3D STRUCTURES COPPER-NICKEL FOAMS DECORATED WITH PLATINUM PARTICLES FOR THE ELECTROOXIDATION OF SODIUM BOROHYDRIDE

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INTRODUCTION

Currently, one of the renewable energy sources is fuel cells, namely chemical energy is directly converted into electricity. Designing new or enhancing the existing fuel cells, much attention is devoted to the search of new effective catalysts, which would allow increasing the effectiveness of fuel cells and creating the background for designing new technologies for catalysts formation. Everyone knows that precious metal and their alloys effectively catalyze the oxidation reaction of sodium borohydride. The cost of using such catalysts alone is very expensive, so an alternative is being sought.

EXPERIMENTAL

Cu-Ni foam was prepared by electrochemical deposition ($I_{deposition}$=1.5 Acm^{-2} , $t_{deposition}$= 3, 6 and 9 min) on titanium (Ti) surface. The electrolyte was containing 0.5 M Ni^{2+} ions and 0.01 M Cu^{2+} ions. PtNPs were deposited by galvanic displacement on Cu-Ni foam (noted (Pt (CuNi)/Ti)) by its immersion into the 1 mM H_2PtCl_6 solution at 25 °C for 1 min. The morphology and composition of the prepared catalysts were investigated using scanning electron microscopy (SEM), X-ray diffraction (XRD), and inductively coupled plasma optical emission spectroscopy (ICP-OES). The electrocatalytic activity of the prepared catalysts was evaluated towards the electrooxidation of sodium borohydride using the cyclic voltammetry method. The cyclic voltampemograms were recorded on the prepared Cu-Ni foams and Pt(Cu-Ni)/Ti catalysts in a 0.05 M $NaBH_4$ solution in an alkaline medium in the potential range from -1.2 to 0.6 V (vs. Ag/AgCl) and with an electrode potential scan rate of 10 mVs^{-1}.

Table 1. The conditions of the preparation of the NiCu coatings.

Catalysts	Ni^{2+}, M	Cu^{2+}, M	*t*, min	*j*, mA/cm^{-2}
NiCu-1	0.5	0.01	3	1.5
NiCu-2	0.5	0.01	6	1.5
NiCu-3	0.5	0.01	9	1.5

Galvanic displacement

1 mM H_2PtCl_6 60 s, 25° C

Table 2. The composition of the PtNiCu/Ti catalysts was determined by ICP-OES. PtNiCu/Ti catalysts were prepared by immersing NiCu/Ti electrodes in 1 mM H_2PtCl_6 at 25 °C for 60 s.

Catalysts	Ni, loading in catalysts, µgNi cm^{-2}	Cu, loading in catalysts, µgCu cm^{-2}	Pt, loading in catalysts, µgPt cm^{-2}
PtNiCu-1/Ti	9.98	2.47	2.84
PtNiCu-2/Ti	12.41	2.52	4.38
PtNiCu-3/Ti	22.11	2.91	6.08

