MATERIAL NI/ZEOLIT ALAM TERSULFATASI (NI/SNZ) DARI KATODA BATERAI NMC BEKAS SEBAGAI NANOKATALIS UNTUK KONVERSI SAMPAH PLASTIK LDPE MENJADI FRAKSI HIDROKARBON CAIR

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INTISARI

Material katalis nanozeolit (NZ), nanozeolit tersulfatasi (SNZ), dan Ni-nanozeolit tersulfatasi (Ni/SNZ) telah berhasil dipreparasi, dikarakterisasi, serta diaplikasi sebagai katalis dalam proses perengkahan katalitik terhadap sampah plastik LDPE menjadi fraksi gasolin. Logam Ni yang diimpregnasikan ke dalam matriks nanozeolit tersulfatasi diperoleh dari hasil ekstraksi logam dalam limbah katoda baterai NMC. Limbah baterai NMC dipreparasi melalui tiga tahapan yaitu *discharging*, *dismantling*, dan kalsinasi pada temperatur 300 °C. Produk hasil proses tersebut berupa bubuk katoda baterai NMC. Bubuk ini kemudian dilakukan pelindian dengan kombinasi reagen asam fosfat-asam oksalat. Bubuk katoda baterai NMC sebelum kalsinasi (BC), sesudah kalsinasi (AC), dan setelah pelindian dilakukan analisis FTIR dan XRD. Sementara itu, *leachate* dilakukan analisis untuk mengetahui kandungan komposisi logam dengan AAS. Logam Ni kemudian diekstraksi menjadi padatan $Ni_3(PO_4)_2$ yang kemudian dianalisis dengan XRF dan FTIR. Padatan tersebut digunakan sebagai prekursor dalam proses impregnasi logam Ni ke dalam nanokatalis zeolit alam tersulfatasi. Material katalis NZ, SNZ, dan Ni/SNZ dikarakterisasi dengan FTIR, XRD, uji asam gravimetri uap piridin, SEM-EDX-*Mapping*, dan SAA. Ketiga katalis lalu diaplikasikan dalam proses perengkahan katalitik terhadap sampah plastik LDPE menjadi fraksi gasolin. Cairan hasil perengkahan lalu dianalisis dengan instrumen GC-MS untuk menentukan selektivitas katalis.

Hasil penelitian menunjukkan bahwa sistem kombinasi asam fosfat-asam oksalat sangat efektif dalam mengambil logam Ni dalam sampel bubuk katoda baterai NMC dengan efektivitas pelindian sebesar 99,90%. Nilai efektivitas tersebut diperoleh pada kondisi optimum dengan rasio (v/v) H_3PO_4 : $H_2C_2O_4$ sebesar 8 : 2 pada temperatur 60 °C selama 90 menit. Padatan nikel fosfat hasil ekstraksi berwarna ungu dengan persentase unsur logam Ni mencapai 32,50%. Keberadaan logam Ni dari hasil ekstraksi logam katoda baterai NMC dapat meningkatkan keasaman katalis zeolit alam sulfatasi sebesar 10,52 mmol/g. Pada proses *catalytic hydrocracking* menggunakan katalis NZ, SNZ, dan Ni/SNZ didapat persentase produk cair masing-masing sebesar 17,02%, 29,01%, dan 50,02%. Katalis NZ, SNZ, dan Ni/SNZ juga selektif terhadap fraksi gasolin dengan nilai selektivitas sebesar 10,3%, 20,04%, dan 45,9%.

Kata kunci: fraksi gasolin, katoda baterai NMC, kombinasi sistem asam fosfat-asam oksalat, Ni/SNZ, sampah plastik LDPE.

MATERIAL OF Ni/SULFATED NATURAL ZEOLITE (Ni/SNZ) FROM SPENT NMC CATHODE BATTERY AS A NANOCATALYST FOR CONVERSION OF LDPE PLASTIC WASTE INTO LIQUID HYDROCARBON FRACTION

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ABSTRACT

The catalyst materials nanozeolite (NZ), sulfated nanozeolite (SNZ), and Ni-sulfated nanozeolite (Ni/SNZ) have been successfully prepared, characterized, and applied as catalysts in the catalytic cracking process of LDPE plastic waste into gasoline fractions. Ni metal impregnated into the sulfated nanozeolite matrix was obtained from metal extraction of NMC battery cathode waste. NMC battery waste was prepared through three stages, discharging, dismantling and calcination at a temperature of 300 °C. The product resulting from this process is NMC battery cathode powder. This powder then leached with a combination of phosphoric acid-oxalic acid reagent. NMC battery cathode powder before calcination (BC), after calcination (AC), and after leaching were analysed to FTIR and XRD. Meanwhile, the leachate was analyzed to determine the metal composition using AAS. Ni metal was then extracted into solid $Ni_3(PO_4)_2$ which then analyzed by XRF and FTIR. This solid was used as a precursor in the process of impregnation of Ni metal into sulfated natural zeolite nanocatalysts. The NZ, SNZ, and Ni/SNZ catalyst materials were characterized by FTIR, XRD, pyridine vapor gravimetric acid test, SEM-EDX-Mapping, and SAA. The catalysts are then applied in the catalytic cracking process of LDPE plastic waste into gasoline fractions. The cracking liquid was analyzed using a GC-MS instrument to determine the selectivity of the catalyst.

The research results showed that the phosphoric acid-oxalic acid combination system was effective on removing Ni metal in NMC battery cathode powder samples with a leaching effectiveness of 99.90%. The effectiveness value was obtained under optimum conditions with a ratio (v/v) H_3PO_4 : $H_2C_2O_4$ of 8 : 2 at a temperature of 60 °C for 90 minutes. The extracted nickel phosphate solid is purple in color with a percentage of the Ni metal element reaching 32.50%. The presence of Ni metal from the extraction of NMC battery cathode metal can increase the acidity of the sulfated natural zeolite catalyst by 10.52 mmol/g. In the catalytic hydrocracking process using NZ, SNZ, and Ni/SNZ catalysts, the liquid product percentages were obtained at 17.02%, 29.01%, and 50.02%, respectively. NZ, SNZ, and Ni/SNZ catalysts are also selective towards the gasoline fraction with selectivity values of 10.3%, 20.04%, and 45.9%.

Keywords: combination system of phosphoric acid–oxalic acid, gasoline fraction, LDPE plastic waste, spent NMC-Cathode battery, Ni/SNZ.