

**REMOVAL OF TRACE CADMIUM IONS USING CONTINUOUS  
MULTISTAGE ION FOAM FRACTIONATION**

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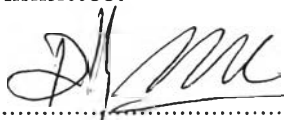
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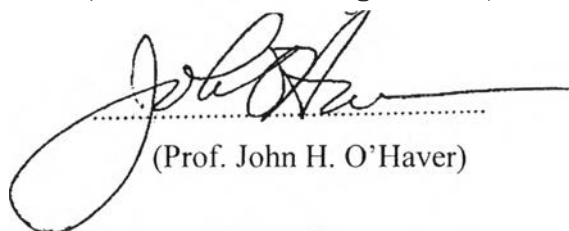
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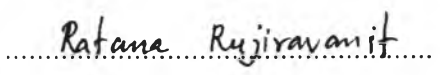
  
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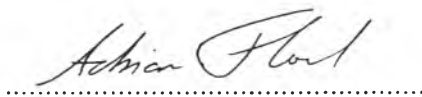
  
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## บทคัดย่อ

วิศรุต รุจิรวนิช : การแยกไอออนแคดเมียมปริมาณน้อยมากโดยการแยกลำดับส่วนฟองไอออนแบบต่อเนื่อง (Removal of Trace Cadmium Ions Using Continuous Multistage Ion Foam Fractionation) อ. ที่ปรึกษา : ศ. ดร. สุเมธ ชวเดช ศ. ดร. จอห์น เอช โอฮาเวอร์ และ รศ. ดร. รัตนา รุจิรวนิช

ในการศึกษานี้ คอลัมน์สกัดส่วนฟองไอออนหลายขั้นตอนแบบต่อเนื่องที่มีภาคประกอบด้วยถ้วยฟองถูกนำมาใช้เพื่อแยกไอออนแคดเมียมจากน้ำที่มีความเข้มข้นแคดเมียมในระดับต่ำ (10 มก./ล.) และโซเดียมโดเดคซิลซัลเฟต (SDS) ถูกใช้สร้างฟอง ในการทำให้ประสิทธิภาพการกำจัดแคดเมียมสูงสุดในรูปของอัตราส่วนการกำจัด แฟลคเตอร์การแยก และแฟลคเตอร์ที่เหลือของแคดเมียม ระบบต้องถูกควบคุมให้มีการขนส่งในแบบดูดซับสูงสุดด้วยการขนส่งแบบของเหลวต่ำสุด ในการเพิ่มของอัตราส่วนโมล SDS ต่อแคดเมียมในน้ำสามารถเพิ่มการกำจัดไอออนแคดเมียมอย่างมีนัยสำคัญ สัดส่วน โมลของ SDS ต่อแคดเมียมในน้ำของฟอง พบว่ามีค่าใกล้เคียงกับอัตราส่วนทางทฤษฎีที่เท่ากับ 2 ต่อ 1 ในการดูดซับบนผิวอากาศต่อน้ำของฟอง ภายใต้สภาวะการทำงานที่เหมาะสม ระบบที่ศึกษานี้สามารถแยกไอออนแคดเมียมได้สูงกว่า 99 เปอร์เซ็นต์ การมีไอออนร่วม ( $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , และ  $\text{Cl}^-$ ) พบว่าไม่มีผลต่อประสิทธิภาพการกำจัดทั้ง SDS และไอออนแคดเมียม แต่ทางตรงกันข้ามพบว่า การเติมไอออนตรงกันข้าม ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  และ  $\text{Mg}^{2+}$ ) มีผลทำให้การกำจัดแคดเมียมลดลงแต่การแยก SDS สูงขึ้น ในการเติมไอออนบวกที่มีวาเลนซ์สอง ( $\text{Ca}^{2+}$  และ  $\text{Mg}^{2+}$ ) ให้ผลสูงกว่าการเติมไอออนบวกที่มีวาเลนซ์หนึ่ง ( $\text{Na}^+$  และ  $\text{K}^+$ ) ทั้งนี้ เพราะไอออนบวกที่มีวาเลนซ์สองสามารถดูดซับร่วมกับ SDS ได้ดีกว่าไอออนบวกที่มีวาเลนซ์หนึ่ง

## ABSTRACT

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Visarut Rujirawanich: Removal of Trace Cadmium Ions Using Continuous Multistage Ion Foam Fractionation.

