*Corynebacterium glutamicum*을 이용한 Basic Blue 3의 생체흡착

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Biosorption of Basic Blue 3 from Aqueous Solution using *Corynebacterium glutamicum*

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1. Introduction

Basic dyes are the brightest class of soluble dyes used in textile industries [1]. Their tinctorial value is very high: less than 1 ppm of the dye produces an obvious coloration [2]. Therefore, there is a definite need for a dye/color-removal technology that works suitably under the above circumstances and should be cost-effective.

Currently the adsorption process is one of the effective and attractive processes for the treatment of these dye-bearing wastewaters. The biomass of *Corynebacterium glutamicum* is generated in a great quantity from the full-scale fermentation process for mono sodium glutamate (MSG) production. Although this fermentation byproduct is potentially recyclable, until now most of it has been dumped in sea [3]. In this study, *C. glutamicum* was used for the removal of basic dye from the aqueous solution.

2. Materials and methods

2.1 Materials

In this study, *C. glutamicum* biomass was obtained in the form of powder from a lysine fermentation industry (Deasang, Gunsan, Korea). The powder biomass was dried at 60℃ in an oven for 24 h, and then was stored in a desiccator and used as biosorbent in the sorption experiments.

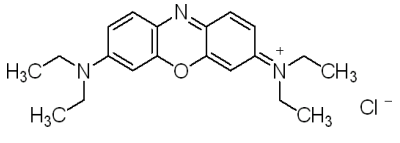

Figure 1. Molecular structure of BB3

Basic Blue 3 (BB 3), a cationic dye, was used as an adsorbate. As shown in Figure 1, BB 3 is

positively charged in an aqueous solution. It was purchased from Sigma-Aldrich Korea Ltd.

2.2 Effect of pH

In the pH edge experiment, the final solution pH was adjusted to the desired value ranging from about 1 ~ 10 using 1 M HNO_3 or 1 M NaOH. Biomass 0.4 g was added into each 50 mL falcon tube containing 40 mL BB3 solution (250 mg/L) and agitated in a shaker at 160 rpm for 24 h at 25±2 ℃, which was sufficient to get equilibrium. After 24 h, the final pH were measured and the samples were then centrifuged and the left out concentration in the supernatant solution were analyzed using UV spectrophotometer (UVmini-1240, Shimadzu, Kyoto, Japan) at 654 nm, where the maximum absorption peak exists.

2.3 Precipitation of dye solution

Basic dye tends to deposit at extreme conditions, such as strong acidic condition. In order to evaluate the real sorption capacity of BB 3, a series of precipitation experiments were conducted in pH ranging from 1~10 using 1 M HNO_3 and 1 M NaOH. A 40 mL dye solution were added into the 50 mL falcon tube without biomass and agitated in the shaker at 160 rpm for 24 h at 25±2 ℃. The final pH were measured and centrifuged for solid-liquid separation. The supernatant were analyzed using UV spectrophotometer, and the spectra were measured in ranging from 800 to 400 nm.

2.4 Adsorption isotherm

Equilibrium studies were carried out by agitating a series of 50 mL falcon tubes containing 40 mL of dye solution of initial BB 3 concentration ranging from 50 ~ 2000 mg/L with 0.4 g biomass at pH 6 and 9, and at room temperature (25±2 ℃) with a constant agitation speed of 160 rpm. After equilibrium the concentrations in the samples were analyzed as mentioned before.

3. Results and discussion

3.1 Effect of pH

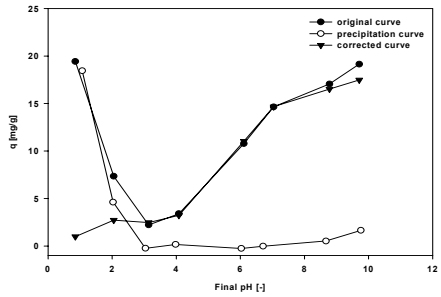

Figure 2. Effect of pH on biosorption of BB 3 at 25±2 ℃. ● is represented original experimental curve. ○ is symbolized the precipitation of BB 3. ▼is shown corrected experimental curve when considering the effect of precipitation of BB 3.

The effect of pH on BB 3 uptake was investigated over a pH range of 1 to 10. As elucidated in Figure 2, the uptake of BB 3 increased with the pH value increasing from 3 to 10. At pH 10, the uptake of BB 3 increased to maximal value of 19.15 mg/L. The biomass of *C. glutamicum*, mainly comprises of carboxyl group, whose pK_a value lies in the range of 3.5~5.0 [4]. At pH <3, the non-ionic form of

carboxyl group was presented, and therefore the sorption capacity of BB 3 was very low. But as shown in Figure 2, at pH 1 and pH 2, the uptake of BB 3 reached 19.44 mg/L and 7.35 mg/L, respectively, which were higher than the value of BB 3 uptake at pH 3. This phenomenon can not seem to attribute to the experimental error.

