PREPARATION OF HIGH SURFACE AREA ACTIVATED CARBON FROM CHEMICAL ACTIVATION WITH BAMBOO CONSTRUCTION WASTE AND PHOSPHORIC ACID

Ken S.T. Lau[1], John. P. Barford and Gordon M[c]Kay

Department of Chemical Engineering,

Hong Kong University of Science and Technology,

Clear Water Bay, Kowloon,

Hong Kong SAR, China

Corresponding author e-mail address: 1 keken@ust.hk

Introduction

Bamboo cane, indigenous to Hong Kong and China, as a sustainable product and a waste material is a useful material for construction and it is widely used in Hong Kong and China as scaffolding in construction and building projects. However, over 50,000 tonnes of bamboo scaffolding waste is disposed as landfill waste each year. Nevertheless, these wastes can be used as raw materials for the production of a range of high value added activated carbons. The bamboo cane can be heated (charred) at a high temperature in the presence of selected activation chemicals to produce activated carbons for various applications e.g. adsorbents, catalysts or catalyst supports.

A challenge in the field of activated carbon production is to produce specific materials with a given pore size distribution from low cost precursors and at low temperature. There are commonly two types of activation process for the preparation of activated carbon, namely chemical and physical. The advantage of chemical activation over physical activation is the lower activation temperature. Phosphoric acid activation of lignocellulosic materials is a conventional preparation method for activated carbon [1]. The precursor is impregnated with a solution of phosphoric acid, heat treated up to about 600+/-10^{o}C, and washed with water to extract the excess acid. Phosphoric acid induces important changes in the pyrolytic decomposition of the lignocellulosic materials since it promotes depolymerization, dehydration and redistribution of constituent biopolymers [2]. So far, few researchers have prepared bamboo carbon, they usually use conventional high temperature physical methods e.g. solely carbonization that obtained a BET N_2 surface areas up to 491m^2/g [3], Steam activation obtained a BET N_2 surface area up to 1038m^2/g [4-6].

This paper describes the preparation and investigation of high BET N_2 surface area activated carbons from scrap construction bamboo by low temperature chemical activation. The findings from this research are very useful as an indicator for the potential application of the novel bamboo based activated carbon.

Experimental

In this research, the raw bamboo, before activation has been washed and sieved to (500-710μm) unless otherwise specified. This raw material has been pretreated by soaking and saturating with ortho-phosphoric acid (H_3PO_4) at different acid to bamboo ratio (Xp) in alumina containers. The mixture has been stirred thoroughly to ensure homogenous mixing of the bamboo and H_3PO_4. Then the samples were subjected to a two step heat treatment at 150°C and 400°C or 600°C, before they were cooled, washed and dried for further analysis and characterization. The benefits of the low temperature reaction treatment phase will be discussed and the mechanism will be proposed for this region. The results will be compared with the more conventional one step high temperature phosphoric acid process.

Results and Discussion

The preliminary analyses and characterization of the samples include the measurement of surface area, pore size distribution, elemental analysis (CHNS) and methylene blue equilibrium capacity.

From Fig. 1, there is a clear trend showing the increase of BET surface area from 227m^2/g to 2517m^2/g with the increase of acid to bamboo ratio (Xp) from 0 to 2.41. Even though limited data have been shown for the second stage temperature effect, it is still conclusive to comment that with lower temperature (400°C), the BET surface area is lowered to740 m^2/g from 1082 m^2/g of 600°C at Xp = 0.48.

