



CODEN [USA]: IAJPB

ISSN: 2349-7750

**INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES**<http://doi.org/10.5281/zenodo.2567669>Available online at: <http://www.iajps.com>

Research Article

**A NOVEL ELECTROCHEMICAL BIOSENSOR FOR
DETERMINATION OF GLUCOSE BASED ON NI/GN
NANOCOMPOSITE**Ali Ahmed Keshk¹, Mohamed Abdelfattah Ibrahim^{2,3}¹ Chemistry Department, Faculty of Science, University of Tabuk, Tabuk, Saudi Arabia,² Chemistry Department, Faculty of Science, El-Arish University, North Sinai, Egypt,³ Chemistry Department, Al-Wajha University College, University of Tabuk, Tabuk, Saudi Arabia.**Abstract:**

Ni/Graphite nanocomposite with different compositions were synthesized by a physico-chemical technique. When we applied this electrode to detect glucose, showed low operating potential, high sensitivity, and fast response time (<3 s) compared with other Ni-based electrodes.

Key words: *glucose, non-enzymatic electrochemical sensors, cyclic voltammetry.*

Corresponding author:**Ali Ahmed Keshk,**

*Chemistry Department, Faculty of Science,
University of Tabuk, Tabuk, Saudi Arabia.*

QR code



Please cite this article in press Ali Ahmed Keshk et al., A Novel Electrochemical Biosensor For Determination Of Glucose Based On Ni/Gn Nanocomposite., Indo Am. J. P. Sci, 2019; 06(02).

INTRODUCTION:

The electrochemical glucose sensors for controlling blood sugar and food industry is very important. [1] This technique is better than spectrophotometric techniques because glucose has no chromophoric and fluorophoric ligands. [2]

A lot of attention paid for electrochemical enzymatic glucose sensors because of its high sensitivity and selectivity, but they lack the stability. So, we concern to non-enzymatic electrochemical glucose sensors because of its high sensing for glucose oxidation as electrocatalyst.

A lot of transition metals electrocatalysts are active towards the electrochemical oxidation of glucose but at high polarization. [3-8] As a result, there are much more concerning on the fabrication of modified electrodes with low operating potential by enhancing electron transfer kinetics.

The multivalent modified electrodes were suggested to be responsible for the mechanism of glucose electrochemical oxidation [9]. Transition metal complexes, including the various transition metal hexacyanoferrate modified electrodes, are efficient electrocatalysts for anodic oxidation of glucose, giving enhanced stability towards the target analyte, with low detection limits and wide analytical ranges achievable [10–15]. In this area problems from the instability of modified electrodes are evident and limit widespread implementation.

In this paper, Ni/Graphite nanocomposite with different compositions were synthesized by a physico-chemical technique. Moreover, such prepared nickel modified electrode is shown to be a good nonenzymatic sensor for the electrocatalytic oxidation of glucose in alkaline solutions.

EXPERIMENTAL TECHNIQUES:

Preparation of Foliated (nanosheets) Graphite

1 gm exfoliated graphite was mixed and saturated with 400 ml alcohol solution consisting of alcohol and distilled water with a ratio of 68:32 for 24 h. Then the mixture was subjected to ultrasonic irradiation with a power 400 watt for 24 h. After 24 h of sonication, exfoliated graphite particles were effectively fragmented into foliated (nanosheets) graphite. The foliated graphite dispersion was then filtered and dried at 100 °C to remove residual solvents. The as-prepared foliated graphite powder, we called graphite nanosheets.

Preparation of Nickel nanoparticles

Nickel nano-particles was prepared by using sol-gel technique and reduced by using hydrazine, the prepared nickel nano-particles is shown in Fig.(1).

Preparation of nanoconducting composites

The conducting fillers utilized here are composed of graphite nanosheets (thickness: 30-50 nm, diameter: 10-30 mm) with a average thickness of about 40 nm (the number of sheets in the platelets is 100) and a mean diameter of roughly 20 mm and Ni with an average particles size of 12 nm. First, mixtures of as prepared graphite nanosheets with conducting nickel nanoparticles with various ratios wt% were grinding together in a grinding machine for 1 h. Then the mixture transfers to a hot press at 40 KN/m² at temperature of 180 °C for 30 min. Several batches of Ni/graphite weight ratios were considered: 80:20, 60:40, and 50:50 respectively.

