A Highly Sensitive Non-enzymatic Glucose Biosensor Based on Regulatory Effect of Glucose on Electrochemical Behaviors of Colloidal Silver Nanoparticles on MoS_2

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ABSTRACT

A novel and highly sensitive non-enzymatic glucose biosensor was developed by nucleating colloidal silver nanoparticles (Ag NPs) on MoS_2. The facile fabrication method, high reproducibility (97.5%) and stability indicates a promising capability for large-scale manufacturing. Additionally, the excellent sensitivity (9044.6 μA mM^{-1} cm^{-2}), low detection limit (0.03 μM), appropriate linear range of 0.1-1000 μM, and high selectivity, suggests that this biosensor has a great potential to be applied for noninvasive glucose detection in human body fluids, such as sweat and saliva.

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INTRODUCTION

Diabetes is a chronic medical condition in which levels of glucose in the blood are raised significantly from the normal range. The high levels of glucose in the blood will eventually cause damage to many tissues in the body, including heart, eyes, kidneys and nerves, leading to painful and life-threatening health complications. According to the international diabetes federation, every 6 seconds a person dies from the health complications associated with diabetes. However, these complications can be prevented or controlled by monitoring blood glucose levels. Accordingly, millions of diabetics test their blood glucose levels daily, which makes glucose the most commonly tested analyte.

Recent studies have showed a strong correlation between the glucose levels in human blood and those in other body fluids, such as sweat and saliva. For example, sweat glucose that was properly harvested to prevent contamination from other sources on the skin accurately reflected the blood glucose levels of patients (Moyer et al. 2012). The concentrations of glucose in these biofluids are in the μM range (Jurysta et al. 2009; Moyer et al. 2012). Thus, the development of nonintrusive, inexpensive and non-enzymatic glucose biosensors that are sensitive enough to effectively detect glucose in alternative body fluids of sweat and saliva is in great need.

Here, colloidal Ag NPs were synthesized in the presence of MoS2, which was used to fabricate highly sensitive, non-enzymatic biosensors for the detection of relatively low glucose levels in human sweat and saliva. To our best knowledge, this is the first report of colloidal Ag NPs/MoS2-based non-enzymatic glucose biosensor.

METHODS AND MATERIALS

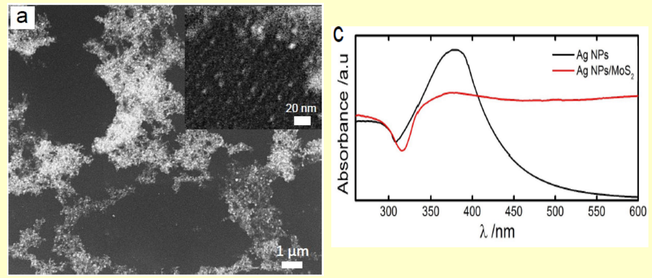
The Ag NPs/MoS2 modified electrode was fabricated by coating 20 μL Ag NPs/MoS2 solution onto the surface of polished glassy carbon (GC) electrodes.

Electrochemical measurements were performed on a PGSTAT204 electrochemical workstation (Metrohm USA) in a three-electrode electrochemical cell at room temperature of 25oC. The Ag NPs or Ag NPs/MoS2 modified GC electrode was used as the working electrode, Ag/AgCl as the reference electrode, and Pt wire as the counter electrode.

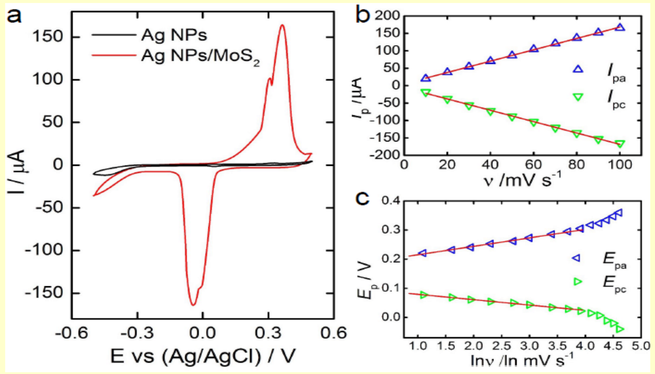
The morphology of the Ag NPs/MoS2 modified electrode was determined using scanning electron microscopy

RESULTS

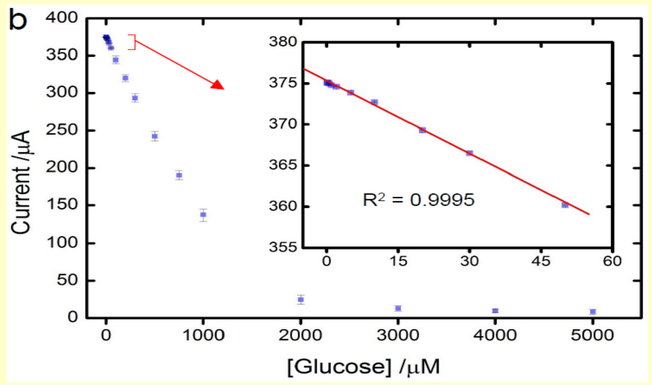
SEM and UV-Vis characterization of the modified electrode surface



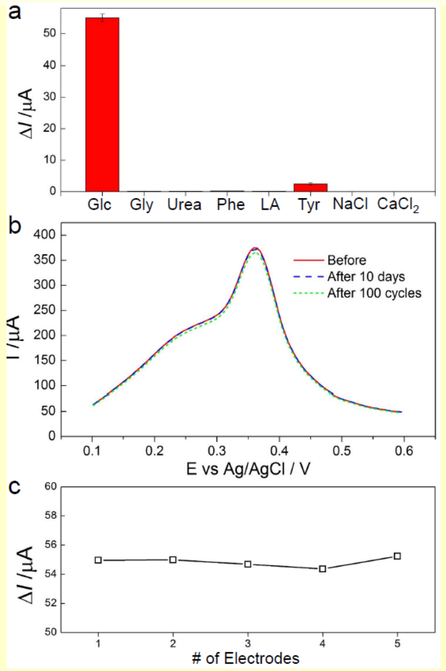
Electrochemical characterization of the modified electrodes



Electrochemical detection of glucose



Performance of the fabricated biosensor



CONCLUSIONS

A highly sensitive non-enzymatic glucose biosensor was developed using inexpensive fabrication method and biocompatible materials. The detection of glucose was achieved by a mechanism where glucose precisely regulates the electrochemical reactivity of Ag NPs through potentially physical separation of Ag NPs and MoS2. The biosensor exhibited excellent sensitivity, stability and reproducibility, low LoD, and high selectivity, suggesting a novel candidate for noninvasive glucose monitoring for patients with diabetes. Further, the mechanism of action and facile fabrication method offer a novel approach for the development of other non-enzymatic biosensors and large-scale manufacturing.

REFERENCES

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2. Moyer, J., Wilson, D., Finkelshtein, I., Wong, B., Potts, R., 2012. Diabetes technology & therapeutics 14(5), 398-402.