The detection of HIV using plasmonically active colloidal gold nanoparticles

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ABSTRACT

Localized surface plasmon resonance (LSPR) phenomenon occurs when incident light of specific wavelength excites the free electrons on the gold nanoparticles surface, which leads to the enhancement of the nanoparticle surface electromagnetic field. The enhanced electromagnetic field has a short decay length and is localized in LSPR as opposed to the (SPR) where the activated surface plasmons propagate. The short electromagnetic field decay length in LSPR means that it is highly sensitive to the refractive index changes near the gold nanoparticle. This makes this technique efficient particularly to changes induced by subtle interactions. In this work, LSPR was used to differentiate between samples with HIV and the ones with no HIV. A glass slide was treated with 1% APTES solution in ethanol before depositing a layer of gold nanoparticles. An anti-HIV-gp120 antibody was added as a biorecognition element prior to the addition of the HIV pseudovirus as the analyte. Thereafter the slide was analyzed on an LSPR system using a green LED light. The results showed that when using 50 nm gold nanoparticles, there was a clear distinction between a sample with the pseudovirus and the one without it as shown by the varying light transmission intensities between the negative sample and the sample with the virus. This denotes that LSPR is sensitive enough as a label free detection method for virus detection. This can be used for the development of simple and cost-effective ways of detecting various diseases in developing countries.

INTRODUCTION

LSPR occurs when light excites the free electrons on the surface of nanoparticles, resulting in the enhancement of the nanoparticle surface electromagnetic field with a short decay length [1]. When the refractive index of the surrounding medium changes, the LSPR peak shifts [2]. LSPR biosensing is performed without the use of dyes, thus simplifying the process, reducing costs and allows low concentration of analytes [3]. In this work, LSPR was used for the detection of HIV. There remains no cure for the HIV infection and according to the World Health Organization recommendations; all people should get tested and the infected ones are to start treatment as early as they are aware of their HIV status regardless of their CD4 count [4]. This has created a need to increase testing platforms to reach as many people as possible irrespective of geographical location and socioeconomic factors. The investigation of photonics-based technologies for HIV diagnostics seeks to provide a sensitive, accurate and simple to use device that can be used at point of care particularly in resource limited settings.

