

Study the Influences of Electrolyte Solution on the Electrochemical and Magnetic Properties of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ Alloys

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Abstract: In this report, we studied the effect of electrolyte concentration on the electrochemical and magnetic properties of the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ alloys used as the negative electrode in Ni-MH rechargeable batteries. Effect of electrolyte concentration on the electrochemical and magnetic properties of the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ alloys was investigated by the measurements of magnetization curves and charge-discharge performance of the material. The results showed that the composition electrolyte solution $\text{KOH}(5.1) + \text{LiOH}(0.9)$, the charge-discharge performance is the highest. With this concentration of magnetization curves show superparamagnetic status and the magnetized values is the highest.

Keywords: Nano, Ni-MH batteries, LaNi_5 , magnetic properties, hydrogen absorption.

1. Introduction

The compounds RT_5 have been known and studied a lot because of the ability to absorb and disabsorb the very large amounts of hydrogen at atmospheric pressure and room temperature which does not damage the lattice structure [1, 2]. Hydrogen accumulation in the crystal lattice of the material creates a permanent-form hydrogen container and energy reserves [3]. This feature has been applied in many fields of science and technology, one of the applications that is built rechargeable battery cathode Ni-MH [4, 5]. The advantages of Ni-MH battery are high-capacity battery and its waste does not pollute the environment [6, 7]. On the other hand, compared with Ni-Cd or the lithium battery are familiar products in the electronics and communications handed, Ni-MH battery have longer lifetime and lower cost [8].

Currently, NiMH batteries are widely used, thus improving the quality and innovation are necessary. There are many ways to improve the battery performance has been studied as: doping 3d elements capable of absorbing hydrogen [9,10], reducing particle size which increase the surface area of the electrode in contact with the electrolyte solution to increase the level of hydrogen absorption

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[11, 12], changes capable of releasing hydrogen absorption and by acting on the electrolyte solution [13, 14]. The third way takes very few interested, earlier with NiCd batteries, the electrolyte solution has been carefully studied and selected by the 6M KOH electrolyte solution thus selected now for the same type of positive electrode is NaOH [15, 16].

2. Experimental

$\text{LaNi}_{5-x}\text{Ge}_x$ system compounds were prepared by arc-melting method in Ar gas atmosphere from the metal components of purity at least 99.9%. Here a slight excess of La and were added to compensate for the weight loss during arc-melting. The samples were turned over and re-melted several times to attain good homogeneity. The powder samples were created by milling in agate mortar during 30 minutes to grain size about 50 μm . The crystalline structure and the phase impurity of the samples at room temperature were examined by X-ray powder diffractometer, using $\text{Cu-K}\alpha$ radiation. The obtained powder XRD patterns were analyzed by means of a Rietveld refinement [9] procedure using X'pert High Score Plus in order to determine the type of structure and the lattice parameters. For the electrochemical measurements, negative electrodes were prepared by mixing $\text{LaNi}_{5-x}\text{Ge}_x$ powder with copper and nickel powders and binder in 70:28:2 ratio of weight. This mixture was pressed onto a Nickel mesh at a pressure of 6 tons/ cm^2 . In charge-discharge capacity measurements, the all electrodes are connected to a potential device called a Bi-Potentiostat 366A. The electrodes were fully charged at current density of 50 mA/g, and then discharged at the same current density to cut-off potential of -0.7 V (versus SCE). The data is transmitted to a computer containing the software for treatment and display of results by graphical and data files. The magnetic properties of the alloys $\text{LaNi}_{5-x}\text{Ge}_x$ were measured on vibrating sample magnetometer (VSM) in magnetic fields up to 1.2 T.

3. Results and discussion

3.1. Crystal structure analysis

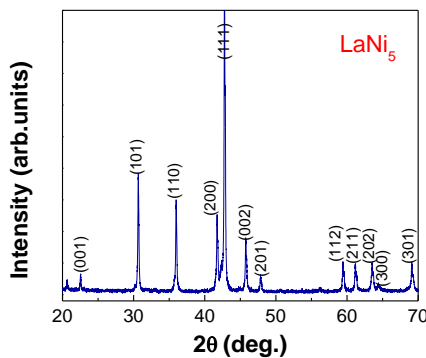


Fig. 1. The X-ray diffraction spectrum of the LaNi_5 alloys.

