ABSTRAK

Muhammad Fatra Arganda Saragih, NIM 4213210025 (2025). Upgrading Bahan Bakar Cair Dari Limbah Plastik Hdpe Melalui Reaksi Hidrogenasi Menggunakan Katalis Heterogen Berbasis Ni/Biochar Dari Limbah Cangkang Kelapa Sawit.

Limbah plastik, khususnya High Density Polyethylene (HDPE), merupakan salah satu penyumbang pencemaran lingkungan terbesar karena sifatnya yang sulit terurai secara alami. Upaya konversi limbah plastik menjadi bahan bakar cair melalui pirolisis telah banyak dilakukan, namun kualitas bahan bakar yang dihasilkan masih perlu ditingkatkan. Penelitian ini bertujuan untuk melakukan *upgrading* bahan bakar cair hasil pirolisis limbah plastik HDPE melalui reaksi hidrogenasi menggunakan katalis heterogen berbasis Ni/biochar dari limbah cangkang kelapa sawit. Biochar dipreparasi melalui pirolisis cangkang kelapa sawit pada 550 °C, kemudian diaktivasi dengan KOH 2 M, dan diimpregnasi dengan $Ni(NO_3)_2 \cdot 6H_2O$ untuk menghasilkan katalis Ni/biochar. Proses *upgrading* dilakukan pada suhu 450 °C, pada tekanan gas H_2 sebesar 40 bar selama 2 jam dengan variasi katalis 1%, 3%, dan 5%. Produk cair hasil *upgrading* dianalisis menggunakan GC–MS, FTIR, elemental analysis, serta pengujian densitas, viskositas, nilai kalor, dan bilangan iodin. Karakterisasi SEM menunjukkan bahwa katalis Ni/biochar memiliki morfologi berpori dengan persebaran logam Ni yang merata di permukaan biochar, sedangkan hasil EDS mengonfirmasi kandungan nikel sebesar 0,32% berat, menandakan proses impregnasi berlangsung efektif. Hasil penelitian menunjukkan bahwa pirolisis 50 g limbah HDPE menghasilkan fraksi cair 60–86%. Proses hidrogenasi dengan katalis Ni/biochar mampu menurunkan bilangan iodin hingga 7,18%, menandakan berkurangnya ikatan rangkap C=C. Sifat fisika bahan bakar hasil *upgrading* memiliki densitas 0,848 g/mL, viskositas 2,248 cSt, dan nilai kalor 44.903 kJ/kg, mendekati standar solar komersial. Variasi katalis menunjukkan bahwa Ni/biochar 3% memberikan hasil terbaik. Dengan demikian, katalis Ni/biochar dari limbah cangkang kelapa sawit efektif digunakan dalam proses *upgrading* bahan bakar cair hasil pirolisis HDPE, sehingga berpotensi menjadi solusi pengelolaan limbah plastik sekaligus penyediaan energi alternatif ramah lingkungan.

Kata Kunci: limbah plastik HDPE, pirolisis, hidrogenasi, Ni/biochar, bahan bakar cair.

ABSTRACT

Muhammad Fatra Arganda Saragih, NIM 4213210025 (2025). Upgrading Bahan Bakar Cair Dari Limbah Plastik Hdpe Melalui Reaksi Hidrogenasi Menggunakan Katalis Heterogen Berbasis Ni/Biochar Dari Limbah Cangkang Kelapa Sawit.

Plastic waste, particularly High Density Polyethylene (HDPE), is one of the major environmental pollutants due to its non-biodegradable nature. Converting plastic waste into liquid fuel through pyrolysis has been widely studied; however, the resulting fuel quality still requires improvement. This research aims to upgrade the liquid fuel obtained from HDPE pyrolysis through a hydrogenation reaction using a heterogeneous Ni/biochar catalyst derived from oil palm shell waste. The biochar was prepared via pyrolysis at 550 °C, activated with 2 M KOH, and impregnated with $Ni(NO_3)_2 \cdot 6H_2O$ to produce the Ni/biochar catalyst. The upgrading process was conducted at 450 °C under an H_2 pressure of 40 bar for 2 hours with catalyst variations of 1%, 3%, and 5%. The liquid product was analyzed using GC–MS, FTIR, elemental analysis, and physical property tests including density, viscosity, calorific value, and iodine number. SEM characterization revealed that the Ni/biochar catalyst exhibited a porous surface morphology with evenly distributed Ni particles, while EDS analysis confirmed a nickel content of 0.32 wt%, indicating effective impregnation of Ni on the biochar surface. The pyrolysis of 50 g HDPE yielded 60–86% liquid fraction. Hydrogenation with the Ni/biochar catalyst reduced the iodine number by 7.18%, indicating a decrease in C=C unsaturation. The upgraded fuel exhibited a density of 0.848 g/mL, viscosity of 2.248 cSt, and calorific value of 44,903 kJ/kg, approaching the properties of commercial diesel fuel. The 3% Ni/biochar catalyst provided the best performance. Therefore, Ni/biochar derived from oil palm shell waste is effective for upgrading HDPE-derived pyrolysis oil and shows potential as an environmentally friendly alternative energy solution.

Keywords: HDPE plastic waste, pyrolysis, hydrogenation, Ni/biochar, liquid fuel.