

**DEACTIVATION MODELING FOR THE ADSORPTION ISOTHERM OF
DEACTIVATED ADSORBENTS USED IN NATURAL GAS
DEHYDRATION PROCESS**

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ABSTRACT

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Keywords: Adsorption/ Activated alumina/ Molecular sieve zeolite 4A/ Hydrothermal steaming/ Deactivation/ Adsorption isotherm/ Breakthrough Curve/ Natural gas dehydration

Two types of adsorbents, activated alumina and molecular sieve zeolite 4A, used in the natural gas dehydration process were studied for their adsorption behaviour, both static and dynamic along the adsorption process. Deactivation by hydrothermal steaming was employed for deactivating the adsorbents. The effect of the deactivated adsorbents on the adsorption capacity was then studied. The results showed a decrease in the specific surface area of activated alumina, when hydrothermally steamed at 300 to 550°C, from 200.2 to 124.0 m²/g. The adsorption capacity of the activated alumina decreased linearly with surface area. The adsorption capacity of the molecular sieve zeolite was also decreased by steaming, but not in a linear fashion. SEM analysis indicated a decrease in average crystal size from about 2 to 1 microns with the increase of steaming time. The adsorption isotherms of fresh and deactivated adsorbents were examined at 25°C, 1atm, and it was found that Freundlich model gave good agreement for alumina, and Aranovich and Donohue (A-D) for Toth model fitted the data of molecular sieve zeolite. Also, the adsorption isotherms are used in a previously developed mathematical model to predict the breakthrough time of the multi-layered adsorber. From the dynamic adsorption of a packed column with the fresh and deactivated adsorbents, it was found the breakthrough time of the deactivated bed was shorter than the fresh one. The predicted breakthrough time agrees well with the experimental one.

บทคัดย่อ

วรรณพร คำคำ : การศึกษาการเสื่อมสภาพของตัวดูดซับและการสร้างแบบจำลองทางคณิตศาสตร์สำหรับไอโซเทอร์มของตัวดูดซับที่เกิดการเสื่อมสภาพในกระบวนการกำจัดน้ำจากก๊าซธรรมชาติโดยใช้ตัวดูดซับ (Deactivation Modeling for the Adsorption Isotherm of Deactivated Adsorbents used in Natural Gas Dehydration Process) อ. ที่ปรึกษา : ผศ. ดร. ศิริรัตน์ จิตการคำ, ผศ. ดร. กิติพัฒน์ สیمانนค์, ดร. ธนา ศรีธานี และนายสุทธิภูมิ พุ่มหิรัญ 94 หน้า

