ABSTRAK

Proses daur ulang baterai bekas dan *recovery* ion logam pada katoda menjadi salah satu proses efektif untuk menekan angka limbah baterai yang menjadi masalah serius karena mengandung zat berbahaya dan sifatnya yang beracun bagi lingkungan. Pada penelitian ini, daur ulang katoda baterai bekas melibatkan proses *pre-treatment, hydrometallurgy, molarity adjustment,* dan sintesis dengan metode *flame assisted spray pyrolysis*. Penelitian ini bertujuan untuk sintesis nanopartikel katoda baterai dari *leachate* baterai bekas menggunakan asam anorganik dan organik.

Proses *pre-treatment* baterai diawali dengan *discharge*, *dismantling*, *separation* katoda, kominusi, *sieving,* dan *heat treatment* (kalsinasi) guna menghilangkan pengikat (*binder*). *Recovery* ion logam Li, Ni, Mn, dan Co memanfaatkan ekstraksi dengan metode *hydrometallurgy (leaching)* dengan variasi jenis asam (HNO_3 dan CH_3COOH), konsentrasi asam (0,25; 0,5; 0,75; 1; 1,25 M), *solid to liquid ratio* (10; 15; 20; 25; 30 g/L) dan temperatur *leaching* (40; 50; 60; 70; 80ºC) untuk menemukan parameter optimum pada *leaching* asam anorganik dan organik. Hidrogen peroksida (H_2O_2) 1,7% volume pada *leaching* HNO_3 dan 4% volume pada *leaching* CH_3COOH digunakan sebagai oksidator yang efektif meningkatkan efisiensi *leaching*. Kondisi optimum *leaching* anorganik (HNO_3) didapatkan pada 0,75M HNO_3 + 1,7% volume H_2O_2, *solid to liquid ratio* 20 gr/L, dan temperatur 60ºC dengan % *recovery* mencapai 83%; 71,15%; 85,82%; dan 99,76% untuk logam Li, Ni, Mn dan Co secara berurutan. Sedangkan kondisi optimum *leaching* organik (CH_3COOH) didapatkan pada 1,25M CH_3COOH + 4% volume H_2O_2, *solid to liquid ratio* 30 gr/L, dan temperatur 70ºC dengan % *recovery* mencapai 87,16%; 64,34%; 82,89%; dan 99,24% untuk logam Li, Ni, Mn dan Co secara berurutan.

Molarity adjustment dilakukan pada *leachate* baterai bekas untuk mendapatkan komposisi katoda $Li(Ni_{0,3}Mn_{0,3}Co_{0,3})O_2$. Pada penelitian ini digunakan *flame assisted spray pyrolysis* untuk sintesis larutan prekursor komersial dan *leachate* baterai bekas dengan HNO_3 dan CH_3COOH. Hasil XRD menunjukkan dengan perlakuan kalsinasi pada suhu 800ºC selama 6 jam katoda hasil sintesis dengan metode FASP memiliki tingkat kristalisasi yang baik tanpa terdeteksi *impurities*. Morfologi bentuk dan ukuran partikel diteliti dengan pengujian SEM-EDX dan PSA mengungkapkan bahwa sintesis nanopartikel dengan metode *flame assisted spray pyrolysis* menunjukkan morfologi bentuk bola dengan agregrat polikristalin yang khas dan memiliki distribusi ukuran partikel pada rentang 200-400 nm.

Kata Kunci: *Flame Assisted Spray Pyrolysis, Leaching*, *Recovery*, Baterai NMC bekas.

ABSTRACT

Spent used battery recycling process and metal ion recovery on the cathode become one of the effective processes to reduce the number of battery waste which is a serious problem because it contains hazardous substances and its toxic nature to the environment. In this study, spent used battery cathode recycling involved pre-treatment, hydrometallurgy, molarity adjustment, and synthesis with the flame assisted spray pyrolysis method. This study aims to synthesis of battery cathode nanoparticles from. This study aims to synthesize battery cathode nanoparticles from leachate spent used batteries using inorganic and organic acids.

Battery pre-treatment process begins with discharge, dismantling, cathode separation, comminution, sieving, and heat treatment (calcination) to remove binders. Recovery of metal ions Li, Ni, Mn, dan *Co with extraction by hydrometallurgical method (leaching) with various types of acid (*HNO_3 *and* CH_3COOH*), acid concentration (0,25; 0,5; 0,75; 1; 1,25 M), solid to liquid ratio (10; 15; 20; 25; 30 g/L)* dan *leaching temperature (40; 50; 60; 70; 80ºC) to find the optimum parameters for inorganic* dan *organic acid leaching. Hydrogen peroxide (*H_2O_2*) 1.7% by volume in* HNO_3 *leaching* dan *4% by volume in* CH_3COOH *leaching was used as an effective oxidizing agent to increase leaching efficiency. The optimum condition of inorganic leaching (*HNO_3*) was found at 0,75M* HNO_3 *+ 1.7% by volume* H_2O_2*, solid to liquid ratio of 20gr/L,* dan *temperature of 60ºC with %recovery reaching 83%; 71,15%; 85,82%;* dan *99,76% for Li, Ni, Mn* dan *Co metals, respectively. While the optimum conditions for organic leaching (*CH_3COOH*) were found at 1,25M* CH_3COOH *+ 4% volume* H_2O_2*, solid to liquid ratio 30gr/L,* dan *temperature 70ºC with % recovery reaching 87,16%; 64,34%; 82,89%;* dan *99,24% for Li, Ni, Mn and Co metals, respectively.*

Molarity adjustment was carried out on the spent used battery leachate to obtain the cathode composition of $Li(Ni_{0,3}Mn_{0,3}Co_{0,3})O_2$*. In this study, flame-assisted spray pyrolysis was used for the synthesis of commercial precursor solutions and spent used battery leachate with* HNO_3 *and* CH_3COOH. XRD *results showed that the calcination at 800ºC for 6 hours affect the cathode that synthesized by* FASP *method had a good crystallization rate without detecting impurities. The morphology of the shape and size studied by* SEM-EDX *and* PSA *tests revealed that the synthesis of nanoparticles by the flame assisted spray pyrolysis method showed a spherical morphology with typical polycrystalline aggregates and had a particle size distribution in the range of 200-400nm.*

***Keywords**: Flame Assisted Spray Pyrolysis, Leaching, Recovery, Spent NMC Batteries.*