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## ENHANCEMENT OF THE ELECTROCATALYTIC ACTIVITY OF Ni ELECTRODE FOR HYDROGEN EVOLUTION BY ELECTRODEPOSITED V AND Co ON ITS SURFACE

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### Abstract

Enhancement of the electrocatalytic effect of Ni electrode for hydrogen evolution reaction (HER) by co-electrodeposited V and Co at metallic Ni (Ni-V-Co) was studied by using quasi-potentiostatic polarization technique from 1 M KOH at 25 °C. The obtained exchange current density for HER with Ni-V-Co electrode, ( $5.5 \times 10^{-4} \text{ A cm}^{-2}$ ), is about two orders of magnitude higher than for metallic Ni electrode. The results suggested the existence of the synergetic effect of V and Co deposit on the catalytic activity of Ni electrode for HER. By using X-ray fluorescence (XRF) analysis the presence of Co and V at metallic Ni support was proved.

### Introduction

The increase of the Ni electrocatalytic effectiveness for HER is to be expected throughout co-deposition processes of appropriated Brewer intermetallic compounds. A series of prepared electrodes by co-deposition of V and Co were investigated. Throughout Tafel parameters G. Wu et al showed that Ni-Co and Ni-Co-LaNi<sub>5</sub> co-depositites have higher electroactivity for HER over the Ni electrode [1]. Optimization of the hydrogen evolution activity was found also on Ni-RuO<sub>2</sub> by A.C. Tavares and S. Trasatti [2]. Some novel trends in this field were presented by A. Damian and S. Omanovic [3] by improved intrinsic activity of Ni and electrodeposited Ni-Mo for HER in a three-dimensional polyaniline matrix. R.M. Abouatallah et al reported that addition of dissolved V<sub>2</sub>O<sub>5</sub> in 8M KOH solution was found to produce the reactivation of Ni cathode by formation of vanadium-bearing deposit [4].

In this work, the electrocatalytic activity of Ni electrode was compared to the electrode obtained by electrodeposition of V and Co species on metallic Ni support (Ni-V-Co).

### Experimental

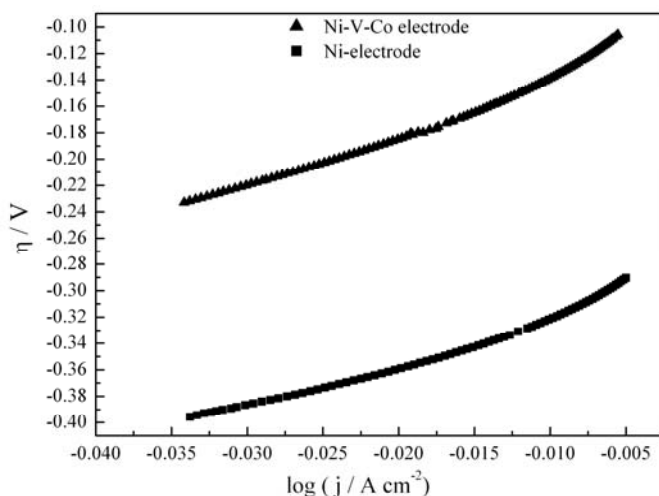
The electrocatalytic activity of Ni and Ni-V-Co electrodes for the HER was studied by using quasi-potentiostatic polarization technique by applying of sweep rate  $1 \text{ mV s}^{-1}$ , corrosion measurement software (CorrWare<sup>®</sup>) with a Solartron 1286 electrochemical interface. Experiments were carried out in a two electrode compartment electrochemical cell containing 1M KOH as electrolyte at the temperature of  $(25 \pm 0.1) \text{ }^\circ\text{C}$ . The saturated calomel electrode (SCE) served as a reference one. Large-area Pt-mesh was used

as a counter electrode. Electrodeposition of V and Co on the metallic Ni support was provided from  $V_2O_5$  and  $[Co(en)_3]Cl_3$  dissolved in 1M KOH at -1.5 V vs. SCE during 500s.

