

**ADSORPTION KINETICS OF AN ION-EXCHANGE COLUMN IN
FIXED-BED OPERATION: A SIMPLE MODEL APPROACH**



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A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Master of Science
The Petroleum and Petrochemical College, Chulalongkorn University
in Academic Partnership with
The University of Michigan, The University of Oklahoma,
and Case Western Reserve University

2001

ISBN 974-13-0698-9

Thesis Title : Adsorption Kinetics of an Ion-Exchange Column
in Fixed-Bed Operation: A Simple Model Approach
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Accepted by the Petroleum and Petrochemical College, Chulalongkorn University, in partial fulfilment of the requirements for the Degree of Master of Science.

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บทคัดย่อ

นางสาว อัจฉรา วรศิลป์ชัย : กลไกการดูดซับของการแลกเปลี่ยนไอออนในคอลัมน์ที่มีทิศทางไหลลง : ผลการทดลองถูกทำนายโดยรูปแบบจำลองอย่างง่าย (Adsorption Kinetics of an Ion-Exchange Column in Fixed-Bed Operation: A Simple Model Approach) อ. ที่ปรึกษา : ศ. เจมส์ โอ วิลค์, ดร. ปมทอง มาลากุล ณ อยุธยา และ ดร. ปราโมช รังสรรค์วิจิตร 104 หน้า ISBN 974-13-0698-9

การวิจัยนี้ศึกษาพฤติกรรมของการแลกเปลี่ยนไอออนของแคลเซียมไอออนและแมกนีเซียมไอออนสำหรับไฮโดรเจนไอออนบนเรซินที่มีประจุบวกและชอบกรดแก่ (Dowex50-x8) กลไกการดูดซับนี้ได้ถูกศึกษาในคอลัมน์แบบฟีกเบดที่อุณหภูมิห้อง ก่อนที่จะทำการศึกษาการดูดซับในคอลัมน์ ความสัมพันธ์ระหว่างปริมาณแคลเซียมไอออนในเรซินและในสารละลายที่สมดุล, q^e , c^e , จะถูกพัฒนาจากการทดลองแบบกะ (Batch) ความสัมพันธ์นี้จะถูกนำไปรวมกับสูตรการดูดซับอย่างง่ายซึ่งจะถูกใช้ในการคาดเดาการดูดซับของไอออนในคอลัมน์แบบฟีกเบดต่อไป ลักษณะการไหลของของเหลวในคอลัมน์ได้ทำการตรวจสอบโดยการทดลองแบบไม่มีการดูดซับ จากการทดลองแบบไม่มีการดูดซับนี้พบว่า การรวมตัวของ CSTR ขนาด 2.5 มิลลิลิตร 1 ตัว และ PFR 1 ตัว สามารถถูกใช้ในรูปแบบของลักษณะการไหลของของเหลวในคอลัมน์ได้เป็นอย่างดี ในที่นี้ การแข่งขันการดูดซับของแคลเซียมและแมกนีเซียมไอออนในสารละลายเชิงผสมได้ถูกศึกษาเช่นกัน เมื่อได้ทำการทดลองการแลกเปลี่ยนไอออนในคอลัมน์แบบฟีกเบดพบว่าเรซินที่มีประจุบวกและชอบกรดแก่ (Dowex50-x8) ชอบที่จะดูดซับแคลเซียมไอออนมากกว่าแมกนีเซียมไอออน อัตราการถูกดูดซับและจำนวนของไอออนที่ถูกดูดซับที่สมดุลของแคลเซียมไอออนมีค่ามากกว่าแมกนีเซียมไอออน การชอบที่จะดูดซับของเรซินที่มีประจุบวกและชอบกรดแก่ (Dowex50-x8) ได้ถูกสนับสนุนโดยการศึกษาการคายไอออนจากเรซิน



ABSTRACT

4271001063 : PETROCHEMICAL TECHNOLOGY PROGRAM

Atchara Worasinchai: Adsorption Kinetics of an Ion-Exchange Column in Fixed-Bed Operation: Simple Model Approach

