INTISARI

Penggunaan baterai litium-ion, khususnya yang berbasis NMC, semakin meningkat seiring dengan berkembangnya teknologi energi terbarukan dan kendaraan listrik. Namun, masalah limbah baterai pasca pakai menjadi tantangan baru dalam pengelolaan lingkungan dan daur ulangnya. Logam berharga dalam baterai bekas dapat dipungut kembali, diantaranya lithium. Penelitian ini bertujuan untuk melakukan ekstraksi litium secara selektif dari katoda baterai NMC bekas menggunakan metode *roasting* dan pelindian air. Proses *roasting* dilakukan pada variasi suhu 650, 750, 850, dan 950°C, variasi waktu selama 1, 2, dan 3 jam, serta variasi komposisi material anoda sebesar 5, 10, 15, 20, 30, 40, dan 50%. Setelah proses *roasting*, pelindian air dilakukan dengan rasio 1g/50 ml air pada suhu kamar. Litium yang terekstrak dianalisis menggunakan ICP-MS. Kinetika dipelajari dengan mengamati konversi pada dua laju pemanasan (5 dan 10^{o}C/menit) dengan menggunakan DSC. Kondisi operasi optimum diperoleh pada proses *roasting* 750°C selama 2 jam, dengan komposisi material anoda sebesar 50%, yang menghasilkan *recovery* litium maksimum sebesar 97,11% dan 100% selektif terhadap logam litium. Proses *roasting* optimum dapat didekati dengan model kinetika kontraksi area (R2) dengan nilai tetapan pre-eksponensial Arrhenius $2{,}44\times10^{9}$ 1/menit dan nilai energi aktivasi 220 kJ/mol. Temuan ini menunjukkan efektivitas metode *roasting* dan pelindian air dalam ekstraksi litium dari limbah baterai NMC, serta memberikan kontribusi penting terhadap pengembangan teknologi daur ulang baterai litium pasca pakai yang berkelanjutan. Penelitian ini diharapkan dapat menjadi acuan dalam upaya pengelolaan limbah baterai litium yang lebih ramah lingkungan dan efisien.

Kata Kunci : *limbah baterai; baterai NMC; roasting; ekstraksi litium; pelindian air*

ABSTRACT

The utilisation of lithium-ion batteries, particularly those based on NMC (Nickel Manganese Cobalt), has been increasing in tandem with the advancements in renewable energy technologies and electric vehicles. However, the issue of battery waste post-use presents a new challenge for environmental management and recycling efforts. Valuable metals within used batteries, such as lithium, can be reclaimed. This study aims to perform selective lithium extraction from the cathodes of used NMC batteries through roasting and aqueous leaching methods. The roasting process was conducted at varying temperatures of 650, 750, 850, and 950°C, with variations in time set to 1, 2, and 3 h, alongside varying anode material compositions of 5, 10, 15, 20, 30, 40, and 50%. Following the roasting process, aqueous leaching was performed at a ratio of 1g/50ml of water at room temperature. Extracted lithium was analysed using ICP-MS. Kinetics were investigated by observing conversion rates at two heating rates (5 and 10°C/min) using DSC. Optimal operational conditions were identified at a roasting temperature of 750°C for 2 h, with an anode material composition of 50%, yielding a maximum lithium recovery of 97.11% and 100% selectivity towards lithium metal. The optimal roasting process can be modelled by the area contraction kinetic model (R2), with an Arrhenius pre-exponential factor of 2.44×10^9 1/min and an activation energy of 220 kJ/mol. These findings underscore the effectiveness of roasting and aqueous leaching methods in lithium extraction from NMC battery waste, contributing significantly to the development of sustainable post-use lithium battery recycling technologies. This research is anticipated to serve as a reference for environmentally friendly and efficient lithium battery waste management practices.

Keywords: *battery waste, NMC batteries, roasting, lithium extraction, water leaching*