Abstract

Antimicrobial resistance (AMR) has become one of the major public health concerns causing serious obstacles to the successful prevention and treatment of infectious diseases. To curb the spread of AMR, well-equipped laboratories for the early detection of disease-causing pathogens and resistant genes are crucial, something that remains unmet in developing countries due to resource constraints and inadequate infrastructure. This paper presents an affordable and simple nanoparticle-based biosensor for rapidly detecting the bla_{NDM-1} gene in carbapenemase-producing (CP) bacteria. The biosensor employs thiol–ligand surface functionalized gold nanoparticles (GNPs) conjugated with an oligonucleotide probe specific for detecting the bla_{NDM-1} gene. The biosensor was evaluated using DNA extracted from CP bacteria having the target bla_{NDM-1} gene, two non-NDM-1 CP bacteria, and five susceptible bacterial strains. Tuning of the localized surface plasmon resonance (LSPR) of the GNPs was achieved by reducing the surrounding pH of the GNPs, hence inducing aggregation. With the binding of GNPs–probe–target DNA, the stability of GNPs was enhanced, as confirmed by the retention of the red colour when an optimized amount of 0.1 M HCl was added to induce aggregation. The absence of target DNA was indicated by the aggregation of GNPs after the addition of acid, which resulted in a colour change from red to blue/purple and a shift in the LSPR band to a longer wavelength, averaging 620 nm. The biosensor visual detection results were quantified with absorbance spectra measurements and the results were achieved within 30 minutes. The biosensor successfully detected the target DNA from bla_{NDM-1} positive bacteria and distinguished the non-targets. The analytical sensitivity achieved was 2.5 ng μL^{-1} which corresponds to approximately 10^3 colony-forming units per milliliter. These findings were confirmed through PCR amplification. This nano-biosensor offers an inexpensive, simple, rapid, and sensitive method for detecting the bla_{NDM-1} gene in carbapenemase producers, and is readily implementable in resource-limited settings.