Synthesis of conical Co-Fe alloys structures obtained with crystal modifier in the superimposed magnetic field

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INTRODUCTION

The issue of renewable energy sources is more and more important these days, due to the increase in energy demand. One of the idea is using shaped structures, especially in nanoscale, as a catalyst characterized by greater electrocatalytic activity connected with their large active surface area [1]. The one-step method connects the advantages of the electrodeposition process with the control of the structure shapes caused by the presence of a crystal modifier. It promotes specific directions of growth during a single electrodeposition process. The use of an external magnetic field during the electrodeposition process allows the properties of the obtained coatings to be modified. This phenomenon is known as the magnetohydrodynamic effect (MHD) [2].

RESULTS AND DISCUSSION

In this work, the Co-Fe alloy cones were successfully synthesized using the one-step method from an electrolyte containing NH_4Cl as a crystal modifier. The influence of the external superimposed magnetic field on the sample surface development and their electrocatalytic properties were measured. The real, active surface area of samples was determined by various methods and compared. Co-Fe cones were synthesized from the electrolyte containing: 6.5 mM $CoSO_4$, 6.5 mM $FeSO_4$, 93.5 mM Na_2SO_4 and 0.4 M H_3BO_3. In order to produce the conical structures, NH_4Cl was added to the solution as the crystal modifier. The electrodeposition process was carried out in galvantostatic mode at two-electrodes cell. Pt foil was an anode and Cu foil was a cathode. Due to the ferromagnetic properties of alloy components, the influence of the external superimposed magnetic field on the sample surface development and therefore their electrocatalytic properties were checked. The magnetic field was applied in two different directions by the electromagnet LakeShore (Model 642). The intensity value was 500 mT.

Produced coatings were analyzed using a Scanning Electron Microscope SEM (Figure). Their electrocatalytic properties were determined using the linear scan voltammetry (LSV) and chronopotentiometry (CP) measurements in 1 M NaOH. Due to the significant influence of the sample's active area, it was determined by various methods using: Brunauer-Emmett-Teller (BET) analysis, and the double-layer capacitance measurements during the CV's scans, Atomic Force Microscope AFM, and a Confocal Microscope.

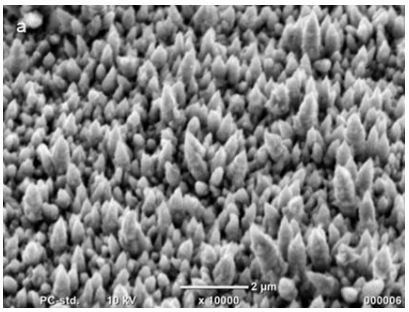

Fig. Sample obtained from the electrolyte without the magnetic field.

Performed experiments and obtained results confirm that the synthesis of conical Co-Fe alloy structures by one-step method is possible. Measurements of the electrocatalytic properties showed that the sample synthesized in the parallel magnetic field is characterized by the best electrocatalytic activity. It is probably connected with the largest development of its surface corroborated by BET, the double-layer capacitance measurements during the CV's scans, and the sample roughness value (Table).

Table. Comparison of the sample surface development determined by various methods.

Sample	Average value of R_a [µm] measured by Confocal Microscope	BET [m^2/m^2]	Ratio of double layer capacities. [mF/mF_{Cu}]

Without magnetic field	0.360	36.11	84.47
With perpendicular magnetic field	0.415	19.74	54.03
With parallel magnetic field	0.345	73.50	97.22

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