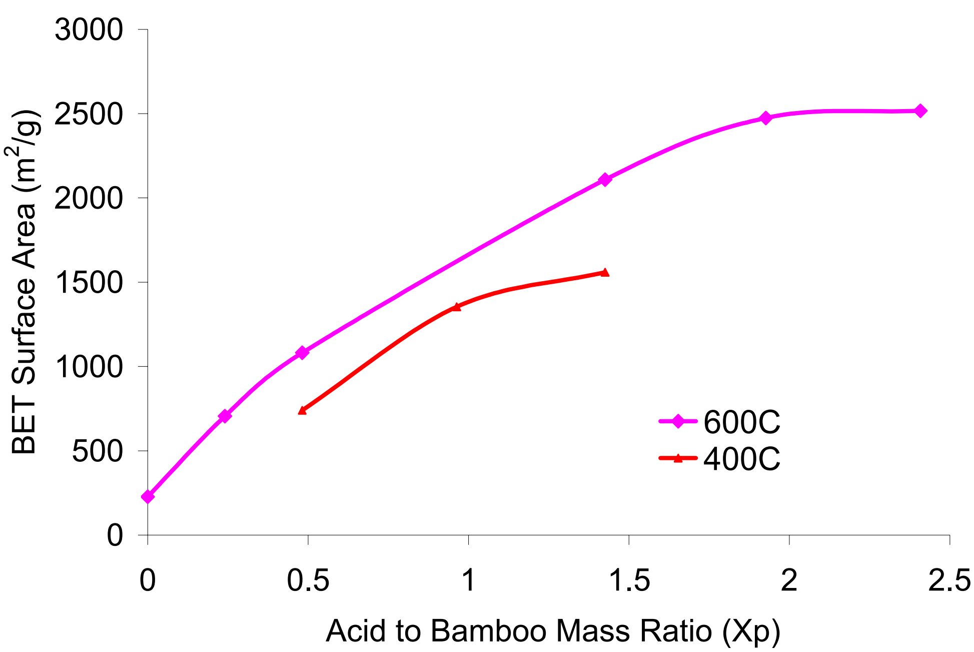

Fig. 1. BET Surface Area Vs Xp

The BET surface areas and the pore volume fractions have been correlated with the Acid : Bamboo mass ration (Xp).

In addition, Fig. 2 and Fig.3 suggested the major pore contribution of the surface area in the low mesopore range (<10nm) with relatively high pore volume (>1.3cc/g). An interesting observation is the trend of increasing Xp with the increase of total pore volume, but an optimum micropore volume occurs at Xp = 0.48.

