

Sequential-Injection Amperometric Determination of Glucose, Insulin, Cholesterol, and Uric Acid on Electrodes Modified by Nickel and Cobalt Particles

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Abstract—It was found that nickel particles electrodeposited on the surface of planar carbon electrodes (**PE**; **Ni-PE**) exhibit catalytic activity in the electrooxidation of glucose, insulin, and cholesterol (**CS**) in alkaline media, and cobalt particles (**Co-PE**), in the oxidation of CS, insulin, and uric acid (**UA**) in neutral media. In recording an analytical signal in a system of sequential-injection analysis with amperometric detection, the bilogarithmic dependence of current on the analyte concentration on a Ni-PE electrode is linear in the range from 5×10^{-6} to 5×10^{-2} M for glucose, from 1×10^{-6} to 1×10^{-4} M for insulin, and from 5×10^{-6} to 5×10^{-3} M for CS. On the Co-PE electrode, it is linear from 5×10^{-7} to 5×10^{-3} M for CS, from 5×10^{-8} to 5×10^{-4} M for insulin, and from 5×10^{-8} to 5×10^{-3} M for UA. It is shown that the use of a two-detector system and modified double planar electrodes ensures the selective determination of the studied biologically active compounds in blood serum.

Keywords: chemically modified electrodes, nickel and cobalt particles, electrooxidation of glucose, insulin, cholesterol, uric acid, sequential-injection analysis, amperometric detector, double planar electrode

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In recent years sequential-injection analysis (**SIA**) has been used more and more often for the determination of disease markers in biological fluids of humans because of its low limits of detection and high selectivity. The control of the levels of glucose and insulin is necessary for the diagnosis and treatment of diabetes [1]. It is known that this disease is accompanied by an increased level of cholesterol (**CS**) and by diseases of urinary tract, kidneys, and liver because of the metabolic disorder of UA [2, 3]. In addition, in organisms of patients with diabetes, the level of ascorbic acid is reduced because of metabolic disorder. The development of rapid and selective methods for the determination of the above biologically active compounds (**BACs**) is of great interest for medical diagnosis.

Among methods for the determination of glucose, insulin, CS, and uric acid (**UA**) used in clinical diagnosis, one can distinguish chemical [4, 5], spectrochemical [6–8], chromatographic [6, 9–11], and electrochemical [12–16] ones. The chemical and spectrochemical methods differ by insufficient sensitivity and selectivity, and chromatographic methods, by the long duration of analysis and expensive equipment. In comparison with them, SIA with amperometric detectors based on chemically modified electrodes (**CME**) with electrocatalytic properties ensure highly sensitive, selective, and rapid multicomponent analysis.

In this work, we assessed a possibility of the selective simultaneous determination of glucose, insulin, CS, and UA in a sequential-injection (**SIA**) system with amperometric detectors based on carbon planar electrodes (**PEs**) or double planar electrodes (**DPEs**) modified by cobalt and nickel particles.

EXPERIMENTAL

Cyclic voltammograms and chronoamperograms were recorded with a μ STAT400 bipotentiostat (DropSens, Spain). We used carbon PEs and DPEs from DropSens (Spain). The surface of working carbon electrodes was modified by electrodeposited nickel or cobalt particles. A cobalt electrodeposit on the surface of working PEs and DPEs was obtained by controlled-potential electrolysis from a solution containing cobalt chloride, $\text{CoCl}_2 \cdot 5\text{H}_2\text{O}$, of chemically pure grade (Aldrich, Germany) in a supporting 0.1 M KNO_3 solution. The electrodeposition of nickel particles was carried out from a solution containing nickel chloride $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, of chemically pure grade (Ecofarm, Russia) in a supporting 0.01 M H_2SO_4 solution. A poly-2-vinylpyridine (**PVP**) film was obtained by dropwise application followed by the evaporation of the solvent.