3.2 Effect of precipitation of BB 3

In order to provide a reasonable explanation for the exceptional point at pH 1 and pH 2, a series of UV-VIS absorption spectra of Basic Blue 3 solutions were carried out. All of the spectra were measured in the range of 800 to 400 nm. Figure 3 showed spectra of BB 3 solutions (250 mg/L) during different pH conditions. As indicated by the absorbance at 654 nm, the fast decolorization of BB 3 solution was followed by low pH (pH 1 and pH 2). Furthermore, some solid existed at the bottom of micro-centrifuge tube after centrifugation of BB 3 solution which was controlled at pH 1 and pH 2. It was due to precipitation of basic dye at strong acidic condition. Hence, the removal of BB 3 at pH 1 and 2 can be attributed to precipitation; and not due to biosorption.

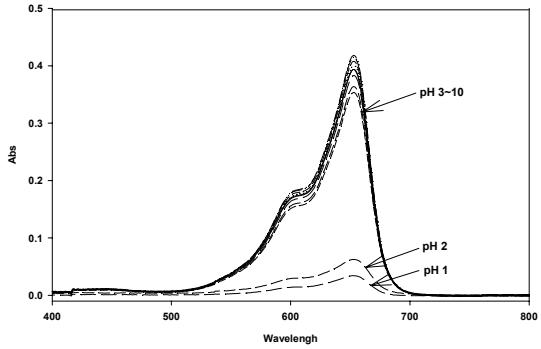

Figure 3. UV-VIS adsorption spectra of BB 3 solution (250 mg/L) at different pH conditions and 25±2 ℃.

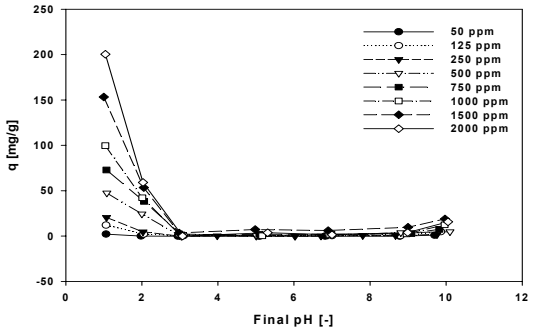

Figure 4. The uptake by precipitation of different initial concentration of BB 3 ranging from 50 ~ 2000 mg/L at 25±2 ℃.

The removal of BB 3 by precipitation at different initial BB 3 concentrations is shown in Figure 4. As elucidated in Figure 4, higher the concentration of BB 3, the more precipitation were occurred. But the precipitation only occurred at pH 1 and pH 2, where as at other pH condition precipitation of dye solution was not observed. Thus, a new experimental curve of pH edge considering the precipitation is shown in Figure 2.

3.3 Adsorption isotherm

In order to evaluate the maximum sorption capacity of BB 3 from experimental data, Langmuir isotherm modeling was employed in the present study. The model parameters are given in Table 1, it was noticed that, the non-linear correlation coefficient R^2 values were found to be high (>0.97). The higher R^2 values confirm that sorption data were well described by the Langmuir equation. The value of the maximum uptake of dye, q_m, were 27.95 mg/g and 63.33 mg/g at pH 6 and pH 9, respectively.

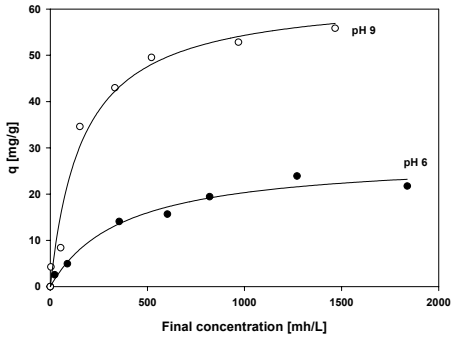

Figure 5. Isotherm of BB 3 on the biomass of *C. glutamicum* at pH 6 and 9. The lines were created according to the Langmuir model.

Table 1. Langmuir isotherm parameters for the adsorption of BB 3 on biomass of *C. glutamicum* at pH 6 and 9 and 25±2℃

pH	q_m [mg/g]	b [L/mg]	R^2
6	27.95 (± 2.2068)	0.0027(± 0.0007)	0.9807
9	63.33 (± 4.0947)	0.006 (± 0.0015)	0.9779

4. Conclusion

The present investigation showed that pH value of the solution is an important controlling parameter in the adsorption process. The removal of BB 3 increased with pH. However, the experimental data showed that the uptake of BB was higher at pH 1 and 2. It could attribute to the precipitation of BB 3 at strong acidic conditions. Control experiments at different pH conditions confirmed the precipitation of BB 3 in the pH range of 1~2. Hence pH edge experiments were corrected for BB 3 precipitation at acidic condition and pH 9 was identified as optimum for BB 3 biosorption. The equilibrium data were found to be well represented by the Langmuir isotherm model according to the non-linear regressive analysis. The value of the maximum uptake of dye, q_m, were 27.95 mg/g and 63.33 mg/g at pH 6 and pH 9, respectively.

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