

การดูดซับไอของเบนซีน โทลูอีน และไฮโซลีนด้วยถ่านกัมมันต์ที่เตรียมจาก  
ผักตบชวาโดยการกระตุ้นด้วยซิงก์คลอไรด์

นายจิระศักดิ์ แสงพุ่ม



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต

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ADSORPTION OF BENZENE, TOLUENE, AND O-XYLENE VAPOURS ON  
ACTIVATED CARBONS PREPARED FROM WATER HYACINTH  
ACTIVATED BY ZINC CHLORIDE

Mr. Chirasak Sangpoum

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วัตถุดิบที่นำมาเตรียมตัวดูดซับชนิดถ่าน ได้แก่ ผักตบชวา แกลบ และชานอ้อย วัตถุดิบดังกล่าวจะถูกทำให้เป็นถ่านและถูกกระตุ้นไปพร้อม ๆ กัน ด้วยสารละลายซิงค์คลอไรด์ที่มีความเข้มข้น 600 กรัม/ลิตร กระบวนการเตรียมตัวดูดซับชนิดถ่านถูกทดลองกระทำที่อุณหภูมิ 400, 500, และ 600 องศาเซลเซียส และที่เวลา 1, 2, และ 3 ชั่วโมง ปริมาณผลิตภัณฑ์ของตัวดูดซับชนิดถ่านที่ได้ ลดลงเมื่ออุณหภูมิเพิ่มขึ้น ในขณะที่พื้นที่ผิว การดูดซับไอไอดีน และค่าเฉลี่ยขนาดของโพรงจะแปรผันตามอุณหภูมิ เวลาในการกระตุ้นมีอิทธิพลน้อยมากต่อลักษณะสมบัติของตัวดูดซับชนิดถ่าน เมื่อเปรียบเทียบวัตถุดิบที่ถูกทำให้เป็นถ่านพบว่า ปริมาณผลิตภัณฑ์ลดลงประมาณ 25 เปอร์เซ็นต์ สำหรับตัวดูดซับชนิดถ่านที่เตรียมจากผักตบชวา มีพื้นที่ผิวและค่าไอไอดีนที่มากขึ้นหลังจากกระบวนการอย่างน้อย 200 เท่าและ 3 เท่าตามลำดับ โดยเปรียบเทียบกับถ่านผักตบชวา

สมดุผลการดูดซับบนตัวดูดซับชนิดถ่านจากผักตบชวา สำหรับไอเจ็องของเบนซีน โทลูอิน และโอไซลีน ถูกวัดโดยวิธีโครมาโตกราฟีที่อุณหภูมิ 180-270 องศาเซลเซียส สำหรับตัวดูดซับชนิดเดียวกัน เมื่อดูดซับตัวถูกดูดซับ 3 ชนิดพบว่า ค่าคงที่สมดุผลการดูดซับเรียงจากน้อยไปหามาก คือ เบนซีน โทลูอิน และโอไซลีน ค่าความร้อนของการดูดซับไอเบนซีน โทลูอิน และไซลีนสำหรับตัวดูดซับชนิดถ่านทั้งหมดมีค่าประมาณ 72, 81, และ 100 กิโลจูลต่อโมล ตามลำดับ นอกจากนี้ สัมประสิทธิ์การถ่ายโอนมวลสารรวมของไอทั้งหมดเป็นไปตามกฎของอาร์เรเนียส

ภาควิชา ..... วิศวกรรมเคมี ..... ลายมือชื่อนิสิต .....  
สาขาวิชา ..... วิศวกรรมเคมี ..... ลายมือชื่ออาจารย์ที่ปรึกษา .....  
ปีการศึกษา ..... 2542 ..... ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

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CHIRASAK SANGPOUM : ADSORPTION OF BENZENE, TOLUENE, AND O-XYLENE VAPOURS ON ACTIVATED CARBONS PREPARED FROM WATER HYACINTH ACTIVATED BY ZINC CHLORIDE. DISSERTATION ADVISOR : ASSISTANT PROFESSOR DEACHA CHARSIRIWECH, Ph.D. DISSERTATION CO-ADVISOR : ASSISTANT PROFESSOR VICHITRA CHONGVISAL, Ph.D. 147 pp. ISBN 974-334-881-6

