생체흡착제에 의한 반응성 염료의 흡착특성

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Adsorption characteristics of Reactive Dye onto Biosorbent

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Introduction

Reactive dyes are typically azo-based chromophores combined with different types of reactive groups e.g., vinyl sulfone, chlorotriazine. They differ from all other classes of dyes in that they bind to the textile fibers such as cotton through covalent bonds. They have the favourable characteristics of bright color, water fast, simple application techniques with low energy consumption. They are used extensively in textile industries. Hence their removal is also of great importance.

It is difficult to remove the dyes from effluents since they are stable to light, heat and oxidizing agents and are biologically non-degradable. Although some existing technologies-conventional chemical coagulation/flocculation, ozonation, oxidation, adsorption-may have a certain efficiency in the removal of reactive dyes, their initial and operational costs are so great that they constitute an inhibition to dyeing and finishing industries. Activated carbon is the most widely used adsorbent for the removal of color and treatment of textile effluents but due to its high price it is not used on a great scale. This has led many workers to search for the use of cheap and efficient alternative materials such as bagasse pith, carbonized bark, peat, soil, tree and eucalyptus barks, chitosan, rice husk, wood and fly ash. Using microorganism as adsorbents for textile dyes also offers a potential alternative to existing methods for detoxification.

Biosorption is defined as the accumulation and concentration of pollutants from aqueous solutions on biological materials, thus allowing the recovery and/or environmentally acceptable disposal of the pollutants. Biosorption of various organic pollutants in wastewaters has been investigated by other workers. Biosorption for dyes could be also adopted for the treatment of textile effluents. Textile dyes vary greatly in their chemistries, and their interactions with microorganisms depend on the chemistry of a particular dye and the specific chemistry of microbial biomass.

In this work, the waste brewery yeast was obtained from a fermentation process of a brewery plant, and the biosorption of reactive orange 16 was studied in a batch reactor at different pH and temperature.

Materials and Methods

The biomass used in this study is dead cells of brewery yeast obtained from a beer brewery. The yeast was washed with deionized water and then the biomass was dried in a vacuum drying oven (LVO-2060, Daihan Labtech CO.) at 80 ℃ for 48h. The dry biomass was ground to powder using a ball mill. The powdered biomass was sieved through a sieve (U.S. standard testing sieve) to make the average diameter 112. 5㎛ and kept in desiccator. The physical properties of the biomass used in this study shown in Table 1.

The dye used in this study is reactive orange 16 (C.I. number) and supplied by Aldrich Chemical Company. The dye solution was prepared by dissolving accurately weighed the dye in distilled water at a concentration of 100 mg/L. To compare dye removal on the different basis, pH and temperature were adjusted at each experiment. The concentration of dye solution was determined using a UV-VIS spectrometer (UV-1601, Shimadzu) at wavelength 492 nm.

Experimental

Adsorption Isotherm

The RO 16 was dissolved in deionized water to the required concentration. The pH of dye solutions was adjusted to 3, 7. For adsorption equilibrium experiments, the biomass (0 ~ 2.5 g) and the dye solution (500 ㎖) were placed in a 1,000㎖ beaker and then shaken for 8h on a jar tester. The dye concentration of the solutions was analyzed using UV-VIS spectrometer at wavelength 492 nm. The amount of adsorption at equilibrium, q_e (mol/kg), was obtained as follows :

$$q_e = (C_o - C_e)\frac{V}{W} \quad (1)$$

Where, C_o and C_e are the initial and equilibrium solution concentrations (mol/m^3), respectively, V is the volume of the solutions (m^3) and W is the weight of the biomass used (kg).

Batch Experimental

The batch experiments were conducted in 1,000 ㎖ beakers containing 1,000 ㎖ of dye solution. The beakers were agitated on a jar tester at 300 rpm for 2h. Samples (about 5 ㎖) were taken before mixing the biosorbent in the reactive dye solution and dye bearing solution at predetermined time intervals for the residual dye concentration in the solution. The samples were filtered by filter paper (NO. 5A, Toyo Roshi Kaisha, Ltd. Japan) before analysis.

Result

The adsorption capacities of reactive dye onto biomass at different pH and temperature are shown in Figs. 1 and 2. The adsorption capacity of the dye increased with decreasing pH and temperature. Reactive dyes are typically azo-based chromophores combined with different types of reactive groups which interact with the active groups on the cell surface of yeast such as chitin, acidic polysaccharides, lipids, amino acids and other cellular components of the microorganism. Solution pH influences both dye binding sites on the cell surface and the dye chemistry in water. The reactive dyes release colored dye anions in solution. Higher sorption

capacity of the biomass obtained at lower pH values may be due to the electrostatic attractions between these negatively charged dye anions and positively charged cell surface. Hydrogen ion also acts as a bridging ligand between the yeast cell wall and the dye molecule. Fig. 3 represents the experimental data and model prediction for the adsorption of reactive dye for three pH values in a batch adsorber. The pore diffusion model (PDM) shows satisfactory prediction of concentration decay curves. Fig. 4 shows the results of uptake for RO 16 using different adsorbents. As can be seen in this figure, compared with conventional adsorbent GAC and the biomass for adsorption of RO 16, the adsorption capacity of the biomass is much greater than that of GAC. This implied that the biomass used for removing RO 16 is obviously positive.

