

COMPARATIVE STUDIES FOR 2-PROPANOL ELECTROOXIDATION ON PLATINUM AND NICKEL ELECTRODES IN ALKALINE MEDIA

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Abstract

In this paper, new aspects of 2-propanol oxidation electrocatalytic effect on platinum and nickel electrodes, in aqueous alkaline solution was investigated using voltammetric studies. 2-propanol oxidation reaction has been studied by cyclic and linear voltammetry.

Introduction

Small alcohols electrooxidation from C1 - C3 group has been intensely studied, mainly because of their possible use in fuel cells [1]. Methanol, although extensively used, is toxic inflammable with low boiling point and is not a primary fuel. Ethanol isn't toxic and can easily be obtained from sugar and biomass [1,2]. The use of alcohols with longer chains for applications in fuel cells can also be attractive considering the high energy content emitted in fuel [3]. 2-propanol is the smallest secondary alcohol and far less toxic than methanol. Its electrochemical oxidation has aroused great interest due to its particular molecular structure [4,5]. Alcohols with more than two carbon atoms in their structure have several isomers and special features of non-CO adsorption [6]. When the onset potentials for oxidation of different alcohols were compared, the performance of 2-propanol was superior as against of methanol and ethanol [7]. The possibility to use 2-propanol as electrolyte in direct alcohols fuel cells (DAFCs) has been reported since 1995 [8].

Platinum has been extensively investigated as electrocatalyst for 2-propanol electrooxidation in both acid and alkaline electrolytes. Pt is easily poisoned by the reaction intermediates [9]. Also, platinum high price and limited supply constitute a major barrier for DAFCs development, other materials with similar catalytic properties being necessary [4,10]. Nickel is a good electrocatalyst for methanol and ethanol oxidation in alkaline electrolyte. However, there is little information on the electrocatalytic properties of 2-propanol oxidation on nickel in alkaline medium.

In this paper, comparative studies for 2-propanol electrooxidation on platinum and nickel electrodes in alkaline media are presented using different electrochemical methods, such as: cyclic voltammetry, linear polarization and chronoamperometry.

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: Pt/Ni working electrodes, Ag/AgCl reference electrode and two graphite rods used counter electrodes. For performed experiments, the exposed surface of working electrode was 0.5 cm². Different concentrations of 2-propanol were added: 0.125, 0.25, 0.5, 0.75 and 1 mol L⁻¹ in 1 mol L⁻¹ KOH, all prepared from Sigma-Aldrich reagent p.a. min 99.8%.

Results and discussion

Cyclic voltammograms recorded on platinum electrode, between -1.5 and +2.0 V/Ag/AgCl, at 50 mV s^{-1} scan rate, in 1 mol L^{-1} KOH with different 2-propanol concentration, are depicted in Figure 1, starting from open circuit potential (OCP). Potential domain associated with 2-propanol oxidation on platinum electrode is between +0.7 and +1.8 V.

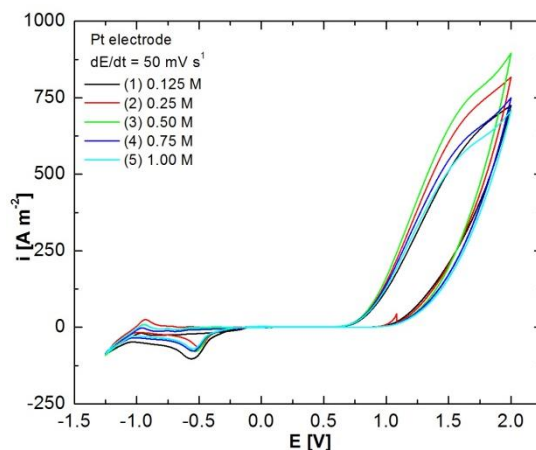


Figure 1. Cyclic voltammograms plotted on platinum electrode in 1 mol L^{-1} KOH with different concentration of 2-propanol, scan rate: 50 mVs^{-1} .

In order to study the electrochemical processes occurring at platinum electrode surface in 1 mol L^{-1} KOH with 0.75 mol L^{-1} 2-propanol, cyclic voltammograms (3 cycles) were recorded, starting from OCP, in the potential range between -1.00 and +0.60V, at 50 mVs^{-1} scan rate, when current density is small, few A m^{-2} . Platinum oxides formation/dissolution on electrode surface and oxidation/reduction of different intermediate products formed in 2-propanol electrooxidation were followed.