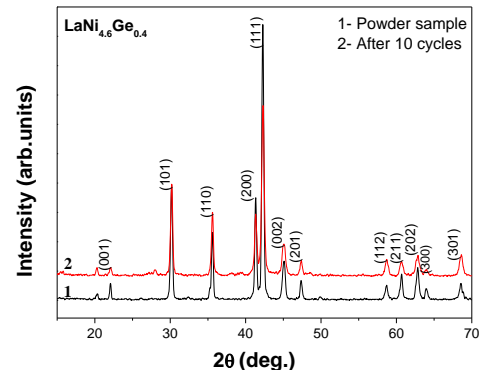


Fig. 2. The X-ray diffraction spectrum of the powder alloys $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ and after charge-discharge 10 cycles.

X-ray diffraction (XRD) was used to investigate the crystal structure and lattice parameters of synthesized materials. Figure 2 shows the XRD patterns of the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ system. The data confirmed that all the samples are single phase, and crystallize in the hexagonal CaCu_5 -type structure, the same structure, as does the prototype LaNi_5 in Figure 1, and no secondary phase was detected within 1% error of measurements. When replacing a part of Ni by Ge in LaNi_5 alloy, crystal characteristics of the alloy remains unchanged compared to the LaNi_5 original material. Figure 2, we show the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ alloy, the alloys remains CaCu_5 structure. Characteristics of the sample crystal decrease, it presented in of the expanded diffraction peaks and the intensity of diffraction peaks decreased. This is because the doping process can cause the stretch lattice but not much.

3.2. The electrochemical properties

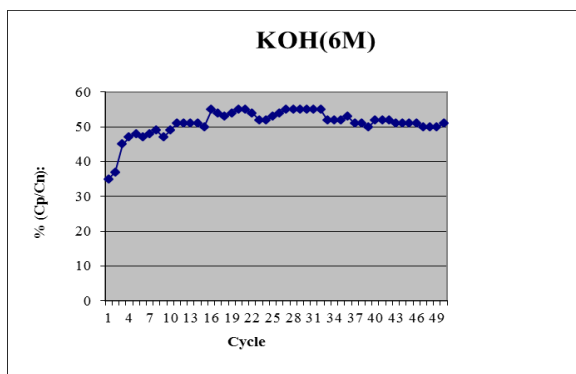


Fig. 3. Cycle performance of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ in $\text{KOH}(6\text{M})$.

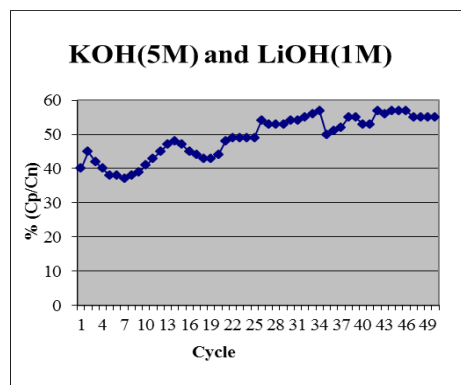


Fig. 4. Cycle performance of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ in $\text{KOH}(5\text{M})$ and $\text{LiOH}(1\text{M})$.

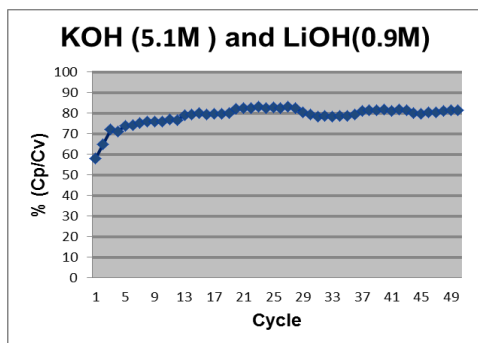


Fig. 5. Cycle performance of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ in $\text{KOH}(5.1\text{M})$ and $\text{LiOH}(0.9\text{M})$.

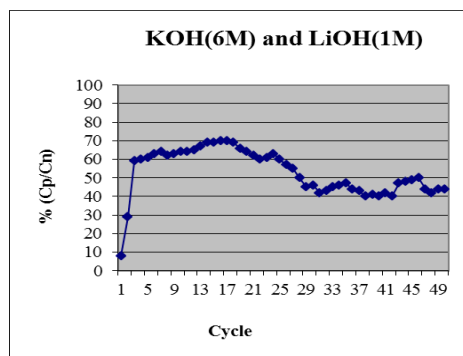


Fig. 6. Cycle performance of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ in $\text{KOH}(6\text{M})$ and $\text{LiOH}(1\text{M})$.

