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Online evolved gas analysis by Thermogravimetric-Mass Spectroscopy for thermal decomposition of biomass and its components under different atmospheres: Part I. Lignin

Dekui Shen [a], Jun Hu [a], Rui Xiao [a,*], Huiyan Zhang [a], Shefeng Li [b], Sai Gu [c]

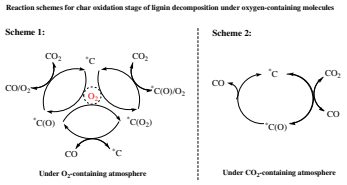
[a] Key Laboratory of Energy Thermal Conversion and Control of Ministry of Education, School of Energy and Environment, Southeast University, Nanjing 210096, China
[b] China City Environment Protection Engineering Limited Company, Wuhan 430071, China
[c] Centre for Renewable Energy, School of Engineering, Cranfield University, Cranfield, Bedfordshire MK43 0AL, United Kingdom

HIGHLIGHTS

- The first mass loss stage was not significantly influenced by oxidative atmospheres.
- Gas evolution profiles were in accordance with the DTG curves.
- Ratio of CO/CO_2 at the second evolution peak was declined with oxygen concentration.
- The second mass loss stage under CO_2 gave a high activation energy of 514.9 kJ/mol.

GRAPHICAL ABSTRACT

Reaction schemes for char oxidation stage of lignin decomposition under oxygen-containing molecules.



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ABSTRACT

Thermogravimetric-Mass Spectroscopy (TG-MS) study on lignin decomposition under different (oxygen-containing) atmospheres was carried out to investigate thermal performance of lignin during pyrolysis, oxidative gasification, oxy/fuel combustion and CO_2 gasification. Only one significant mass loss stage was observed for lignin decomposition under helium (He), while another stage, representing char oxidation, appeared under oxygen and CO_2 conditions. No significant variation of the activation energy was presented for the first pyrolysis stage under different atmospheres (from 40.4 to 53.2 kJ/mol). A much higher temperature was required for char oxidation under CO_2 than those under O_2 atmospheres, giving the activation energy of 541.9 kJ/mol as compared to around 160 kJ/mol for O_2-containing atmospheres. The evolution profiles of CO and CO_2 under different atmospheres were in good accordance with the DTG curves regardless of atmospheres.

1. Introduction

Thermo-chemical processes including pyrolysis, gasification and hydrogenolysis have great potential for the production of bio-materials, bio-chemicals, fuel from biomass. Lignin is one of the most abundant constituents in biomass, accounting for about 20–30% of the weight of biomass. Lignin is also a major by-product from pulping processes and can be used as feedstock to produce energy, fuels and bio-chemicals through thermal conversion (Jakab et al., 1995).

Thermal degradation of lignin, has been investigated using coupled pyrolysis techniques e.g. Py-GC/MS and Py-MS (Evans et al., 1986; Faix et al., 1987; Shen et al., 2010; Yang et al., 2010) and thermal analysis methods e.g. DTA, DSC, TG-FTIR, TG-MS (Avni and Coughlin, 1985; Theander, 1985; Jakab et al., 1997; Ferdous et al., 2002; Liu et al., 2008; Yang et al., 2010; Sanchez-Silva et al., 2012). The distribution of monomeric and dimeric degradation products of lignin with a mass of up to 500 Da were examined through Py-GC/MS and Py-MS, considering effects of temperatures,

* Corresponding author. Tel.: +86 25 8379 5726; fax: +86 25 8379 5508.
E-mail addresses: ruixiao@seu.edu.cn, 101011398@seu.edu.cn (R. Xiao).

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