INTISARI

Sampah plastik *polypropylene* (PP) dan *low-density polyethylene* (LDPE) merupakan limbah polimer dengan kandungan energi tinggi yang berpotensi dikonversi melalui proses pirolisis. Penelitian ini bertujuan untuk mengkaji pengaruh katalis berbasis ZSM-5 (HZSM-5, Ni/ZSM-5, dan Ni–Mg/ZSM-5) serta variasi loading katalis terhadap hasil pirolisis PP dan LDPE, ditinjau dari distribusi produk, karakteristik energi, dan perilaku katalis.

Pirolisis dilakukan pada temperatur 450 °C selama 120 menit dalam atmosfer nitrogen menggunakan reaktor *fixed-bed* dengan massa plastik 50 g setiap percobaan. Produk pirolisis dianalisis untuk menentukan distribusi yield fraksi cair dan gas, nilai kalor minyak menggunakan *bomb calorimeter*, serta komposisi dan nilai kalor gas berdasarkan analisis Gas *Chromatography* (GC). Karakteristik katalis sebelum dan sesudah reaksi dianalisis menggunakan FTIR dan SEM-EDX, sedangkan kinerja energi proses dievaluasi melalui perhitungan neraca energi berbasis nilai kalor produk.

Hasil penelitian menunjukkan bahwa pada seluruh kondisi percobaan tidak terbentuk *wax*, sehingga produk pirolisis hanya terdiri dari fraksi cair dan gas. *Yield* fraksi cair berada pada kisaran 30,08–52,54%, sedangkan fraksi gas berada pada kisaran 47,46–69,92%. Nilai kalor minyak berkisar antara 45,73–47,99 MJ/kg, sementara nilai kalor gas berada pada rentang 6,63–26,21 MJ/kg *feed,* dengan PP umumnya menghasilkan gas berenergi lebih tinggi dibandingkan LDPE. Analisis FTIR menunjukkan bahwa kerangka ZSM-5 tetap stabil setelah reaksi, sedangkan SEM-EDX mengonfirmasi sebaran Ni dan Ni–Mg yang relatif homogen tanpa aglomerasi signifikan. Analisis neraca energi menunjukkan bahwa *energy recovery* total berada pada kisaran 46,97–81,04%, yang dipengaruhi oleh jenis plastik, jenis katalis, dan *loading katalis*.

ABSTRACT

Polypropylene (PP) and low-density polyethylene (LDPE) plastic wastes are polymeric materials with high energy content that can be converted through pyrolysis. This study aims to investigate the effects of ZSM-5 based catalysts (HZSM-5, Ni/ZSM-5, and Ni–Mg/ZSM-5) and catalyst loading on the pyrolysis of PP and LDPE, in terms of product distribution, energy characteristics, and catalyst behavior.

Pyrolysis was carried out at 450 °C for 120 minutes under a nitrogen atmosphere using a fixed-bed reactor with a plastic feed mass of 50 g for each experiment. The pyrolysis products were analyzed to determine the yield distribution of liquid and gas fractions, the heating value of the liquid product using a bomb calorimeter, and the gas composition and heating value based on Gas Chromatography (GC) analysis. Catalyst characteristics before and after reaction were examined using FTIR and SEM-EDX, while the energy performance of the process was evaluated through an energy balance calculation based on the heating values of the products.

The results showed that no wax was formed under all experimental conditions, resulting in pyrolysis products consisting only of liquid and gas fractions. The liquid yield ranged from 30.08 to 52.54%, while the gas yield ranged from 47.46 to 69.92%. The heating value of the liquid product was in the range of 45.73–47.99 MJ/kg, whereas the gas heating value ranged from 6.63 to 26.21 MJ/kg feed, with PP generally producing higher-energy gas than LDPE. FTIR analysis indicated that the ZSM-5 framework remained structurally stable after reaction, while SEM-EDX confirmed relatively homogeneous dispersion of Ni and Ni–Mg without significant agglomeration. Energy balance analysis showed that the total energy recovery ranged from 46.97 to 81.04%, influenced by the type of plastic, catalyst type, and catalyst loading.