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Fabrication of modified α-Fe_2O_3 NPs on ZnO NRs/Ni-foam nanocomposite as electrode for electrochemical detection of arsenic in drinking water

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Highlights:

- Modification of α-Fe_2O_3 NPs on ZnO NRs/Ni-foam nanocomposite have been successfully synthesized.
- ZnO NRs/Ni-foam/ α-Fe_2O_3 NPs nanocomposite was synthesized by hydrothermal and dip coating method using ZnO nanorods and α-Fe_2O_3 nanoparticles.
- Optimum of conditions for As (V) detection by ZnO NRs/Ni-foam/ α-Fe_2O_3 NPs electrode was determined.

Keywords: nanoparticles synthesis, hydrothermal synthesis, electrochemical sensor, arsenic detection, nanocomposite metal oxide

Abstract

Arsenic (As) is a highly toxic contamination element which is especially found in drinking water[1]. Arsenic exposure to drinking water is a major concern due to environmental pollution and health hazards[2,3]. Arsenic detection in drinking water is analyzed by fabrication of an efficient electrode for demonstrating an electrochemical sensor. The electrode is based on a modified surface of the ZnO nanorods (NRs) synthesized on Ni-foam substrate by depositing α-Fe_2O_3 nanoparticles (NPs) to detect the contamination of arsenic(V) in drinking water. This electrode is synthesized through two separate growth steps which are the hydrothermal (ZnO NRs) step followed by the dip coating method (α-Fe_2O_3 NPs). The dip coating method was repeated for different dipping cycles, 2 times (ZNF-2), 3 times (ZNF- 3) and 4 times (ZNF- 4) in order to achieve a uniform coverage of the ZnO NRs surface. Through different dip coatings, the ZNF-3 samples indicated that uniform and homogeneous morphology was observed from the SEM images accompanied by the highest oxidation current. The electrodes were characterized by XRD, XPS, SEM and UV-vis spectroscopy. In this study, we analyzed the electrode by the electrochemical performance of sensor electrode in a wide range of arsenic(V) concentrations from 0 to 50 ppb and was monitored by cyclic voltammetry. This study has shown a calibration plot that is linear over a concentration range of 0-50 ppb of arsenic(V), and the regression equation extracted from the calibration curve was found to be y = 0.003x -0.6271 (with R^2 = 0.991). The limit of detection (LOD) and limit of quantification (LOQ) were found to be 4.12 ppb and 13.74 ppb, respectively, which are lower than the maximum allowed value recommended by the World Health Organization (WHO) for arsenic in drinking water. This reasonable performance of the ZnO NRs/Ni-foam/α-Fe_2O_3NPs nanocomposite electrode can be further developed and utilized toward efficient arsenic(V) detection in drinking water. Future work will expand the development of efficiency for electrochemical detection of arsenic(V) in drinking water in real samples.

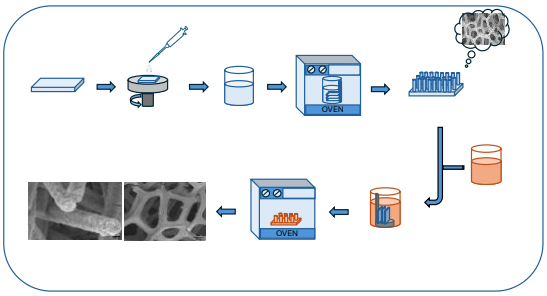

Fig 1: Schematic diagram showing the process for synthesis of the ZnO NRs/Ni-foam/α-Fe_2O_3NPs nanocomposite electrode.

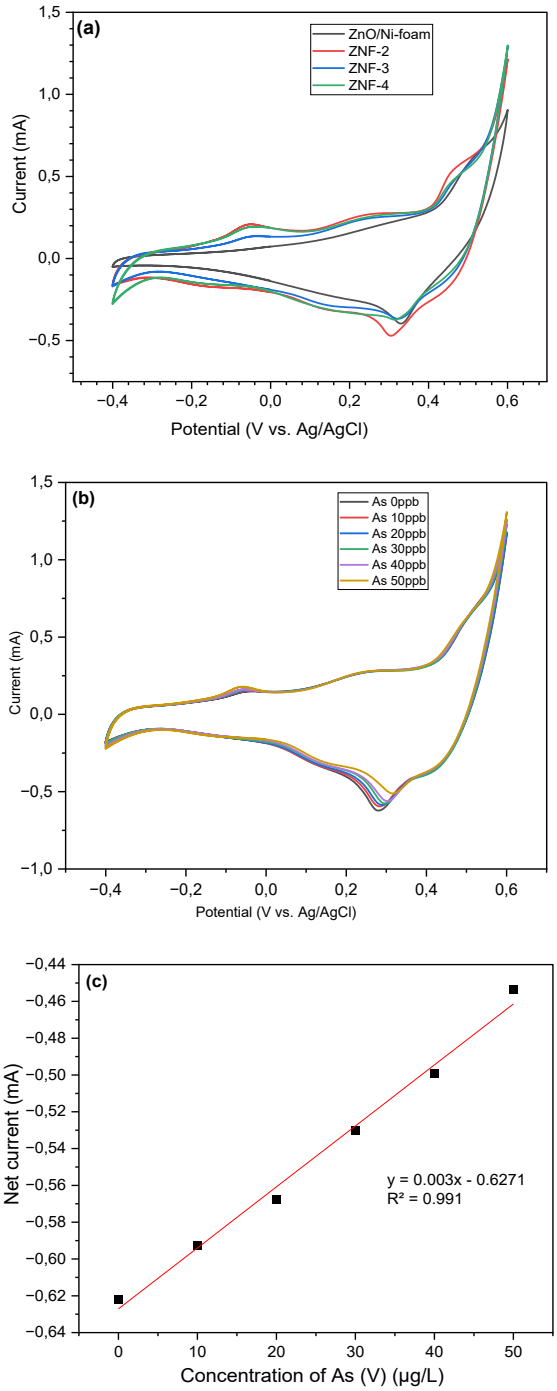

Fig 2: Cyclic voltammetry curves of (a). ZnONRs/Ni-foam, (ZNF- 2), (ZNF- 3) and (ZNF- 4) electrode in 1M KOH electrolyte (b). ZNF-3 electrode at different concentrations of arsenic(V) at potential scan from -0.4 to 0.6 V, and scan rate 100 mV/s. (c) the corresponding linear calibration plots of the net current against arsenic(V) concentrations.

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