대나무 활성탄의 흡착능 평가

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Evaluation of Adsorption Performance of Bamboo Activated Carbon

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1.Introduction

Dye in wastewater is difficult to treat due to its large molecular size and stability, and common treatment techniques of wastewater have been proved to be ineffective for the substance. Activated carbon is widely used in water treatment because of its large capacity and wide applicability of adsorption and ready availability. However, the adsorption capacity is significantly affected by the pore size and structure of the carbon and the molecular size of adsorbates. The coconut-based or coal-based activated carbon is widely utilized in the adsorption of small molecules, because it has a large volume of micropore. The utilization includes various applications of water treatment.

On the other hand, large molecules, such as dye, are not treated with the common activated carbon due to its pore characteristic. Because the large molecular size and stability of dye prevent from applying conventional removal techniques from water, various alternative methods have been proposed and tested for the dye removal. Using a simple adsorption treatment, food and wood wastes have been utilized to the dye treatment [1-3]. On top of the treatment, an electrochemical processing [4] and photocatalytic technique [5] were added for the improvement of treatment effectiveness. Also, the photocatalytic decomposition was enhanced using titanium oxide catalyst in Mohamed and Al-Esaimi [6]. Due to the large molecular size of dye, several studies have used mesoporous adsorbents for the dye removal. Hydrogel is readily designed its pore size in the preparation process, and it has been utilized with various modifications of surface [7,8]. Though conventional activated carbon contains mostly micropore, the activated carbon produced from some raw materials has large volume of mesopore. Basar [9] utilized the activated carbon from apricot waste for the dye removal from water. In this study, the dye removal was conducted with bamboo activated carbon having mostly mesopore. The activated carbon was characterized for the dye adsorption through microscopic observation, pore size distribution determination and adsorption isotherm fitting, and its removal performance was examined with three different sizes of molecules.

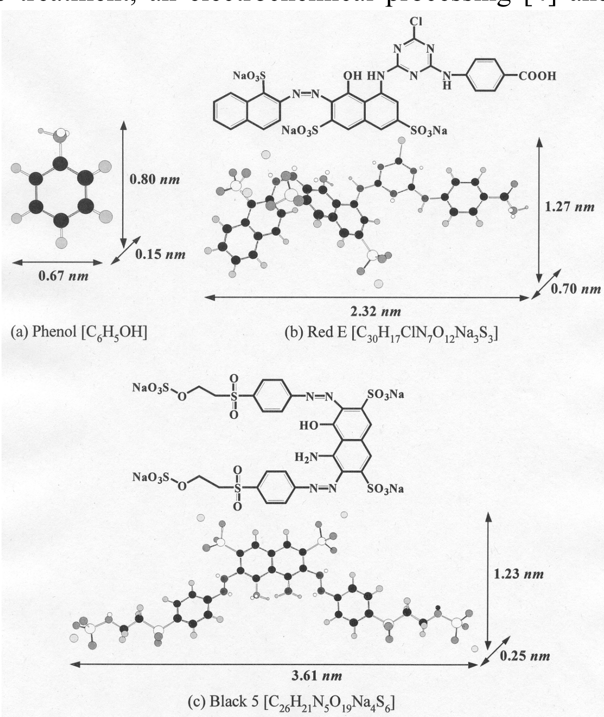

Figure 1. Molecular structures of phenol and dyes

2. Experimental

2.1 Materials

The adsorbent used in this study was obtained from a local company (Eulji Chemical Co., Korea). In the performance evaluation of dye removal, Black 5 (Sigma-Aldrich, U.S.A., No. 306452) and Red E (Nippon Kayaku Ltd., Japan) were utilized for large molecule substances, and phenol (Sanko Kagaku Ltd., Japan) was for small molecule one. All the materials were used as received.

2.2 Equipments

The dye concentration in water was measured with a UV-VIS spectrophotometer (Varian, Inc., U.S.A., Model Cary 50), and pore size distribution was determined with an adsorption analyzer (Micromeritics Instrument Co., U.S.A., Model TriStar 3000). The surface of activated carbon was observed with a scanning electron microscope (JEOL Ltd., Japan, Model JSM 6700F).