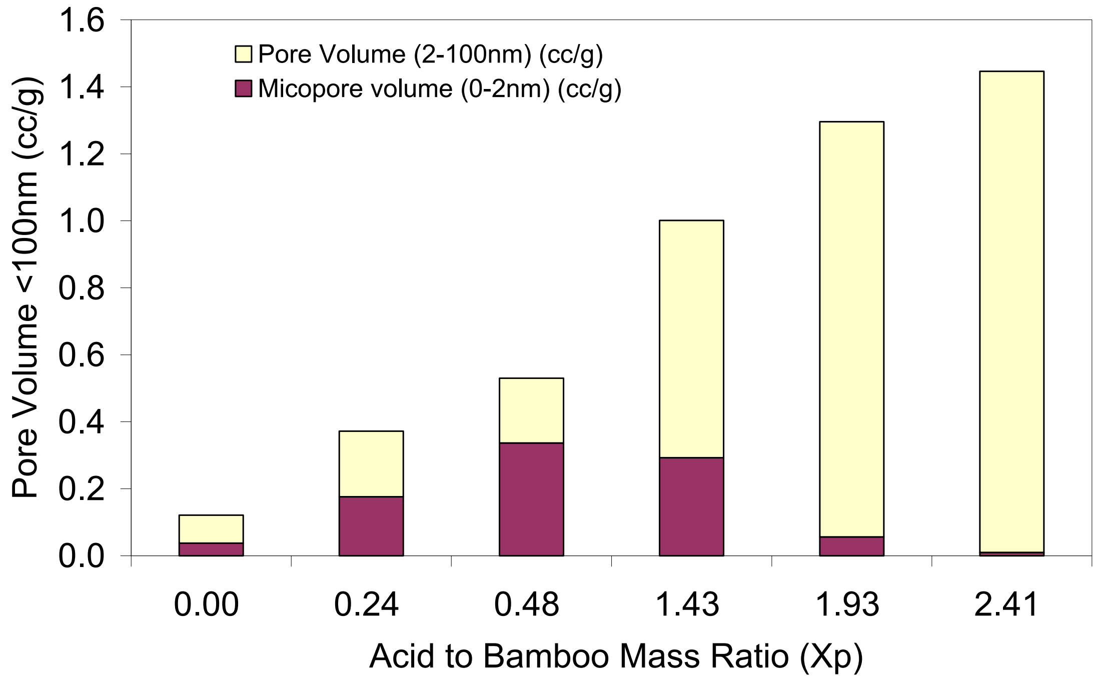

Fig. 2. Pore Volume <100nm Vs Xp

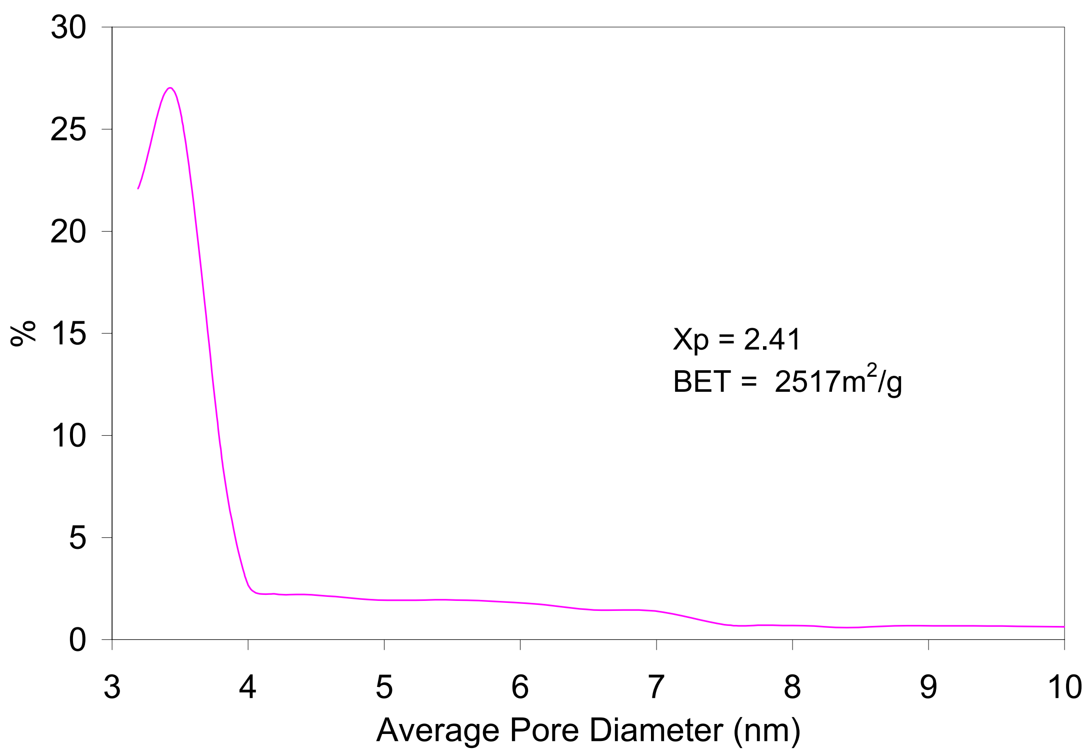

Fig. 3. Pore Size Distribution of Carbon Sample

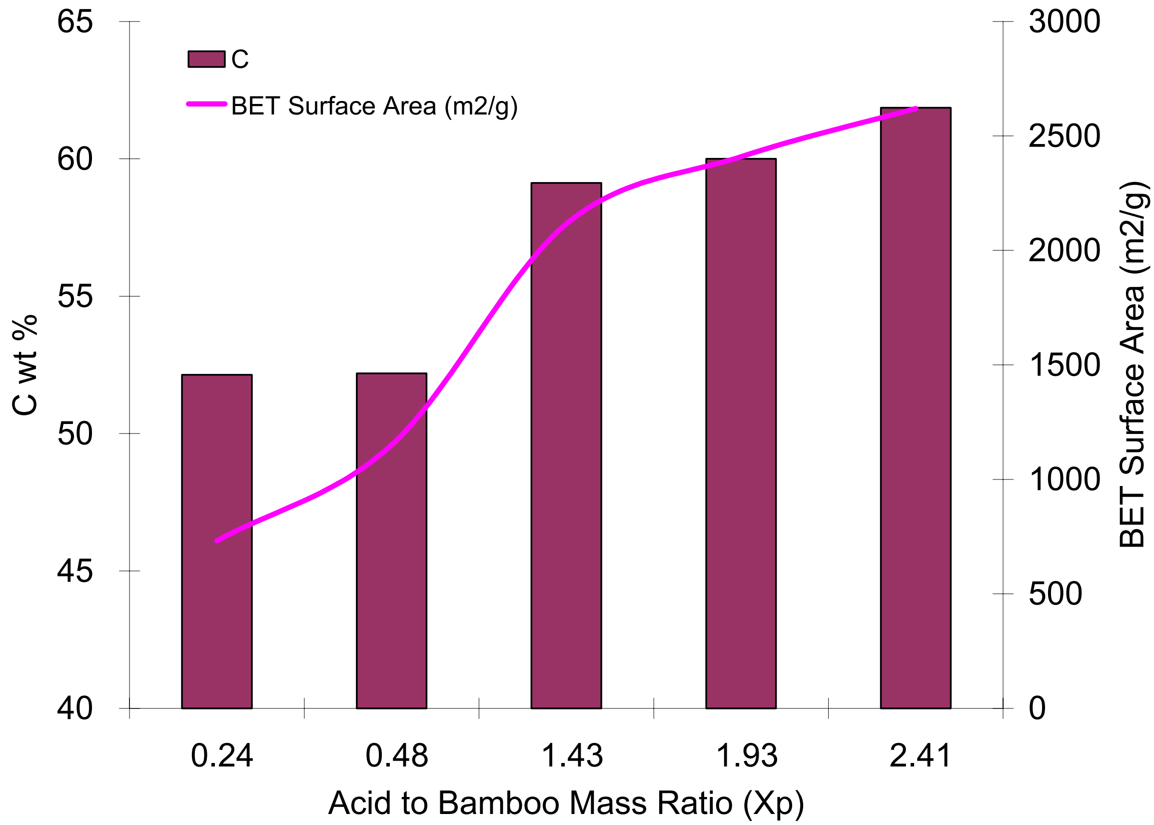

Fig. 4. Elemental Carbon Wt% and BET Vs Xp

The elemental analysis of carbon as weight percent is shown in Fig. 4 with corresponding BET surface area against Xp showing a gradual increase of percentage carbon with increasing Xp. A simple standard experiment has been performed and confirmed that the methylene blue equilibrium capacity is 750mg dye/g carbon which is highly favorable in comparison to commercial water treatment carbon e.g. F-400 at 250 mg dye/g carbon. These results are presented and analyzed

Conclusions

1. The preparation and investigation of high BET surface area activated carbons from scrap construction bamboo by low temperature chemical activation has been demonstrated.
2. The high adsorption capacity of a model dye has suggested the potential of the high BET surface area activated carbons as a good adsorbents for colored pollutants

References