METHODOLOGY

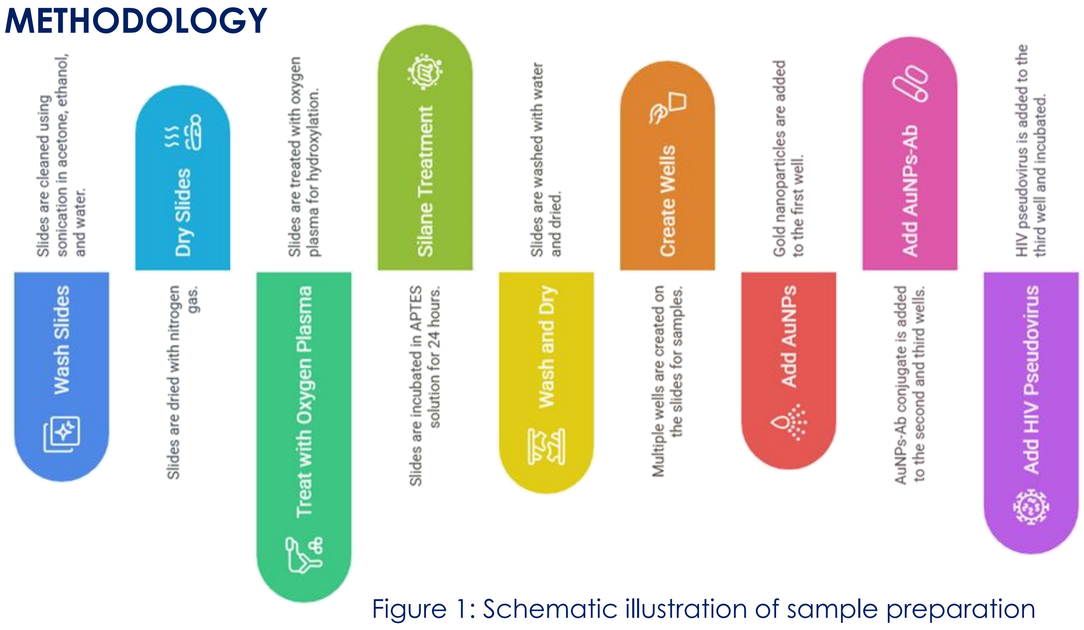

Figure 1: Schematic illustration of sample preparation

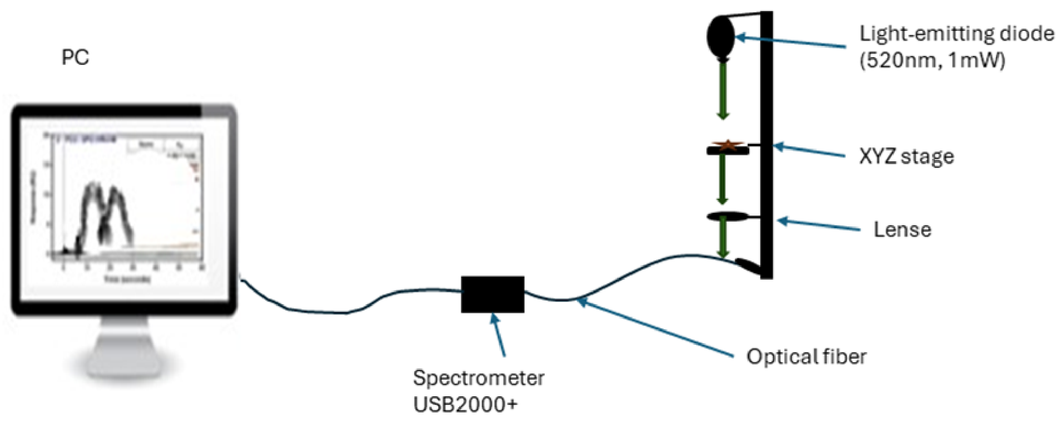

Figure 2: Schematic illustration of the LSPR system

RESULTS

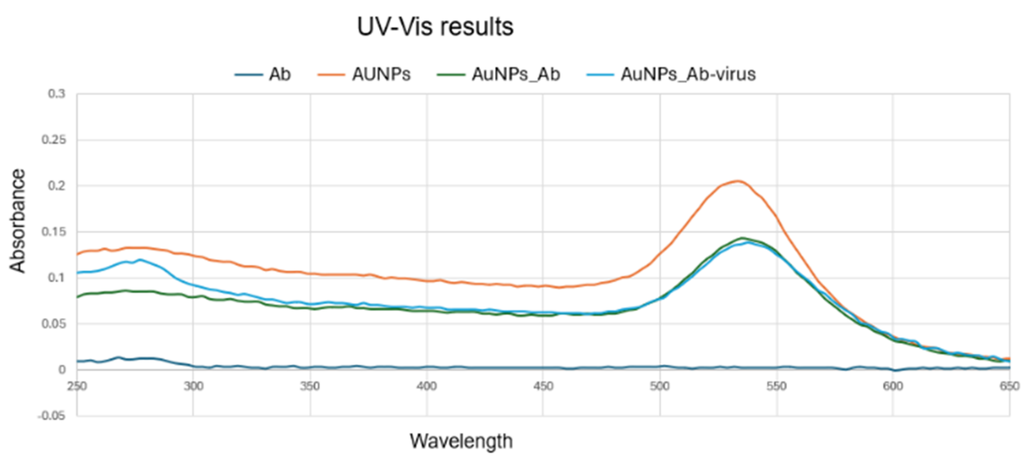

Figure 3: Graph representing UV-Vis spectra of nanoparticles (AuNPs), nanoparticles conjugated to the antibody(AuNPs-Ab) and the nanoparticles antibody conjugate with the virus (AuNPs-Ab-virus) and the antibody (Ab) only. The antibody and the virus show a peak at 280 nm while the nanoparticles show a peak at 540 nm.

