

REMOVAL OF BASIC DYES USING GREEN MACROALGA  
*CAULERPA LENTILLIFERA*

Mrs. Khanidtha Meevasana

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การกำจัดสีย้อมชนิดเบสิก โดยใช้สารห่วยช่อพริกไทย

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต

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ปีการศึกษา 2550

ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

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วิทยานิพนธ์ มีวาสนา : การกำจัดสีย้อมชนิดเบสิก โดยใช้สาหร่ายช่อพริกไทย. (REMOVAL OF BASIC DYES USING GREEN MACROALGA *CAULERPA LENTILLIFERA*) อ. ที่ปรึกษา : ร.ศ.ดร.ประเสริฐ ภาวนันต์, 150 หน้า.

งานวิจัยนี้ศึกษาความสามารถในการดูดซับสีย้อมชนิดเบสิกของสาหร่ายช่อพริกไทย โดยพบว่าสาหร่ายช่อพริกไทยหรือ *Caulerpa lentillifera* มีความสามารถในการดูดซับสีย้อมชนิดเบสิกหลายชนิด สำหรับการทดลองในช่วงความเข้มข้นของสี Astrazon® Blue FGRL 20-1,280 มิลลิกรัมต่อลิตร พบว่าการดูดซับเข้าสู่สมดุลภายในเวลา 1 ชั่วโมง ข้อมูลทางจลศาสตร์ที่ได้จากการทดลองมีความสอดคล้องกับแบบจำลองทางจลศาสตร์ชนิด pseudo second-order และพบว่าค่าคงที่อัตราลดลงเมื่อความเข้มข้นเริ่มต้นของสีเพิ่มมากขึ้น สมดุลของการดูดซับในช่วงอุณหภูมิ 18-70 องศาเซลเซียส เป็นไปตามแบบจำลองสมดุลการดูดซับของ Langmuir และ Freundlich และให้ค่าการดูดซับสูงสุดที่อุณหภูมิ 50 องศาเซลเซียส และค่าเอนทัลปีของการดูดซับที่คำนวณได้มีค่าเท่ากับ 14.87 กิโลจูลต่อโมล ซึ่งบ่งบอกว่าการดูดซับดังกล่าวมีลักษณะของการดูดซับทางเคมี

เมื่อเปรียบเทียบประสิทธิภาพการดูดซับของสาหร่ายช่อพริกไทยกับถ่านกัมมันต์ โดยทำการทดลองกับสีเบสิก 3 ชนิด Astrazon® Blue FGRL Astrazon® Red GTLN และ methylene blue พบว่าสาหร่ายช่อพริกไทยมีประสิทธิภาพในการดูดซับสีทั้งสามชนิดมากกว่าถ่านกัมมันต์ นอกจากนั้นยังพบว่าจลศาสตร์ของการดูดซับเป็นไปตามแบบจำลองชนิด pseudo second order และขั้นตอนของการดูดซับควบคุมโดยกลไกชนิด film และ pore diffusion ในการทดลองกับระบบการดูดซับแบบต่อเนื่อง ได้นำแบบจำลอง BDST และแบบจำลองของ Thomas มาใช้เปรียบเทียบกับผลการทดลอง ซึ่งพบว่าผลการทดลองมีความสอดคล้องกับแบบจำลองดังกล่าวเป็นอย่างดี นอกจากนั้นในการศึกษาสเปกตรัมสองชนิดพบว่าเมื่อสัดส่วนของสีที่นำมาผสมกันนั้นเปลี่ยนไป จะทำให้เกิดการเลื่อนของเส้นสเปกตรัม จากการค้นพบดังกล่าวนำมาสู่การเสนอวิธีการใหม่ ไม่ซับซ้อน ที่ใช้วัสดุองค์ประกอบย่อยในสเปกตรัมสองชนิดได้

สาขาวิชา การจัดการสิ่งแวดล้อม .....ลายมือชื่อนิสิต.....  
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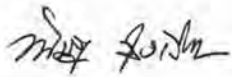
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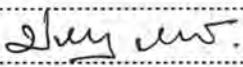
KEY WORD: BIOSORPTION / WASTEWATER TREATMENT / BASIC DYES / METHYLENE BLUE

KHANIDTHA MEEVASANA : REMOVAL OF BASIC DYES USING GREEN MACROALGA *CAULERPA LENTILLIFERA*. THESIS ADVISOR : ASSOC. PROF. PRASERT PAVASANT, Ph.D., 150 pp.

