



Pyrolysis of high-ash sewage sludge in a circulating fluidized bed reactor for production of liquids rich in heterocyclic nitrogenated compounds

Wu Zuo, Baosheng Jin*, Yaji Huang, Yu Sun, Rui Li, Jiqiang Jia

Ministry of Education of Key Laboratory of Energy Thermal Conversion and Control, School of Energy and Environment, Southeast University, Nanjing 210096, China

HIGHLIGHTS

- ▶ A circulating fluidized bed reactor was used for pyrolysis of sewage sludge with a high ash content.
- ▶ The pyrolysis liquid contained large amounts of heterocyclic nitrogenated compounds.
- ▶ Hydrocarbon cracking was promoted by long solid retention times and high ash contents.
- ▶ Heterocyclic nitrogenated compounds could be refined as chemical feedstock.

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ABSTRACT

A circulating fluidized bed reactor was used for pyrolyzing sewage sludge with a high ash content to produce liquids rich in heterocyclic nitrogenated compounds. GC/MS and FTIR analyses showed that heterocyclic nitrogenated compounds and hydrocarbons made up 38.5–61.21% and 2.24–17.48% of the pyrolysis liquids, respectively. A fluidized gas velocity of 1.13 m/s, a sludge feed rate of 10.78 kg/h and a particle size of 1–2 mm promoted heterocyclic nitrogenated compound production. Utilizing heterocyclic nitrogenated compounds as chemical feedstock could be a way for offsetting the cost of sewage sludge treatment.

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1. Introduction

At present, China produces more than 50,000 t sewage sludge per day that have to be disposed of. Pyrolysis is a possible way of converting some of the sludge into useful chemicals (Park et al., 2010). Shen and Zhang (2003) pyrolyzed sewage sludge in a fluidized bed reactor with a diameter of 50 mm and obtained a pyrolysis oil yield of 30 wt.% of sludge fed at 525 °C. The authors found that secondary cracking reactions became significant when the temperature was increased above 450 °C at short retention times. Others (Cao et al., 2011; Fonts et al., 2008; Park et al., 2008) reported on pyrolysis using fluidized bed reactors and sewage sludge that contained a high content of volatile matters (especially lipids) which may promote the oil production. These authors achieved production of high heating value bio-oil from sewage sludge with ash content ranged from 20–40 wt.% of sludge fed.

Sewage sludge can lead to the production of nitrogenated compounds in the pyrolysis liquid (Cao et al., 2011; Fairous et al., 2010;

Pognani et al., 2011), and Parnaudeau and Dignac (2007) indicated that pyrrolidine and piperidinone may be derived from asparagine-containing peptides in the sewage sludge.

The main goal of the present research was to retrieve liquids generated from pyrolysis of sewage sludge with a high ash content from a continuous CFB pyrolysis reactor. In order to improve the concentration of heterocyclic nitrogenated component in the pyrolysis liquid, the influence of sludge particle size, sludge feed rate and fluidized gas speed on the composition of pyrolysis liquid were investigated by FTIR and GC–MS.

2. Methods

2.1. Raw material

The sewage sludge was collected from a sewage water treatment facility located in Jurong, China. The sludge (80% moisture) was dried in a fluidized bed, in order to convert the sludge to granules with a diameter of 0.5–2 mm. Table 1 shows the characteristics of the JuRong sewage sludge (JRSS) after drying.

* Corresponding author. Tel.: +86 25 8379 4744; fax: +86 25 8379 5508.

E-mail addresses: zuow0319@126.com (W. Zuo), bsjin@seu.edu.cn (B. Jin).