การศึกษาการดูดซับน้ำออกจากก๊าซธรรมชาติโดยใช้ตัวดูดซับสองชนิด คือ อลูมินา และ 4A ซีโอไลท์ ในขณะที่ตัวดูดซับเกิดการเสื่อมสภาพเนื่องมาจากกระบวนการผ่านความร้อนและไอน้ำ (Hydrothermal Steaming) โดยได้ศึกษาเชิงกายภาพถึงผลของการเสื่อมสภาพของตัวดูดซับที่มีต่อค่าการดูดซับน้ำ จากการศึกษาพบว่าตัวดูดซับอลูมินาเมื่อผ่านความร้อนและไอน้ำในช่วงอุณหภูมิ 300 ถึง 550 องศาเซลเซียส จะส่งผลให้พื้นที่ผิวลดลงจาก 200.2 เหลือเพียง 124.0 ตารางเมตรต่อกรัมตามลำดับ และค่าการดูดซับน้ำก็ลดลงเป็นความสัมพันธ์แบบเส้นตรงตามจำนวนพื้นที่ผิวที่ลดลงนี้ด้วย สำหรับตัวดูดซับ 4A ซีโอไลท์ จากการศึกษาพบว่าตัวดูดซับชนิดนี้เกิดการเสื่อมสภาพจากกระบวนการผ่านความร้อนและไอน้ำเช่นเดียวกัน แต่ความสัมพันธ์ระหว่างค่าการเสื่อมสภาพต่อค่าการดูดซับของตัวดูดซับชนิดนี้ไม่เป็นแบบเส้นตรง ทั้งนี้ผลการวิเคราะห์โดยเครื่องสแกนนิ่งอิเล็กตรอนไมโครสโคป (SEM) ซึ่งให้เห็นว่าขนาดของผลึกซีโอไลท์ 4A ที่เสื่อมสภาพมีขนาดลดลงจากประมาณ 2 เป็น 1 ไมครอน นอกจากนี้ยังได้ทำการศึกษาหาไอโซเทอร์มของการดูดซับน้ำที่อุณหภูมิ 25 องศาเซลเซียส ความดัน 1 บรรยากาศ ของตัวดูดซับแต่ละชนิดทั้งยังไม่ได้เสื่อมสภาพและเมื่อเสื่อมสภาพแล้ว พบว่าสมการ Freundlich สามารถอธิบายไอโซเทอร์มของอลูมินาได้อย่างแม่นยำ และในส่วนของซีโอไลท์สมการของ Aranovich-Donohue ที่ปรับปรุงใช้กับสมการของ Toth นั้นสามารถอธิบายไอโซเทอร์มได้เป็นอย่างดีด้วย ซึ่งค่าคงที่ของไอโซเทอร์มที่ได้จะถูกนำมาใช้ในแบบจำลองทางคณิตศาสตร์สำหรับหอดูดซับน้ำที่บรรจุตัวดูดซับหลายชนิดอยู่ภายใน (หอดูดซับแบบมัลติเลเยอร์) ที่ถูกสร้างและพัฒนามาแล้วในงานก่อนหน้านี้นี้ เพื่อนำมาใช้ในการทำนายเวลาเบรคทิวในเชิงทฤษฎีได้ และจากการทดลองพบว่าคุณลักษณะและแนวโน้มของกราฟเบรคทิวในทางทฤษฎีที่ได้จากการทำนายโดยแบบจำลองทางคณิตศาสตร์สามารถทำนายความสามารถในการดูดซับน้ำได้อย่างแม่นยำ

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TABLE OF CONTENTS

	PAGE
Title Page	i
Abstract (in English)	iii
Abstract (in Thai)	iv
Acknowledgements	v
Table of Contents	vi
List of Tables	x
List of Figures	xiii
List of Symbols	xvii
CHAPTER	
I INTRODUCTION	1
II BACKGROUND AND LITERATURE SURVEY	3
2.1 Background	3
2.1.1 Natural Gas Components	3
2.1.2 Natural Gas Dehydration	4
2.1.3 Adsorption Dehydration	4
2.1.4 Adsorption Equipment	5
2.1.5 Adsorption Isotherms	7
2.1.6 Adsorbents	10
2.1.7 Deactivation	12
2.1.8 Mathematical Model	13
2.2 Literature Survey	14
III EXPERIMENTAL	18
3.1 Materials and Equipments	18
3.1.1 Equipment	18
3.1.2 Software	18

CHAPTER	PAGE
3.1.3 Chemicals	18
3.2 Experimental Procedures	19
3.2.1 Adsorbents Preparation	19
3.2.2 Adsorbents Characterization	19
3.2.3 Adsorption Isotherm	20
IV MATHEMATICAL SOLVING METHOD	24
4.1 Adsorption Isotherm Equations	24
4.2 Mass Balance for Adsorber	24
4.3 Deactivation Modeling Approaches	27
V RESULTS AND DISCUSSION	31
5.1 Adsorbent Preparation for Deactivation	31
5.2 Adsorbent Characterization	32
5.2.1 Fresh Adsorbent Characterization	32
5.2.1.1 Static Adsorption Capacity	32
5.2.1.2 Scanning Electron Microscopy	35
5.2.1.3 Surface Area	37
5.2.1.4 X-Ray Diffraction Patterns	37
5.2.2 Deactivated Adsorbent Characterization	39
5.2.2.1 Deactivated Alumina Characterization	39
A. Static Adsorption Capacity	40
B. Specific Surface Area	40
C. Scanning Electron Microscopy	42
D. X-Ray Diffraction Pattern	42
5.2.2.2 Deactivated Molecular Sieve Zeolite Characterization	44
A. Static Adsorption Capacity	44
B. Specific Surface Area	44