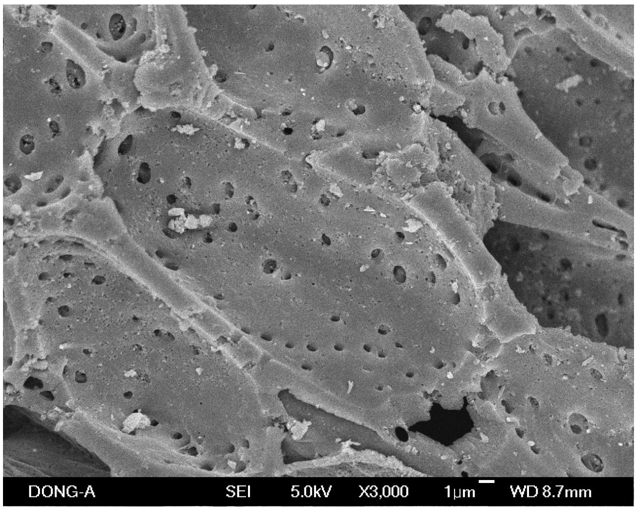

Figure 2. An SEM photograph of bamboo activated carbon

2.3 Procedures

The dye solutions used in the experiment were prepared for the concentrations between 6.25 ppm and 1,000 ppm. The solution up to 100 ppm was diluted from the standard solution of 200 ppm, which was prepared by dissolving a 0.2 g of dye into a 1 L of water. For instance, the 6.25 ppm solution was obtained by diluting a 6.25 mL of 200 ppm solution into the solution of 200 mL. Higher concentration solution than 100 ppm was directly prepared without dilution. Bamboo activated carbon was sieved to separate the particles of a size between 150 μm and 250 μm.

A 100 mL of the dye solution was placed in a 300 mL Erlenmeyer flask, and a 50 mg of the bamboo activated carbon was put into the flask. The solution in the flask with a lid was stirred on a magnetic stirrer at room temperature for 48 hours. The solution concentration after 48 hour treatment was measured with the spectrophotometer. The wavelength was set at 599.5 nm, 545 nm and 269.9 nm for Black 5, Red E and phenol, respectively.

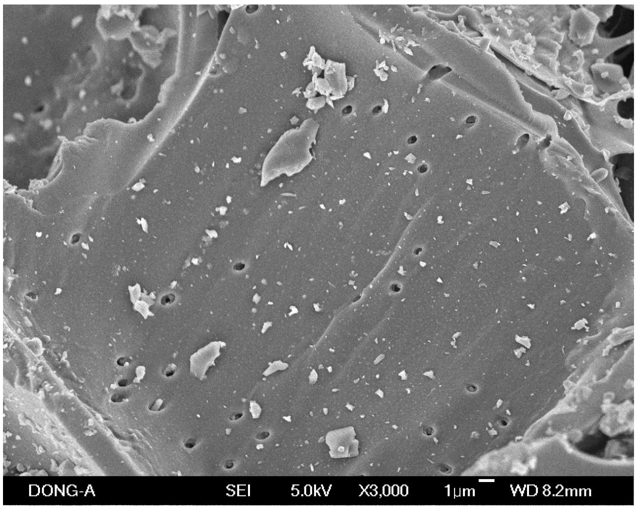

Figure 3. An SEM photograph of bamboo charcoal.

3. Results and discussion

Unlike common activated carbon made from coconut shell or coal, bamboo activated carbon has relatively large size of pores suitable for the adsorption of large molecules. Figure 1 compares the molecules of Black 5, Red E and phenol. Phenol is about 1/25 of Red E in volume. How the difference of molecular sizes affects the adsorption in the mesoporous bamboo activated carbon is examined here.The surfaces of bamboo activated carbon and bamboo charcoal, raw material of the activated carbon, were observed with a scanning electron microscope as illustrated in Figures 2 and 3, respectively. Though the photograph of charcoal shows many debris and large holes, no tiny hole as displayed in the photograph of the activated carbon is found in the charcoal. The pore structure of the bamboo activated carbon was investigated with the measurement of pore size distribution plotted in Figure 4. The distribution shows a large peak of 30 Å in diameter with the bamboo activated carbon. Whereas coconut activated carbon gives some distribution at the diameter, no distribution is yielded with the bamboo charcoal.