Acknowledgment

This research was financially supported by the RRC for photonic materials and devices.

Reference

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Table 1 Physical properties of the biomass

Properties	Values
Particle size(mm)	0.075~0.150
BET surface area(m^2/g)	1.792
Average pore radius(Å)	21.13
Total pore volume(cm^3/g)	0.0002
Particle density(kg/m^3)	418.61
Porosity(%)	66.62

Table 2. Adsorption equilibrium isotherm parameters of reactive dye onto biomass (298.15K)

Isotherm type	Parameters	pH		
		3	7	10
Langmuir	q_m	0.604	0.090	0.050
	b	13.52	2.576	5.637
	$error(\%)$	7.916	2.500	2.961
Freundlich	k	2.385	0.118	0.087
	n	1.310	1.236	1.454
	$error(\%)$	10.31	2.167	4.020

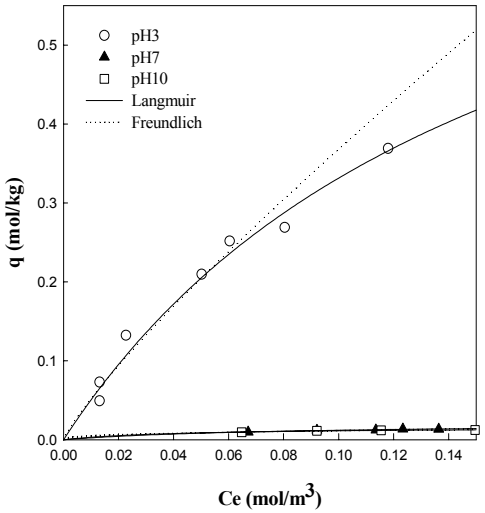

Fig. 1. Adsorption isotherm of RO 16 onto the biomass at different initial pH (298.15K)

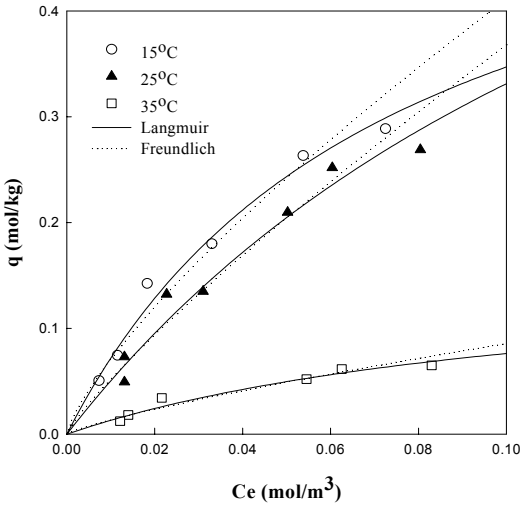

Fig. 2. Adsorption isotherm of RO 16 onto the biomass at different temp. (pH 3)

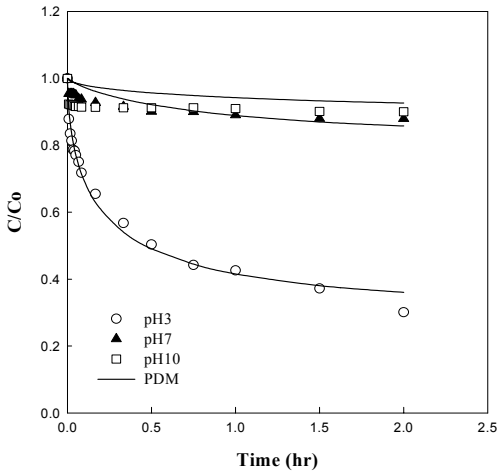

Fig. 3 Observed uptake curves of RO 16 onto the biomass at different pH (0.5g)

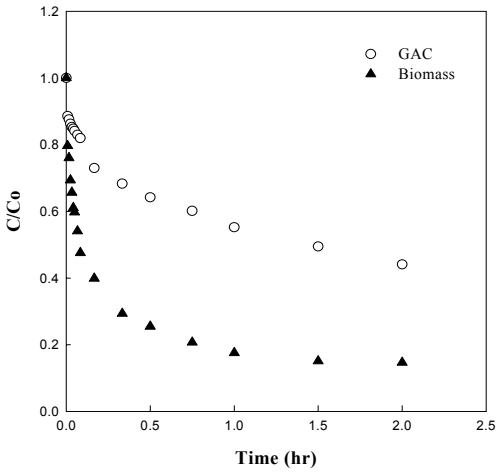

Fig. 4. Observed uptake curves of RO 16 onto different adsorbents (pH 3, 1.0g)