Nickel-Ferronickel Composite as a Cathode Material for Low Cost Sodium-Metal Chloride (Na-MCl₂) Batteries

Jinuk Choi, Seungmi Lee, Hanul Choi, Geyoung Choi, Yoon-Heol Park, Choonmo Yang, Younki Lee, David Reed, Vincent Sprenkle, Guosheng Li, Young-Hoon Yun, and Keeyoung Jung*

Materials Research Division, Research Institute of Industrial Science and Technology (RIST), Pohang, Republic of Korea 37673
School of Materials Science and Engineering, RIGET, Kyungpook National University (GNU), Jinju, Republic of Korea 52828
Battery Materials and Systems Group, Pacific Northwest National Laboratory (PNNL), Richland WA, USA 99352
Department of Renewable Energy, Dongshin University, Naju, Republic of Korea 58245

Introduction
- Sodium-metal chloride battery (Na-MCl₂, M=Ni, Fe, and more) has been considered as a promising battery candidate for stationary energy storage applications because of its superior features of high safety, long cycle life, and proven performance. The battery is built in its discharged state typically made of transient metal (Ni and/or Fe) and sodium chloride (NaCl) powders as its cathode materials soaked in a molten catholyte (NaAlCl₃) (constant current mode) at 200 °C. The cell at 180 °C oxidizes NaAlCl₃ to AlCl₃(s) and NaCl(l) in the cathode compartment. Recently, intensive efforts have been exerted to reduce its cost by making a larger contact area. Also, it was demonstrated that a low grade ferronickel alloy can be used as an active material for Na-NiCl₂ batteries without compensating cell performance.

- In this study, a set of Fe-containing cathodes were prepared (a part of Ni was replaced with Fe or ferronickel (20%Ni-80%Fe) alloy), and their electrochemical performance were evaluated. It showed that unwanted voltage drops occurred due to direct reaction between Ni and Fe, especially upon discharging, and it was able to be mitigated by minimizing the Ni-Fe contact area. Also, it was demonstrated that a low grade ferronickel alloy can be used as an active material for Na-NiCl₂ batteries without compensating cell performance.

Statement of the Problem
1. Planar Na-NiCl₂ Cell at 180°C

Cathode Preparation
1. Cathode Granule

2. Fe-Ni Phase Diagram

3. XRD of Transient Metals

4. Calculated OCV for Ni, Fe, and FN Redox

cathode compartment. Recently, intensive efforts have been exerted to reduce its cost by making a larger contact area. Also, it was demonstrated that a low grade ferronickel alloy can be used as an active material for Na-NiCl₂ batteries without compensating cell performance.

Statement of the Problem
1. Planar Na-NiCl₂ Cell at 180°C

Cathode Preparation
1. Cathode Granule

2. Fe-Ni Phase Diagram

3. XRD of Transient Metals

4. Calculated OCV for Ni, Fe, and FN Redox

Electrochemical testing and Discussion
1. Voltage-Capacity Profiles with Different Cathodes

Current density: 3.3 mA/cm² (constant current mode) at 200°C

2. Voltage-Capacity Profiles and Their Corresponding Microstructural Evolution

Charging at 10 mA, Discharging at 10, 30, 60, and 90 mA at 200°C

Conclusion
- A ferronickel cathode for sodium metal chloride batteries was successfully demonstrated in order to investigate the possibility of potential use of ultra low cost alloys.
- The cell with Ni and ferronickel mixture showed higher discharge voltage and energy density than that with Ni and Fe mixture (commercial).

Acknowledgement
- This work was supported by grants from the International Collaborative Energy Technology R&D program of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) under the authority of the Ministry of Trade, Industry, and Energy (MOTIE) of the Republic of Korea, Korea Electric Power Corporation (KEPCO), and the U.S. Department of Energy (DoE) (Contract No. 20198510050010).