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Characteristics of products from fast pyrolysis of fractions of waste square timber and ordinary plywood using a fluidized bed reactor

Su-Hwa Jung, Seon-Jin Kim, Joo-Sik Kim *

Department of Energy and Environmental System Engineering, Univ. of Seoul, 90 Jeonnong-Dong, Dongdaemun-Gu, Seoul 130-743, Republic of Korea

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ABSTRACT

Fractions of waste square timber and waste ordinary plywood were pyrolyzed in a pyrolysis plant equipped with a fluidized bed reactor and a dual char separation system. The maximum bio-oil yield of about 65 wt.% was obtained at reaction temperatures of 450–500 °C for both feed materials. For quantitative analysis of bio-oil, the relative response factor (RRF) of each component was calculated using an effective carbon number (ECN) that was multiplied by the peak area of each component detected by a GC-FID. The predominant compounds in the bio-oils were methyl acetate, acids, hydroxyacetone, furfural, non-aromatic ketones, levoglucosan and phenolic compounds. The WOP-derived bio-oil showed it to have relatively high nitrogen content. Increasing the reaction temperature was shown to have little effect on nitrogen removal. The ash and solid contents of both bio-oils were below 0.1 wt.% due to the excellent performance of the char separation system.

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1. Introduction

Lignocellulosic biomass has recently been considered for its potential as a source of clean energy (zero net CO_2) that may help address fossil fuel shortages and climate change. Technologies have been developed to convert biomass into useful fuels and other resources, primarily by biochemical and thermochemical conversion. Bioethanol can be produced through the biochemical conversion of starch-based biomass, but the enzymatic and fermentative conversion of lignocellulosic biomass is not yet economically feasible (Boateng et al., 2007). The thermochemical conversion processes, however, can cost effectively produce fuels or other chemicals from lignocellulosic biomass. Pyrolysis, a thermochemical conversion process, has attracted attention as a promising method of producing bio-oil, which is a mixture of organic compounds that can be used as fuel oil or chemical. Fast pyrolysis is a subset of the conversion process that yields more bio-oil than conventional pyrolysis through providing a higher heating rate and short residence time of pyrolysis gas in the reactor. There have been extensive researches on fast pyrolysis of various biomass types for the production and analysis of bio-oil (Abdullah and Gerhauser, 2008; Azeez et al., 2010; Luo et al., 2004; Lee et al., 2005; Mullen and Boateng, 2008; Oasmaa et al., 2003; Tsai et al., 2006; Yanik et al., 2007; Zhang et al., 2009). These researches reveal that the physical and chemical characteristics of bio-oil depend greatly on reactor type, reaction temperature, heating rate and the chemical nature of biomass.

About 1.5 million tons of construction wood wastes, typically including square timber and plywood, are generated annually in South Korea. Historically, construction wood wastes have been disposed of in landfills, recycled or incinerated, although a portion of wood wastes are not readily treatable for their paint, oil or resin content. Generally, plywood contains nitrogen-containing resins, such as melamine or urea resins, which through combustion are emitted as NOx, an environmental pollutant. A few researches on the pyrolysis of wood wastes containing such resins have been carried out using a small tubular reactor (Girods et al., 2008; Nakai et al., 2007).

In this study, samples of waste square timber (WST) and waste ordinary plywood (WOP) were pyrolyzed in a bench-scale pyrolysis plant equipped with a fluidized bed reactor, dual char-separation system, quenching system and gas circulation system. The aim of this study was to find out the effects of various reaction parameters (reaction temperature, feed rate, flow rate and fluidizing medium) on the yield of the pyrolysis products, namely bio-oil, gas and char. Each of the pyrolysis products was analyzed using various instruments to investigate the chemical property. In particular, it is very difficult to quantitatively analyze the components of bio-oil. Most of researches reported the GC-detectable components only via area percentage of each peak, which had limitation on the reliable quantitation of bio-oil (Li et al., 2007; Lu et al., 2011; Smets et al., 2011). For a more accurate analysis of bio-oil with a GC, relative response factor (RRF) for each component can be applied. The RRF is the expected ratio of an analyte to a reference. The effective

* Corresponding author. Tel.: +82 2 2210 5621; fax: +82 2 2244 2245.
E-mail address: joosik@uos.ac.kr (J.-S. Kim).

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