C. Average Crystal Size	45
D. X-Ray Diffraction Pattern	47
5.3 Equilibrium Adsorption Isotherm Development	49
5.3.1 The Equilibrium Adsorption Isotherm of Fresh Adsorbents	49
5.3.1.1 Fresh Alumina	49
5.3.1.2 Fresh Molecular Sieve Zeolite	49
A. Fresh 1/8" Molecular Sieve Zeolite	50
B. Fresh 1/16" Molecular Sieve Zeolite	51
5.3.2 The Equilibrium Adsorption isotherms of Deactivated Adsorbents	52
5.3.2.1 Deactivated Alumina	52
5.3.2.2 Deactivated Molecular Sieve Zeolite	53
A. Deactivated 1/8" Molecular Sieve Zeolite	54
B. Deactivated 1/16" Molecular Sieve Zeolite	55
5.3.3 Correlation of Constants in Equilibrium Adsorption Isotherm with Degree of Deactivation	56
5.3.3.1 Activated Alumina	56
5.3.3.2 Molecular Sieve Zeolite	57
5.4 Experimental Breakthrough Curves	59
5.4.1 Experimental Breakthrough Curve of Fresh Fixed-bed Adsorber packed with All Fresh Adsorbents	60
5.4.2 Experimental Breakthrough Curve of Fixed-bed Adsorber packed with Deactivated Adsorbents	60
5.5 Theoretical Breakthrough Curve	61
5.5.1 Comparison of Experimental and Theoretical Breakthrough Curves of Fixed-bed packed with Fresh Adsorbents	62
5.5.2 Comparison of Experimental and Theoretical Breakthrough Curves of Fixed-bed packed with Deactivated Adsorbent	63

5.6 Predicted Breakthrough Time of Multi-Layer Deactivated Adsorbers	63
V CONCLUSIONS AND RECOMMENDATIONS	69
6.1 Conclusions	69
6.2 Recommendations	70
REFERENCES	71
APPENDICES	73
Appendix A Crystal size data from SEM analysis	73
Appendix B Crystal Size Distribution Plot of Molecular Sieve Zeolite of size 1/8" and 1/16"	74
Appendix C Conditions for Adsorption experiment	79
Appendix D Conditions for breakthrough curve experiments	80
Appendix E Parameters Applied in Mathematical Model	81
Appendix F Bed void fraction of each adsorbent	83
Appendix G The Study of Sensitivity of Overall Mass Transfer Coefficient (k) to the Shape of the Breakthrough Curve	84
Appendix H The Study of Effect of the Bed Voidage to the Breakthrough Time of Deactivated Adsorbents	85
Appendix I Hydrothermal steaming apparatus	87
Appendix J Simulation Program	88
CURRICULUM VITAE	94

LIST OF TABLES

TABLE	PAGE	
2.1	Typical composition of natural gas	3
2.2	Names and equations of applied conventional adsorption isotherm models	8
2.3	Properties and applications of zeolites	11
2.4	Representative properties of commercial porous adsorbents	12
5.1	Static adsorption capacity of fresh adsorbents at 100%RH and 25°C	32
5.2	Desorption temperature of fresh adsorbents at 100%RH and 25°C	34
5.3	Scanning Electron microscopy images of fresh adsorbents	35
5.4	Surface area of the general commercial adsorbents	37
5.5	The specific surface area, pore volume, and monolayer volume of fresh activated alumina from BET analysis	37
5.6	The adsorption capacity analysis of fresh and deactivated alumina	40
5.7	The specific surface area analysis of fresh and deactivated alumina	40
5.8	Scanning Electron microscopy images of activated alumina at several deactivation conditions	43
5.9	Adsorption capacity at several aging conditions and percentage of deactivation due to the loss of adsorption capacity	44
5.10	Average crystal size of molecular sieve zeolite and the %deactivation at several aging conditions	45
5.11	Comparison of the equilibrium adsorption isotherm equations for fresh molecular sieve zeolite of size 1/8”	51

