom-like fluorescent nanoparticle with dual-faces and tri-functions for SERS-active Raman sensing, fluorescence detecting, cancer marker targeting, and drug carrying and delivering inside a cell. A one-step oxygen plasma process was employed to tailor commercial-available fluorescent PS beads into corrugated hemispheres and simultaneously modify the entire surface with carboxylic groups, and then a gold film was coated on the corrugated hemisphere for SEARs. Sulfo-NHS-SS-biotin disulfide linker and anti-CD44 monoclonal antibody could be modified simultaneously onto the top gold surfaces and bottom carboxyl groups through Au-S and peptide bonds, respectively. In exploiting the dual-module surface, highly selective modifications were performed to the Au-S bond using thiols and/or the peptide bond using a dehydration reaction between –COOH and $–NH_2$. For applications in cancer, the DFPSBs were modified by attaching anti-CD44 antibody (on the carboxylated polystyrene) and a sulfo-NHS-SS-biotin disulfide linker (onto the amine or gold surface). The anti-CD44-modified DFPSBs can be utilized to target cancer cells (such as HeLa and MCF-7) with CD44 over-expressed. For drug delivery, a relatively weak covalent bond in the disulfide linker has the advantage of being capable of cleavage via reduction. The disulfide cleavage, dividing one R-SS-R into two R-SH molecules, occurs with cell cytoplasm environment. In the intracellular space, the cell regulatory mechanism can retain the redox equilibrium; consequently, the disulfide linker-modified DFPSBs act as vehicles releasing their load inside the cell membrane. Therefore, surface-modified DFPSBs can integrate three functions on the nanoparticles for biomedical applications.

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