Enhancement of a Conducting Polymer-Based Biosensor Using Carbon Nanotube-Doped Polyaniline

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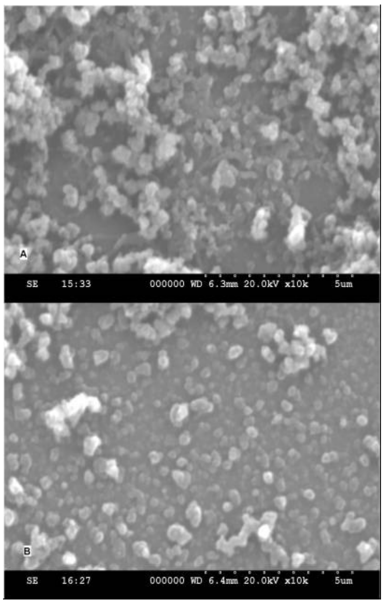
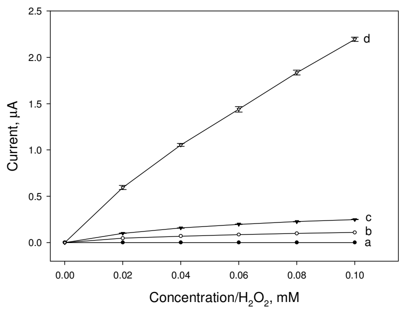
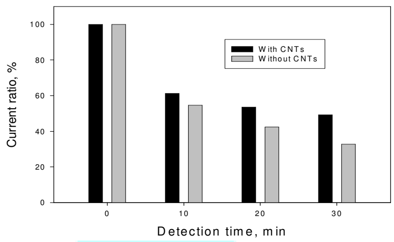
A biosensor with improved performance was developed through the immobilization of horseradish peroxidase (HRP) onto electropolymerized polyaniline (PANI) films doped with carbon nanotubes (CNTs). The effects of electropolymerization cycle and CNT concentration on the response of the biosensor toward H_2O_2 were investigated. It was found that the integration of CNTs into the biosensor system could increase the amount and stability of immobilized enzyme, and greatly enhance the biosensor response. Compared with the biosensor fabricated without CNTs, the proposed biosensor exhibited enhanced stability and approximately eight-fold higher sensitivity. A linear range from 0.2 to 19 µM for the detection of H_2O_2 was observed, with a detection limit of 68 nM at a signal-to-noise ratio of 3 and a response time of less than 5 s.



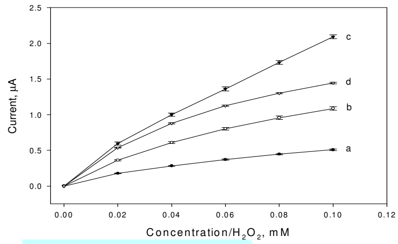
SEM of PANI grown on glassy carbon electrodes modified with (A) and without (B) CNTs. The electropolymerization cycle is 3.



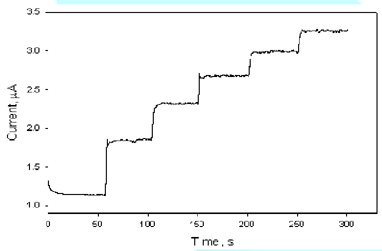
Amperometric responses of different electrodes toward H_2O_2 at a potential of –100 mV vs. Ag/AgCl. a, PANI/GC; b, PANI/CNT/GC; c, HRP/PANI/GC; d, HRP/PANI/CNT/GC.



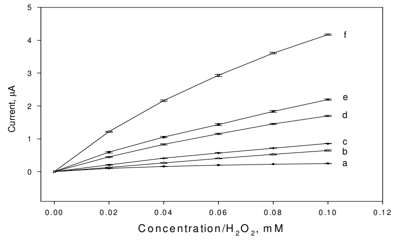
Successive detection of 1.0 mM H_2O_2 at –100 mV vs. Ag/AgCl with newly prepared biosensors with (dark) and without (grey) CNTs. Detection was performed repeatedly at intervals of 10 min during which the biosensors were dipped into stirring PBS, and the initial response was taken as 100%..



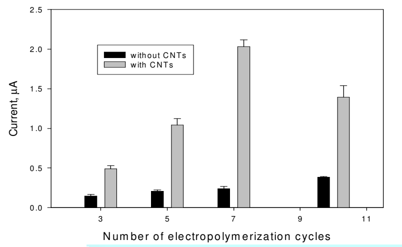
Amperometric responses of CNT-modified HRP biosensors prepared with different numbers of electropolymerization cycles of PANI. a, 3; b, 5; c, 7 and d, 10 cycles. Detection potential: –100 mV vs. Ag/AgCl.



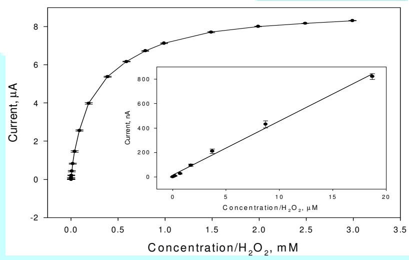
Typical response of the biosensor toward the sequential injection of 0.02 mM H_2O_2 at –100 mV vs. Ag/AgCl. The biosensor was prepared with 1.0 mg mL^{-1} CNTs and 7 electropolymerization cycles of PANI.



Amperometric responses of the HRP biosensors prepared with different concentrations of CNTs toward H_2O_2 at –100 mV vs. Ag/AgCl. CNT concentration: a, 0; b, 0.1; c, 0.3; d, 0.6; e, 1.0 and f, 1.5 mg mL^{-1}.



Comparison of the effect of electropolymerization cycle on the response of the biosensors with (grey) and without (dark) CNTs towards H_2O_2 at –100 mV vs. Ag/AgCl.



Calibration curve of the response of the CNT-modified HRP biosensor toward H_2O_2. Inset: The linear part of the calibration curve.

Conclusions

CNTs were successfully integrated into a PANI-HRP biosensor system, and were shown to greatly enhance the performance of the resulting biosensor. In the proposed biosensor system, CNTs play two important roles. On one hand, as a type of nanomaterial, CNTs can effectively adsorb enzyme and thus increase the amount of immobilized enzyme and enhance the stability of the biosensor. On the other hand, the doping of the PANI film with CNTs can greatly enhance the conductivity of the resulting film and increase the electron transfer efficiency. The PANI/CNT/HRP biosensor responded to H_2O_2 very rapidly with good sensitivity, and could be suitable for interference-free detection of H_2O_2. It is also hopeful that this protocol could be used to immobilize other enzymes to construct a range of biosensors.

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