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Antibody functionalized graphene biosensor for label-free electrochemical immunosensing of fibrinogen, an indicator of trauma induced coagulopathy

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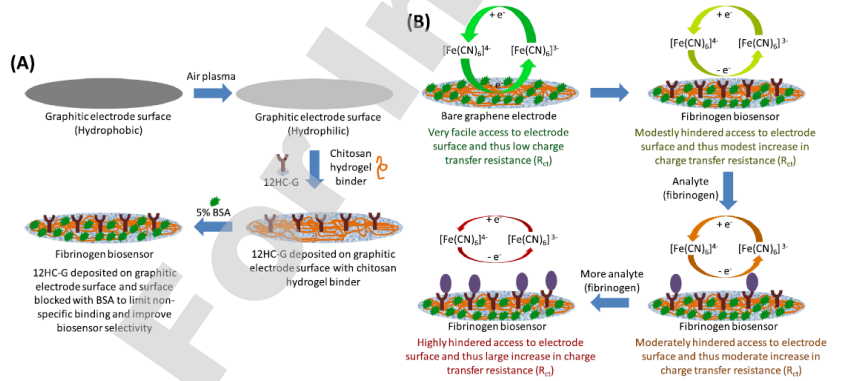
ABSTRACT

An antibody, specific to fibrinogen, has been covalently attached to graphene and deposited onto screen printed electrodes using a chitosan hydrogel binder to prepare an inexpensive electrochemical fibrinogen biosensor. Fourier Transform Infrared (FT-IR) spectroscopy has been utilized to confirm the presence of the antibody on the graphene scaffold. Electrochemical Impedance Spectroscopy (EIS) has been utilized to demonstrate that the biosensor responds in a selective manner to fibrinogen in aqueous media even in the presence of plasminogen, a potentially interfering molecule in the coagulopathy cascade. Furthermore, the biosensor was shown to reliably sense fibrinogen in the presence of high background serum albumin levels. Finally, we demonstrated detection of clinically relevant fibrinogen concentrations (938–44,542 μg/dL) from human serum and human whole blood samples using this biosensor. This biosensor can potentially be used in a point-of-care device to detect the onset of coagulopathy and monitor response following therapeutic intervention in trauma patients. Thus this biosensor may improve the clinical management of patients with trauma-induced coagulopathy.



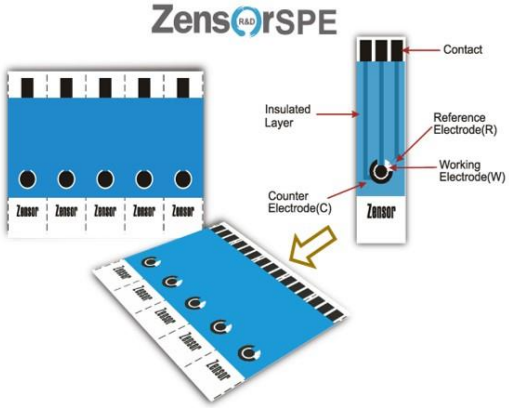


Fig. 2. (A) Preparation of fibrinogen biosensor by deposition of 12HC-G followed by blocking with BSA. (B) Principle of fibrinogen sensing with the biosensor. As more fibrinogen is bound to the antibodies, surface access is hindered which is manifested as increasing charge transfer resistance as seen *via* EIS spectroscopy.

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DNA mediated electrocatalytic enhancement of α-Fe_2O_3–PEDOT–C-MoS_2 hybrid nanostructures for riboflavin detection on screen printed electrode†

