Hybrid plasmonic materials based on gold nanobones and bovine serum albumin for application in pharmacology and medicine

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Bovine serum albumin (BSA) is widely used for coating various types of nanoparticles to provide them bioinertness (Chaudhari et al., 2011; Höller et al., 2020). At the same time, BSA is an excellent surface stabilizer which prevents coagulation of nanoparticles, and it is also able to mask the nanoobjects from the human immune system at *in vivo* applications because its structure is 70% identical to human albumin (Shimada & Matsushita, 1981). Cross-linking of individual BSA molecules to each other with glutaraldehyde (a homobifunctional covalent linker of amino groups) can provide the better stabilization of nanoparticles together with the denser and thicker shell.

In this study, bovine serum albumin was used to obtain the shells of anisotropic bone-shaped gold nanoparticles, as well as hydrogels with plasmonic properties. The choice of anisotropic gold nanoparticles was made to opportunity of the application of resulting nanohybrid systems in the near-infrared region of biological tissues transparency (Smirnov et al., 2022).

According to the method for obtaining three-dimensional BSA hydrogel, published in 2016 (Ma et al., 2016), the reaction takes place at neutral pH. Similarly, colored hydrogels containing gold nanobones were obtained. By varying the BSA/glutaraldehyde ratio, the hydrogels differing in density and optical properties were prepared (Fig. 1A). The resulting hydrogel suspensions can be brought into a state of homogeneous paste by centrifugation for further research and applications.

In the case of performing the reaction in the basic medium, the kinetics of cross-linking seems to be significantly slowed down, therefore optically pure colloidal solutions of nanoparticles coated with a thin layer of stitched BSA can be obtained. At the top of Figure 1B. the SEM images are shown, where the BSA shell of gold nanoparticles can be clearly distinguished. These solutions remains as a true colloid, in contrast to the suspensions obtained by the original method (Fig. 1B).

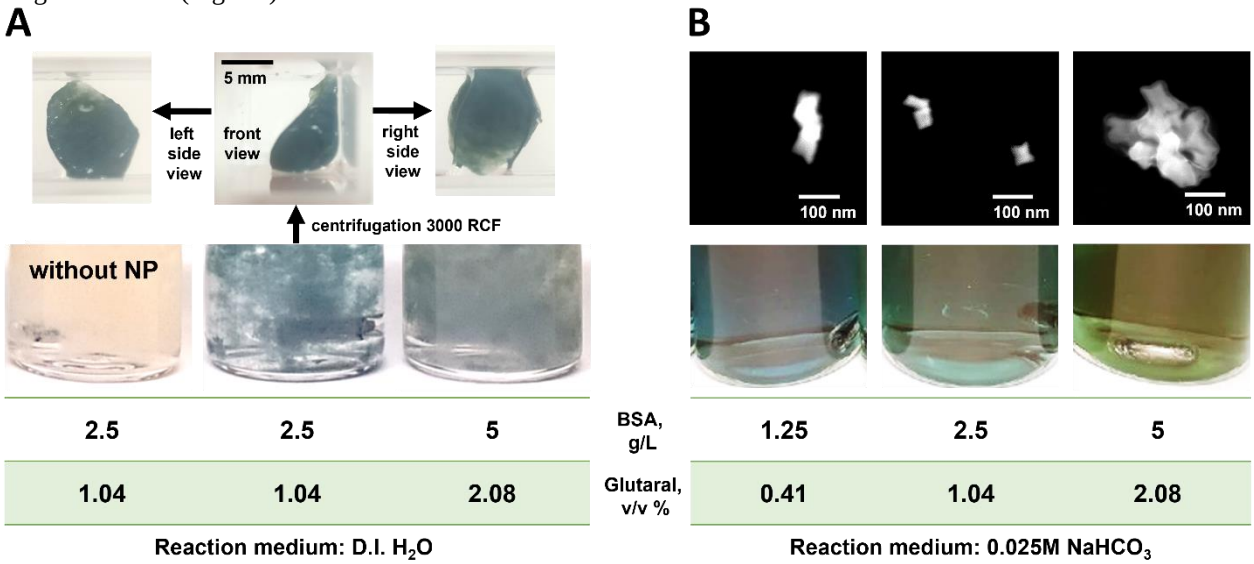

Fig. 1. A) BSA hydrohels-modified with Au nanobones obtained in the reaction medium H_2O before and after centrifugation.; B) Au nanobones coated by BSA obtained in 0.025 M $NaHCO_3$ reaction medium. SEM images show hybrid nanoparticles at high resolution. The reaction conditions are indicated at the bottom.

The average of zeta potential of nanoparticles in a solution of bovine serum albumin prepared in 0.025 M $NaHCO_3$, without additives of glutaraldehyde, changed from –25 mV to –7 mV with the increase of BSA concentration from 0.5 to 5 g/L. In contrast, for similar systems with proportional additives of glutaraldehyde (Fig. 1B.), zeta potential varied from -32 mV for the system containing 0.5 g/l BSA to -27 mV for the system with 5 g/l BSA. Apparently, glutaraldehyde compensated for the drop in zeta potential with an increase in the BSA concentration by crosslinking the amino groups. Cross-linking also provides the increased stability of nanoparticles by maintaining surface zeta potential close to -30 mV.

Thus, on the one hand, using bovine serum albumin together with gold nanoparticles allows obtaining the colloids with increased stability and nanoparticle shell of required thickness and variable optical parameters, on the other hand, it also makes possible a preparation of homogeneous hydrogels with plasmonic properties. The resulting nanohybrids show promise for further optical research and biological applications.

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