Study on absorption of Cd$^{2+}$ and Pb$^{2+}$ by bamboo shoots superfine powder modified at high temperature

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Abstract. In order to find better heavy metal absorption material, this modification by heating bamboo shoots superfine powder at 50 °C with 5, 30 and 90 min. The effect on the absorption of Pb$^{2+}$ and Cd$^{2+}$ was determined through scanning electron microscopy (SEM) and infrared spectra (FTIR). The results showed that the heating time of 30 min, its absorption of Cd$^{2+}$ and Pb$^{2+}$ was best, and the highest absorption Cd$^{2+}$ and Pb$^{2+}$ were 56.46% and 74.18%, respectively. The heating time for 5 min and 90 min, absorption rate of the kinds of ions was lower than those modified.

1. Introduction

With the rapid development of industry, smelting industry, pesticide, dye and so on every year to produce a large number of industrial waste-water with heavy metal ions$^{[1]}$. Heavy metal pollution has become one of the most serious problems in our country, the river water quality pollution rate is as high as 80.10%$^{[2]}$. Due to Pb$^{2+}$ and Cd$^{2+}$ is easy to be absorbed by human and cause a lot of diseases$^{[3-5]}$. Conventional method of removing heavy metals$^{[6]}$, such as chemical precipitation, membrane separation and ion exchange cannot well solve the problem of heavy metal pollution. Heavy metal pollution has seriously harmed to our health and life safety, looking for efficient and low-cost the adsorption material of heavy metal is urgent.

Superfine grinding technology is a process of material crushing to micron grade$^{[7]}$, as a new type of high technical processing methods, it will be applied to food processing. Studies have shown that material by superfine grinding processing could make food has delicate taste and the high absorption rate. It makes materials good solubility, absorption and liquidity. This will greatly promote the development of food industry$^{[8]}$. Superfine grinding technology damages fiber acicular structure of material surface, increase the content of soluble dietary fiber and carbohydrate, reduce the content of insoluble dietary fiber, but protein, fat and other nutrients content is no significant change$^{[9]}$. 

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Bamboo shoots is the tender part of the bamboo, it is a branch of *Gramineae Bambusoideae* the general [10]. Bamboo shoots enrich dietary fiber, protein, amino acids and multifarious mineral elements [11]. Bamboo shoots are planted widely in our country, the existing area about 5.38 million hectares is the highest in the world, and it is growing at an annual rate of 100000 hectares [12]. Rich bamboo resources cause bamboo shoots produce a large amount of waste in the process of machining. According to statistics, the annual output of bamboo shoot and bamboo pulp waste about 1.60 million ton [13]. Superfine grinding is nondestructive processing way, the application of bamboo shoots processing also is less, the study of absorption properties of heavy metals and bamboo shoots superfine powder there has been no relevant report. This research through studying the high temperature of modified superfine powder on the absorption of Pb$^{2+}$ and Cd$^{2+}$, provide a basis for the development of efficient low-cost absorbent of heavy metals.

2. Experimental

2.1. Materials
Moao bamboo shoots was purchased from Fengnong food Co., Ltd. in Fujian. All chemicals used were of analytical grade.

2.2. The bamboo shoots of superfine powder preparation
After picking the shelled, cut into parts, ground up soaking, rinsing, boiled, drying treatment, fresh bamboo shoots will become the dried bamboo shoot, it’s moisture content is under 10.00%. Dried bamboo shoot become the bamboo shoots of coarse powder by the universal mill, and further grinding using the vibrating crusher at 15 °C low temperature under the condition of grinding 40 min after the bamboo shoots of the superfine powder, stored in a dry environment, set aside.

2.3. Heat treatment
Heating the bamboo shoots superfine powder under 50 °C, respectively, 5, 30, 90 min, freeze drying the sample after processing.

2.4. SEM analysis
Microstructural images were obtained from scanning electron microscope (XL-30, Dutch Philips electronics optical Co., and Ltd) at 20-2 low magnification and an accelerating voltage of 0.2-3.0 kV to eliminate the samples charge.

2.5. FTIR analysis
A small amount of sample are taken, some dried KBr is added, mixture is grounded into powder uniform in the mortar powder, then pressured into small rounds in tablet press, and FTIR is set scanning range 4000 - 400 cm$^{-1}$ and 0.1 cm$^{-1}$ of scanning step length, scanning number of 32, is set in the air. Each sample deduct background before scanning. The small round piece put in infrared spectrometer scanning to obtain the infrared spectra of the sample.