Characterization

Scanning Electron Microscopy (SEM) micrographs and energy dispersive x-ray analysis (EDX) spectra were obtained with a JEOL JSM 6400 scanning electron microscope equipped with a Link analytical system. The electron energy used was 15 keV. The specimens were coated with carbon using a vacuum evaporator (JEOL, GEE 500).

Electrochemical measurements

Electrochemical studies were conducted in a two-compartment, three-electrode glass cell using a Wenking PGS95 electrochemical potentioglvanoostat. A Ag/AgCl electrode saturated with KCl was used as the reference electrode and a Pt wire as the counter electrode. To prepare a catalyst-coated electrode, 4 μL of the colloidal suspension in hexane was spin-coated on a polished glassy carbon (GC) electrode (diameter 5 mm). The electrochemical measurements were performed in 0.1 M NaOH solution. All electrolyte solutions were prepared using water purified by a de-ionized water. All of the electrochemical evaluations were conducted at room temperature (23 ± 1 °C).

RESULTS AND DISCUSSION:

Network Structure Observation of Nanocomposites

SEM observations from cross-sections of foliated graphite's were performed to understand the microstructure occur during intercalation. Fig. (2a, b) shows the SEM image of foliated graphite nanosheets with different magnification prepared upon 24 h ultrasonic irradiation. Clearly, exfoliated graphite worms have been completely torn into foliated sheets

of 5–20 micrometer in diameter and 30–80 nm in thickness, named graphite nanosheets. Image analysis calculation results based on 50 graphite nanosheets showed that the average sheet diameter is approximately 8 micrometers. The average thickness of the nanosheets was estimated to be about 40 nm, based on the values of 50 graphite sheets. The powder has an apparent density of about 0.015 g/cm^3 , much lower than the mass density of the original natural flake graphite, which is 2.2 g/cm^3 [16]. SEM micrograph of Ni/GN nanocomposite is shown in Fig. (2c) for GN20 sample.

Fig. (2d) shows the EDX pattern recorded for GN nanoparticles. The strong peaks for graphite and nickel were noted in the spectrum. No other impurities such as sulfur, nitrogen were detected confirming the high purity of graphite nanosheets. The elemental analysis was carried out for graphite and nickel, the average atomic percentages of G:Ni was 80:20, consistent with the elemental stoichiometric ratio of starting materials.

Electrochemical Measurements

Fig.3 shows the electrocatalytic oxidation of glucose in 0.1 M NaOH on nickel and Ni/GN modified glassy carbon electrode. The Ni/GN modified glassy carbon shows good behavior towards electrocatalytic oxidation of glucose than Ni where the anodic peak current increases and shifts to more negative potential. The proposed mechanism is the deprotonation of glucose and isomerization to its diol form followed by adsorption onto the electrode surface. It is considered that the transform between Ni(II) and Ni(III) on electrode surface during the positive potential scan plays an important role during the oxidation of glucose which offers active intermediate for charge transfer, and finally achieves the electrocatalytic oxidation. [17]

Fig. 4 shows The concentration dependence of the oxidative current density of glucose in 0.1 M NaOH solution at Ni/GN modified glassy carbon electrode. The current density of the electrocatalytic peaks increased with increasing the concentration of glucose and the peak current density showed linear response to the glucose concentration. Obviously, the Ni/GN modified glassy carbon electrode shows good response to various concentrations of glucose and the current response almost unchanged after successive scanning, suggesting the high stability of the Nano composite film to the oxidation of glucose in alkaline media.

Fig. 5 illustrates current-time response on the Ni/GN modified glassy carbon electrode with

successive addition of 0.1 mM glucose. The nano composite electrode reached 95 % of the steady-state current within 3s, which is faster than those of 5 s [18, 19], demonstrating a fast current response of the electrode towards glucose oxidation.

Fig. 6 showed the calibration curve of different concentrations of glucose on the Ni/GN modified glassy carbon electrode. Linear currents were obtained in the glucose concentration range of $1.0 \times 10^{-6} \text{ M}$ to $5.0 \times 10^{-4} \text{ M}$. The lowest detected concentration glucose of glucose was $5.0 \times 10^{-7} \text{ M}$. The current response of this sensor reached $699.4499 \text{ mA mM}^{-1} \text{ cm}^{-2}$, which is much enhanced than that of other enzymeless sensor based on Ni-based electrode [19].

