Bioresource Technology 267 (2018) 54–62

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Kinetic analyses and synergistic effects of CO_2 co-gasification of low sulphur petroleum coke and biomass wastes

Elbager M.A. Edreis[a,b,c], Xian Li[a,d,*], Guangqian Luo[a], S.W. Sharshir[a,e], Hong Yao[a]

[a] State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology, Wuhan, Hubei 430074, China
[b] Department of Mechanical Engineering, Faculty of Engineering, University of Blue Nile, Roseires, Sudan
[c] Department of Mechanical Engineering, Alsalama College of Sciences & Technology (ACST), Khartoum Bahri, Sudan
[d] Key Laboratory of Coal Clean Conversion and Chemical Process Autonomous Region, College of Chemistry and Chemical Engineering, Xinjiang University, Urumqi 830000, Xinjiang, China
[e] Mechanical Engineering Department, Faculty of Engineering, Kafrelsheikh University, Egypt

ARTICLE INFO

Keywords:
Low sulphur petroleum coke
Biomass wastes
Co-gasification
Synergistic effect
Reactivity

ABSTRACT

This study presents thermogravimetric analyses (TGA) of CO_2 co-gasification of petroleum coke with low sulphur (PC) and various types of biomass wastes including agricultural (rice husk (RH), rice stalk (RS) and cotton straw (CS)) and by-product wastes (saw dust (SD) and sugar cane bagasse (SCB)). Their reactivities, synergistic effect and kinetics were studied and compared in detail. The homogeneous model (HM) and shrinking core models (SCM) were applied to estimate the kinetic parameters. The results indicated that obvious synergistic effect was observed during the co-gasification of the blends. The PC gasification reactivity was significantly improved by the addition of biomass wastes. The model of R2 was found to be most suitable for the co-gasification. The activation energy of PC was decrease from 293.72 kJ/mol to117.04 kJ/mol by the addition of SD. The co-gasification of PC and biomass waste is a promising way for the efficient utilization of PC and biomass wastes.

1. Introduction

Over the last few periods, biomass energy has attracted an increasing interest as it is an environmental friendly and renewable energy resource to alleviate the shortage of fossil energy and reduce the potential environmental impact of fossil fuels (Chen et al., 2017; Edreis et al., 2014; Emami-Taba et al., 2013; Fu et al., 2011; Zhu et al., 2016, 2017a,b). Sudan, as the largest agricultural country in Africa, has a great amount of biomass wastes. However, due to the lack of technological these wastes are used in a traditional way by burning directly to produce thermal energy for cooking purposes and other uses.

Petroleum coke (PC) has advantages of high calorific value and low ash content for the utilization as fuel and chemicals. However, it has a very low reactivity due to its aromatic nature (Edreis et al., 2014; Nemanova et al., 2014). It is well known that the aromatic carbon atoms are less reactive than aliphatic carbons. This cause a severe gasification condition such as high temperature and long reaction time (Edreis et al., 2013, 2014). Besides, it is well known that the high sulphur content is another disadvantage for the PC utilization as fuel. But the Sudanese PC has rather low sulphur content.

It is believed that the gasification is promising technology for converting the heavy oil residue PC and biomass into valuable synthetic gas (Edreis et al., 2017; Edreis and Yao, 2016; Huo et al., 2014; Nemanova et al., 2014). The co-gasification of PC and biomass is found to be a good choice to effectively convert them to syngas (Edreis et al., 2013, 2014; Nemanova et al., 2014). Because the biomass gasification produces much H_2O, CO_2 and other volatiles, which are the agents for the PC gasification and can promote the PC gasification effectively (Edreis et al., 2013; Edreis et al., 2014). Besides, the minerals in biomass, such as potassium and sodium, can be a catalyst for promoting the PC gasification (Edreis et al., 2013, 2014; Yan et al., 2018). This is the so-called synergistic interactions.

The synergistic interactions during conversion of the combining fuels such as coal or PC with biomass have been investigated by several authors (Edreis et al., 2013, 2014). The synergistic effect between coal or PC and biomass during the thermal co-process was observed by some researchers (Aboyade et al., 2012; Edreis et al., 2013, 2017, 2014; Fermoso et al., 2010a,b; Haykiri-Acma and Yaman, 2007; JuntaoWei et al., 2017; Sadhukhan et al., 2008; Wei et al., 2017b; Wu et al., 2017). On the other hand, negative synergistic effect was reported by others

* Corresponding author at: State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology, Wuhan, Hubei 430074, China.
E-mail address: xian_li@hust.edu.cn (X. Li).

https://doi.org/10.1016/j.biortech.2018.06.089
Received 30 April 2018; Received in revised form 20 June 2018; Accepted 21 June 2018
Available online 28 June 2018
0960-8524/