Water hyacinth, rice husk, and sugarcane bagasses were used as raw materials for the preparation of carbon adsorbent. They were carbonized and activated simultaneously with 600 grams/liter zinc chloride solution. The preparation process was carried out at the temperatures of 400, 500, and 600°C for 1, 2, and 3 hours. The yield of carbon adsorbents decreased with an increase in temperature. While the specific surface area, as well as iodine adsorption and the average pore size varied directly with temperature. The activation period hardly affected the adsorbent characteristics. In comparison with carbonized materials, the yield was reduced by about 25%. For the water hyacinth, both the specific surface area and the iodine adsorption were improved by at least two-hundred fold and three-fold, respectively.

Adsorption equilibria on carbon adsorbents from water hyacinth for dilute vapours of benzene, toluene, or o-xylene were measured by chromatographic method at the temperature of 180–270°C. The increasing sequence of the equilibrium constants for those vapours on a given carbon adsorbent was benzene, toluene, and o-xylene. Heats of adsorption of BTX on all carbon adsorbents were about 72, 81, and 100 kJ/mol, respectively. In addition, the overall mass-transfer coefficients of all vapours obeyed Arrhenius' Law.

ภาควิชา ..... วิศวกรรมเคมี .....ลายมือชื่อนิสิต .....  
สาขาวิชา ..... วิศวกรรมเคมี .....ลายมือชื่ออาจารย์ที่ปรึกษา .....  
ปีการศึกษา ..... 2542 .....ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....  
*Chirajak Sangpoum*  
*ผศ. เดชา ชาร์สิริเวช*  
*ดร. อ.*



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## CONTENTS

ABSTRACT IN THAI .....	iv
ABSTRACT IN ENGLISH .....	v
ACKNOWLEDGEMENTS .....	vi
LIST OF TABLES .....	ix
LIST OF FIGURES .....	xi
NOMENCLATURE .....	xvi
CHAPTER I INTRODUCTION .....	1
CHAPTER II ADSORPTION THEORY .....	5
2.1 Introduction .....	5
2.2 Adsorbents .....	7
2.2.1 Molecular-Sieve Zeolites .....	7
2.2.2 Silica Gel .....	9
2.2.3 Activated Alumina .....	10
2.2.4 Carbon Adsorbents .....	11
2.3 Adsorption Equilibrium .....	14
2.3.1 Types of Adsorption Isotherms .....	15
2.4 Adsorption Equilibrium Measurement .....	19
2.4.1 Volumetric Method .....	19
2.4.2 Gravimetric Method .....	20
2.4.3 Chromatographic Method .....	20
2.5 Adsorption Kinetics .....	21
2.5.1 External Film Diffusion .....	22
2.5.2 Pore Diffusion .....	23
CHAPTER III LITERATURE REVIEW .....	26
CHAPTER IV EXPERIMENTS .....	32
4.1 Adsorbent Preparations .....	32
4.2 Adsorption Experiments .....	34

4.2.1 Determination of Packed-Bed Characteristics .....	34
4.2.2 Adsorbate-Vapour Preparation .....	36
4.2.3 Gas Chromatography Experiments .....	37
CHAPTER V RESULTS AND DISCUSSION .....	40
5.1 Effects of Chemical Reagents .....	40
5.2 Characterization of Carbon Adsorbents .....	47
5.2.1 Effects of Reaction Temperature and Reaction Period .....	47
5.2.2 Functional Groups .....	61
5.2.3 Particle Density .....	67
5.3 First Moment Analysis .....	68
5.3.1 Adsorption Equilibrium Constants .....	68
5.4 Second Moment Analysis .....	80
5.4.1 Overall Mass-Transfer Coefficients .....	80
CHAPTER VI CONCLUSION AND RECOMMENDATION .....	83
6.1 Conclusion .....	83
6.2 Recommendation .....	85
REFERENCES .....	86
APPENDICES .....	94
APPENDIX A .....	95
A.1 Evaluation of Moments of the Chromatogram .....	95
A.2 Calculation of Adsorption Equilibrium Constant .....	96
A.3 Calculation of Heat of Adsorption .....	97
A.4 Calculation of Overall Mass-Transfer Coefficients .....	99
A.5 Calculation of Concentrations of Toluene Vapour .....	99
A.6 Calculation of Iodine Number of Carbon Adsorbents .....	101
A.7 Calculation of Bed Porosity and Particle Density .....	102
APPENDIX B Scanning Electron Microscope .....	105
APPENDIX C Experimental Data .....	118
APPENDIX D Adsorption Equilibrium Constants and Heat of Adsorption .....	133
APPENDIX E Characteristics Data .....	142
CIRRICULUM VITAE .....	147