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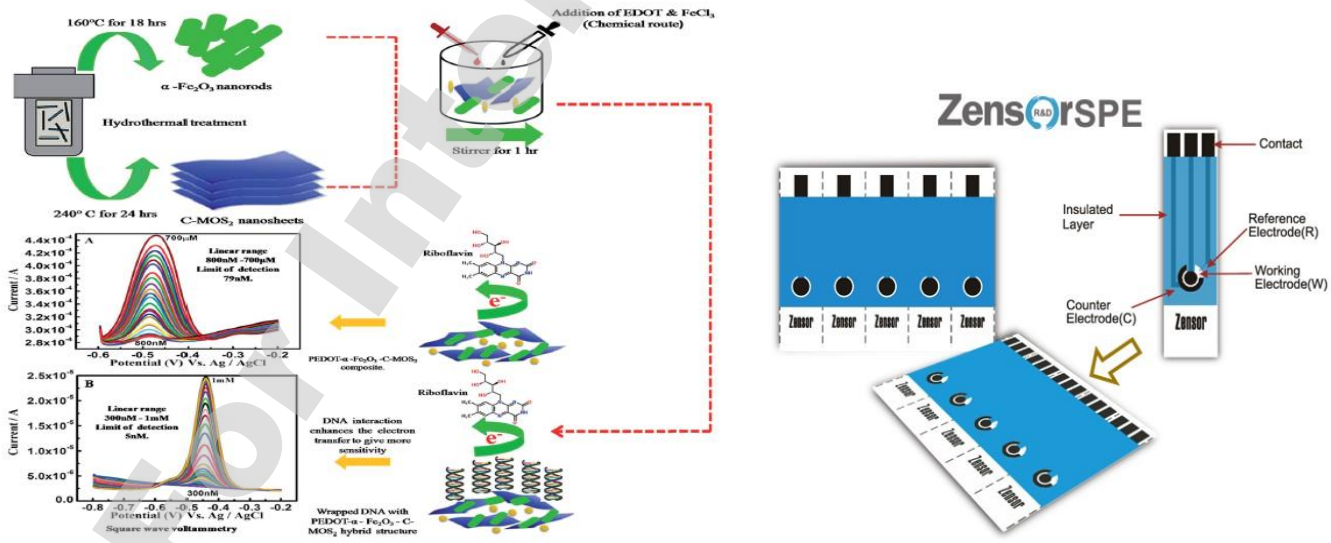
A facile synthesis of iron oxide nanorods and PEDOT(poly(3,4-ethylenedioxythiophene)) nanospheres on carbon supported MoS_2 (C-MoS_2) is reported for riboflavin (RF) sensing. Furthermore, a novel aqueous-based DNA wrapped on an α-Fe_2O_3–PEDOT–C-MoS_2 scaffold shows high electrocatalytic activity compared to that of the α-Fe_2O_3–PEDOT–C-MoS_2 composite in biosensing. α-Fe_2O_3–PEDOT–C-MoS_2/GCE demonstrates the linear response of RF in the concentration range from 800 nM to 700 μM, with a detection limit of 79 nM (S/N = 3σ/b), whereas the α-Fe_2O_3–PEDOT–C-MoS_2–DNA/GCE composite shows a wider range from 300 nM to 1 mM with a comparatively low detection limit of 5 nM. Similarly, α-Fe_2O_3–PEDOT–C-MoS_2–DNA/SPE exhibits a still wider range from 100 nM to 1 mM, with a detection limit of 12 nM. Interestingly, it is also observed that α-Fe_2O_3–PEDOT–C-MoS_2–DNA/GCE reduces the oxidation potential of RF by 30 mV. Thus, the excellent behavior of the proposed biosensor can be attributed to the unique behavior of DNA, which provides a wider detection range and good electrocatalytic behavior towards RF. The fabricated sensor exhibited highly sensitive and selective detection of RF. Real sample analysis was also executed for human urine, milk powder and pharmaceutical drugs without any preliminary treatment.



Scheme 1 Illustration of preparation of the PEDOT–α-Fe_2O_3–C-MoS_2–DNA hybrid nanostructure and RF detection.

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Label-free electrochemical detection of malaria-infected red blood cells†

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The precise and rapid diagnosis of malaria is key to prevent indiscriminate use of antimalarial drugs and help in timely treatment and management of the disease. This paper reports a label-free detection of *P. falciparum* infected red blood cells using a gold nanoparticle (GNP) enhanced platform. The GNPs were electrodeposited on screen-printed electrodes to form a well-controlled matrix that served the dual role of antibody immobilization and signal enhancement. The detection of infected red blood cells was carried out by measuring changes in electrical parameters as a result of its binding to cell reactive antibodies immobilized on the electrode. The assay showed good sensitivity and a linear response between the electron transfer resistance and the logarithm of the number of infected red blood cells which was observed over a concentration range of 10^2 cells per mL to 10^8 cells per mL. This is the first report where an antibody-functionalized electrochemical biosensing platform has been employed for the quantitative detection of *P. falciparum* infected whole red blood cells.