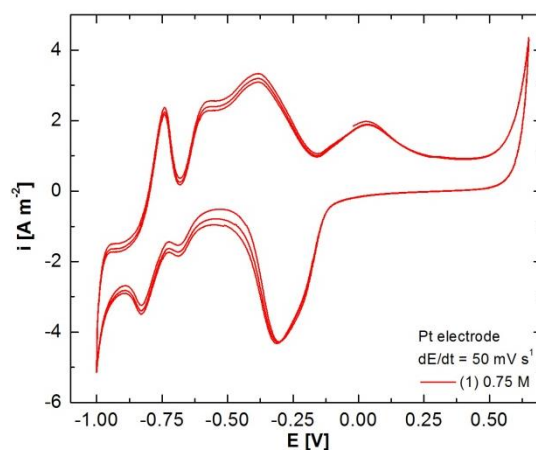


Figure 2. Cyclic voltammograms plotted on platinum electrode in 1 mol L^{-1} KOH with 0.75 mol L^{-1} 2-propanol, scan rate: 50 mVs^{-1} .

Similarly, in figure 2 are presented cyclic curves plotted in 1 mol L^{-1} KOH with different concentration of 2-propanol, on nickel electrode, between -1.4 and +0.6 V/Ag/AgCl potential range, at 50 mV s^{-1} scan rate. Potential domain characteristic for 2-propanol electrooxidation is between +0.4 and +0.6 V, depending on the alcohol concentration added in electrolyte solution.

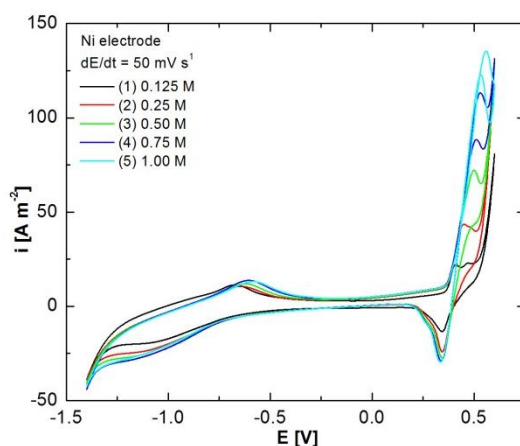


Figure 3. Cyclic voltammograms plotted on nickel electrode in 1 mol L⁻¹ KOH solutions with different concentration of 2-propanol, scan rate: 50 mVs⁻¹.

Linear voltammograms plotted at low scan rate (1 mV s⁻¹) in 1 mol L⁻¹ KOH + 0.75 mol L⁻¹ 2-propanol, on both platinum and nickelelectrodes are shown in figure 4 a and b. The curves shape indicates only one oxidation process on electrode surface.

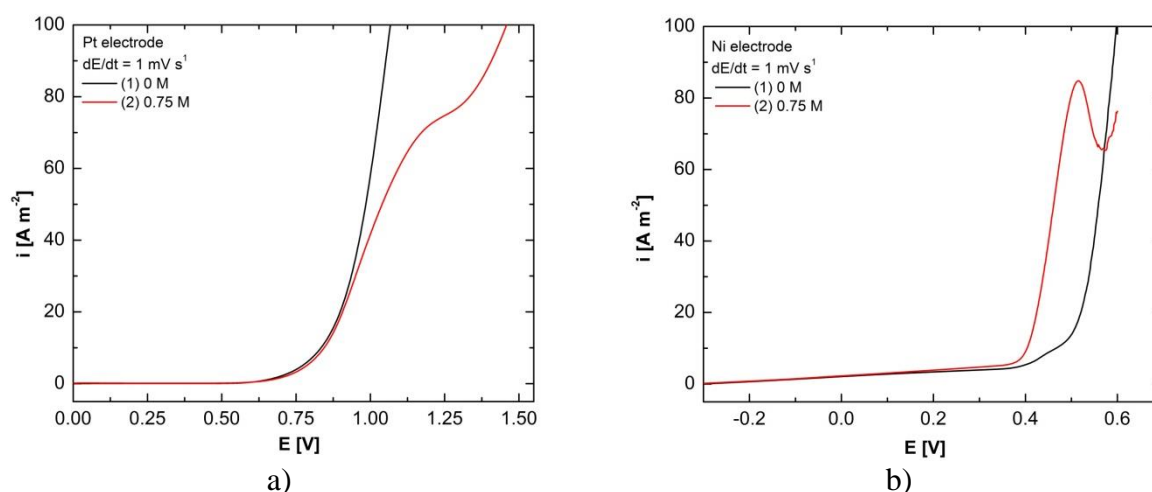


Figure 4. Linear voltammograms plotted on platinum (a) and nickel (b) electrode in 1 mol L⁻¹ KOH + 0.75 mol L⁻¹ 2-propanol, scan rate: 1 mV s⁻¹.