5.12	Comparison of the equilibrium adsorption isotherm equations for fresh molecular sieve zeolite of size 1/16"	52
5.13	Equilibrium adsorption isotherm equations of fresh and deactivated alumina	53
5.14	Equilibrium adsorption isotherm equations of fresh and deactivated 1/8" molecular sieve zeolite	54
5.15	Equilibrium adsorption isotherm equations of fresh and deactivated 1/16" molecular sieve zeolite	55
5.16	Values of all constants in the equilibrium adsorption isotherm equations of fresh and deactivated alumina	56
5.17	Values of all constants in the A-D equations of the fresh and deactivated molecular sieve zeolite	58
5.18	Notation for adsorbents at various degrees of deactivation	64
5.19	The theoretically predicted breakthrough time of several sets of deactivated beds	65
5.20	Predicted breakthrough time of the adsorber packed with 42.5% deactivated alumina (D_{1A}) on the top and Molsiv adsorbents with various degrees of deactivation in the bottom	66
5.21	Predicted breakthrough time of the adsorber packed with 88.3% deactivated alumina (D_{2A}) on the top and Molsiv adsorbents with various degrees of deactivation in the bottom	67
6.1	The deactivation range studied in this work	69
6.2	The differences of the experimental and theoretical breakthrough times of fresh and deactivated bed	70
A1	Crystal size data of Molecular Sieve Zeolite of size 1/8"	73
A2	Crystal size data of Molecular Sieve Zeolite of size 1/16"	73
B1	Crystal Size Distribution of Molecular Sieve Zeolite of size 1/8"	74

B2	Crystal Size Distribution of Molecular Sieve Zeolite of size 1/16"	76
C1	Conditions for Adsorption Experiments	79
D1	Multi-layer adsorber	80
E1	Parameters applied in mathematical model	81
G1	The comparison of breakthrough time predicted from several k value	84
H1	The bed void fraction provided in theoretical breakthrough model for 88.3% deactivated alumina, 15.13% deactivated 1/8" molsiv, and 14.10% deactivated molsiv at the contact time of 9.83 sec and the feed humidity of 30%RH	85

LIST OF FIGURES

FIGURE	PAGE	
2.1	Pressure-swing adsorption for the dehydration process	6
2.2	IUPAC classifications of gas adsorption isotherms	7
4.1	Change of the breakthrough time upon degree of deactivation in a packed bed adsorber	28
4.2	Activity as a function of process time	28
4.3	Relationship between the breakthrough time ratio and deactivation ratio of the deactivated adsorbents in various expected manners	30
5.1	Weight loss of water saturated on fresh adsorbents from TG/DTA experiments	33
5.2	Weight loss derivative of water saturated on fresh adsorbents from TG/DTA experiments	34
5.3	The size distribution of molecular sieve zeolite of size 1/8"	36
5.4	The size distribution of molecular sieve zeolite of size 1/16"	36
5.5	X-Ray Diffraction pattern of fresh activated alumina	38
5.6	X-Ray Diffraction pattern of fresh molecular sieve zeolite of size 1/8"	38
5.7	X-Ray Diffraction pattern of fresh molecular sieve zeolite of size 1/16"	39
5.8	Specific surface area and the adsorption capacity of the activated alumina at several aging conditions	41
5.9	Relationship between the loss of adsorption capacity and the reduction of specific surface area of deactivated alumina	42
5.10	The XRD patterns of fresh alumina: (a) fresh, (b) 67.92% deactivation, and (c) 88.30% deactivation	42

