Development of Cadmium Sulfide Quantum Dots-Polyamidoamine Dendrimer Thin Films for Detection of Dengue Virus E-protein Antigens

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Abstract: In this work, cadmium sulfide quantum dots composited with polyamidoamine (PAMAM) dendrimer (CdSQDs-PAMAM) thin film had been successfully developed for use in the detection of DENV E-proteins. The SPR results suggested that DENV E-protein can be detected in the range 0.0001 to 10 nM. The successful binding between antibodies and antigens in an immunoassay sensor was further confirmed using UV-Vis spectroscopy, by observing the red shift of absorption edge.
***Keywords*:** Surface plasmon resonance, PAMAM dendrimer, DENV E-protein

INTRODUCTION

Currently, effective vaccine or specific therapy for the treatment of dengue virus (DENV) infection are still unavailable, and therefore a timely diagnosis a dengue virus employing real time surface plasmon resonance sensor is the demand of the day to prevent the spread of the disease [1]. Recently, quantum dots-based cadmium sulfide (CdS) nanoparticles with reduced graphene oxide (NH_2GO) were reported with the detection limit of 8.948 $x10^{-13}$ M in sensing M. Tuberculosis [2]. In order to extend their potential for sensing applications, efforts have been made for preparing CdSQDs in polyamidoamine (PAMAM) dendrimers to detect the dengue virus (DENV) E-protein using surface plasmon resonance.

MATERIALS AND METHODS

The CdSQDs preparation begins by dissolving 0.5 mmol of MPA and 0.5 mmol of $CdCl_2.10H_2O$ in 250 ml of double distilled deionized water. The pH of the solution was taken and adjusted to 6.0 by adding dropwise of NaOH solution (1M) under constant stirring. The solution was then purged with nitrogen gas for at least 60 min under vigorous stirring. The dissolved sodium sulfide (0.5 mmol) was then added into stirred solution until the clear yellowish suspension of CdSQDs was obtained. The obtained suspension was quenched to 0 °C in freezer for 45 mins and stored in a refrigerator at 4 °C. The stock solution of PAMAM was prepared at 10 mM in PBS (pH 7.0) and stored at 4 °C. Then, the solution of CdSQDs-PAMAM was prepared by vortex 0.25 ml CdSQDs in 0.5 ml PAMAM. Approximately 0.55 ml of the CdSQDs-PAMAM solution was first dropped on the top Au film covering the surface. They were spun at 6000 rev/min for 30 s using a Spin Coating System, P-6708D. A cross link solution containing EDC (2mM) and NHS (5mM) was then coated on following surfaces, followed by IgM immobilization. The standard powders of DENV E-protein and IgM were diluted in PBS (pH 7.4) to produce DENV E-protein and IgM solutions. The SPR measurement was then carried out by measuring the reflected He-Ne laser beam (632.8 nm, 5mW) as a function of incident angle. The absorption spectra in the wavelength range of 250–800 nm was performed using Shimadzu UV–Vis–NIR spectroscopy.

RESULTS AND DISCUSSION

In this experiment, the developed Au/CdS-NH_2GO/EDC-NHS/IgM thin film is exposed to DENV E-protein (0.0001-10 nM) and were separately injected into the flow cell. Prior to that, the PBS solution was first injected into the cell to obtain the control resonance angle. As observed (Fig. 1), the resonance angle for PBS solution is 53.764°. The resonance angle of SPR was increased gradually to 53.842° when the sensor surface exposed to 0.01 nM DENV E-protein. Thereafter, the amount of binding can be quantitatively measured by taking the difference between the resonance angle of the sample and the PBS solution. It is observed the measured shift of resonance angle was increased as the DENV E-protein concentration increased to 0.01 nM and attained a steady shift towards 10 nM DENV E-protein concentration due to the maximal binding of DENV E-proteins.

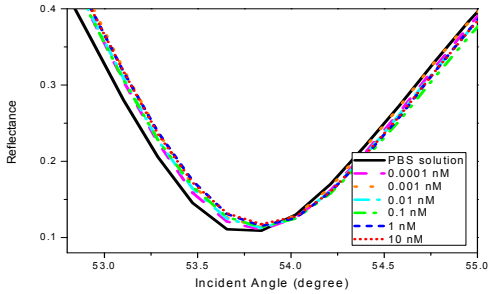

Fig. 1. The SPR curves for the Au/CdSQDs-PAMAM/EDC-NHS/IgM thin film exposed to DENV E-proteins

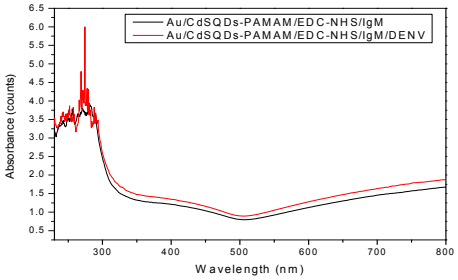

Fig. 2. Absorption spectra of Au/CdSQDs-PAMAM/EDC-NHS/IgM before and after the introduction DENV E-protein.

Fig. 2 shows the absorption spectra of Au/CdSQDs-PAMAM/EDC-NHS/IgM before and after antigen binding. Both spectra have an absorption peak at 277 nm. In another study, the absorption peaks for CdSQDs and PAMAM-NH_2 have been found at 470 nm and 275 nm, respectively [4, 5]. The slight shifting of the absorption peak for CdSQDs-PAMAM composites was observed in comparison to CdSQDS and PAMAM bands, which is probably related to the presence of multi-layers over the sensor film. After contact with DENV E-protein, the absorption edge was slightly shifted to longer wavelength due to the strong coupling between DENV E-protein and surface immobilized antibody [6].

CONCLUSIONS

In the present paper, the Au/CdSQDS-PAMAM/IgM thin film for detection of DENV E-protein using SPR was developed. The SPR and UV-Vis results showed the successful binding of the antigens on the sensor surface by observing the shift in resonance angle and the red shift of absorption edge, respectively. The above results showed that Au/CdSQDs-PAMAM/IgM thin film has high potential as a dengue virus E-protein sensing material in SPR technique. Further studies on the modification of the sensing layer for the early detection of the dengue virus using SPR method is important. Hence, it is envisaged that the future directions in the diagnosis of dengue virus will focus on the improvement of the sensitivity and selectivity.

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