## LIST OF TABLES

Table 2.1	Pore sizes in typical activated carbon .....	12
Table 5.1	Observation results of carbon adsorbents from water hyacinth reacted with the various chemical reagents at the temperature of 110°C, 17 hours in the oven .....	41
Table 5.2	The experimental results using 50% (w/w) zinc chloride solution with coconut shell at 500°C .....	55
Table 5.3	Peak height of the functional group at 3438 and 1632 cm <sup>-1</sup> .....	66
Table 5.4	Particle density of prepared carbon adsorbents .....	67
Table 5.5	Summary of heat of adsorption .....	70
Table 5.6	Characteristics of carbon adsorbents from water hyacinth .....	74
Table A.1	Correction factor <i>D</i> for iodine number test .....	104
Table C.1	The retention times and variences of benzene vapour on WH401 .....	118
Table C.2	The retention times and variences of benzene vapour on WH402 .....	119
Table C.3	The retention times and variences of benzene vapour on WH403 .....	119
Table C.4	The retention times and variences of benzene vapour on WH501 .....	120
Table C.5	The retention times and variences of benzene vapour on WH502 .....	121
Table C.6	The retention times and variences of benzene vapour on WH503 .....	121
Table C.7	The retention times and variences of benzene vapour on WH601 .....	122
Table C.8	The retention times and variences of benzene vapour on WH602 .....	122
Table C.9	The retention times and variences of benzene vapour on WH603 .....	123
Table C.10	The retention times and variences of toluene vapour on WH401 .....	124
Table C.11	The retention times and variences of toluene vapour on WH402 .....	125
Table C.12	The retention times and variences of toluene vapour on WH403 .....	125
Table C.13	The retention times and variences of toluene vapour on WH501 .....	126
Table C.14	The retention times and variences of toluene vapour on WH502 .....	126
Table C.15	The retention times and variences of toluene vapour on WH503 .....	127
Table C.16	The retention times and variences of toluene vapour on WH601 .....	127
Table C.17	The retention times and variences of toluene vapour on WH602 .....	128
Table C.18	The retention times and variences of toluene vapour on WH603 .....	128

Table C.19	The retention times and variences of o-xylene vapour on WH401	129
Table C.20	The retention times and variences of o-xylene vapour on WH402	129
Table C.21	The retention times and variences of o-xylene vapour on WH403	130
Table C.22	The retention times and variences of o-xylene vapour on WH501	130
Table C.23	The retention times and variences of o-xylene vapour on WH502	130
Table C.24	The retention times and variences of o-xylene vapour on WH503	131
Table C.25	The retention times and variences of o-xylene vapour on WH601	131
Table C.26	The retention times and variences of o-xylene vapour on WH602	131
Table C.27	The retention times and variences of o-xylene vapour on WH603	132
Table D.1	Adsorption equilibrium constant of BTX vapours on WH401	133
Table D.2	Adsorption equilibrium constant of BTX vapours on WH402	134
Table D.3	Adsorption equilibrium constant of BTX vapours on WH403	135
Table D.4	Adsorption equilibrium constant of BTX vapours on WH501	136
Table D.5	Adsorption equilibrium constant of BTX vapours on WH502	137
Table D.6	Adsorption equilibrium constant of BTX vapours on WH503	138
Table D.7	Adsorption equilibrium constant of BTX vapours on WH601	139
Table D.8	Adsorption equilibrium constant of BTX vapours on WH602	140
Table D.9	Adsorption equilibrium constant of BTX vapours on WH603	141
Table E.1	Characteristics of carbon adsorbents from rice husk	142
Table E.2	Characteristics of carbon adsorbents from sugar-cane bagasses	143
Table E.3	Physical properties of the chemical reagents used	144
Table E.4	Bed characteristics of packed column	145
Table E.5	Physical properties of benzene, toluene, and o-xylene vapours	146

