

# Formic Acid-Assisted Sustainable Recycling of Ni, Cd, and Co from Spent Ni-Cd Batteries

Masud Rana<sup>1</sup>, Young-Tae Jo<sup>1,2</sup> and Jeong-Hun Park<sup>1</sup>

<sup>1</sup>Department of Environment & Energy Engineering, Chonnam National University,  
77 Yongbong ro, Bukgu, Gwangju 61186, Republic of Korea

<sup>2</sup>Soil Technology and Research Institute, Chonnam National University, 77 Yongbong ro, Bukgu, Gwangju  
61186, Republic of Korea

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Presenting author email: [tlmanager@hanmail.net](mailto:tlmanager@hanmail.net)

The study focuses on recycling nickel (Ni), cadmium (Cd), and cobalt (Co) from spent Ni-Cd batteries, which is crucial for addressing metal scarcity and environmental protection. Various methods for recycling these metals have been explored, but achieving simultaneous leaching and recovery of Ni, Cd, and Co in an environmentally friendly and cost-effective way remains a challenge. This research proposes a formic acid-assisted process for extracting these metals from the cathode and anode materials of spent Ni-Cd batteries. The process's efficiency under different temperatures, durations, and liquid/solid ratios was thoroughly examined. Results showed that over 95% of Cd and Co could be leached at 80 °C in 2.5 hours, while up to 81% of Ni could be leached in formic acid at 90 °C over 4 hours with a 30 mL/g liquid/solid ratio. Temperature and time were found to significantly impact Ni and Cd leaching. While metallic Ni in the cathode was initially resistant due to its inertness, using H<sub>2</sub>O<sub>2</sub> as an oxidizing agent resulted in 99.70% conversion of Ni at 60 °C in 2 hours. The study concludes that the formic acid-assisted process is a sustainable alternative for efficiently leaching and recovering valuable metals from spent Ni-Cd batteries, offering advantages like lower corrosive acid use, milder leaching conditions, and reduced environmental impact.