3. Results and discussion

3.1. Absorption of heavy metals
The figure. 1 showed Cd$^{2+}$ (a) and Pb$^{2+}$ (b) absorption of the bamboo shoots superfine powder after heat treatment. It can be seen that Cd$^{2+}$ absorption rate of untreated bamboo shoots superfine powder is about 30.00%, and the absorption of Pb$^{2+}$ rate can reach 50.00%. After heating 30 min at 50 °C, Cd$^{2+}$ and Pb$^{2+}$ absorption effect of the bamboo shoots superfine powder is best, and the highest absorption Cd$^{2+}$ and Pb$^{2+}$ were 56.46% and 74.18%, respectively. The absorption increased significantly. After heating 5 min and 90 min at 50 °C, two kinds of ion absorption rate is lower than the untreated absorption rate. Therefore, the heating 30 min can enhance Cd$^{2+}$ and Pb$^{2+}$ absorption ability of bamboo
shoots superfine powder appropriately. At the beginning of the absorption is lower. With the absorption time, absorption also increased. This was due to heavy metal ions and the bamboo shoots superfine powder cannot contact incompletely in the beginning, with the extension of absorption time, absorbent and heavy metal ions can reach good contact, then getting absorption saturation state.

![Figure 1](image1.png)

**Figure 1.** Absorption rate of Cd²⁺ (a) and Pb²⁺ (b) by bamboo shoots superfine powder at atmospheric 50 °C.

3.2. **SEM**

The figure. 2 showed SEM picture of the bamboo shoots superfine powder after heating treatment, figure a, b, c is morphology structure of the bamboo shoots superfine powder after heating 5 min, 30 min and 90 min, respectively. Dimensional administrative levels of powder particles is enhanced after heating for 30 min, fold and whole is increased. It is advantageous to the absorption. The powder particle surface fold and the hole are increased after heating 5 min and 90 min, but the administrative levels is poorer, the absorption effect is not obvious, and this result is consistent with the absorption rate.

![Figure 2](image2.png)

**Figure 2.** SEM images of bamboo shoots superfine powder at atmospheric 50 °C (a, 5 min; b, 30 min; c, 90 min)

3.3. **FTIR**

The figure. 3 showed the infrared spectrometer of the absorption before and after heating treatment of the bamboo shoots superfine powder. And a, b, c is control, 50 °C heating but no absorption, 50 °C heating and absorption of the bamboo shoots superfine powder, respectively. As can be seen there are a number of peaks in 3445.02 ~ 3239.33 cm⁻¹ of untreated bamboo shoots superfine powder. They are stretching vibration peak of -OH, intramolecular hydrogen bond and intermolecular hydrogen bond.
There is a peak only in 3370.71 cm\(^{-1}\) after heating treatment, the peak only is -OH stretching vibration peak. The reason may be breaking hydrogen bonds in the bamboo shoots make -OH multiply after heating. And there is a number of peaks in 1113.94~1048.61 cm\(^{-1}\) of untreated bamboo shoots superfine powder, it is C-N stretching vibration peak. And there is a peak only in 1038.57 cm\(^{-1}\) after heating treatment that is heating treatment can make change C-N. The bamboo shoots superfine powder by heating treatment absorbed heavy metal ions, it’s peaks occurred red shift of different level in 3370.71 cm\(^{-1}\) -OH stretching vibration peak, 1651.15 cm\(^{-1}\) C=O stretching vibration peak, 1156.37 cm\(^{-1}\) -OH stretching vibration peak and 1153.75 cm\(^{-1}\) C-N stretching vibration peak, respectively. Strength of the peak is abate, this shows that absorption process -OH, C=O and C-N participate in the coordination reaction.

Figure 3. FTIR spectra for bamboo shoots superfine powder before treated and after absorption at atmospheric pressure and 50 °C

4. Conclusion
The results showed that absorption of Cd\(^{2+}\) and Pb\(^{2+}\) could obviously increase of bamboo shoots superfine powder after heating treatment of 30 min. SEM showed that the surface of the bamboo shoots superfine powder was destroyed and structure level got enhanced. FTIR showed hydrogen bond rupture, -OH increase, and the coordination reaction involved in chemical absorption are mainly -OH, C=O and C-N, the rest is physical absorption. Thus the heating 50 °C for 30 min made bamboo shoots superfine powder on the absorption of Pb\(^{2+}\) and Cd\(^{2+}\) effect is better. It has the great potential in removing heavy metal ions as a biological absorbent.

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