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Influence of a glass wool hot vapour filter on yields and properties of bio-oil derived from rapid pyrolysis of paddy residues

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ABSTRACT

This article reports experimental results of rapid or fast pyrolysis of rice straw (RS) and rice husk (RH) in a fluidised-bed reactor unit incorporated with a hot vapour filter. The objective of this research was to investigate the effects of pyrolysis temperatures and the use of glass wool hot vapour filtration on pyrolysis products. The results showed that the optimum pyrolysis temperatures for RS and RH were 405 and 452 °C, which gave maximum bio-oil yields of 54.1 and 57.1 wt.% on dry biomass basis, respectively. The use of the hot filter led to a reduction of 4–7 wt.% bio-oil yield. Nevertheless, the glass wool hot filtered bio-oils appeared to have better quality in terms of initial viscosity, solids content and ash content than the non-filtered ones.

1. Introduction

Biomass can be converted to energy via thermochemical conversion processes, such as direct combustion, pyrolysis and gasification (Bridgwater, 2003). As one of the thermochemical processes, fast or rapid pyrolysis is a promising tool for providing bio-oil that can be used as fuel or chemical feedstock. In rapid pyrolysis, biomass decomposes very quickly to generate mostly vapours and aerosols together with some char and gas. After cooling and condensation, a dark brown homogenous mobile liquid is formed which has a heating value about half that of conventional fuel oil. A high yield of liquid is obtained with most biomass feeds low in ash (Bridgwater, 2012).

Rice is the seed of the monocot plants *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most important staple food for a large part of the world's human population, especially in East Asia, Southeast Asia, South Asia, the Middle East, and the West Indies. Thailand is one of the world's biggest rice producers, with paddy output of 34.5 million tonnes in 2010. This corresponds to the amount of the paddy residues of approximately 30 million tonnes per year. The paddy residues include rice straw and rice husk. The straw is normally burnt in the fields and is not efficiently used for energy and only small part of it is used as a compost and animal feed. The rice husk is used as solid fuel for household heating. By applying rapid pyrolysis or co-pyrolysis (Yuan et al., 2012) technology to rice straw and rice husk for bio-oil production, the advantage that could be gained is not only on the fuel value aspect, but also on the environmental aspect.

Rapid or fast pyrolysis of rice straw (RS) and rice husk (RH) has been previously investigated using a fluidised-bed reactor with and without a hot vapour filter (Chen et al., 2011; Guo et al., 2011; Jung et al., 2008; Lee et al., 2005; Yanik et al., 2007; Zheng, 2007). Different groups of researchers reported different maximum bio-oil yields and different optimum pyrolysis temperatures. According to Jung et al. (2008), Lee et al. (2005) and Yanik et al. (2007), fast pyrolysis of rice straw gave maximum bio-oil yields in the range of 41–68 wt.% at optimum pyrolysis temperatures in the range of 412–500 °C. Chen et al. (2011), Guo et al. (2011) and Zheng (2007) reported that the maximum rice husk bio-oil yields and the corresponding optimum pyrolysis temperatures were in the range of 39.5–56 wt.% and 465–520 °C, respectively. The maximum bio-oil yields and the optimum pyrolysis temperatures for both biomass residues found by different research groups were different due to the differences in other parameters such as biomass composition, reactor configuration and process parameters such as the type and flow rate of carrier gas, heat transfer, biomass feed rate, vapour residence time and the use of hot vapour filtration. Among the parameters, the use of hot filtration is of great interest because of its high potential for improving the quality of bio-oil in terms of solids and ash contents, viscosity and stability. In the previous studies of rice straw fast pyrolysis in fluidised-bed reactor, Jung et al. (2008) and Lee et al. (2005) applied ceramic filter candles for hot vapour filtration. However, they did not investigate the effect of the hot filter on bio-oil production. In other words,

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