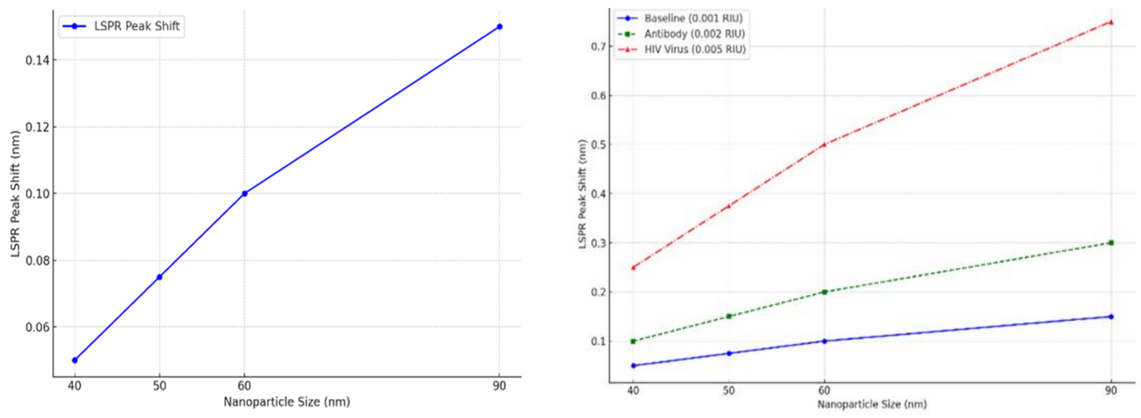

Figure 4: Simulated effect of nanoparticle size with corresponding LSPR wavelength peak shift showing varying LSPR peak shifts for (A) nanoparticles of different sizes and (B) nanoparticles (blue line), nanoparticles conjugated to an antibody (green line) and nanoparticles conjugated to the antibody and the virus (red line).

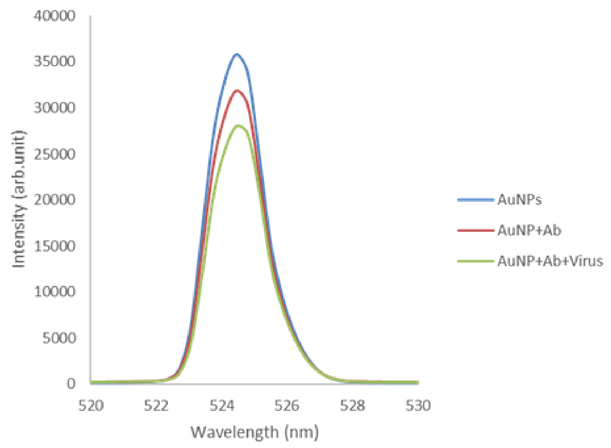

Figure 5: The LSPR wavelength peak for gold nanoparticles (AuNPs), gold nanoparticles with antibody (AuNP+Ab), and gold nanoparticles – antibody – HIV conjugate (AuNP+Ab+Virus). The gold nanoparticle size used in this experiment was 50 nm, hence the wavelength peak at 525 nm

CONCLUSION

The LSPR system successfully differentiated between a sample with HIV and the sample without HIV as shown by differences in transmitted intensity. A sample with nanoparticles only had the highest intensity of 36000, while the one with nanoparticles and the antibody had the intensity of 32000, and the one that contained the virus had the intensity of 27000.

REFERENCES

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[2] S. Kastner et al., Small 19(33), 2023.
[3] Unaids, UNAIDS Fact sheet 2024.
[4] World Health Organization, 2021.