A macroalga *Caulerpa lentillifera* was found to have high adsorption capacity for basic dyes. For the sorption of a basic dye Astrazon® Blue FGRL, the adsorption reached equilibrium within the first hour for whole range of concentrations employed in this work (20-1,280 mg l<sup>-1</sup>). The kinetic data corresponded well with the pseudo second-order kinetic model where the rate constants decreased as initial dye concentrations increased. At low dye concentrations (20-80 mg l<sup>-1</sup>), an increase in the adsorbent dosage resulted in a higher removal percentage of the dye, but a lower amount of dye adsorbed per unit mass ( $q$ ). The adsorption isotherm followed both the Langmuir and Freundlich models within the temperature range of 18-70°C. The highest maximum adsorption capacity ( $q_m$ ) was obtained at 50°C. The enthalpy of adsorption was estimated at 14.87 kJ mol<sup>-1</sup> suggesting a chemical adsorption mechanism.

The results were compared to the sorption performance of a commercial activated carbon. The comparison studies were done using 3 basic dyes, i.e. Astrazon® Blue FGRL, Astrazon® Red GTLN, and methylene blue. The evaluation revealed that the alga exhibited greater sorption capacity than activated carbon for all types of basic dyes. Further investigation showed that the sorption process obeyed the pseudo second order kinetic model. The sorption processes were controlled by both film and pore-diffusion. BDST and Thomas models were used to analyze experimental data from continuous flow study and the model parameters were evaluated. Good agreement of experimental results on breakthrough characteristics with the model prediction was observed. In the study of binary dye mixture, shifts of spectral peaks were observed when the composition of the mixture changed and the area beneath the light absorbance curve corresponded to the quantity of the dyes in the mixture. Then the new, simple analytical method was proposed for the measurement of individual dye component in the mixture of two dyes.

Field of study Environmental Management Student's signature 

Academic year 2007 Advisor's signature 

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## ABBREVIATIONS

$A_c$	area under the breakthrough curve ( $\text{mg ml}^{-1}$ )
$A$	light absorbance (-)
$A_{AB}$	light absorbance of AB (-)
$A_{AR}$	light absorbance of AR (-)
$A_{AY}$	light absorbance of AY (-)
$A_{max}$	maximum light absorbance (-)
$b$	Langmuir constant ( $\text{l mg}^{-1}$ )
$C$	concentration of a dye component ( $\text{mg l}^{-1}$ )
$C_{AB}$	concentration of AB ( $\text{mg l}^{-1}$ )
$C_{ad}$	adsorbed concentration ( $\text{mg l}^{-1}$ )
$C_{AR}$	concentration of AR ( $\text{mg l}^{-1}$ )
$C_{AY}$	concentration of AY ( $\text{mg l}^{-1}$ )
$C_b$	desired breakthrough concentration ( $\text{mg l}^{-1}$ )
$C_e$	dye concentration in liquid phase at equilibrium ( $\text{mg l}^{-1}$ )
$C_o$	initial concentration ( $\text{mg l}^{-1}$ )
$C_s$	sorbed concentration ( $\text{mg l}^{-1}$ )
$C_t$	remaining concentration at time $t$ ( $\text{mg l}^{-1}$ )
$C_T$	total dye concentration ( $\text{mg l}^{-1}$ )
$C_x$	desired exhaust concentration ( $\text{mg l}^{-1}$ )
$D$	bed depth (cm)
$D$	effective diffusivity of solutes within particle ( $\text{m}^2 \text{min}^{-1}$ )
$D_{min}$	minimum bed depth (cm)