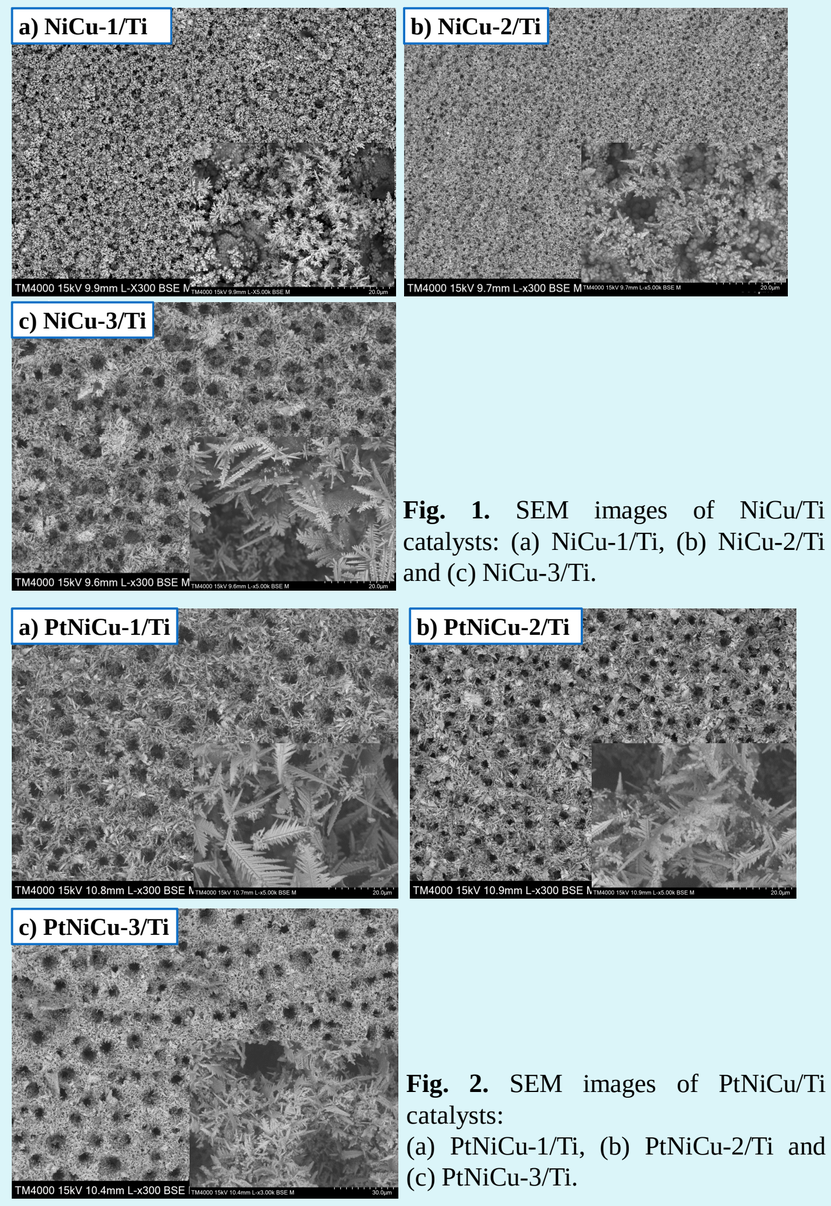

Fig. 1. SEM images of NiCu/Ti catalysts: (a) NiCu-1/Ti, (b) NiCu-2/Ti and (c) NiCu-3/Ti.

Fig. 2. SEM images of PtNiCu/Ti catalysts:
(a) PtNiCu-1/Ti, (b) PtNiCu-2/Ti and (c) PtNiCu-3/Ti.