Thesis Advisors: Prof. James O. Wilkes, Dr. Pomthong Malakul and Dr. Pramoch Rangsunvigit, 104 pp ISBN 974-13-0698-9

Keywords : Ion-Exchange/ Kinetics Adsorption/ Cation Exchange/ Resin/ Fixed-Bed/ Modeling Ion Exchange

The adsorption kinetics of Ca^{2+} and Mg^{2+} ions on a strongly acid cation resin (Dowex50-X8) in packed-bed column were studied at room temperature. Prior to the column studies, the adsorption of the metal ions from single-ion and mixed-ion solutions was carried out in batch operation in order to develop a correlation between equilibrium adsorption capacity (q^e) and equilibrium metal concentration (c^e). The correlation was then incorporated into a simple expression for the adsorption rate which, subsequently, was shown to predict the adsorption of metal ions in fixed-bed operation reasonably well. In addition, the no adsorption experiment was performed so as to investigate the flow characteristics of the ion-exchange column. It was found that the column could be modelled by one CSTR and one ideal PFR connected in series with a CSTR volume of 2.5 ml. Lastly, the competitive adsorption of Ca^{2+} and Mg^{2+} in mixed-ion system was examined. The results strongly suggested that Ca^{2+} was preferentially adsorbed by the Dowex50-X8 resin than Mg^{2+} . The adsorption rate and adsorbed amount at equilibrium of Ca^{2+} were higher than those of Mg^{2+} . This preferential adsorption was also supported by the results obtained from the desorption studies.

ACKNOWLEDGEMENTS

I would like to express my heart-to-heart gratitude to my kindhearted advisor, Professor James O. Wilkes, for his esteemed suggestions and essential comments. I am also intensely under my co-advisor, Dr. Pomthong Malakul, obligation. He is not only provide the standard in theory and practice but suggest the appreciate ideals as well.

I wish to extend my profundity for all professors who furnished the plenty of learning to me at the Petroleum and Petrochemical College, Chulalongkorn University.

I greatly thank to all of my friends for their helpful and the college staffs who rejoiced to give sufficient assistance.

Ultimately, I would like to praise to my father and mother, Worachai and Pensri Worasinchai, for their love, willpower, understanding and infinite financial aid.

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NOTATION

Symbol	Definition
c_0	initial concentration of calcium chloride
c	concentration of NaCl, CaCl ₂ or MgCl ₂ in the solution phase
c_1	calcium ion concentration at the exit of CSTR
c_2	calcium ion concentration at the exit of PFR
c^e	calcium ion concentration in the solution at equilibrium
$c_{i, n}$	calcium ion concentration in the solution at time i and distance subscript n
$c_{i, n+1}$	calcium ion concentration in the solution at time i and distance subscript n+1
h	hydrogen ion concentration in the solution phase
h_0	entering hydrogen ion concentration
h_1	hydrogen ion concentration at the exit of CSTR
h_2	hydrogen ion concentration at the exit of PFR
h_m	hydrogen ion concentration measured by the pH electrode
h^e	hydrogen ion concentration in the solution at equilibrium
q	concentration of NaCl, CaCl ₂ or MgCl ₂ in the resin phase
q_t	total exchange capacity of the resin

q^e	calcium ion concentration onto the resin at equilibrium
$q_{i, n}$	calcium ion concentration onto the resin at time i and distance subscript n
$q_{i, n+1}$	calcium ion concentration onto the resin at time i and distance subscript n+1
V_R	volume occupied by the resin bed
V_L	volume occupied by the liquid bed
V_I	volume of CSTR.
v	superficial velocity
H	height of fluidized bed
H_0	height of compacted bed
ε	bed void fraction.
ε_0	compacted bed void fraction, 0.41
x	length of column
α_e	response time constant of the pH electrode
dq/dt	adsorption rate
dc/dt	desorption rate
K	rate constant
β	constant, $v^* dt/V_I$
n	constant
φ	under-relaxation
eq	amount of ion divided by its ion charge named equivalent
eq	$\frac{\text{molar mass}}{\text{ion charge}} = \frac{\text{mole of ion}}{\text{ion charge}}$