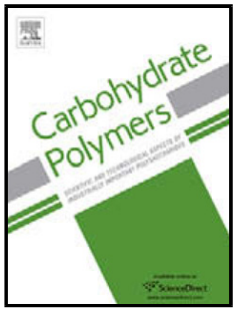

Title: Pyrolytic and Kinetic Characteristics of *Platycodon Grandiflorum* Peel and its Cellulose Extract

Author: Hong-Wei Qiu Quan-Cheng Zhou Jie Geng

PII: S0144-8617(14)00931-X
DOI: http://dx.doi.org/doi:10.1016/j.carbpol.2014.09.034
Reference: CARP 9291

To appear in:

Received date: 25-4-2014
Revised date: 4-9-2014
Accepted date: 6-9-2014

Please cite this article as: Qiu, H.-W., Zhou, Q.-C., and Geng, J.,Pyrolytic and Kinetic Characteristics of *Platycodon Grandiflorum* Peel and its Cellulose Extract, *Carbohydrate Polymers* (2014), http://dx.doi.org/10.1016/j.carbpol.2014.09.034

Pyrolytic and Kinetic Characteristics of *Platycodon Grandiflorum* Peel and its Cellulose Extract

Hong-Wei Qiu[a], Quan-Cheng Zhou[b,*] Jie Geng[b],

[a] School of Food Science and Engineering, Qingdao Agricultural University, Zibo, 255049 China

[b] School of Agricultural Engineering and Food Science, Shandong University of Technology, Zibo, 255049 China

Abstract - The pyrolytic and kinetic characteristics of a biomass waste material, namely *Platycodon grandiflorum A. DC* (*P. G.*) peel and its cellulose extract were studied at heating rates of 10, 30 and 50 °C min^{-1} under a nitrogen flow atmosphere. The most probable mechanism function and activation energy pre-exponential factors were calculated by using the Popescu, FWO and KAS methods. The three stages appeared during pyrolysis include: moisture evaporation, primary devolatilization and residual decomposition. Significant differences in the average activation energy, thermal stability, final residuals and reaction rates of the *P. G.* peel and its cellulose extract were observed. Stage II of the *P. G.* peel and its cellulose extract could be described by the function Avrami-Erofeev $[-\ln(1-\alpha)]^3$ and the function Chemical reaction $(1-\alpha)^{-0.5}$, respectively. The average activation energy of *P. G.* peel and its cellulose extract were 157 and 196 kJ mol^{-1}, respectively. Kinetic compensation effects of the pre-exponential factors and activation energy were also observed.

Keywords: p*latycodon grandiflorum* peel, cellulose, pyrolysis, kinetics

*: Corresponding author: Quan-Cheng Zhou Phone: +86-0533-2786382. Fax: +86-0533-2786382. E-mail: zhouquancheng@126.com

1. Introduction

Platycodon grandiflorum A. DC (P.G.) has been used as either a food material or a traditional oriental medicine in China and Korea, such as for treating cough, phlegm, sore throat, hyperlipidemia, hypertension and diabetes. As a sustainable and clean bio-energy resource, P.G. has great potential for its high carbohydrate content (about 50% of the total weight) and the major carbohydrate is oligosaccharide that is utilized to produce ethanol (He, et al., 2005; Zhou, 2011). In addition, the plant area of P.G. is about 13 million m^2 and the amount of wasted P.G. peels is 200 tons (http://www.cu-market.com.cn/hgjj/2010-8-31/14253045.html). Huge amounts of *P.G.* peels are discarded as useless residues, which caused not only the environmental pollution but also a waste of bio-resource.

Bio-oil and chemical products can be extracted from the residues of pyrolysis (Cornelia, et al., 2011). But the carbonhydrate composition and form have a strong effect on pyrolytic reaction and behavior (Korkut, 2010; Cai & Bi, 2009). So both the development of the pyrolytic process and pyrolytic reactor design require complete elucidation of the pyrolytic mechanism.

Cellulose is the most abundant polymer on the earth (Korkut, 2010; Cai & Bi, 2009). Understanding the cellulose thermal degradation is of great importance in a vast array of areas such as generation of energy from biomass and the improvement in flame retardants of cellulosic fibers (Cai & Bi, 2009; He, Yi & Sun, 2002; Li, et al., 2010; Luis & Noureddine, 2010; Matheus, et al., 2010). Although extensive research focusing on cellulose pyrolysis, especially research on the effects of chemicals and different pretreatment on cellulose pyrolysis have been conducted (Dorez, et al., 2014; Lédé, 2012; Matsuoka, Kawamoto, & Saka, 2014; Shaik, Sharratt, & Tan, 2013; Wei, et al., 2014), it is not yet fully understood on pyrolytic process and kinetics model of *P. G.* peel and cellulose extract. Besides, it is not well introduced on the application of differential thermal and thermo-gravimetric analyses to cellulose and its derivatives.

Thermogravimetric (TG) analysis is a widely used technique in this area (Li, et al., 2010; Matheus, et al., 2010). It is useful for the thermal characterization of both inorganic and organic materials, including polymers (such as cellulose) (Luis & Noureddine, 2010; Raveendran, Ganesh & Khilar, 1996). It provides quantitative results regarding the loss of mass as a function of increasing temperature or time. Moreover, TG provides basic information on the thermal properties of the material and its composition. The first derivative thermogravimetry (DTG) can be used to investigate the differences among TG curves (Matheus, et al., 2010).