CONCLUSIONS:

We have successfully fabricated a novel nano composite to construct an enzymeless glucose sensors. The synthesized electrode has strong and sensitive current response to glucose. The optimum potential of the sensor is at 0.40 V, the response time is about 3-8 s. This work provides a low cost and simply controlled nano composite for nonenzymatic glucose sensor fabrication.

Acknowledgement

The researchers are appreciating to the deanship of scientific research, university of Tabuk for financial support

REFERENCES:

1. J. D. Newman, A. P.F. Turner, Biosens. Bioelectron. 200-2435.
2. Wen-Zhi Jia, Kang Wang, Xing-Hua Xia, Trends in Analytical Chemistry, Vol. 29, No. 4, 2010.
3. X.L. Ren, X.W. Meng, F.Q. Tang, J. Sens. Actuators B 110 (2005) 358.
4. X.L. Ren, X.W. Meng, D. Chen, F.Q. Tang, J. Jiao, J. Biosens. Bioelectron. 21 (2005) 433.
5. A.F. Wang, X.Y. Ye, P.G. He, Y.Z. Fang, J. Electroanalysis 15 (2007) 1603.
6. L.H. Zhu, L.H. Yang, X.L. Yang, C.Z. Li, J. Electroanalysis 6 (2007) 717.
7. Haipeng Yang, Yongfa Zhu, J. Biosens. Bioelectron 22 (2007) 2989.
8. J. Shen, L. Dudik, C.C. Liu, J. Sens. Actuators B 125 (2007) 106.
9. I. H. Yeo, D. C. Johnson, J. Electroanal. Chem. 2000, 484,157.
10. J. Wang, X.J. Zhang, L. Chen, J. Electroanalysis 16 (2000) 1277.

11. G.L. de Lara Gonz'alez, H. Kahlert, F. Scholz, J. Electrochim. Acta 52 (2007) 1968.
12. Q.L. Sheng, Y. Shen, H.F. Yang, J.B. Zheng, J. Electrochim. Acta 14 (2008) 4687.
13. S.M. Chen, C.Y. Liou, R. Thangamuthu, J. Electroanalysis 23 (2007) 2457.
14. M.H. Yang, J.H. Jiang, Y.S. Lu, Y. He, G.L. Shen, R.Q. Yu, J. Biomaterials 28 (2007) 3408.
15. Q.L. Sheng, Y. Shen, H.F. Zhang, J.B. Zheng, J. Electrochim. Acta 14 (2008) 4687.
16. Chen G, Weng W, Wu D, Wu C, Lu J, Wang P, Chen X., Carbon 2004; 42; 753-59.
17. J. M. Marioli, T. Kuwana, Electrochim. Acta 1992, 37, 1187.
18. X. H. Kang, Z. B. Mai, X. Y. Zou, P. X. Cai, J. Y. Mo, Anal. Biochem. 2007, 363, 143.
19. X. Li, Q. Y. Zhu, S. F. Tong, W. Wang, W. B. Song, Sens. Actuators B 2009, 136, 444.

