3ème Conférence Internationale sur les Sciences Appliquées et l'Innovation (CISAI-2025)
Proceedings Book Series –PBS- Vol 25, 205-208

Comparative Study of Kinetic, Corrosion, and Cycling Properties of $LaNi_{3.55}Mn_{0.4}Al_{0.3}Co_{0.75}$ and $Sm_{0.6}Zn_{0.4}Fe_2O_4$ Electrodes for Ni-MH Batteries

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Introduction:

The increasing demand for portable electronics and electric vehicles (EVs) has driven significant research into rechargeable batteries, particularly for systems that are compact, thermally stable, environmentally friendly, and safe. While lithium-ion (Li-ion) batteries offer high energy densities, they face concerns related to thermal runaway and safety [1-5]. Nickel-metal hydride (Ni-MH) batteries, on the other hand, are appreciated for their thermal stability, ease of recycling, overcharge tolerance, and long cycle life, making them suitable for applications such as hybrid electric vehicles (HEVs).

The performance of Ni-MH batteries depends greatly on the intrinsic properties of the electrode materials. This study compares two different negative electrode materials:

- A metallic compound: $LaNi_{3.55}Mn_{0.4}Al_{0.3}Co_{0.75}$
- A spinel ferrite: $Sm_{0.6}Zn_{0.4}Fe_2O_4$

Résultats :

Potential Jump and Corrosion Behavior

- The potential jump was consistently lower for the metallic electrode, indicating better kinetic behavior.
- For example, by the 24th cycle:
  - $\Delta E \approx 0.03$ V (metallic)
  - $\Delta E \approx 0.14$ V (ferrite)
- A lower ΔE implies improved reaction kinetics and reduced internal resistance.
- Corrosion rates, calculated from potential jump and polarization behavior, were similar for both electrodes, despite differences in performance.

ISSN: 2961-6611

Discharge Capacity

- The metallic electrode reached a maximum discharge capacity of ~337 mAh/g by the 7th cycle.
- The ferrite electrode peaked at ~169 mAh/g by the 5th cycle.
- After 24 cycles, discharge capacity degraded:
  - ~10% loss for $LaNi_{3.55}Mn_{0.4}Al_{0.3}Co_{0.75}$
  - ~16% loss for $Sm_{0.6}Zn_{0.4}Fe_2O_4$
- The higher capacity and lower degradation rate of the metallic electrode confirm its better electrochemical performance.

Conclusion:

The metallic compound $LaNi_{3.55}Mn_{0.4}Al_{0.3}Co_{0.75}$ demonstrates superior kinetic behavior, higher discharge capacity, and greater cycling stability compared to the spinel ferrite $Sm_{0.6}Zn_{0.4}Fe_2O_4$. Despite these performance advantages, both electrodes exhibit similar corrosion rates, indicating that corrosion is not the primary factor limiting the ferrite's performance. Consequently, the metallic electrode is more suitable for use in nickel-metal hydride batteries, particularly in applications that demand high energy density and long-term durability.

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ISSN: 2961-6611