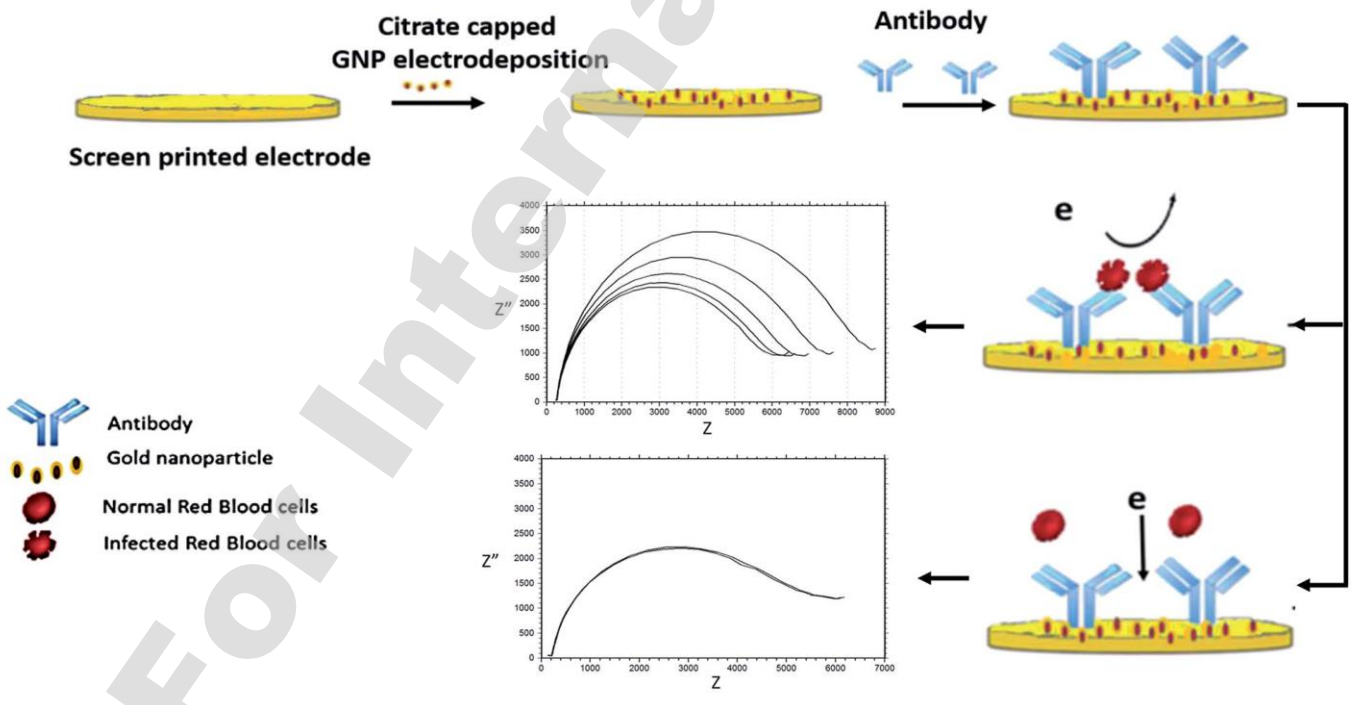

Fig. 1 Schematic showing the detection of *P. falciparum* infected red blood cells by electrochemical impedance spectroscopy.

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Multiwalled Carbon Nanotube-Graphene Nanosheet-Chitosan-1-Butyl-3-Methylimidazolium Hexafluorophosphate Nanocomposites and Gold Nanoparticle-Thionine for Electrochemical Detection of Cytomegalovirus Phosphoprotein

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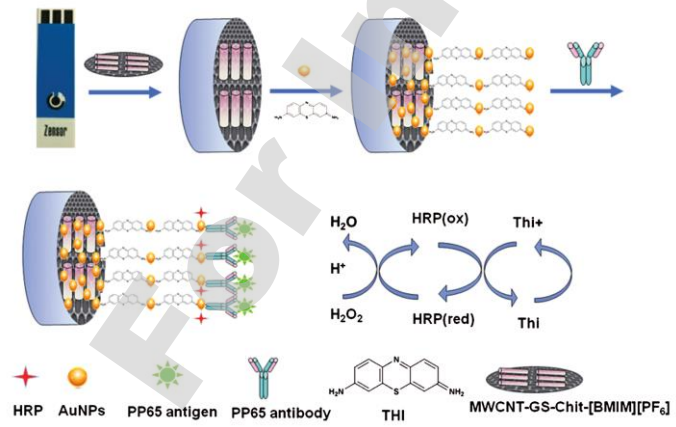
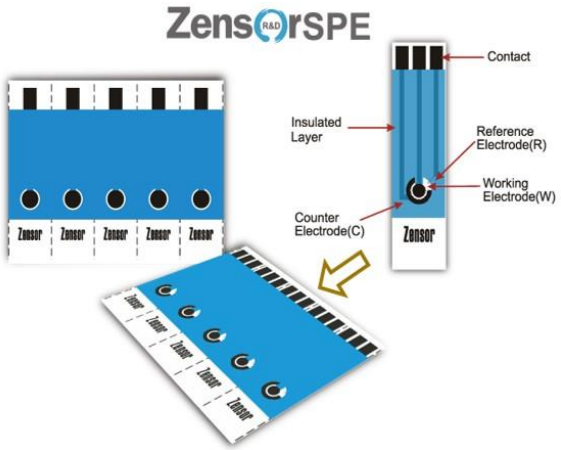
We describe a sensitive and selective electrochemical immunosensor for the determination of the PP65 phosphoprotein antigen. A screen-printed carbon electrode was modified with a nanocomposite made from multiwalled carbon nanotubes, graphene nanosheets, chitosan and 1-butyl-3-methylimidazolium hexafluorophosphate. Gold nanoparticles were immobilized on the modified electrode and incorporated into layers of the polymeric redox mediator thionine. Next, monoclonal antibodies against PP65 were immobilized on the surface via an amine-gold interaction. Finally, horseradish peroxidase was used to block the remaining active sites on the gold nanoparticles and to act as an enzyme in the immunoassay. The decreased electrocatalytic reduction of hydrogen peroxide by horseradish peroxidase was monitored by differential pulse voltammetry. Under optimized conditions, the differential pulse voltammetry signal at a typical working voltage of 0.5 V decreased with increasing concentration of PP65 from 0.12 to 300 pg mL^{-1}, with a detection limit as low as 30 fg mL^{-1} (at a signal to noise ratio of 3). The immunosensor is highly specific with acceptable precision, and good stability and repeatability.





Scheme 1. Schematic representation of the immunosensor preparation process.