On metallic electrode, especially platinum, 2-propanol electrooxidation in alkaline medium can be described by following reactions [4]:



The overall reaction is:



S.G. Sun and Y. Lin demonstrated that equation (1) is a fast reaction, and acetone oxidized into CO₂ is a relatively slow reaction [12].

Chronoamperometric measurements had as starting point the linear voltammograms shown in figure 4 a and b. Analyzing these curves, three potential values were chosen for the 2-propanol electrooxidation in alkaline solution on each electrode:

(1) $E = +1.00$ V, (2) $E = +1.25$ V and (3) $E = +1.50$ V for platinum electrode;

(1) $E = +0.40$ V, (2) $E = +0.45$ V and (3) $E = +0.50$ V for nickel electrode.

All potentials values are given versus the reference electrode ($E_{\text{ref}} = 0.197 \text{ V vs NHE}$). Chronoamperometric studies were performed for 60 minutes. Graphical results are presented in figure 5 a and b. Also, chronoamperometric comparative data recorded on both platinum and nickel electrodes, in alkaline electrolyte without and with 0.75 mol L^{-1} 2-propanol are presented. Anodic oxidation of 2-propanol at different potential values are inserted in figures.

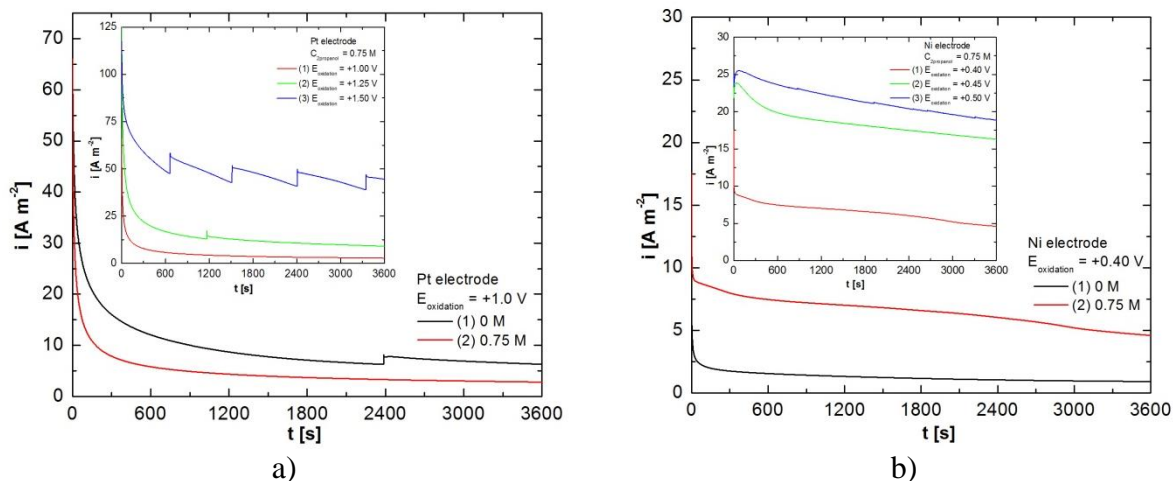


Figure 5. Chronoamperometric studies on platinum (a) and nickel (b) electrode 1 mol L^{-1} KOH in the absence and presence of 0.75 mol L^{-1} 2-propanol.

Analyzing graphical data recorded on platinum electrode can conclude that at +1.00 and +1.25 V potential values, the only process occurring at the interface is 2-propanol oxidation. If chronoamperometric measurements are carried out at +1.50 V, the curve shape indicates oxygen evolution reaction on electrode surface.

Conclusion

In this study, platinum and nickel electrodes have been tested for 2-propanol electrooxidation reaction. Cyclic voltammetry, linear polarization and chronoamperometry used as electrochemical analysis techniques confirm an increased activity for studied process in alkaline solution.

Acknowledgements

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