5.11	Adsorption capacity and the average crystal size of the deactivated 1/8" molecular sieve zeolite at various numbers of batches	46
5.12	Adsorption capacity and the average crystal size of the deactivated 1/16" molecular sieve zeolite at various numbers of batches	46
5.13	The relationship of the loss of adsorption capacity and the reduction of average crystal size of 1/8" molecular sieve zeolite	47
5.14	The relationship of the loss of adsorption capacity and the reduction of average crystal size of 1/16" molecular sieve zeolite	47
5.15	The XRD patterns of 1/8" Molecular sieve: (a) fresh, (b)10.81% deactivation, and (c) 15.13% deactivation	48
5.16	The XRD patterns of 1/16" Molecular sieve: (a) fresh, (b) 5.79% deactivation, and (c) 14.10% deactivation	48
5.17	Adsorption Isotherm of fresh alumina	49
5.18	Equilibrium adsorption isotherm of fresh 1/8" molecular sieve zeolite	50
5.19	Equilibrium dsorption isotherm of fresh 1/16" molecular sieve zeolite	51
5.20	The equilibrium adsorption isotherms of activated alumina of fresh, 42.46, 67.92, 77.97, and 88.30% deactivated due to loss of their adsorption capacities	53
5.21	The equilibrium adsorption isotherms of 1/8" molecular sieve zeolite at several percentages of deactivation by the loss of their adsorption capacity	54
5.22	The equilibrium adsorption isotherms of 1/16" molecular sieve zeolite at several percentages of deactivation by the loss of their adsorption capacity	56

5.23	Relationship between constants a and b in the Freundlich equations and degree of deactivation of the alumina	57
5.24	Relationship between constant b in A-D for Toth equations of the 1/8" and 1/16" molecular sieve zeolite and degree of deactivation	58
5.25	Relationship between constant t in A-D for Toth equations of the 1/8" and 1/16" molecular sieve zeolite and degree of deactivation	59
5.26	Relationship between constant d in A-D for Toth equations of the 1/8" and 1/16" molecular sieve zeolite and degree of deactivation	59
5.27	Experimental breakthrough curve of the fresh bed packed with the fresh adsorbents (the inlet water concentration of 30%RH and the contact time of 9.83s)	60
5.28	Experimental breakthrough curve of the bed packed with 88.3% deactivated alumina, 15.13%deactivated 1/8" mol siv, and 14.10% deactivated molsiv (inlet water concentration of 30%RH, and the contact time of 9.83s)	61
5.29	Comparison between the experimental and theoretical breakthrough curves at the contact time of 9.83 sec and the feed humidity of 30%RH	62
5.30	Comparison between experimental and theoretical breakthrough curves of fixed-bed adsorber packed with 88.3% deactivated alumina, 15.13%deactivated 1/8" molsiv, and 14.10% deactivated molsiv at the contact time of 9.83 sec and the feed humidity of 30%RH	63
5.31	Relationship of deactivation ratio and theoretical breakthrough time ratio for each adsorbents	65

5.32	Predicted breakthrough time of the adsorber packed with 42.5% deactivated alumina (D_{1A}) on the top and Molsiv adsorbents with various degrees of deactivation in the bottom	67
5.33	Predicted breakthrough time of the adsorber packed with 88.3% deactivated alumina (D_{2A}) on the top and Molsiv adsorbents with various degrees of deactivation in the bottom	68
F1	The porosity as a function of the ratio of particle diameter to bed diameter	83
G1	Comparison between the experimental and theoretical breakthrough curves with influence of the overall mass transfer coefficient at the contact time of 9.83 sec and the feed humidity of 30%RH	84
H1	Comparison between the experimental and theoretical breakthrough curves of deactivated adsorbents at the contact time of 9.83 sec and the feed humidity of 30%RH	86
I1	Hydrothermal steaming apparatus	87

LIST OF SYMBOLS

SYMBOL

a, b, t, d	adsorption constant
c	adsorbate concentration in fluid phase, (mol/l)
C	total concentration, (mol/l)
D_L	axial dispersion coefficient, (cm^2/s)
K	overall mass transfer coefficient, (l/s)
P	water vapor pressure, (kP)
q^*	equilibrium value of q
t	time, (s)
T	temperature, (K)
v	interstitial velocity of fluid, (cm/s)
z	distance measure from column inlet, (cm)

GREEK LETTERS

ε	bed void fraction
ρ	density of mixing gas, (g/cm.s)
σ_{AB}	collision diameter from Lennard-Jones potential
Ω_{AB}	collision integral