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Steam activation of woodceramics

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As a porous carbon material, woodceramics has potential applications such as water purification, air filtration and reaction catalyst etc., where the surface area of the woodceramics is one of the main considerations. The present work describes the steam activation of woodceramics with the mixture of nitrogen and water. The effects of phenolic content, activation time, water amount and the activation temperature during the steam activation were investigated. The experimental results showed that the existence of phenolic resin will reduce the surface area of the woodceramcis, but high surface area of the woodceramics, over 1000 m^2/g, and high yield ratio of activated woodceramics still could be available through the combination of the appropriate parameters during the steam activation.

Key word: Woodceramics, steam activation, surface area

1. INTRODUCTION

Activated carbons present a group of well -established, universal and versatile adsorbents. They owe their distinguished properties to an extensive surface area, high degree of surface reactivity and favorable pore size distribution. The activity of an activated carbon is primarily determined by the raw material, as well as the conditions of preparation. Carbon precursors may be of botanical origin (wood, field wastes, coconut shells and fruit seeds), of mineral origin (coal, lignite, peat, petroleum coke), or from polymeric material (rubber tyres, plastics).

As a novel porous material, woodceramics are receiving more and more attentions in recent years, where the woodceramics are made from the wood or woody material impregnated with phenolic resin and carbonized at high temperature in a vacuum atmosphere. During the carbonization, wood or woody material changed into soft carbon and the phenolic resin changed into the hard glassy carbon. Accordingly, woodceramics is a kind of soft carbon/glassy carbon composite material, which make woodceramics have multiple mechanical and physical properties such as far infrared property and electrical-magnetic property and chemical corrosion. [1-4] Due to its porous microstructure, woodceramics have been found interesting and potential applications in air filtration, water treatment and catalysis *etc*, where the surface chemistry is the main considerations.As a result, the surface area of woodceramics is an critical parameter in these applications.

The product of simple carbonization, which is pyrolysis of the starting material, with exclusion of air and without addition of chemical agents, is usually an inactive material with low specific surface area. As a result of deposition or decomposition of tarry substance pores become filled, or at least blocked, by the disorganized carbon, accordingly, the activation processing is quite necessary to enhance the volume and to enlarge the surface area that are created during the carbonization and to create new porosity.[5,6] The methods of activation commonly employed are broadly divided into two main types: thermal or physical activation and chemical activation. Thermal activation is the process through which the carbonization product develops an extended surface area with a porous structure of molecular dimensions, under action of an oxidizing agent at high temperature. This step is generally carried out at temperatures between 800 and 1100 °C in presence of oxidizing gases such as steam, CO_2, air or any mixture of these gases. Oxygen in the activating agents basically reacts with the more reactive portions of the carbon skeleton forming CO and CO_2. But unfortunately, these activation process sometimes were lack of efficiency due to the non-well-distribution of these gases in the activation furnace. Accordingly, in the present work, new trend was developed and the woodceramics were activated by this novel steam activation process.

2. EXPERIMENTAL PROCEDURE

2.1 Material Preparation

Woodceramics used in the present work were made from Japanese cedar with the size about 3-5 mm, which were impregnated with phenolic resin using an ultrasonic impregnation system and then carbonized at 800 °C.

2.2 Steam Activation

The activated woodceramics were obtained by steam activation process, where the high temperature water steam mixed with N_2 was introduced into woodceramics chip in the activation furnace when the desired activated temperature was reached. In the conventional thermal activation processes, the efficiencies of the activation were often low due to the non-well-distribution of the activation agent. In this method, the generated N_2 flowed into the water tank firstly, and the mixture of the N_2 and the water steam was then introduced into the activation furnace after the preheating at 200 °C, so that the distribution of activation agent, *i.e.*,water steam, was well distributed in the furnace.

2.3 Surface area measurement

The surface area measurements of woodceramics were carried out primarily degassing at 250 °C for 1 hour, followed by N_2 adsorption at 77K, using an automatic apparatus, Shimadtu Flowsorb II2300, the surface area was calculated from the isotherms by the Brunauer-Emmett-Teller(BET) equation.

3. RESULTS AND DISCUSSION

Fig. 1 shows the effect of the phenolic content upon the surface area of woodceramics during the steam activation mixed with N_2. As indicated in Fig. 1, the surface area of both two kinds of woodceramics with different phenolic contents increased with the activation time, but it is noteworthy that the surface area of the woodceramics with low phenolic content is higher than that of woodceramics with high phenolic content; this result suggests that phenolic content in the woodceramics will restrain the surface area of the woodceramics during the steam activation.

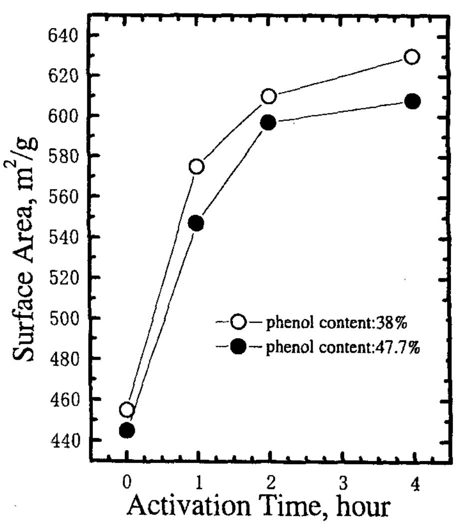

Fig.1 Effect of the phenolic content upon the surface area of woodceramics during the steam activation mixed with N_2

Fig. 2 and Fig. 3 show the effect of the steam amount upon the surface area of the woodceramics, ash content and yield ratio of activated woodceramics during the steam activation respectively when the woodceramics has been activated at 800 °C. As indicated in Fig. 2, the surface area of the woodceramics increased with increasing the N_2 amount in the steam . In the steam activation of the present work, the water amount in the steam increased with increasing the accompanied N_2. Accordingly, this result indicated that the surface area of the woodcermics increased with increasing water amount in the steam. As indicated in the Fig. 3, the ash content during the steam activation increased, while the yield ratio of activated woodceramics decreased with increasing the activation time and the water amount in the steam mixed with N_2.

