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Preparation of bamboo charcoal/polyvinyl formal foam as biological support material

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Abstract. Biological material was prepared by adhering different amount of bamboo charcoal filler into the matrix of polyvinyl formal foam by manual controlled foaming process. The material bears properties of low density, high strength, and good adsorption ability from the advantage of polyvinyl formal. It can be used as new efficient biological supporting material in sewage disposal system. The effects of hydrochloric acid, formaldehyde, bamboo charcoal, and temperature on the preparation were investigated.

Introduction

Polyvinyl formal (PVFM) is prepared from the condensation of polyvinyl alcohol and aldehyde. It is an important polymer material[1,2,3]. PVFM is prepared from the raw materials that are easy attainable with low cost[4,5,6]. The softening temperature of the material is higher than that of acetals. The porosity and the cell size of the foam are easy to control. The chemical stability, wear resistance, cement ability, mechanical strength, and electric and magnetic[7,8,9,10] properties of the material are excellent for its wide applications. Thus, PVFM found wide uses in cosmetology, c1eaner production, environment protection, and used as medical material, military muffler material, and biological supporting material.

The bamboo resource is abundant in China. There is a long history of cultivating and processing bamboo in China. Bamboo can be growing in a wide range of environment and its growth is fast. Thus, there is tremendous advantage for development its application with a short period of operating cycle. Bamboo charcoal is the solid remaining obtained by pyrolyzing bamboo at anaerobic condition. It has high porosity and high specific surface. Its special structure enables its good properties in adsorption, and in electricity[11] and magnetism[12,13,14,15,16]. Bamboo charcoal products are promising in applications for environment protection, medicine, food industry. We have investigated the preparation conditions for producing biological supporting material containing various amount of bamboo charcoal in PVFM by foaming method. PVFM is used as matrix. And bamboo charcoal is used as filler.

Experimental and measuring methods

Experimental procedures

(1) Dissolving sodium hydroxide in a suitable amount of deionized water.
(2) Adding polyvinyl alcohol to water at 70°C. The resulted solution was stirred at temperature in the range of 90-95°C until all the polyvinyl alcohol was dissolved.
(3) Adding concentrated hydrochloric acid to the solution prepared in step (2). Then, formaldehyde (36%) was added slowly in 30 minutes. Keeping the temperature in the range of 78-80°C and stirred for 1 h.
(4) Adding the sodium hydroxide solution prepared in step (1) into the solution prepared in step (3). Stirring until temperature decrease to 50°C. Transferring the solution to a bigger beaker.
(5) Adding bamboo charcoal into the solution prepared in step (4), stirring the solution to make it uniformly.

(6) Adding sodium bicarbonate into the solution prepared in step (5), stirring the solution to make it uniformly.
(7) Adding citric acid into the solution prepared in step (6), stirring the solution to make it uniformly. Then waiting for the foaming process to be finished.
(8) Washing the product with deionized water.

Determination method for iodine adsorption number
Iodine adsorption number is determined by adding mercuric acetate catalyst without changing the operational procedure of the Hanus method. Compared with the Hanus method in which it will take at least 30 minutes to finish, this method can make the determination only in 4 minutes. The relative error of the method is lower than 0.5% and coefficient of variation is lower than 0.2%.

Determination method for bulk density
The bulk density of powder was determined by a simple filing method using sieving. The powder is packed uniformly and the measurements are repeatable. The interaction force between particles, the grade or coagulation of particles etc. can also be estimated correctly by this method.

