INTISARI

Limbah padat industri minyak kelapa sawit dan sampah plastik merupakan penyumbang utama limbah dan sampah di Indonesia. Keberadaan limbah dan sampah tersebut perlu mendapatkan perhatian ekstra agar tidak menimbulkan permasalahan lingkungan di masa yang akan datang. Pemanfaatan campuran limbah padat industri minyak kelapa sawit dan sampah plastik berpotensi menghasilkan bahan bakar dan bahan kimia melalui proses *microwave-assisted co-pyrolysis*. Dalam satu decade terakhir, penggunaan metode *co-pyrolysis* dapat memperbaiki karakteristik minyak pirolisis karena adanya sifat-sifat material yang akan saling melengkapi dalam proses pirolisis.

Penelitian ini telah melakukan pengujian karakteristik pengeringan, kinetika *microwave-assisted co-pyrolysis*, dan produktivitas *microwave-assisted co-pyrolysis* campuran limbah padat industri minyak kelapa sawit (cangkang, tandan kosong, dan serat) dan sampah plastik (PET dan LDPE). Pengujian pengeringan menggunakan oven konvensional dan *microwave* dengan variasi temperatur pengeringan 40 °C, 45 °C, 50 °C, 55 °C, 60 °C, dan 65 °C. Sedangkan pengujian kinetika *microwave-assisted co-pyrolysis* dilaksanakan menggunakan variasi campuran bahan baku (biomassa:plastik) dengan komposisi 100:0, 75:25, 50:50, 25:75, dan 0:100, serta variasi daya keluaran *microwave* sebesar 150 W, 300 W, 450 W, 600 W, dan 800 W. Sebagai parameter yang tetap, proses *microwave-assisted co-pyrolysis* dikarakterisasi menggunakan *fixed bed reactor* dengan kondisi: suhu *pyrolysis* 500 °C, laju alir nitrogen 2 l / menit, dan *holding time* 180 menit. Selanjutnya, produk cair *microwave-assisted co-pyrolysis* diuji menggunakan metode GC-MS untuk mengetahui unsur senyawa penyusunnya.

Hasil penelitian menunjukkan bahwa pengeringan dengan oven *microwave* memberikan efektivitas yang lebih tinggi dan tidak ditemukan perbedaan struktur pori produk pengeringan apabila dibandingkan dengan pengeringan menggunakan oven konvensional. Daya keluaran *microwave* dan jenis bahan baku berpengaruh pada karakteristik kinetika dan hasil produksi *microwave-assisted co-pyrolysis*. Metode *microwave-assisted co-pyrolysis* akan berjalan optimal pada penggunaan daya keluaran 450 W, 600 W, dan 800 W. Sementara, produksi produk cair mencapai nilai maksimum pada komposisi campuran 75% biomassa dan 25% plastik, dengan indikasi semakin banyak kandungan plastik (PET atau LDPE) akan cenderung menyebabkan semakin tingginya persentase produk gas. Penggunaan bahan baku campuran biomassa dan PET akan menghasilkan persentase produk padat tertinggi pada penggunaan daya *microwave* 450 W, dihasilkan produk cair dengan persentase tertinggi pada penggunaan daya *microwave* 800 W, dan didapatkan produk gas dengan persentase tertinggi pada daya *microwave* 600 W. Penggunaan campuran biomassa dan LDPE akan menghasilkan persentase produk padat tertinggi pada daya *microwave* 450 W, produk cair mencapai persentase tertinggi pada daya *microwave* 600 W, dan diperoleh produk gas dengan nilai persentase tertinggi pada daya *microwave* 800 W. Pada pengamatan terhadap campuran bahan baku antara biomassa dan PET didapatkan bahwa produk cair yang diperoleh didominasi oleh senyawa turunan *benzene* (asam benzoat dan phenol) dengan produk sampingan karbon rantai pendek seperti asetaldehid dan asam asetat. Sedangkan untuk campuran biomassa dan LDPE diperoleh produk cair dalam bentuk asam asetat dan phenol dengan sisa berupa *impurities* berkadar di bawah 1%.

Kata kunci: biomassa, *co-pyrolysis*, kinetika, *low-density polyethylene*, *microwave*, *polyethylene terephthalate*.

ABSTRACT

Solid waste of palm oil industry and plastic waste are the main contributors to waste in Indonesia. Its existence needs extra attention as not to cause environmental problems in the future. The utilization of a mixture of solid palm and plastic waste has the potential to produce fuel and chemicals through microwave-assisted co-pyrolysis process. Within last decade, co-pyrolysis method is expected to improve the characteristic of pyrolysis oil because of the material properties that complement each other in the process.

The research tests the drying characteristics, kinetics, and productivity of microwave-assisted co-pyrolysis of a mixture of solid palm oil industry waste (shells, empty bunches, and fibers) and plastics (PET and LDPE) waste. Drying tests are using conventional and microwave oven with drying temperature variations of 40 ºC, 45 ºC, 50 ºC, 55 ºC, 60 ºC, and 65 ºC. Meanwhile, the co-pyrolysis kinetics test is performed using a variety of raw material mixtures with composition of solid-palm-waste: plastic of 100: 0, 75: 25, 50: 50, 25: 75, and 0: 100, as well as variation of the microwave output power of 150 W, 300 W, 450 W, 600 W, and 800 W. In addition, as a fixed parameter, the microwave-assisted co-pyrolysis process was characterized using a fixed bed reactor with the following conditions: pyrolysis temperature of 500 ºC, nitrogen flow rate of 2 l/minute, and holding time of 180 minutes. Furthermore, the liquid product from co-pyrolysis is tested using GC-MS method to determine the elements of its constituent compounds.

The result shows that using microwave oven for drying give higher effectiveness and no difference in the pore structure of the drying product when compared to conventional oven. In addition, the output power of microwave and the type of raw material affects the kinetic characteristics and yields of co-pyrolysis. The microwave-assisted co-pyrolysis will run optimally at output power of 450 W, 600 W, and 800 W. The liquid products production reaches maximum value at a mixture of 75% biomass and 25% plastic, with indication that the more plastic content (PET or LDPE) will cause the more gas products percentage. Observation on raw materials mixture of biomass and PET will be producing highest percentage of solid products at 450 W, of liquid products at 800 W, and of gas products at 600 W microwave output power, respectively. In addition, observation on the use of mixture of biomass and LDPE will get the highest percentage of solid products at 450 W, liquid products at 600 W, and gas products at 800 W microwave output power, respectively. Finally, in the observation on the use of mixture of solid palm waste and PET, noticed that the liquid products obtained are dominated by benzene derivatives (benzoic acid and phenol), also short chain carbon by products such as acetaldehyde and acetic acid. Meanwhile, for mixture of solid palm waste and LDPE, liquid products are obtained in the form of acetic acid and phenol with impurities residue below 1%.

Keywords: biomass, solid palm waste, co-pyrolysis, kinetics, low-density polyethylene, microwave, polyethylene terephthalate.