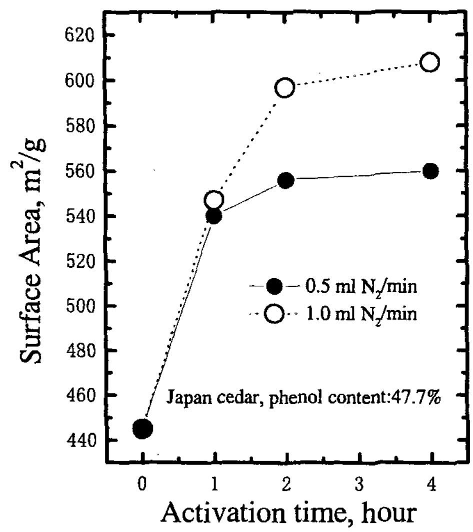

Fig. 2 Effect of stream mixed with N_2 upon the surface area of the woodceramcis

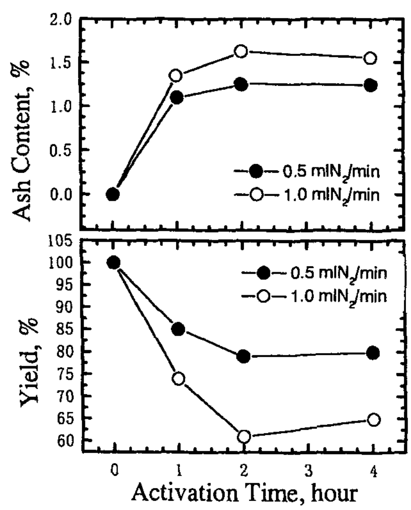

Fig.3 Ash content and the yield ratio during the stream activation mixed with N_2

Fig. 4 and Fig. 5 show the effect of activation temperature upon the surface area of woodceramics and the yield ratio during the steam activation mixed with N_2 gas (1ml/min.), respectively. As indicated in Fig. 4, the surface area of the woodceramics increased with increasing the activation temperature. Although the surface area of the woodceramics impregnated with phenolic resin presented relatively low surface area during the carbonization, the result in Fig. 4 suggested that high surface area of woodceramics, over 1000 m^2/g, still could be available through the steam activation mixed with N_2. Fig. 5 showed the yield ratio of the woodceramics during the steam activation. The result indicated that the yield ratio decreased with increasing activation temperature, when the activation temperature was above 950 °C, the yield ratio of the steam activation was lowered to a very low level. As seen in Fig. 4 and Fig. 5, it was deduced that good combination of the high surface area and the high yield ratio could be available when woodceramics was activated at 950 °C in steam activation mixed with N_2.

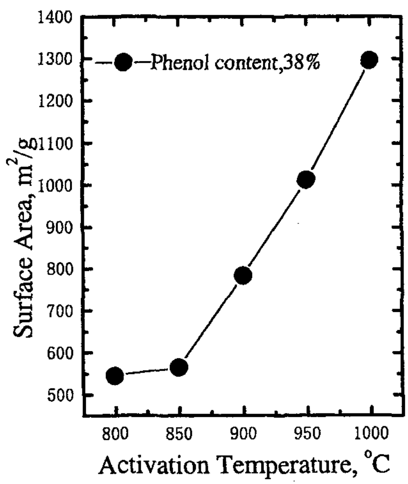

Fig.4 Effect of activation temperature upon the surface area of woodceramics

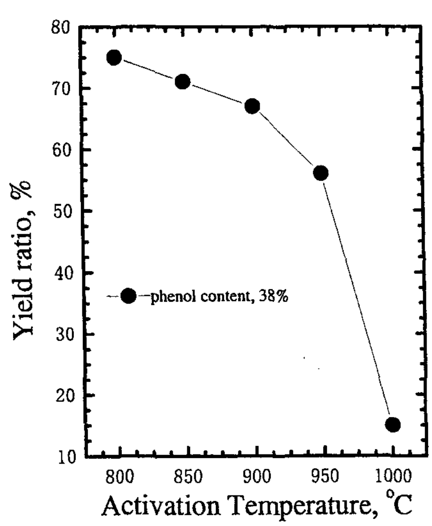

Fig.5 Yield ratio of activated woodceramics during the steam activation mixed with N_2

4. SUMMARY

In the present work, the steam accompanied with N_2 was introduced for woodceramics activation, the results were summarized as follows:

(1) Phenolic content in the woodceramics will restrain the surface area of the woodceramics during the steam activation.

(2) The surface area of the woodceramics increased with increasing the water amount in the steam activation mixed with N_2, while yield ratio decreased.

(3) The combination of the high surface area and high yield ratio of the woodceramics in the steam activation could be available through the appropriate parameters during the steam activation.

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