RESULTS

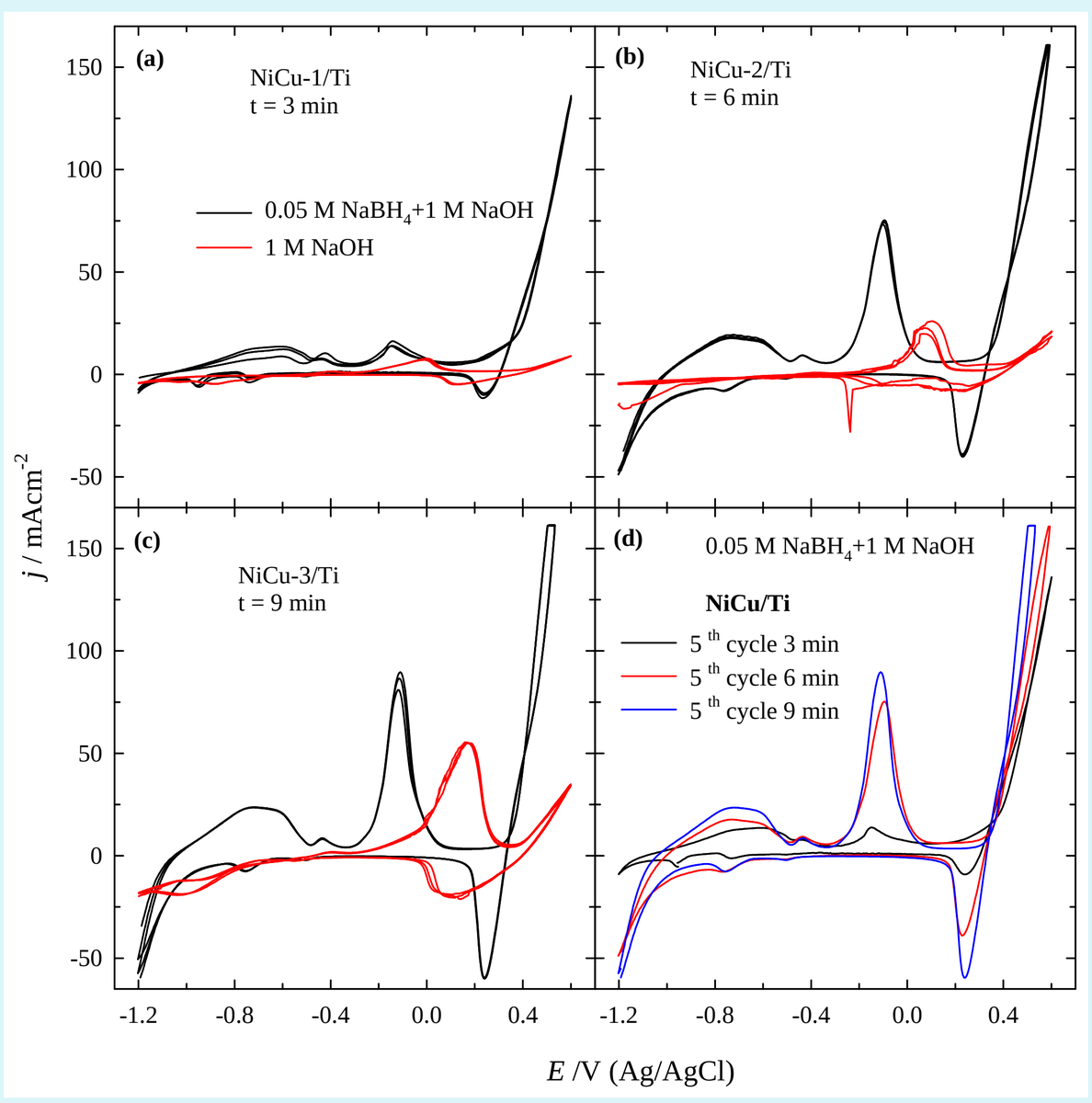

Fig. 3. Cyclic voltammograms of NiCu/Ti catalysts: (a) NiCu/Ti-1, (b) NiCu/Ti-2, (c) NiCu/Ti-3 in 1 M NaOH sulution (*red line*) and in 0.05 M $NaBH_4$+1 M NaOH sulution (*black line*). (d) Comparison of different NiCu/Ti catalysts in 0.05 M $NaBH_4$+1 M NaOH sulution. Potential scan rate 10 mVs^{-1} at 25°C.

