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Two-Protein Modified Gold Nanoparticles for Serological Diagnosis of Borreliosis

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Abstract : Gold is a noble metal; in its nano-scale level (e.g. spherical nanoparticles), the conduction electrons are triggered to collectively oscillate with a resonant frequency when certain wavelengths of electromagnetic radiation interact with its surface; this phenomenon is known as surface plasmon resonance (SPR). SPR is responsible for giving the gold nanoparticles its intense red color depending mainly on its size, shape and distance between nanoparticles. A decreased distance between gold nanoparticles results in aggregation of them causing a change in color from red to blue. This aggregation enables gold nanoparticles to serve as a sensitive biosensoric indicator. In the proposed work, gold nanoparticles were modified with two proteins: i) Borrelia antigen, variable lipoprotein surface-exposed protein (VlsE), and ii) protein A. VlsE antigen induces a strong antibody response against Lyme disease and can be detected from early to late phase during the disease in humans infected with Borrelia. In addition, it shows low cross-reaction with the other non-pathogenic Borrelia strains. The high specificity of VlsE antigen to anti-Borrelia antibodies, combined simultaneously with the high specificity of protein A to the Fc region of all IgG human antibodies, was utilized to develop a rapid test for serological point of care diagnosis of borreliosis in human serum. Only in the presence of anti-Borrelia antibodies in the serum probe, an aggregation of gold nanoparticles can be observed, which is visible by a concentration-dependent colour shift from red (low IgG) to blue (high IgG). Experiments showed it is clearly possible to distinguish between positive and negative sera samples using a simple suspension of the two-protein modified gold nanoparticles in a very short time (30 minutes). The proposed work showed the potential of using such modified gold nanoparticles generally for serological diagnosis. Improved specificity and reduced assay time can be archived in applying increased salt concentrations combined with decreased pH values (pH 5).

Keywords : gold nanoparticles, gold aggregation, serological diagnosis, protein A, lyme borreliosis
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