SKELETAL NICKEL BASED 6 LAYERS PLATINUM NANOPARTICLES ELECTRODE WITH CATALYTIC EFFECT FOR ETHANOL ELECTROOXIDATION IN ALKALINE MEDIA

Mircea Laurentiu Dan, Delia Andrada Duca, Nicolae Vaszilcsin

University Politehnica Timişoara, Faculty of Industrial Chemistry and Environmental Engineering, 300223, Parvan 6, Timisoara, Romania
e-mail: mircea.dan@upt.ro

Abstract

In this paper, preliminary aspects of ethanol electrocatalytic oxidation on skeletal nickel based 6 layers platinum nanoparticles electrode in aqueous alkaline solution have been investigated using voltammetric studies. Ethanol oxidation reaction (EOR) was studied by cyclic and linear voltammetry.

Introduction

Recently, from the alkaline fuel cells (AFCs) existing types, direct ethanol fuel cells (DEFCs) had part of huge development and many resources were invested for this purpose, because ethanol is less toxic compared to methanol and can be easily produced in large quantity [1]. The electrode material effect on the electrocatalytic activity of ethanol oxidation is of continuing interest.

Platinum is known to be the optimum electrocatalyst for ethanol oxidation in different fuel cells, because it is chemically stable in both acid and alkaline electrolytes [1,2]. For oxidation of various organic compounds, especially for saturated alcohols, nickel has been reported as an efficient anode material [1]. It was demonstrated that platinum and nickel alloys materials exhibit superior characteristics as against of single metal materials in the catalysis of organic compounds oxidation [1]. Skeletal nickel electrode, due to its morphology and considerable porosity, was considered suitable as anode in fuel cells as catalyst for different anodic reactions [3,4].

Besides pure platinum, nickel and skeletal nickel electrodes, as well as other nickel-based electrodes, like skeletal nickel based 6 layers platinum nanoparticles, have been tested for many reactions of applied interest, such as hydrogen evolution reaction, or methanol and sulphite anodic oxidation. All processes were studied in alkaline media [5].

In this paper, a skeletal nickel based 6 layers platinum nanoparticles electrode as electrocatalyst for ethanol oxidation in an alkaline solution has been used.

Experimental

Electrochemical tests were performed at room temperature using a SP-150 potentiostat/galvanostat (Bio-Logic, SAS, France). A 100 mL typical glass cell was equipped with three electrodes: skeletal nickel based 6 layers platinum nanoparticles working electrodes, Ag/AgCl reference electrode and two graphite rods counter electrodes. For performed experiments, working electrode exposed surface was 0.5 cm^2.

Skeletal nickel electrode was prepared using thermal arc spraying technique. Skeletal nickel-platinum based electrodes have been prepared by spray pyrolysis technique.

Different concentrations of ethanol were added: 0.125, 0.25, 0.5, 1 and 2 mol L^{-1} in the alkaline media (1 mol L^{-1} KOH). All reagents were prepared from Sigma-Aldrich p.a. min 99.8%

Results and discussion

Cyclic voltammograms plotted at 500 mV s^{-1} scan rate, in +0.70 ÷ -1.20 V potential range, on skeletal nickel based 6 layers platinum nanoparticles electrode in 1 mol L^{-1} KOH solution with different ethanol concentrations, between 0.125 and 1 mol L^{-1}, are shown in figure 1. Starting from open circuit potential (OCP) the characteristics processes for metallic electrode/ethanol added in alkaline solution, depicted in CVs are: ethanol oxidation reaction and oxygen evolution reaction on anodic branch, adsorbed oxygen reduction and reduction of ethanol oxidation products (acetate, acetaldehyde, etc.) on the backward scan. Specific anodic and cathodic peaks corresponding to acetaldehyde/acetate redox couple are observed between -0.50 and 0.00 V potential values. When the potential values are more negative than -1.00 V, hydrogen evolution reaction occurs on the surface of the working electrode. Anodic characteristic peak for oxidation of acetaldehyde to acetate are also inserted in the figure.

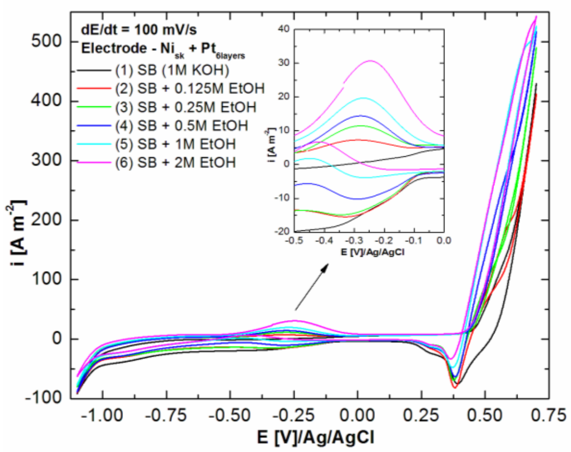

Figure 1. CVs recorded on Ni_{sk} + $Pt_{6layers}$ electrode in 1 mol L^{-1} KOH without and with different concentration of ethanol, scan rate: 100 mV s^{-1}.

In figure 2, cyclic voltammograms recorded on skeletal nickel based 6 layers platinum electrode in 1 mol L^{-1} KOH + 0.25 mol L^{-1} ethanol solution, with 10 mV s^{-1} polarization speed are presented, starting from OCP, in different potential range, from +0.70 to -1.20 V value. Anodic plateau for ethanol oxidation are also inserted.