The analysis of Ni electrode surfaces after electrodeposition was made by XRF spectrometer (ARL Optim'X 108) with a wavelength dispersive analysis system. The sample was excited with the Rh X-ray tube operated at 50 kV and 1 mA. The crystal analyzer was a plane LiF (200) and the emitted radiation was detected with a gas flow proportional counter. The  $2\theta$  angle of the spectrometer was scanned with steps of  $0.1^\circ$ , and the counting time was 1s in each step.

## Results and Discussion

The Tafel plots for HER obtained by using Ni and Ni-V-Co electrodes are presented in Figure 1. From the obtained Tafel plot the Tafel slope  $b_c$ , and exchange current density  $j_o$ , was obtained. In case of Ni electrode obtained Tafel parameters are,  $b_c = 0.117 \text{ V dec}^{-1}$ ,  $j_o = 5.8 \times 10^{-6} \text{ A cm}^{-2}$ . The same parameters for Ni-V-Co electrode are:  $b_c = 0.133 \text{ V dec}^{-1}$ ,  $j_o = 5.5 \times 10^{-4} \text{ A cm}^{-2}$ .

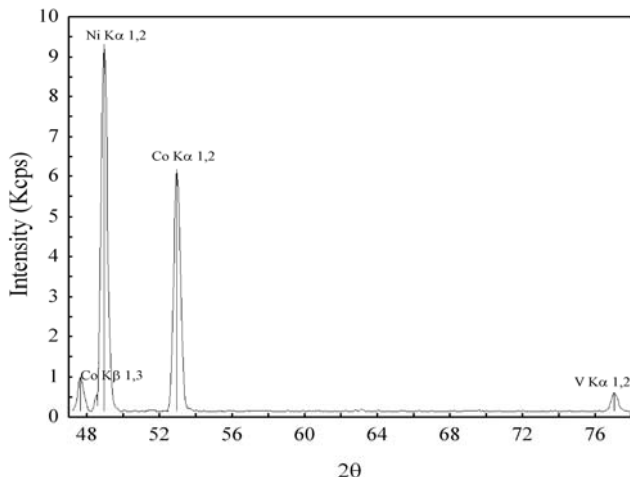


**Fig. 1.** The Tafel plots displays for HER on Ni and Ni-V-Co electrode in 1 M KOH at 25 °C .

The  $j_o$  value which characterized the charge transfer reaction occurring at the electrode surface during HER is generally accepted as an important parameter describing the electrocatalytic activity of the electrode. Based on the noticeable higher value of  $j_o$  obtained for Ni-V-Co electrode relative to the Ni one, suggests the existence of the synergetic effects of the hypo-hyper-d-electronic metals (V and Co) on improving electrocatalytic activity of conventional Ni electrode.

In order to prove the existence of the electrodeposited layer on the metallic Ni, XRF analysis was applied separately on the Ni and Ni-V-Co electrode. Figure 2. presents the XRF spectrum in the form of differences between these two electrodes. The

presence of the Ni spectral line suggested the partial coverage of the metallic Ni with electrodeposited V and Co, having also the corresponding lines.



**Fig. 2.** XRF spectrum obtained from differences of spectral lines for Ni and Ni-V-Co electrode.

## Conclusion

Based on the quasi-potentiostatic polarization technique applied on the investigated system, it was possible to determine the relevant Tafel parameters for hydrogen evolution reaction on the Ni, as well as on the Ni-V-Co electrode. The exchange current density determined for Ni-V-Co electrode is two order of magnitude higher compared to the Ni electrode. Existence of the electrodeposited layer containing V and Co was proved by means of XRF analysis.

## References

- [1] G. Wu, N. Li, C.S. Dai, D. R. Zhou, *Mater. Chem. Phys.*, 2004, **83**, 307-314.
- [2] A.C. Tavares, S. Trassati, *Electrochim. Acta*, 2000, **45**, 4195-4202.
- [3] A. Damian, S. Omanovic, *J. Power Sources*, 2005, **158**, 464-476.
- [4] R.M. Abouatallah, D.W. Kirk, S.J. Thorpe, J.W. Graydon, *Electrochim. Acta*, 2001, **47**, 613-621.