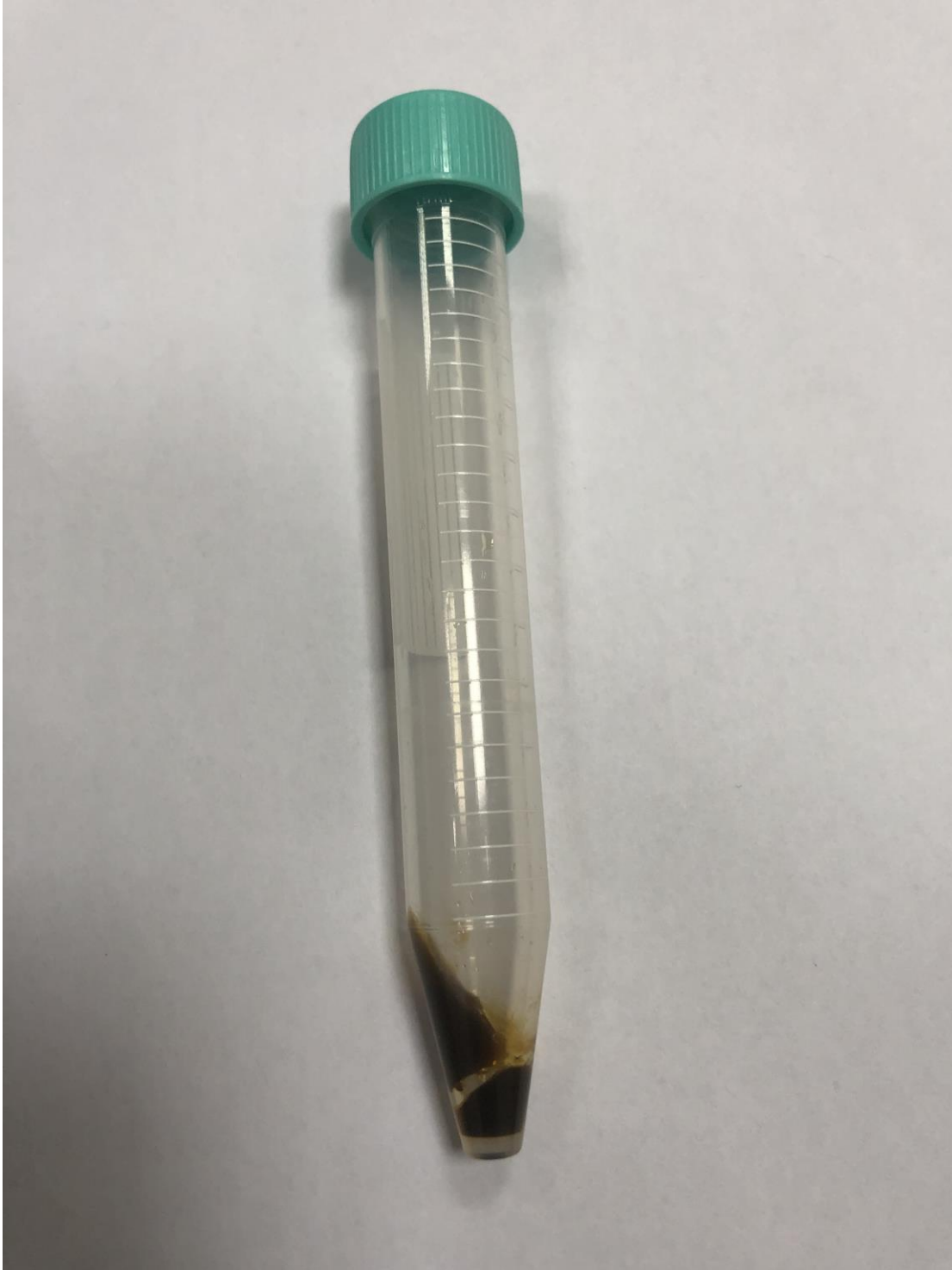
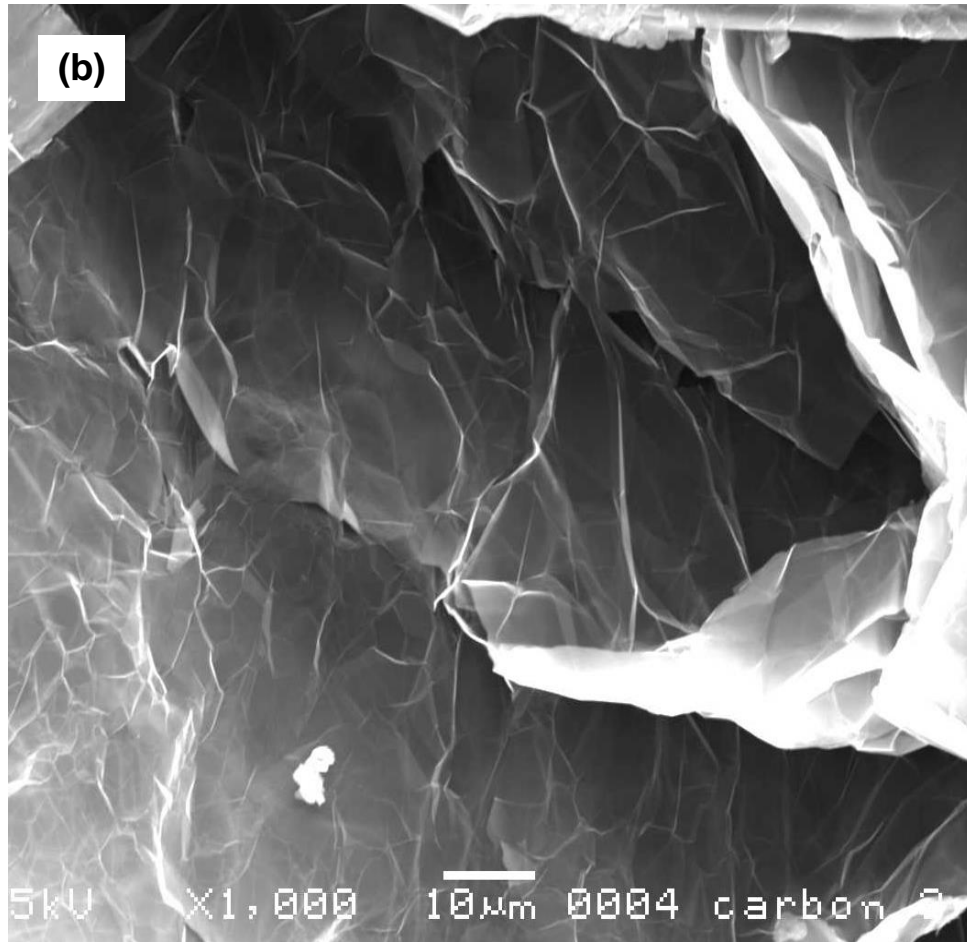