Electrochemical measurements were performed in a three electrodes system consisting of the working electrode (WE) was the prepared sample, the counter electrode (CE) was made from inert metal (Platinum), and the reference electrode was the saturation calomel electrode (SCE) ($\text{Hg}/\text{Hg}_2\text{Cl}_2$, calomel). $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ sample is charged-discharged with constant current ($I = 50 \text{ mA}$) in the electrolyte solution has been studied. Figure 3 - 6 showed the clear influence of electrolyte

composition on the performance charge/discharge of samples. The results also indicate that the sample $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ is charged/discharge in solution $\text{KOH}(5,1\text{M})$ and $\text{LiOH}(0,9\text{M})$ gives the highest performance and most stable. The purpose of LiOH addition into the 6M KOH electrolyte is to increase electrochemical activity of the MH electrode. The existence of Li in the surface oxide layer accelerates the H_2 dissociation on the surface. Therefore, under significantly oxidizing condition the powder sample of LaNi_5 can more easily react with H_2 .

These results demonstrate that when much Ni is released on the surface, it will act as a catalyst for electrochemical reactions Chemical happen, raising cycle performance of materials

3.3. The magnetic properties

The magnetization curve of bulk LaNi_5 and $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ samples curve is a straight line passing through the origin of this is characteristic of Pauli paramagnetic with magnetic susceptibility are 3.70 and 1.72, respectively. Results are shown in Figure 7.

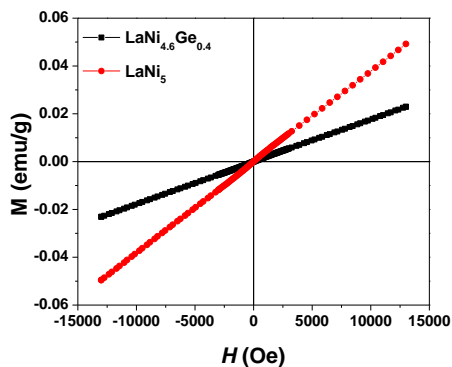


Fig. 7. Magnetization curve of the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ samples in bulk and powder states.

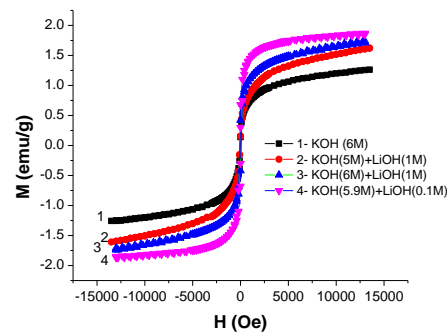


Fig. 8. Magnetization curve of the $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ samples after 10 charge-discharge cycles.

The measured magnetization curves of powder samples after 10 charge/discharge cycles at room temperature are shown in figure 8. The magnetization curves of bulk sample shows that it is paramagnetic. In contrast to the bulk sample, the magnetization curves of all powder samples after 10 charge/discharge cycles the magnetic moment of these sample have been increase significant. It is due to during repeated charge/discharge cycling this materials were undergone volumetric deformation, broken and oxidized lead to the Ni decomposed on the surface, this amount of Ni is the main cause of magnetic properties, the larger magnetic demonstrates Ni is released more.

These results demonstrate that when much Ni is released on the surface, it will act as a catalyst for electrochemical reactions Chemical happen, raising cycle performance of materials. The obtained results showed that although measurements of magnetic characteristics is relatively simple but can give us quantitative information about the microscopic processes occurring in the material used as the negative electrode in Ni -MH rechargeable battery.

4. Conclusion

The influences of electrolyte solution on the electrochemical and magnetic properties of $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ alloys have been studied. The results show that the all $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ sample in bulk state

and after 10 charge-discharge cycles to be single phase, and crystallize in the hexagonal CaCu_5 -type structure. The sample $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ after 10 charge-discharge cycles in solution $\text{KOH}(5,1\text{M})$ and $\text{LiOH}(0,9\text{M})$ gives the highest performance and most stable. The existence of Li in the surface oxide layer accelerates the H_2 dissociation on the surface. Therefore, under significantly oxidizing condition the powder sample of LaNi_5 can more easily react with H_2 . The bulk $\text{LaNi}_{4.6}\text{Ge}_{0.4}$ samples showed Pauli paramagnetic state, after 10 charge-discharge cycles transferred to superparamagnetic state. It is due to decomposed Ni during charging/discharging cycles. The results of magnetic measurements allow us to discuss the nature of charge-discharge process.

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