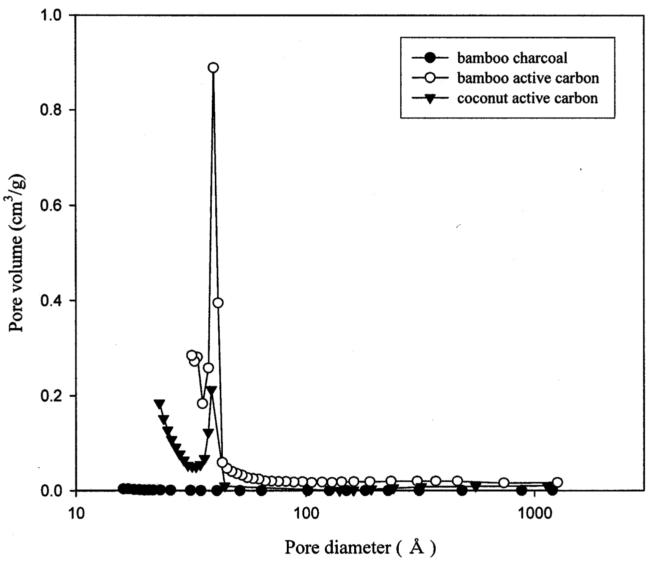

Figure 4. Pore size distributions of bamboo active carbon, coconut active carbon and bamboo charcoal

The adsorption capacity of bamboo activated carbon was compared with that of coconut activated carbon and carbon cryogel through batch adsorption tests. In the adsorption of Black 5, the bamboo activated carbon gives a comparable capacity with carbon cryogel. The cryogel is known to have a large volume of mesopore similar to the bamboo activated carbon [10]. Because coconut activated carbon has low volume of mesopore, the adsorption capacity is much less than the mesoporous adsorbents. However, the adsorption capacity is very low with all three adsorbents in the adsorption of Red. Note that the scale of ordinate is much smaller than the previous figure. The molecules of Red E and Black 5 have similar size in plane as shown in Figure 1, but the thickness of Red E is almost three times that of Black 5. Therefore, the adsorption of Red E is difficult even with the mesoporous adsorbents. The same outcome was obtained with the carbon cryogel [10]. In case of phenol adsorption as shown in Figure 5, coconut activated carbon illustrates the highest capacity due to its large volume of micropore suitable for the adsorption of small size phenol molecules.

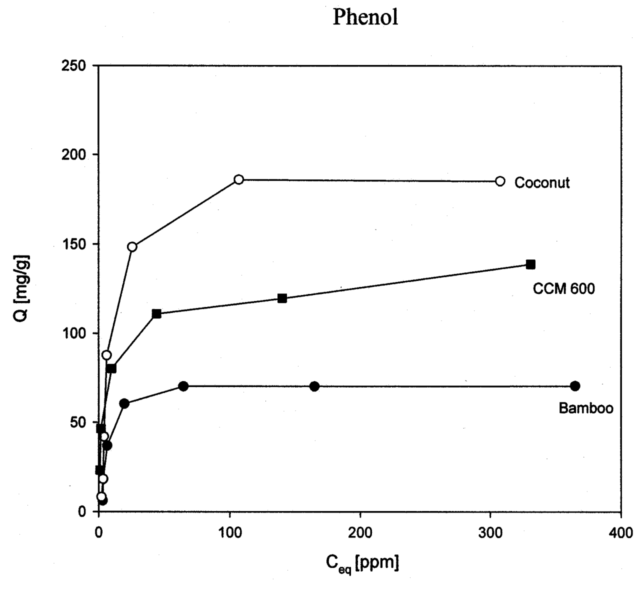

Figure 5. Comparison of phenol adsorption capacity at different equilibrium concentrations

The adsorption capacity of bamboo activated carbon is fitted in two adsorption isotherms of Freundlich and Langmuir, and their parameters are summarized in Table 1. Because good adsorption is yielded with Black 5, relatively good correlation is found with it. The adsorptions of Red E and phenol are poor resulting in relatively poor correlation as given the table.

4. Conclusion

Bamboo activated carbon was implemented in the removal of dye substances from aqueous solution, which is difficult to separate with common adsorbents. The characterization of the bamboo activated carbon was conducted with surface observation and the measurement of pore size distribution. The adsorption capacity of the bamboo activated carbon was also examined and compared with different adsorbents. From the adsorption experiments with Black 5, Red E and phenol, it is found that the mesoporous activated carbon is suitable for the removal of large dye molecule but thick molecule is difficult to separate. The adsorption capacity was explained with the result of characterization of the carbon and fitting to adsorption isotherms.

Table 1. The Freundlich and Langmuir parameters and correlation coefficients of adsorption isotherms.

	Freundlich			Langmuir		
Adsorbate	K_f	1/n	r	Q_0	b	r
Black 5	0.338	1.025	0.957	1,216	0.00031	0.966
Red E	1.366	0.238	0.927	6.777	0.0236	0.878
phenol	6.305	0.655	0.867	97.55	0.0454	0.937

Acknowledgment

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5. References

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