Results and discussions

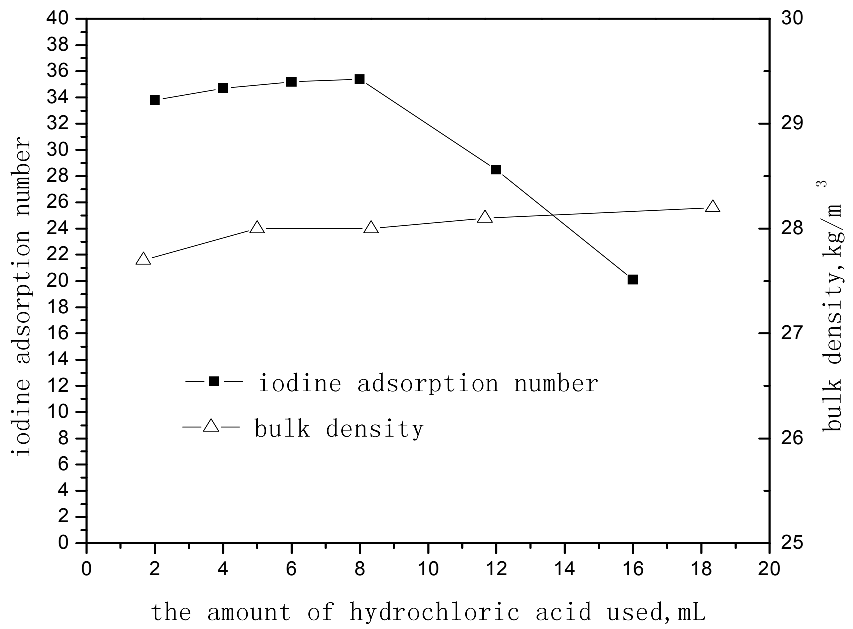

Fig. 1 The effects of the amount of hydrochloric acid used on iodine adsorption number and on bulk density

The effect of the amount of hydrochloric acid used. The effects of the amount of hydrochloric acid used on iodine adsorption number and on bulk density are shown in Fig. 1. The iodine adsorption number was increase with the amount of hydrochloric acid until 8 ml was used. The iodine adsorption number was attained the maximum value of 35.4 and bulk density become 28.1kg/m3 when the hydrochloric acid added reached 8 ml. The iodine adsorption number started to decrease when the amount of hydrochloric acid added was more than 8 ml. The optimal condition is adding 8 ml of hydrochloric acid to achieve a relative lower bulk density and the highest iodine adsorption number. All the following experiments were done at this optimal condition. High porosity is directly related with low bulk density. The adsorption ability is directly related with iodine adsorption number.

The effect of the amount of formaldehyde used. The effects of the amount of formaldehyde used on iodine adsorption number and on bulk density are shown in Fig.2.The best amount of formaldehyde used should be 2 - 4 ml with the iodine adsorption number of 35.4 as indicated by Fig. 2.The following experiments were done with 4 ml of formaldehyde.

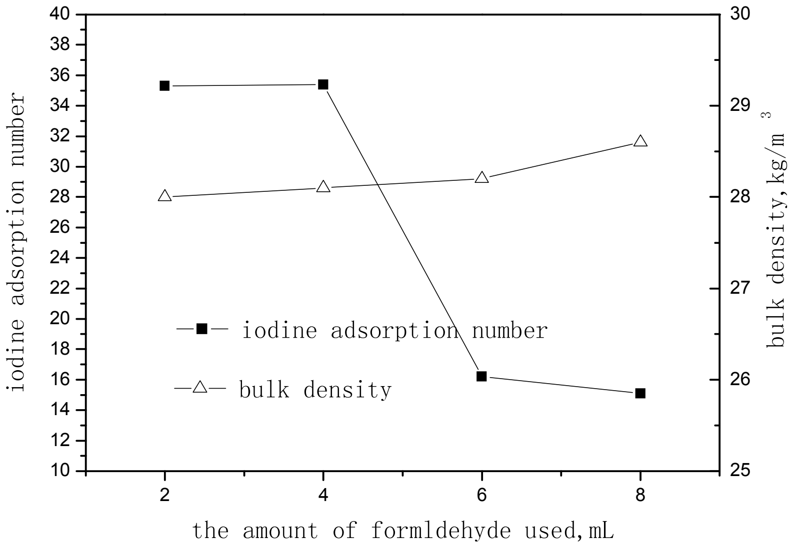

Fig.2 The effects of the amount of formaldehyde used on iodine adsorption number and on bulk density

The effect of the amount of bamboo charcoal used. The effects of the amount of bamboo charcoal used on iodine adsorption number and on bulk density are shown in Fig. 3. The iodine adsorption number attained its highest value of 36.1 when the bamboo charcoal added reached 3 g. The bulk density is not sensitive to the amount of bamboo charcoal added. However, the boundary of pore can be seen clearly with environmental scanning electron microscopy only when the amount of bamboo charcoal used was 2g. Thus 2g of the amount of bamboo charcoal used was set for the next experiment.

