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Letter

Accumulation of rare-earth metal on the surface of the microencapsulated hydrogen storage alloy

Zhang Yunshi, Chen Youxiao, Chen Jun and Cao Xuejun

New Energy Material Chemical Institute, Nankai University, Tianjin 300071 (China)

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Abstract

The rare-earth metal of M_mNi_5-based alloys (M_m = mischmetal) can accumulate on some microencapsulated surfaces. The accumulation is selective and may be due to the different tendency of M_m in the alloy to accumulate on the various coated-metal layers.

1. Introduction

Previous work has shown that M_mNi_5-based alloys are good electrode materials because of their high kinetics and high energy density [1, 2]. However, rapid capacity decay of the anode caused by oxidation and disintegration occurs during repeated charge–discharge cycles [3, 4]. At present, one effective way of solving the problem is to microencapsulate a thin film of metal such as Cu or Ni [5, 6]. Therefore we have investigated changes in the coated-alloy surface and the effect of the coated layer on the characteristics of the alloy.

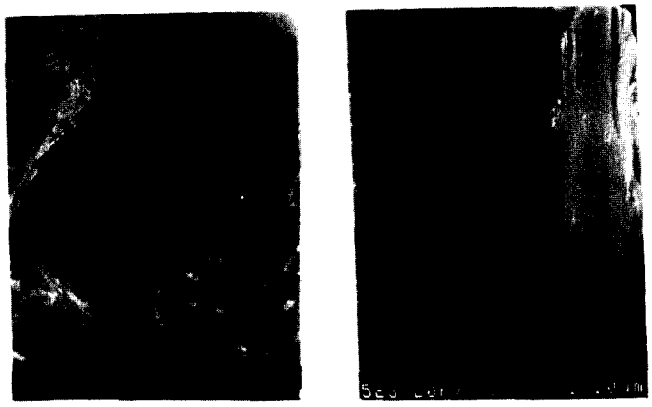

Fig. 1. SEM images of the $M_mNi_{3.8}Co_{0.5}Mn_{0.4}Al_{0.3}$ alloy: (a) uncoated alloy; (b) Ni-coated alloy.

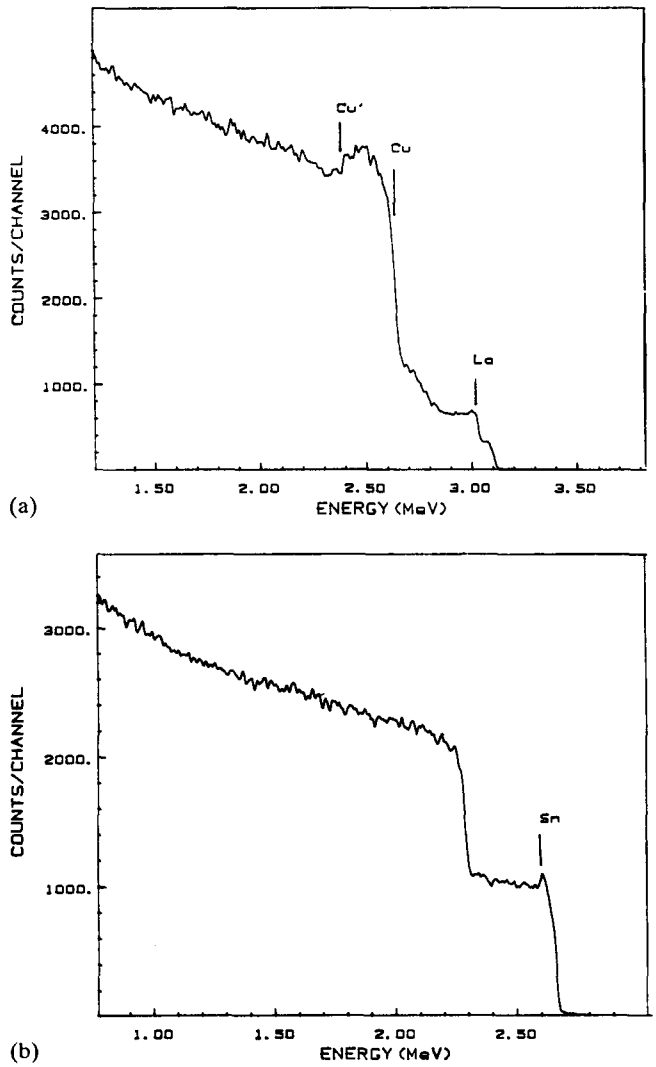

Fig. 2. Results of RBS experiments for (a) Cu-coated and (b) Ni–Sn-coated $M_mNi_{3.8}Co_{0.5}Mn_{0.4}Al_{0.3}$ alloy.

TABLE 1. Effect of the coated metal on accumulation

Coated metal	Cu	Cr	Co	Ni	Ni–Co	Ni–Sn	Ni–W
Thickness (μm)	1.6	1.6	1.5	1.5	1.2	1.2	1.4
Presence of M_m	Yes	Yes	Yes	No	No	No	No

2. Experimental details

The alloy $M_mNi_{3.8}Co_{0.5}Mn_{0.4}Al_{0.3}$ was prepared by arc melting of the constituent elements under an argon atmosphere. The ingot of the alloy was mechanically pulverized. Fine powders having an average particle

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TABLE 2. The capacity of the electrode ($mAh \cdot g^{-1}$) as a function of the cycle number, where C_{100} is the electrode capacity after 100 charge–discharge cycles and C_5 is the electrode capacity after five charge–discharge cycles

Anodes	No. of cycles				
	5	10	50	100	C_{100}/C_5
Alloy/Cu	251.2	244.3	209.7	175.9	0.70
Alloy/Cr	250.4	244.6	211.6	178.7	0.71
Alloy/Ni	249.8	248.7	247.1	245.9	0.98
Alloy/Ni–Co	249.6	248.4	247.7	244.9	0.98

size of about 72 μm were put into a chemical plating solution to microencapsulate them with Cu, Cr, Co, Ni, Ni–Co, Ni–Sn and Ni–W with a thickness of 1–2 μm.

The uncoated and coated alloy surfaces were examined by scanning electron microscopy (SEM). The concentration of the coated metal and presence of M_m on the surface were analysed by Rutherford backscattering spectroscopy (RBS).

3. Results and discussion

Using SEM (Fig. 1), we could see that the coated nickel layer is very homogeneous, as are the other coated metal layers.

Using RBS (Fig. 2), we determined that the thickness of the coated film was about 1.5 μm. Interestingly, we found an accumulation of rare-earth metal on some of the coated layers, for example La on the Cu-coated layer. This accumulation is selective (see Table 1). We consider it possible that the main cause of the accumulation is the different tendency of M_m to accumulate on the various coated metal layers.

The larger the concentration of rare-earth metal on the surface, the larger the decrease in the hydrogen absorption property of the alloy. This can be seen from the capacity decrease of the electrodes using various coated alloys (see Table 2).

4. Conclusion

The rare-earth metal of $M_mNi_{3.8}Co_{0.5}Mn_{0.4}Al_{0.3}$ can accumulate on a Cu-, Co-, or Cr-coated surface. Microencapsulation with Ni, Ni–Co, Ni–Sn and Ni–W is one effective way of restricting the accumulation.

When accumulated $M_mNi_{3.8}Co_{0.5}Mn_{0.4}Al_{0.3}$ powders are used as electrode materials, the hydrogen storage capacity is found to decrease with increasing degrees of accumulation.

Acknowledgments

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