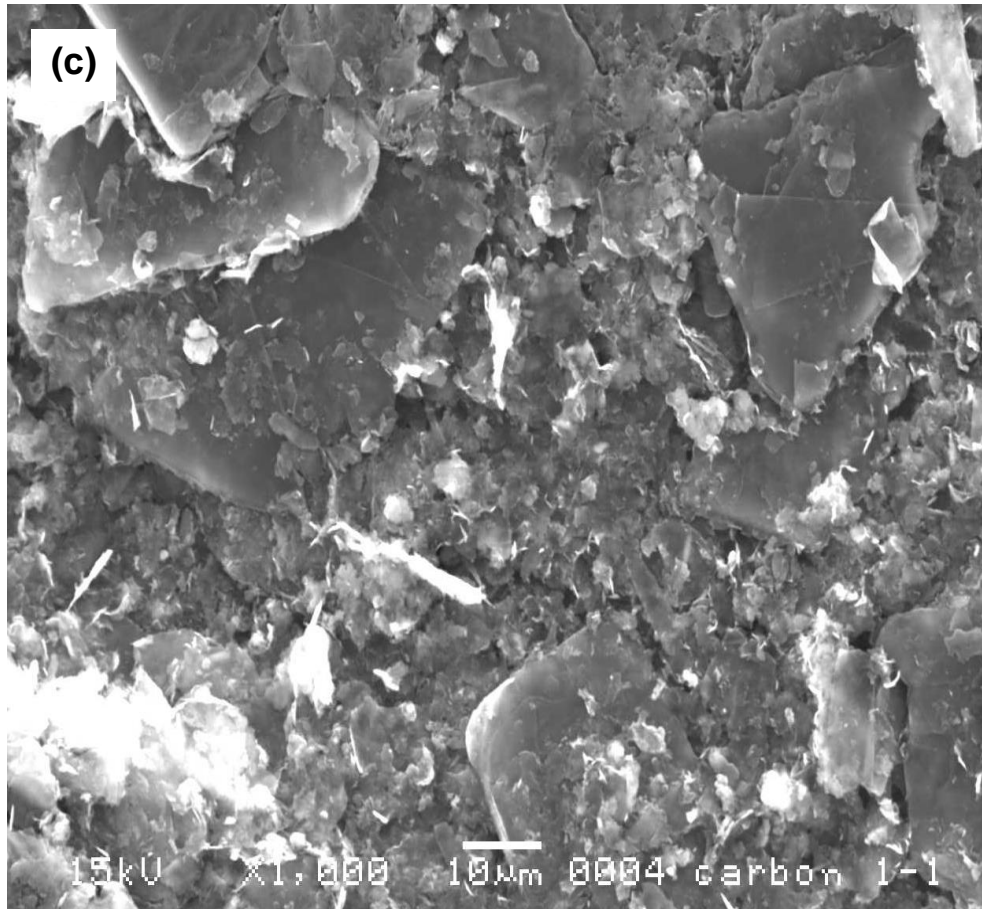


