SENSING OF NICKEL(II) IONS BY IMMOBILIZING LIGANDS AND USING DIFFERENT SPEs

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Abstract
The aim of this paper is the development of a sensor for the quantification of nickel ions in food raw materials and foods. It seems that about 15% of the human population suffers from nickel allergy. In addition to digestive manifestations, food intolerance to nickel may also have systemic manifestations, such as: diffuse dermatitis, diffuse itching, fever, rhinitis, headache, altered general condition. Therefore, it is necessary to control this content of nickel ions for the health of the human population by developing this new method that brings advantages such as: it is fast, not expensive, in situ and provides accurate analysis. For this purpose, bismuth oxide –SPEs (screen-printed electrodes) and graphene modified (GPH) SPEs were used with very small amount of dimethylglyoxime and amino acid L-histidine which were deposited. A potentiostat which displays the response in the form of a cyclic voltammogram was used to study the electrochemical properties of nickel standard solution with different concentration. The results were compared and the most sensitive sensor proved to be bismuth oxide –SPEs with dimethylglyoxime (Bi_2O_3/C - $dmgH_2$) with a linear response over a wide range (0.1–10 ppm) of nickel concentrations. Furthermore, the sensor shows excellent selectivity in the presence of common interfering species. The (Bi_2O_3/C - $dmgH_2$ sensor showed good viability for nickel analysis in food samples (cocoa, spinach, cabbage and red wine) and demonstrated significant advancement in sensor technology for practical applications.

Introduction

The importance of determining the concentration of nickel ions in the food raw materials and foods is represented by their toxicity to the population' health. It is estimated that approximately 8–10% of women and 1–2% of men are sensitive to Ni.
Total nickel content analysis is performed using flame atomic absorption spectrometry, graphite furnace atomic absorption spectrometry, inductively coupled plasma optical emission spectrometry, or mass spectrometry. These methods used to detect Ni in food and water samples, can be with or without preconcentration or separation steps.
The application of this sensor solves the problem of the determination of nickel ions from foods which nowadays is difficult, expensive, requires specialized personnel and is limited to carried out in the laboratory because there are no in situ methods.

Materials and methods

Reagents

Nickel sulphate, dimethylglyoxime, amino acid L-histidine, ammonium buffer, and were purchased from Sigma-Aldrich (Steinheim, Germany). Graphene and bismuth screen-printed electrodes were purchased from Dropsens.

Electrochemical Measurements

The electrochemical measurements were performed with a Metrohm Autolab bipotentiostat µStat 300 controlled by DropView 8400 software. The testing conditions were: starting potential -0.1 V, switching potential 0.9 V, and scanning rate 0.1 V/s.

Immobilization of receptor on SPE and Development of sensor

The receptor, dimethylglyoxime 1% and 1 µL amino acid L-histidine solution 1% were pipetted on the surface of the working electrode of the SPE. Then the miniaturized electrode was used for nickel ions analyses by cyclic voltammetry.

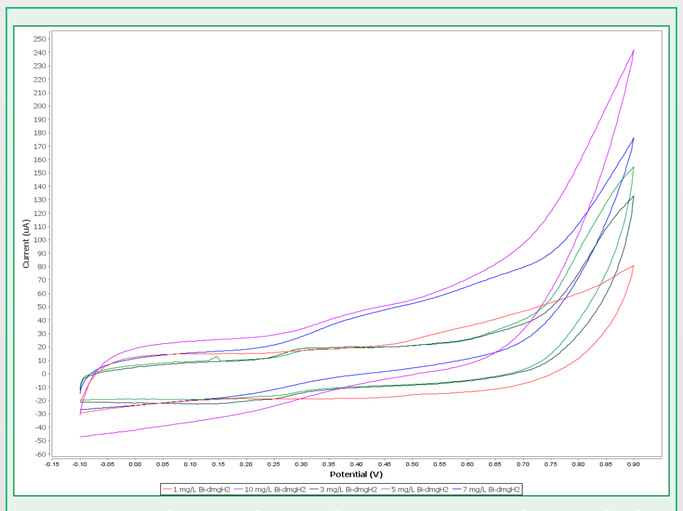


Figure 1 The cyclic voltammogram obtained for nickel standard solutions with SPE- Bi_2O_3/C - $dmgH_2$