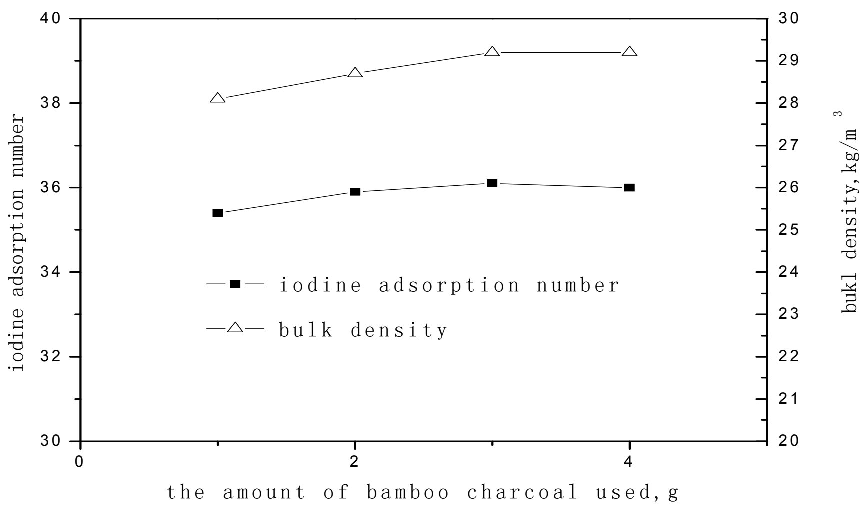

Fig.3 The effects of the amount of bamboo charcoal used on iodine adsorption number and on bulk density

The effect of temperature. The effects of temperature on iodine adsorption number and on bulk density are shown in Fig. 4. It can be seen that bulk density did not affected very much by temperature. However, the higher the temperature, the higher the valued of the iodine adsorption number was. It should be aware that too high a temperature is not a good choice especially when the conservation of energy is considered. 40°C is what we have chosen.

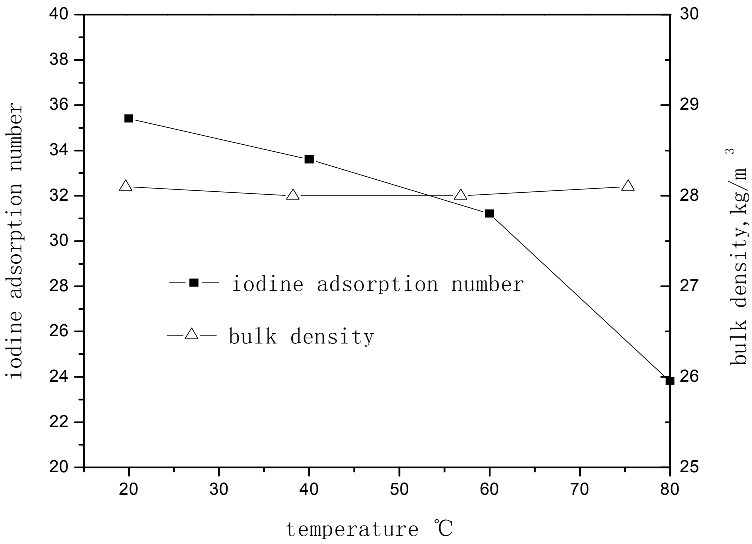

Fig.4 The effects of temperature on iodine adsorption number and on bulk density

Conclusions

The optimum conditions for the amount of hydrochloric acid, formaldehyde, bamboo charcoal, and temperature on preparing the supporting material are 8, 4 ml, 2g, and 40°C, respectively. The product of the black, elastic, sponge water-absorbing powder was obtained with reticular macropore structure and microporous framework. The biological support material with bamboo charcoal/polyvinyl formal composite foam has large specific surface, large permeability, large hydrophilicity, and large adsorption loading. The mass transfer ability is well characterized. The material has good microbial affinity, biological load, and good chemical and physical stability with good suspension liquidity and mobility. Its manufacture cost was low and it is well suited to be used as suspended packing in waste water treatment system.

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