Fig. (1) The synthesized Nickel nano-particles.





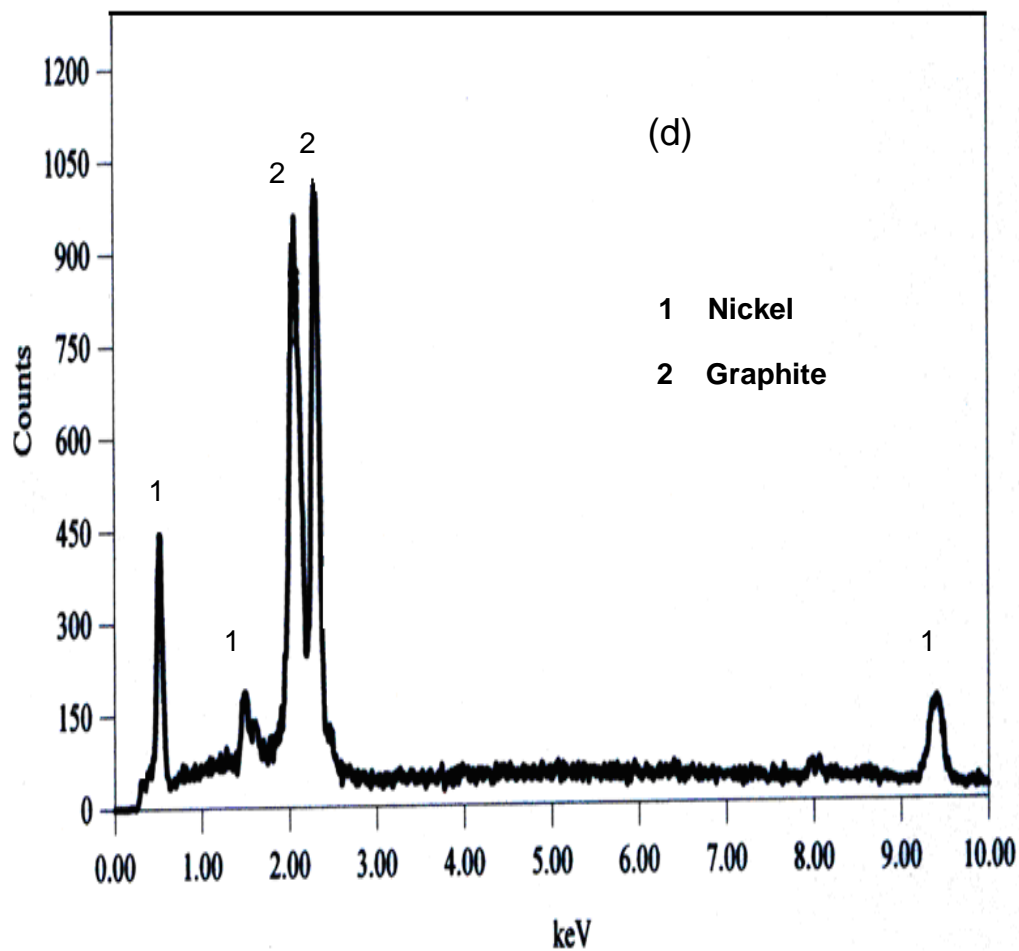


Fig. (2): SEM images of:

- (a,b) foliated graphite sheets prepared upon 24 h ultrasonic irradiation with different magnification,**
- (c) SEM image of GN20 sample; and**
- (d) EDX pattern recorded for GN nanoparticles.**