## LIST OF FIGURES

Figure 2.1 Arrangement of carbon atoms in a single-layer plane of crystallites formed at different temperature (400, 510, and 610°C) .....	12
Figure 2.2 Theoretical structure of crystallites .....	13
Figure 2.3 Linear isotherms .....	16
Figure 2.4 Langmuir isotherm .....	17
Figure 2.5 Mass-transfer steps .....	22
Figure 4.1 A typical packed column of an adsorbent for adsorption experiments ..	34
Figure 4.2 Adsorbate-vapour preparation apparatus .....	37
Figure 4.3 Schematic diagram of GC experiment .....	38
Figure 4.4 A chromatogram from the experimental result .....	39
Figure 5.1 BET surface areas of nitrogen adsorption of carbon adsorbents from water hyacinth which reacted with various chemicals at preactivation time of 1 and 17 hours at 110°C .....	42
Figure 5.2 (1) Partial pressure of hydrogen chloride gas in hydrochloric acid solution and partial pressure of water in sulfuric acid, and (2) partial pressure of water vapor and hydrogen nitrate in nitric acid solution .....	44
Figure 5.3 Carbon adsorbents yields from water hyacinth reacted with zinc chloride .....	48
Figure 5.4 Carbon adsorbent yields from rice husk reacted with zinc chloride .....	48
Figure 5.5 Carbon adsorbent yields from sugar-cane bagasse reacted with zinc chloride .....	49
Figure 5.6 External surfaces of carbon adsorbents from water hyacinth: (a) without zinc chloride and (b) with zinc chloride at 400°C, 1 hour .....	50
Figure 5.7 External surfaces of carbon adsorbents from rice husk without zinc chloride at 400°C, 1 hour .....	51
Figure 5.8 External surfaces of carbon adsorbents from rice husk reacted with zinc chloride at 400°C, 1 hour .....	51

Figure 5.9 External surface area of carbon adsorbent from sugar-cane bagasse reacted without zinc chloride at 400°C, 1 hour .....	52
Figure 5.10 External surface area of carbon adsorbent from sugar-cane bagasse reacted with zinc chloride at 400°C, 1 hour .....	52
Figure 5.11 External surface area of raw material (sugar-cane bagasse) .....	53
Figure 5.12 BET surface area of carbon adsorbents from water hyacinth reacted with zinc chloride .....	54
Figure 5.13 BET surface areas of carbon adsorbents from rice husk reacted with zinc chloride .....	54
Figure 5.14 BET surface areas of carbon adsorbents from sugar-cane bagasse reacted with zinc chloride .....	55
Figure 5.15 Iodine numbers of carbon adsorbents from water hyacinth reacted with zinc chloride .....	58
Figure 5.16 Iodine number of carbon adsorbents from rice husk reacted with zinc chloride .....	58
Figure 5.17 Iodine number of carbon adsorbents from sugar-cane bagasse reacted with zinc chloride .....	59
Figure 5.18 The average pore sizes of carbon adsorbents from water hyacinth reacted with zinc chloride .....	60
Figure 5.19 The average pore sizes of carbon adsorbents from rice husk reacted with zinc chloride .....	60
Figure 5.20 The average pore sizes of carbon adsorbents from sugar-cane bagasse reacted with zinc chloride .....	61
Figure 5.21 IR spectrum of carbon adsorbent WH401 .....	62
Figure 5.22 IR spectrum of carbon adsorbent WH402 .....	62
Figure 5.23 IR spectrum of carbon adsorbent WH403 .....	63
Figure 5.24 IR spectrum of carbon adsorbent WH501 .....	63
Figure 5.25 IR spectrum of carbon adsorbent WH502 .....	64
Figure 5.26 IR spectrum of carbon adsorbent WH503 .....	64
Figure 5.27 IR spectrum of carbon adsorbent WH601 .....	65
Figure 5.28 IR spectrum of carbon adsorbent WH602 .....	65
Figure 5.29 IR spectrum of carbon adsorbent WH603 .....	66

