

ABSTRAK

Peningkatan timbunan limbah plastik, khususnya jenis *polypropylene* (PP) dan *polyethylene* (PE), menimbulkan permasalahan lingkungan yang memerlukan teknologi pengolahan yang mampu mengurangi volume limbah sekaligus menghasilkan produk bernilai tambah. Salah satu teknologi yang berpotensi dikembangkan adalah pirolisis dengan bantuan katalis zeolit alam jenis clinoptilolite. Penelitian ini bertujuan menganalisis pengaruh variasi konsentrasi katalis zeolit clinoptilolite terhadap karakteristik minyak hasil pirolisis campuran limbah PP dan limbah PE campuran HDPE. Penelitian menggunakan metode eksperimen laboratorium dengan variasi katalis sebesar 0%, 5%, 10%, dan 15%. Proses pirolisis dilakukan pada suhu 550°C selama 120 menit menggunakan campuran limbah plastik sebanyak 2 kg dengan komposisi PP dan PE (HDPE) sebesar 50:50. Karakteristik minyak yang dianalisis meliputi volume, rendemen, densitas, viskositas, dan nilai kalor. Hasil penelitian menunjukkan bahwa peningkatan konsentrasi katalis meningkatkan volume dan rendemen minyak pirolisis. Volume tertinggi sebesar 1.365 mL dan rendemen sebesar 63,47% diperoleh pada penggunaan katalis 15%. Nilai densitas tertinggi sebesar 0,9408 g/mL diperoleh pada katalis 10%, sedangkan viskositas terendah sebesar 0,652 mm²/s diperoleh pada katalis 15%. Pengujian nilai kalor menunjukkan bahwa katalis 5% menghasilkan nilai kalor tertinggi sebesar 11.521,45 cal/g, yang mendekati karakteristik bahan bakar jenis pertalite. Hasil penelitian mengindikasikan bahwa variasi konsentrasi zeolit clinoptilolite memberikan pengaruh nyata terhadap kuantitas maupun karakteristik fisik minyak pirolisis. Penggunaan katalis 5% memberikan keseimbangan terbaik terhadap kualitas energi minyak yang dihasilkan, sedangkan katalis 15% lebih efektif dalam meningkatkan volume dan rendemen produk cair. Temuan ini menunjukkan bahwa zeolit clinoptilolite berpotensi digunakan sebagai katalis untuk meningkatkan pemanfaatan limbah plastik menjadi bahan bakar alternatif yang lebih bernilai.

ABSTRACT

The increasing generation of plastic waste, particularly *polypropylene* (PP) and *polyethylene* (PE), has become a major environmental concern that requires effective treatment technologies capable of reducing waste volume while producing value-added products. One promising approach is catalytic pyrolysis using natural clinoptilolite zeolite. This study aimed to evaluate the effect of clinoptilolite zeolite catalyst concentration on the characteristics of pyrolysis oil produced from a mixture of PP and PE (HDPE-based) plastic waste. An experimental laboratory method was employed using catalyst concentrations of 0%, 5%, 10%, and 15%. The pyrolysis process was conducted at 550°C for 120 minutes using 2 kg of mixed plastic waste with a 50:50 composition of PP and PE (HDPE). The resulting pyrolysis oil was characterized based on its volume, yield, density, viscosity, and calorific value. The results showed that increasing the catalyst concentration enhanced both the volume and yield of the pyrolysis oil. The highest oil volume (1,365 mL) and yield (63.47%) were obtained at a catalyst concentration of 15%. The highest density (0.9408 g/mL) was achieved with 10% catalyst loading, while the lowest viscosity (0.652 mm²/s) was obtained at 15% catalyst loading. The calorific value analysis indicated that the 5% catalyst concentration produced the highest heating value of 11,521.45 cal/g, which is comparable to the characteristics of commercial gasoline (Pertalite). These findings demonstrate that the concentration of clinoptilolite zeolite significantly influences both the quantity and physicochemical properties of pyrolysis oil. A catalyst concentration of 5% provided the best balance in terms of fuel quality, whereas a concentration of 15% was more effective in maximizing liquid product volume and yield. Therefore, natural clinoptilolite zeolite shows considerable potential as a catalyst for converting plastic waste into alternative liquid fuel with improved quality and production efficiency.