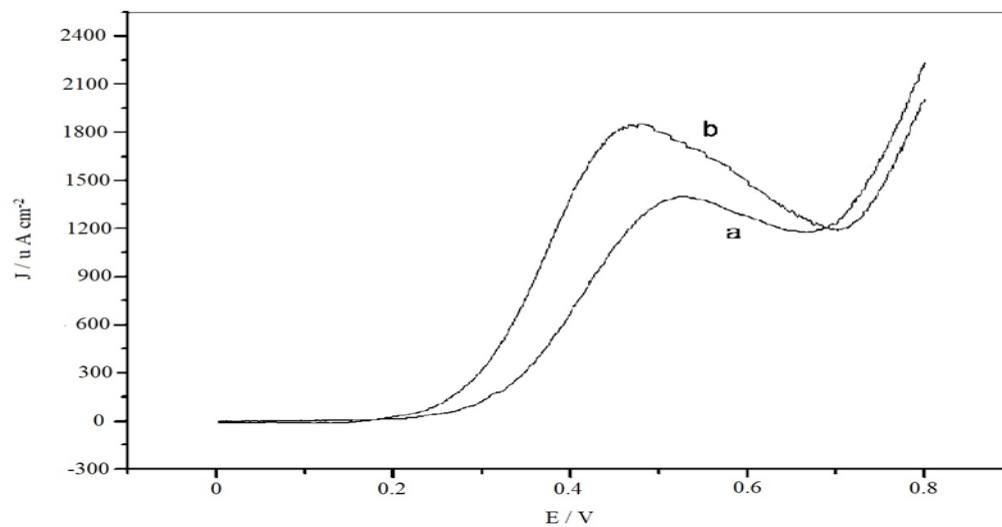


Fig. 3 Linear sweep of (a) Ni and (b) Ni/GN modified glassy carbon electrode in the presence of 0.001 M glucose in 0.1 M NaOH solution. Scan rate: 100 mV s^{-1} .

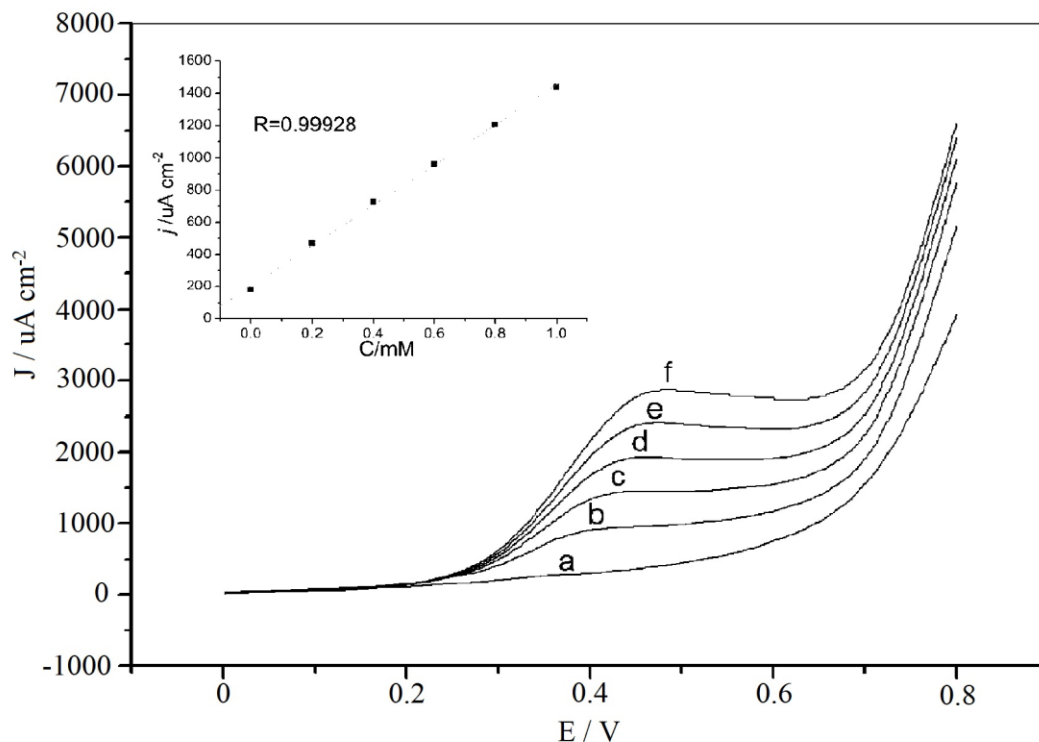


Fig. 4 Glucose concentration dependence of the voltammetric response of the Ni/GN modified glassy carbon in 0.1 M NaOH solution at 100 mV s^{-1} . (a) 0 mM (b) 0.2 mM (c) 0.4 mM (d) 0.6 mM (e) 0.8 mM (f) 1 mM the concentration of glucose. Inset shows the plot of the oxidative peak current density with the glucose concentration.