$G^\circ$	standard Gibbs free energy ( $\text{kJ mol}^{-1}$ )
$\Delta G$	change in Gibbs free energy ( $\text{kJ mol}^{-1}$ )
$H^\circ$	standard enthalpy ( $\text{kJ mol}^{-1}$ )
$\Delta H$	change in enthalpy ( $\text{kJ mol}^{-1}$ )
$k_1$	sorption rate constants for first order kinetic equation ( $\text{min}^{-1}$ )
$k_2$	sorption rate constants for second order kinetic equation ( $\text{g mg}^{-1} \text{min}^{-1}$ )
$K_{BDST}$	rate constant from BDST model ( $\text{l mg}^{-1} \text{min}^{-1}$ )
$K_F$	Freundlich constant ( $\text{mg}^{1-1/n} \text{l}^{1/n} \text{g}^{-1}$ )
$k_i$	Intra-particle diffusion rate constant ( $\text{mg min}^{0.5} \text{g}^{-1}$ )
$k_{TH}$	Thomas rate constant ( $\text{ml min}^{-1} \text{mg}^{-1}$ )
$1/n$	Freundlich exponent (-)
$M$	mass of algal sorbent (g)
$m_{total}$	total amount of dye fed into column (mg)
$N_o$	bed capacity from BDST model ( $\text{mg cm}^{-3}$ )
$Q$	volumetric flow rate ( $\text{ml min}^{-1}$ )
$q$	sorbed dye per unit mass of sorbent ( $\text{mg g}^{-1}$ )
$q_{AB}$	adsorption capacity of AB ( $\text{mg g}^{-1}$ )
$q_{AR}$	adsorption capacity of AR ( $\text{mg g}^{-1}$ )
$q_{AY}$	adsorption capacity of AY ( $\text{mg g}^{-1}$ )
$q_{column}$	maximum capacity of column ( $\text{mg g}^{-1}$ )
$q_e$	equilibrium dye concentration per unit mass of sorbent ( $\text{mg g}^{-1}$ )
$q_m$	maximum amount of dye sorbed per unit mass of sorbent calculated from Langmiur plots ( $\text{mg g}^{-1}$ )
$q_t$	amount of dye sorbed per unit mass of sorbent at time $t$ ( $\text{mg g}^{-1}$ )
$q_{TH}$	the maximum solid phase concentration of the solute ( $\text{mg g}^{-1}$ )



$q_{total}$	total sorbed dye (mg)
$R$	gas constant (8.314 J mol <sup>-1</sup> K <sup>-1</sup> )
$R^2$	linear regression coefficient (-)
$r_p$	particle radius (m)
$S^\circ$	entropy (J mol <sup>-1</sup> K <sup>-1</sup> )
$\Delta S$	change in entropy (J mol <sup>-1</sup> K <sup>-1</sup> )
$T$	absolute temperature (K)
$t$	time (min)
$t^{0.5}$	half sorption time of dye (min <sup>0.5</sup> )
$t_b$	breakthrough time (min)
$t_{total}$	total flow time (min)
$t_x$	exhausted time (min)
$V$	volume of the dye mixture (l)
$V'$	linear flow rate (cm min <sup>-1</sup> )
$V_{eff}$	effluent volume (cm <sup>3</sup> )
$W$	mass of the dye component (mg)
$X$	mass of algal sorbent (g)
$w_d$	total sorbed dye (mg)
$x$	Partial fraction of a dye component in binary dye mixture (-)
$x_{AB}$	Partial fraction of AB (-)
$x_{AR}$	Partial fraction of AR (-)
$x_{AY}$	Partial fraction of AY (-)
$Z$	length of mass transfer zone (cm)
$\lambda_m$	Wavelength of maximum light absorption (nm)