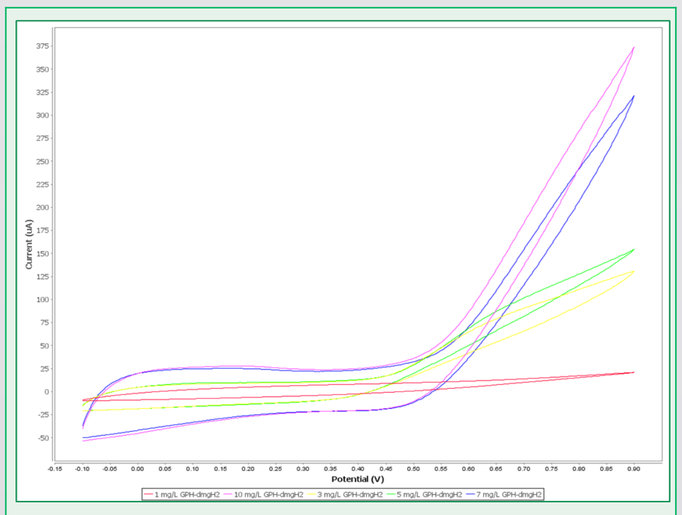
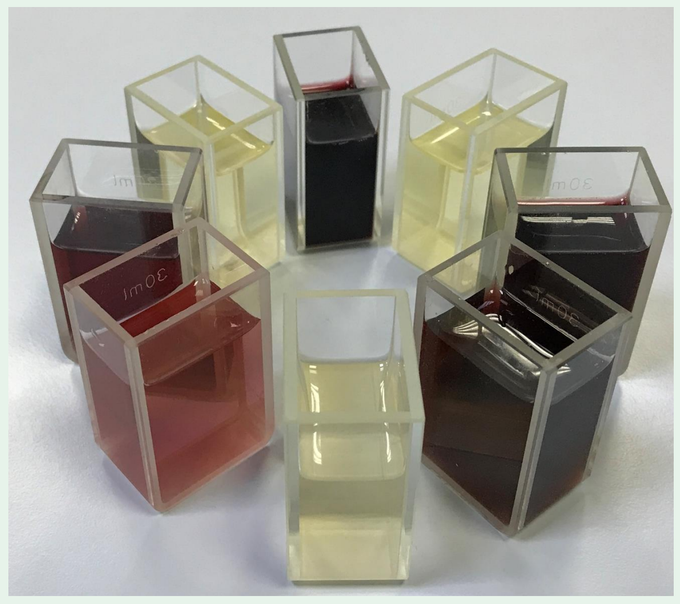


Figure 2 The cyclic voltammogram obtained for nickel standard solutions with SPE- GPH- $dmgH_2$

Testing the sensor on food products

In this study, wine, cocoa, spinach, and cabbage samples were analyzed by voltammetric method. The results obtained were compared with the AAS values of the same samples.



Results and discussions

In order to obtain a calibration curve from the cyclic voltammograms, nickel solutions (1, 3, 5, 7, and 10 mg/L) were used. The concentration was reported at the maximum current density for each solution because the anodic and cathodic peaks are extremely small (Figure 1 and Figure 2).

Conclusion

The results obtained of the proposed sensor for determining nickel ion concentration in foods have proven to be effective both for the performance characteristics and for comparing the results with the reference method. The receptor used showed good selectivity for the target analyte, and also indicated sensitivity and a detection limit that could recommend it as a possible means for the quantification of copper ions in wine.

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