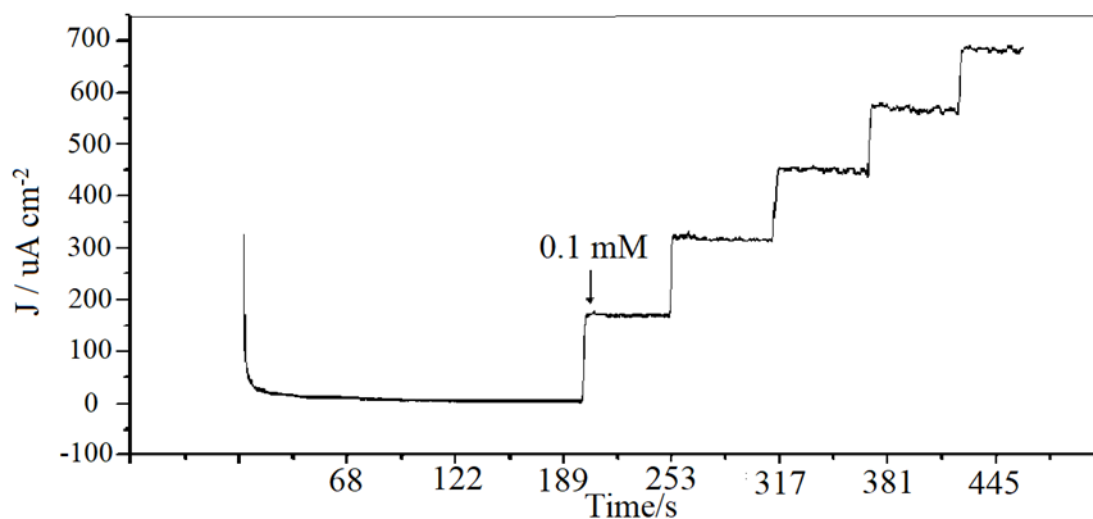


Fig. 5 Current–time response on the Ni/GN modified glassy carbon electrode in the presence of 0.1 mM glucose into 0.1 M NaOH solution at 0.40 V.

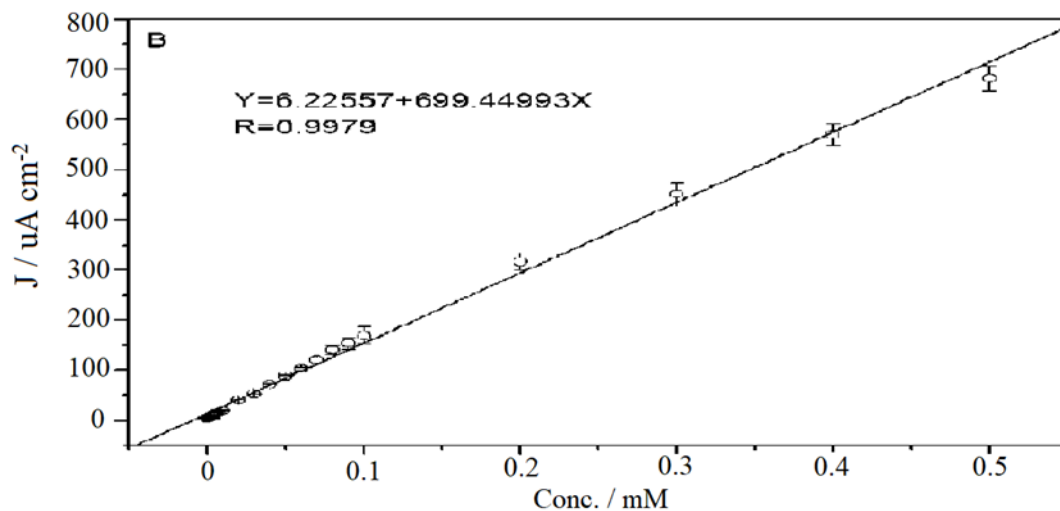


Fig. 6 Calibration curve of glucose on the Ni/GN modified glassy carbon electrode.