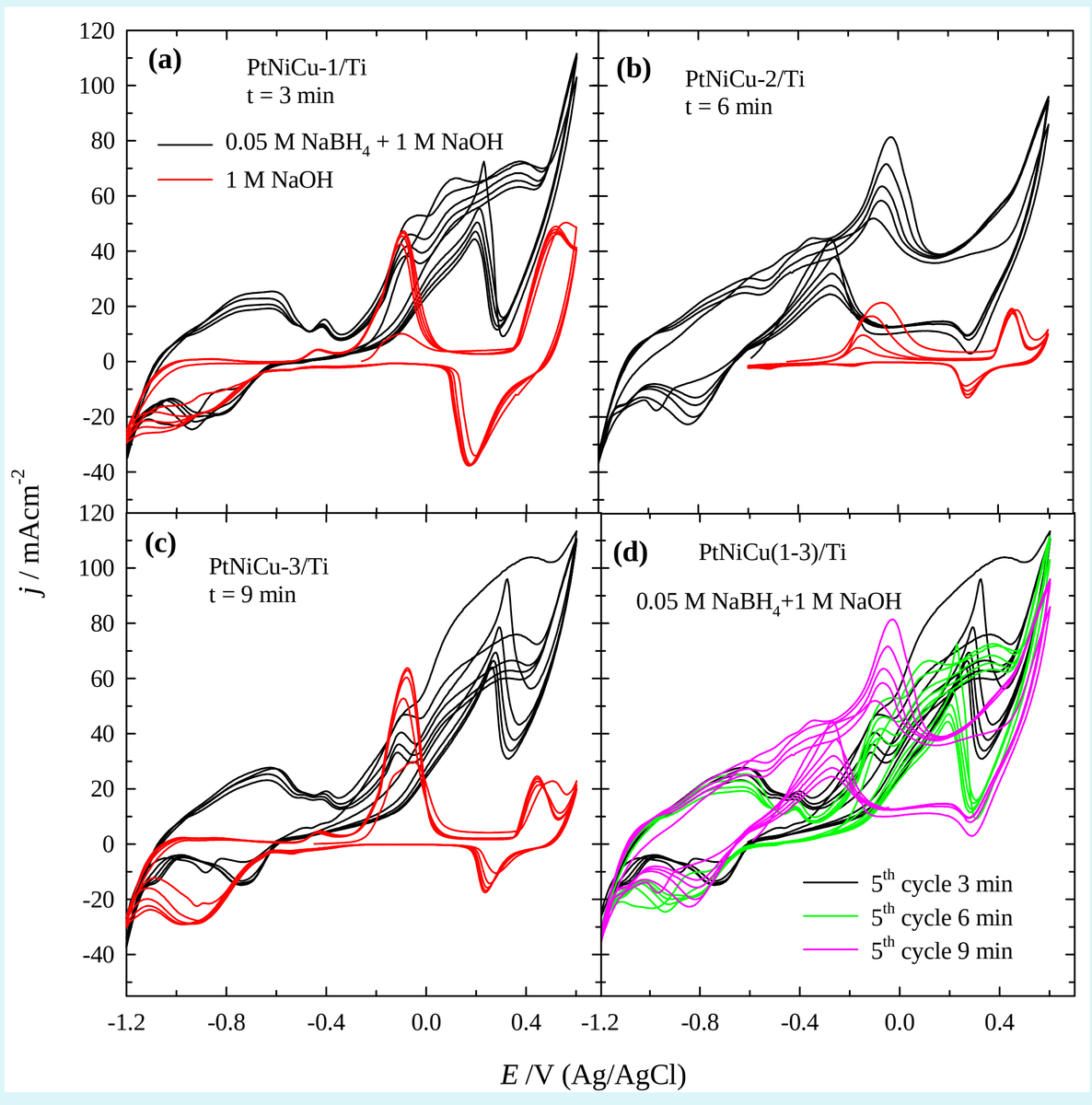

Fig. 4. Cyclic voltammograms of PtNiCu/Ti catalysts: (a) PtNiCu/Ti-1, (b) PtNiCu/Ti-2, (c) PtNiCu/Ti-3 in 1 M NaOH solution (*red line*) and in 0.05 M $NaBH_4$+1 M NaOH sulution (*black line*). (d) Comparison of different PtNiCu/Ti catalysts 0.05 M $NaBH_4$+1 M NaOH solution. Potential scan rate 10 mVs^{-1} at 25°C.

CONCLUSION

The study showed that the prepared 3D metal Cu-Ni foam and Pt(Cu-Ni)/Ti have good electrochemical stability in an alkaline $NaBH_4$ solution. It was also observed that immersion of Cu-Ni foam in a platinum-containing solution for 1 min increased the electrocatalytic activity of the prepared Pt(Cu-Ni)/Ti catalyst for $NaBH_4$ oxidation compared to Cu-Ni foam.

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