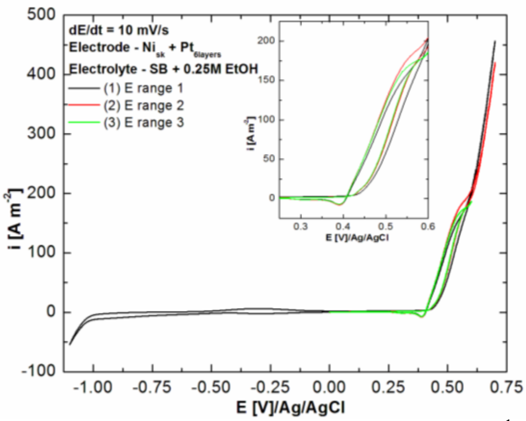

Figure 2. CVs recorded on Ni_{sk} + $Pt_{6layers}$ electrode in 1 mol L^{-1} KOH with 0.25 mol L^{-1} ethanol, in different potential ranges, scan rate: 10 mV s^{-1}.

To study acetaldehyde/acetate redox process, cyclic voltammograms (10 cycles) were recorded in -0.50 ÷ 0.00 V potential range, on skeletal nickel based 6 layers platinum electrode, in 1mol L^{-1} KOH + 0.125mol L^{-1} ethanol solution, with 100 mV s^{-1} scan rate.

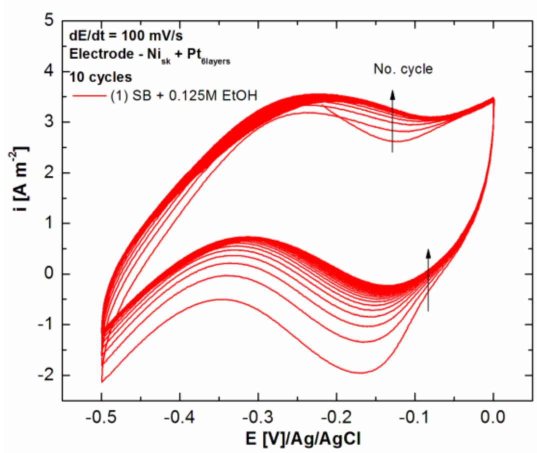

Figure 3. CVs (10 cycles) for acetaldehyde/acetate redox couple, on Ni_{sk} + $Pt_{6layers}$ electrode, in 1 mol L^{-1} KOH with 0.125 mol L^{-1} ethanol, scan rate: 100 mV s^{-1}.

The experimental technique which confirmed the advantages of skeletal nickel based 6 layers platinum electrode compared to platinum or skeletal nickel electrodes is linear voltammetry recorded at very low scan rate (1 mV s^{-1}). Obtained curves plotted on platinum and skeletal nickel based 6 layers platinum electrodes are shown in figure 4.

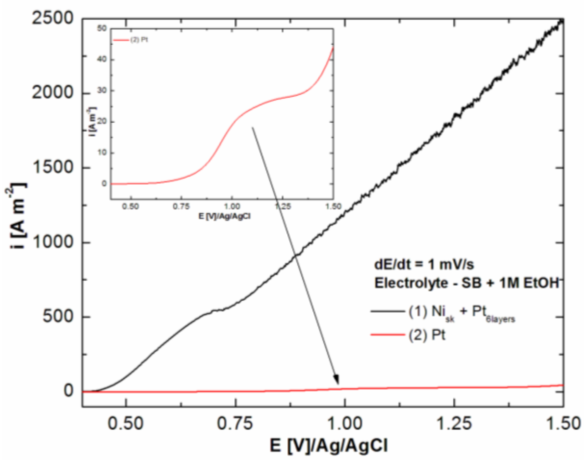

Figure 4. LVs (anodic domain) on Ni_{sk} + $Pt_{6layers}$ and Pt electrodes in 1 mol L^{-1} KOH with 1 mol L^{-1} ethanol, scan rate: 1 mV s^{-1}.

Figure 5 presents curves recorded on skeletal nickel and skeletal nickel based 6 layers platinum electrodes in same conditions.

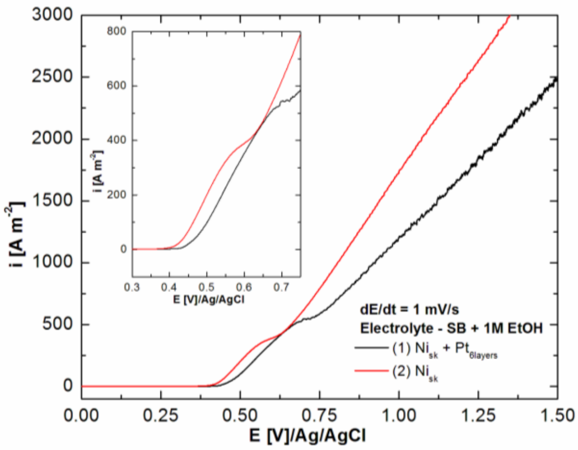

Figure 5. LVs (anodic domain) on Ni_{sk} + $Pt_{6layers}$ and Ni_{sk} electrodes in 1 mol L^{-1} KOH with 1 mol L^{-1} ethanol, scan rate: 1 mV s^{-1}.

Conclusion

In this study, skeletal nickel based 6 layers Pt nanoparticles prepared using spray pyrolysis has been tested for ethanol oxidation reaction. Cyclic and linear voltammetry used as electrochemical analysis techniques confirm an increased activity for studied process in alkaline media. Preliminary results demonstrate this type of electrodes can be a promising anode for DEFC.

Acknowledgements

This work was partially supported by University Politehnica Timisoara in the frame of PhD studies.

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