Supporting Information

Gold-Nanoparticle-Decorated Silica Nanorods for Rapid and Sensitive Visual Detection of Proteins

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ABSTRACT

We report a rapid and highly sensitive approach based on gold-nanoparticle-decorated silica nanorods (GNP-SiNRs) label and lateral flow strip biosensor (LFSB) for visually detecting proteins. Owing to its biocompatibility and convenient surface modification, SiNRs were used as carriers to load numerous GNPs, and the GNP-SiNRs were used as labels for the lateral-flow assay. The LFSB detection limit was lowered 50 times compared to the traditional GNP-based lateral-flow assay. Rabbit IgG was used as a model target to demonstrate the proof-of-concept. Sandwich-type immunoreactions were performed on the immunochromatographic strips, and the accumulation of GNP-SiNRs on the test zone produced the characteristic colored bands, enabling visual detection of proteins without instrumentation. The quantitative detection was performed by reading the intensities of the colored bands with a portable strip reader. The response of the optimized device was highly linear for the range of 0.05-2 ng mL^{-1}, and the detection limit was estimated to be 0.01 ng mL^{-1}. The GNP-SiNR-based LFSB, thus, offered an ultrasensitive method for rapidly detecting trace amounts of proteins. This method has a potential application with point-of-care screening for clinical diagnostics and biomedical research.

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Preparation of GNP-SiNR-Ab_1 Conjugates. Initially, 0.01 mg of Ab_1 was mixed with 1.00 mL of GNP-SiNRs (pH 9.0), followed by gentle shaking for 1 h at room temperature. Then, 0.10 mL of 10.0 wt% BSA were added, and the mixture was incubated for 30 min. The mixture was further washed with PBS (1% BSA) and centrifuged at 6,000 rpm for 5 min to remove the washing liquid. Finally, the as-prepared GNP-SiNR-Ab_1 conjugates were collected and suspended in 1.00 mL of eluent buffer containing 20.00 mM $Na_3PO_4 \cdot 12H_2O$, 0.25% Tween 20, 10% sucrose, and 5% BSA.

Preparation of GNP-Ab_1 conjugates. 0.01 mg of Ab_1 was added to 1.0 mL of fivefold-concentrated GNPs (pH 9.0). The mixture was gently incubated for 1 h and blocked by 0.1 mL of 10 wt% BSA for 30 min. The obtained solution was centrifuged at 12,000 rpm for 18 min, and the nanoparticles were washed with PBS (1% BSA) 3 times. The resulting ruby sediments were dispensed in 1.0 mL of buffer containing 20 mM $Na_3PO_4 \cdot 12H_2O$, 0.25% Tween 20, 10% sucrose, and 5% BSA.

Preparation of the Lateral-Flow Strip Biosensor (LFSB). The LFSB consisted of the following components: a sample-application pad, a conjugate pad, a nitrocellulose membrane, and an absorption pad. Both the sample-application pad and the absorption pad were made from cellulose fiber. The sample-application pad (17 mm × 30 cm) was soaked in a buffer (pH 8.0) containing 0.25% Triton X-100, 0.05 M Tris-HCl, and 0.15 mM NaCl. Then, the sample pad was dried at 37 ^{o}C in the oven and stored in desiccators at room temperature. Ab_1, with a concentration of 1.20 mg mL^{-1}, and Ab_2 (0.85 mg mL^{-1}) were dispensed at different locations of the nitrocellulose membrane (25 mm × 30 mm) to form the test line and the control line by using a Biojet BJQ 3000 dispenser. The nitrocellulose membrane was then dried in the oven at 37 ^{o}C for 1 h. Finally, all the parts were assembled on a plastic, adhesive backing layer (typically an inert plastic, e.g., polyester) using the Clamshell Laminator. Each part overlapped 2 mm to ensure that the solution migrated through the biosensor during the assay. The LFSB with a 3-mm width was cut with the Guillotin cutting-module CM 4000. The GNP-SiNR-Ab_1 or GNP-Ab_1 conjugates were dropped on the conjugate pad using a pipet before each test.

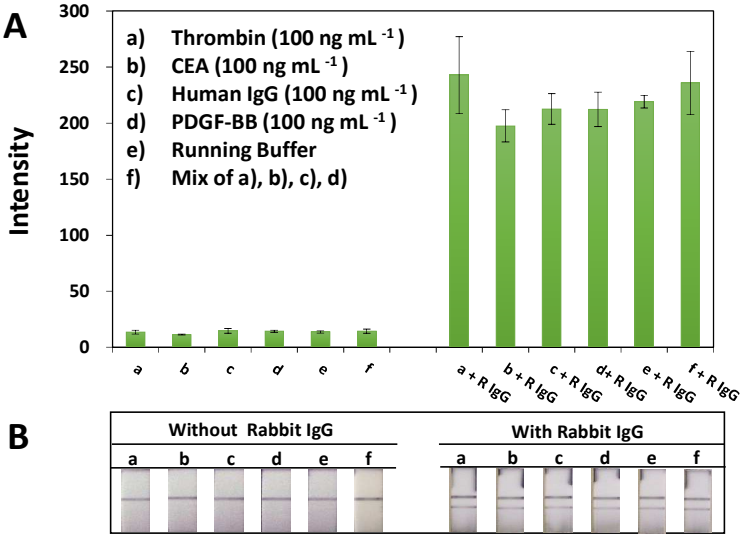

Figure S1. (A) Histogram of the LFSB responses and (B) the corresponding photo images. Rabbit IgG concentration: 1 ng mL^{-1}.

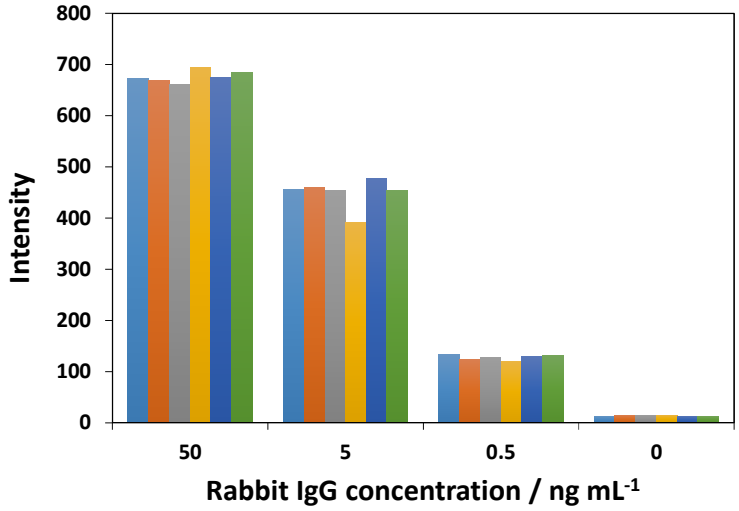

Figure S2. Reproducibility study in the presence of 50, 5, 0.5, and 0 ng mL^{-1} of rabbit IgG. Tests were performed 6 times for each sample solution.