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Rapid Plasmonic Colorimetric Glucose Biosensor via Biocatalytic Enlargement of Gold Nanostars

Authors : Masauso Moses Phiri

Abstract : Frequent glucose monitoring is essential to the management of diabetes. Plasmonic enzyme-based glucose biosensors have the advantages of greater specificity, simplicity and rapidity. The aim of this study was to develop a rapid plasmonic colorimetric glucose biosensor based on biocatalytic enlargement of AuNS guided by GOx. Gold nanoparticles of 18 nm in diameter were synthesized using the citrate method. Using these as seeds, a modified seeded method for the synthesis of monodispersed gold nanostars was followed. Both the spherical and star-shaped nanoparticles were characterized using ultra-violet visible spectroscopy, agarose gel electrophoresis, dynamic light scattering, high-resolution transmission electron microscopy and energy-dispersive X-ray spectroscopy. The feasibility of a plasmonic colorimetric assay through growth of AuNS by silver coating in the presence of hydrogen peroxide was investigated by several control and optimization experiments. Conditions for excellent sensing such as the concentration of the detection solution in the presence of 20 µL AuNS, 10 mM of 2-(N-morpholino) ethanesulfonic acid (MES), ammonia and hydrogen peroxide were optimized. Using the optimized conditions, the glucose assay was developed by adding 5mM of GOx to the solution and varying concentrations of glucose to it. Kinetic readings, as well as color changes, were observed. The results showed that the absorbance values of the AuNS were blue shifting and increasing as the concentration of glucose was elevated. Control experiments indicated no growth of AuNS in the absence of GOx, glucose or molecular O_2. Increased glucose concentration led to an enhanced growth of AuNS. The detection of glucose was also done by naked-eye. The color development was near complete in ± 10 minutes. The kinetic readings which were monitored at 450 and 560 nm showed that the assay could discriminate between different concentrations of glucose by ± 50 seconds and near complete at ± 120 seconds. A calibration curve for the qualitative measurement of glucose was derived. The magnitude of wavelength shifts and absorbance values increased concomitantly with glucose concentrations until 90 µg/mL. Beyond that, it leveled off. The lowest amount of glucose that could produce a blue shift in the localized surface plasmon resonance (LSPR) absorption maxima was found to be 10 – 90 µg/mL. The limit of detection was 0.12 µg/mL. This enabled the construction of a direct sensitivity plasmonic colorimetric detection of glucose using AuNS that was rapid, sensitive and cost-effective with naked-eye detection. It has great potential for transfer of technology for point-of-care devices.

Keywords : colorimetric, gold nanostars, glucose, glucose oxidase, plasmonic
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