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Keywords: Ion foam fractionation/ Heavy metal/ Cadmium removal

In this work, a continuous multistage ion foam fractionation column with bubble-cap trays was used to remove cadmium ions from water having a low cadmium concentration (10 mg/L) and sodium dodecyl sulphate (SDS) was used to generate the foam. To optimize the removal efficiency of cadmium ions in terms of enrichment ratio, removal, separation factor and residual factor of cadmium, the system has to be operated to have the highest adsorptive transport with the lowest bulk liquid transport. An increase in feed SDS/Cd molar ratio enhanced significantly the removal of cadmium ions. The molar ratio of SDS/Cd in foamate was found to be close to the theoretical adsorption molar ratio of 2/1 on the air–water interface of foam. Under the optimum operational conditions, the studied multistage ion foam fractionation system was able to remove cadmium ions greater than 99 %. The presence of added co-ions ( $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , and  $\text{Cl}^-$ ) was found to exhibit no effect on the removal efficiency of both SDS and cadmium ions. In contrast, the addition of counterions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ ) decreased the cadmium removal whereas it increased the SDS separation. The added divalent cations ( $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ ) gave the higher effect than the added monovalent cations ( $\text{Na}^+$  and  $\text{K}^+$ ) because the divalent cations can co-adsorb more preferentially than the monovalent ones with the SDS.

## ACKNOWLEDGEMENTS

This work is dedicated to my beloved parents who have gone forever from my life but will stay constantly in my memory.

I had never dreamt of attending Ph.D. program until one day in March, 2007 when I met Assoc. Prof. Ratana Rujiravanit by chance. No one still knows whether good or bad on this way but I would like to give appreciative thanks to her who encouraged me to attend Ph.D. program when I was a second year Master's degree student. My Ph.D. experience would not have begun Prof. Sumaeth Chavadej had not selected me as his student for RGJ scholarship received. I would like to give deeply grateful thanks for the great opportunity and support. It's my honour to work with and learn so great lessons, ranging from lifestyle to academic subject, from him. Without such the good and generous advisor, this book is not possible to be finished. I would like to give thanks to Asst. Prof. Pomthong Malakul, Asst. Prof. Thammanoon Sreethawong, and Assoc. Prof. Adrian E. Flood for being as my dissertation committees and their useful suggestions on this work. I am grateful for the scholarship and funding of the thesis work provided by the Royal Golden Jubilee Ph.D Program; the Petroleum and Petrochemical College; and the National Center of Excellence for Petroleum, Petrochemicals, and Advanced Materials, Thailand.

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## TABLE OF CONTENTS

	<b>PAGE</b>
Title Page	i
Abstract (in English)	iii
Abstract (in Thai)	iv
Acknowledgements	v
Table of Contents	vi
List of Tables	x
List of Figures	xii
 <b>CHAPTER</b>	
<b>I INTRODUCTION</b>	<b>1</b>
1.1 State of Problem	1
1.2 Objectives	3
1.3 Scope of Work	3
 <b>II LITERATURE REVIEW</b>	 <b>5</b>
2.1 Surfactants	5
2.2 Foam	6
2.2.1 Foam Formation	6
2.2.2 Structure of Foam	7
2.2.3 Foam Stability	9
2.2.3.1 Liquid Film Stability	9
2.2.3.2 Liquid Film Drainage	11
2.3 Surfactant Adsorption at Air–Water Interface	14
2.4 Adsorptive Bubble Separation	14
2.4.1 Principles of Foam Fractionation	16
2.4.2 Mole Balance in Foam Fractionation Column	18
2.4.3 Literature Review on Surfactant Recovery Using Foam Fractionation	22

