Exploring TiV-Based Alloys as Potential Anode Materials for High-Capacity Ni-MH Batteries

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The growing demand for efficient and sustainable energy storage systems has increased interest in advanced electrode materials for rechargeable batteries. Nickel-metal hydride (Ni-MH) batteries remain attractive due to their favorable energy density, long cycle life, and lower environmental impact compared to other chemistries [1].Recently, TiV-based multicomponent alloys have drawn attention as potential anode materials for Ni-MH batteries. These alloys tend to form body-centered cubic (BCC) structures, which provide abundant interstitial sites and efficient hydrogen diffusion pathways, enhancing storage capacity and kinetics. In addition, alloying elements such as Ti, V, Zr, and Nb improve mechanical stability and corrosion resistance, both of which are critical for long-term performance..

This study focuses on the synthesis of TiV-based multicomponent alloys via arc melting and the investigation of their structural, morphological, and electrochemical properties, with particular emphasis on BCC phase stabilization and hydrogen storage behavior. Specifically, Ti-V-La-Ni-x (x = Fe, Zr, Mn) alloys are developed, where each alloying element is introduced to optimize mechanical stability, electrochemical capacity, and reaction kinetics for improved Ni-MH battery performance..

Figure 1. Arc Melter System

High-purity metal powders will be pelleted in stoichiometric ratios determined beforehand. The pellet will be melted multiple times using a turbomolecular vacuum arc melting device until a homogeneous alloy is obtained. The resulting alloy will then be ground to 45 microns using a ball mill. After pulverization, crystal structure analysis will be conducted with X-ray diffraction (XRD). The microstructure will be examined using a field emission scanning electron microscope (FE-SEM) with an acceleration voltage of 15 kV.

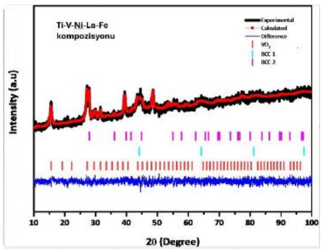

Figure 1. T-V-Ni-La-Fe XRD

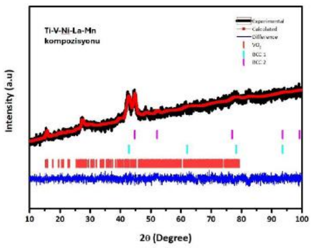

Figure 3. T-V-Ni-La-Mn XRD

Negative electrodes for electrochemical testing will be prepared by mixing 0.25 g of the alloy powder with 0.75 g of high-purity nickel powder (99.999%). The electrolyte solution will be 6 M KOH, while $NiOOH/Ni(OH)_2$ and Hg/HgO will be used as the positive and reference electrodes, respectively. Electrochemical properties will be measured using a Bio-Logic SP-300 electrochemical workstation. Experimental studies on TiV-based multicomponent alloys are still ongoing, with the primary objective of synthesizing alloys exhibiting a BCC crystal structure through arc melting. The results revealed the formation of a dual-phase BCC structure. The formation of such a structure is considered an important finding, since the presence of even a single BCC phase is regarded as sufficient for achieving favorable hydrogen storage characteristics.

Following synthesis, comprehensive characterizations will be conducted, including XRD for phase analysis and FE-SEM for microstructural examination, while electrochemical tests will be performed to evaluate hydrogen storage behavior and assess their potential as anode materials in Ni-MH batteries. The main goal of this study is to obtain high discharge capacity and stable electrochemical performance. The findings are expected to contribute to the design of durable, high-performance electrode materials for future energy storage applications.

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