Figure 5.30	The retention time of toluene vapour on WH401 as a function of $L/v$ .....	69
Figure 5.31	The adsorption equilibrium constants of toluene vapour on various adsorbents .....	72
Figure 5.32	The adsorption equilibrium constants of benzene vapour on various adsorbents .....	72
Figure 5.33	The adsorption equilibrium constants of o-xylene vapour on various adsorbents .....	73
Figure 5.34	The adsorption equilibrium constants of toluene vapour on WH401, 501, and 601 .....	75
Figure 5.35	The adsorption equilibrium constants of benzene vapour on WH401, 501, and 601 .....	75
Figure 5.36	The adsorption equilibrium constants of o-xylene vapour on WH401, 501, and 601 .....	76
Figure 5.37	The adsorption equilibrium constants of BTX vapours on WH401 .....	76
Figure 5.38	The adsorption equilibrium constants of BTX vapours on WH402 .....	77
Figure 5.39	The adsorption equilibrium constants of BTX vapours on WH403 .....	78
Figure 5.40	The adsorption equilibrium constants of BTX vapours on WH501 .....	78
Figure 5.41	The adsorption equilibrium constants of BTX vapours on WH502 .....	79
Figure 5.42	The adsorption equilibrium constants of BTX vapours on WH503 .....	79
Figure 5.43	The overall mass-transfer coefficients of BTX vapours on WH401 .....	80
Figure 5.44	The overall mass-transfer coefficients of BTX vapours on WH403 .....	81
Figure 5.43	The overall mass-transfer coefficients of BTX vapours on WH502 .....	81

Figure A.1	Chromatogram of the experiment result .....	95
Figure A.2	First moment plot of adsorption of toluene vapour on WH401 at 180°C .....	96
Figure A.3	Adsorption equilibrium constants of toluene vapour on WH401 at 180°C .....	98
Figure A.4	Overall mass-transfer coefficient of toluene vapour on WH401 at 180°C .....	98
Figure A.5	The relationship of friction factors versus Reynold numbers for flow through packed bed according to Blake-Kozeny equation on WH401T .....	103
Figure B.1	External surface of carbon adsorbent from WH402 .....	105
Figure B.2	External surface of carbon adsorbent from WH403 .....	106
Figure B.3	External surface of carbon adsorbent from WH501 .....	106
Figure B.4	External surface of carbon adsorbent from WH502 .....	107
Figure B.5	External surface of carbon adsorbent from WH503 .....	107
Figure B.6	External surface of carbon adsorbent from WH601 .....	108
Figure B.7	External surface of carbon adsorbent from WH602 .....	108
Figure B.8	External surface of carbon adsorbent from WH603 .....	109
Figure B.9	External surface of carbon adsorbent from RH402 .....	109
Figure B.10	External surface of carbon adsorbent from RH403 .....	110
Figure B.11	External surface of carbon adsorbent from RH501 .....	110
Figure B.12	External surface of carbon adsorbent from RH502 .....	111
Figure B.13	External surface of carbon adsorbent from RH503 .....	111
Figure B.14	External surface of carbon adsorbent from RH601 .....	112
Figure B.15	External surface of carbon adsorbent from RH602 .....	112
Figure B.16	External surface of carbon adsorbent from RH603 .....	113
Figure B.17	External surface of carbon adsorbent from SCB402 .....	113
Figure B.18	External surface of carbon adsorbent from SCB403 .....	114
Figure B.19	External surface of carbon adsorbent from SCB501 .....	114
Figure B.20	External surface of carbon adsorbent from SCB502 .....	115
Figure B.21	External surface of carbon adsorbent from SCB503 .....	115
Figure B.22	External surface of carbon adsorbent from SCB601 .....	116