[1] J. Laine, A. Calafat, M. Labady, Preparation and characterization of activated carbons from coconut shell impregnated with phosphoric acid, Carbon 27 (1989) p 191-195.

[2] M. Jagtoyen, M. Thwaites, J. Stencel, B. McEnaney, F. Derbyshire, Adsorbent Carbon Synthesis from Coals by Phosphoric-Acid Activation, Carbon 30 (1992) 1089-1096.

[3] T. Asada, S. Ishihara, T. Yamane, A. Toba, A. Yamada, K. Oikawa, Science of bamboo charcoal: Study on carbonizing temperature of bamboo charcoal and removal capability of harmful gases, Journal of Health Science 48 (2002) 473-479.

[4] I. Abe, T. Fukuhara, J. Maruyama, H. Tatsumoto, S. Iwasaki, Preparation of carbonaceous adsorbents for removal of chloroform from drinking water, Carbon 39 (2001) 1069-1073.

[5] N. Kannan, M.M. Sundaram, Kinetics and mechanism of removal of methylene blue by adsorption on various carbons - a comparative study, Dyes and Pigments 51 (2001) 25-40.

[6] F.C. Wu, R.L. Tseng, R.S. Juang, Preparation of activated carbons from bamboo and their adsorption abilities for dyes and phenol, Journal of Environmental Science and Health Part a-Toxic/Hazardous Substances & Environmental Engineering 34 (1999) 1753-1775.