



The kinetics model and pyrolysis behavior of the aqueous fraction of bio-oil

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HIGHLIGHTS

- The pyrolysis characteristics of the aqueous fraction of bio-oil are studied.
- The pyrolysis of aqueous fraction of bio-oil can be divided into three stages.
- The most probable mechanism functions and kinetics model were finally obtained.
- Comparison of the calculated value and the experimental results was performed.

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ABSTRACT

The pyrolysis behavior and kinetics of the aqueous fraction of bio-oil were studied through thermogravimetric (TG) analysis. Based on the experimental data, activation energies and kinetic parameters were calculated by the Achar differential method and the Coats–Redfern integral method, then the most probable mechanism functions and kinetics model were obtained at last. The results show that the pyrolysis of bio-oil aqueous fraction can be divided into three stages, that is, the volatilization of volatile fractions, the decomposition stage of heavy fractions and char combustion. The experimental results show that the activation energy of volatilization is higher than that of the decomposition stage. The first stage was expressed as the first order reaction and the second stage the second order reaction. The correlation coefficient between the two stages illustrates that the reactions are in well conformity with each other and the calculated value of conversion is consistent with the experimental results.

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1. Introduction

Bio-oils refer to the complex mixtures of oxygenated organic compounds including water, carbonaceous materials and structured compounds (Bridgwater, 1999; Mullen and Boateng, 2008; Medrano et al., 2011). They can be separated into oil phase and aqueous phase by adding water. The aqueous phase consists of carbohydrate-derived compounds and light oxygenated compounds (Azad et al., 2012). Due to the lack of fossil fuel resources and the growing greenhouse effect, the utilization of bio-oil as a potential fuel substitute can satisfy the human society's need for energy with wide application prospect (Chen et al., 2011; Garcia et al., 2000; Rioch et al., 2005; Huber and Dumesic, 2006; He et al., 2012). Bio-oil can be used as low level fuels to provide heat or generate power (Czernik and Bridgwater, 2004; Chiaramonti et al., 2007), or used in internal engine after upgrade (Xu et al., 2008; Du et al., 2009).

The pyrolysis of bio-oil is the initial stage of its combustion and gasification, so it is related to the thermal chemical use of bio-oil and the in-depth investigation of pyrolysis kinetics of bio-oil is of vital importance. Many systematic studies have been done on the pyrolysis characteristics and kinetics of bio-oil as well as its compounds (Yahya and Ihsan, 2002). However, the pyrolysis characteristics of crude bio-oil components have represented some issues such as coke formation and low heating value. So far, although many studies (Strenziok and Kinstner, 2001; Kok, 2012; Branca et al., 2005a,b, 2006; Shahla et al., 2012) have been reported, the fundamentals relative to the pyrolysis of bio-oil have not been fully understood. Additionally, great interest has been addressed to the utilization of bio-oil aqueous fraction and the kinetics pyrolysis model of bio-oil aqueous fraction has rarely been studied.

So the chief objectives of this study are concerned with the pyrolysis characteristics and kinetics aiming at providing some meaningful data for the design as well as the optimization of the related gasification and combustion reactor.

Thermal analysis of water soluble components in bio-oil, which is made from stalks waste and conducted under air atmosphere, as well as the effects of heating rate on pyrolysis and combustion

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