Figure B.23 External surface of carbon adsorbent from SCB602 .....	116
Figure B.24 External surface of carbon adsorbent from SCB603 .....	117

## NOMENCLATURE

$a$	surface area per unit volume of pellet, $\text{cm}^2/\text{cm}^3$
$a_s$	specific surface area, $\text{cm}^2/\text{g}$
$C$	sorbate concentration, $\text{mol}/\text{cm}^3$
$C_b$	sorbate concentration at bulk gas phase, $\text{mol}/\text{cm}^3$
$C_e$	sorbate concentration at gas-adsorbed phase interface, $\text{mol}/\text{cm}^3$
$C_s$	sorbate concentration at stagnant gas phase, $\text{mol}/\text{cm}^3$
$D_k$	Knudsen diffusivity, $\text{cm}^2/\text{sec}$
$D_L$	axial dispersion, $\text{cm}^2/\text{sec}$
$D_m$	molecular diffusivity, $\text{cm}^2/\text{sec}$
$D_p$	particle diameter, $\text{cm}$
$E^0$	standard electrode potential, volt
$\Delta H$	heat of adsorption, $\text{kJ}/\text{mol}$
$k$	overall mass-transfer coefficient, $\text{sec}^{-1}$
$k_f$	external fluid film mass-transfer coefficient, $\text{cm}/\text{sec}$
$k_p$	pore mass-transfer coefficient, $\text{cm}/\text{sec}$
$K$	adsorption equilibrium constant, $\text{mol}/\text{cm}^3$ of pellet or $\text{mol}/\text{cm}^3$ of gas
$K_a$	adsorption equilibrium constant for unsaturation isotherm
$K_F$	Freundlich adsorption equilibrium constant, $\text{mmol}/\text{m}^2 \cdot \text{kPa}^{1/n}$
$K_L$	Langmuir adsorption equilibrium constant, $\text{kPa}^{-1}$
$K_{\text{BET}}$	BET adsorption equilibrium constant
$L$	length of packed bed, $\text{cm}$
$M$	molecular weight, $\text{g}/\text{mol}$
$n$	parameter constant
$P$	vapour pressure of adsorbate, $\text{kPa}$
$P_r$	relative pressure
$P_s$	saturated vapour pressure of adsorbate, $\text{kPa}$
$q$	amount of adsorbate adsorbed, $\text{mmol}/\text{g}$
$q_s$	maximum amount adsorbed, $\text{mmol}/\text{g}$
$r_p$	mean pore radius, $\text{cm}$



$R$	gas constant
$R_{\text{ads}}$	rate of adsorption, mol/g·sec
$R_p$	radius of adsorbent pellet, cm
$t_R$	retention time, sec
	weighted mean residence time, sec
$T$	adsorption temperature, K
$v$	interstitial velocity of carrier gas, cm/sec
$v_0$	superficial velocity of carrier gas, cm/sec
XXa0bY	XX means raw material used, i.e. WH is water hyacinth, RH is rice husk, and SCB is sugar-cane bagasses
a	means reacting temperature, i.e. 4 is 400°C, 5 is 500°C, and 6 is 600°C
b	means reacting time, i.e. 1 is 1 hour, 2 is 2 hours, and 3 is 3 hours
Y	means adsorbate used, i.e. B is benzene, T is toluene, and X is o-xylene
	WH401T, for example, means the carbon adsorbent prepared from water hyacinth reacted at 400°C for an hour used for adsorbing toluene vapour.

#### DIMENSIONLESS GROUP

Re	Reynolds number
Sc	Schmidt number
Sh	Sherwood number

#### GREEK LETTERS

$\varepsilon$	bed porosity
$\rho$	fluid density, g/cm <sup>3</sup>
$\rho_b$	bulk density, g/cm <sup>3</sup>
$\rho_p$	particle density, g/cm <sup>3</sup>
$\rho_s$	solid density, g/cm <sup>3</sup>
$\sigma^2$	variance of chromatogram, sec <sup>2</sup>