<b>CHAPTER</b>	<b>PAGE</b>
2.5 Ion Foam Fractionation	23
2.5.1 Principle of Foam Fractionation for Ion Separation	23
2.5.2 Kinetics of Ion Foam Fractionation	24
2.5.3 Recovery of Metal Product from Foamate	25
2.5.4 Literature review on Ion Foam Fractionation and Ion Flotation	27
 <b>III REMOVAL OF TRACE Cd<sup>2+</sup> USING CONTINUOUS MULTISTAGE ION FOAM FRACTIONATION: PART I—THE EFFECT OF FEED SDS/Cd MOLAR RATIO</b>	 29
3.1 Abstract	29
3.2 Introduction	30
3.3 Experimental	32
3.3.1 Materials	32
3.3.2 Setup of The Multistage Foam Fractionation Unit	32
3.3.3 Operation of The Multistage Foam Fractionation Unit	32
3.3.4 Analytical Methods	33
3.3.5 Calculations	34
3.4 Results and Discussion	35
3.4.1 Operating Limits	35
3.4.2 Surface Tension Isotherm Results	38
3.4.3 Correlation of Cd and SDS in Foamates and Effluents	41
3.4.4 Effect of Feed SDS/Cd Molar Ratio	45
3.5 Conclusions	48
3.6 Acknowledgements	49
3.7 References	49

CHAPTER	PAGE
<b>IV</b>	
<b>REMOVAL OF TRACE Cd<sup>2+</sup> USING CONTINUOUS MULTISTAGE ION FOAM FRACTIONATION: PART II—THE EFFECTS OF OPERATIONAL PARAMETERS</b>	53
4.1 Abstract	53
4.2 Introduction	54
4.3 Experimental	56
4.3.1 Materials	56
4.3.2 Multistage Ion Foam Fractionation System	57
4.3.3 Methodology	57
4.3.4 Analytical Methods	58
4.3.5 Surface Tension Measurement	59
4.4 Results and Discussion	59
4.4.1 Effect of Foam Height	59
4.4.2 Effect of Air Flow Rate	63
4.4.3 Effect of Feed Flow Rate	67
4.4.4 Effect of Feed Cd Concentration	71
4.5 Conclusions	75
4.6 Acknowledgements	76
4.7 References	76
<b>V</b>	
<b>REMOVAL OF TRACE Cd<sup>2+</sup> USING CONTINUOUS MULTISTAGE ION FOAM FRACTIONATION: EFFECT OF SALT ADDITION</b>	79
5.1 Abstract	79
5.2 Introduction	80
5.3 Experimental	82
5.3.1 Materials	82
5.3.2 Equipment	83
5.3.3 Methodology	83



<b>CHAPTER</b>	<b>PAGE</b>
5.3.4 Analytical Methods	85
5.3.5 Surface Tension Measurement	85
5.4 Results and Discussion	85
5.4.1 Specie Distribution Diagram	85
5.4.2 Surface Tension Isotherm Results	89
5.4.2.1 Type of Counterion	91
5.4.2.2 Type of Co-ions	95
5.4.3 The Effect of Salt Addition on Separation Efficiency of Multistage Ion Foam Fractionation	96
5.4.3.1 Separation Efficiency of SDS	96
5.4.3.2 Separation Efficiency of Cd	100
5.5 Conclusions	104
5.6 Acknowledgements	105
5.7 References	105
<b>VI CONCLUSIONS AND RECOMMENDATIONS</b>	109
<b>REFERENCES</b>	112
<b>APPENDIX</b>	119
<b>CURRICULUM VITAE</b>	131

## LIST OF TABLES

<b>TABLE</b>		<b>PAGE</b>
<b>CHAPTER III</b>		
3.1	Calculated values of CMC, $\gamma_{\text{cmc}}$ , $\text{pC}_{20}$ , and saturated surface concentrations ( $\Gamma_{\text{m}}$ ) of SDS alone and in the presence of cadmium and sodium ion concentrations	40
<b>CHAPTER V</b>		
5.1	Chemical equilibrium reactions of cadmium complexes with different ligands and their stability constants	86
5.2	Dependence of swamping counterion concentration, effective hydrated diameter, and the calculated value of a partition coefficient for the partition of a counterion between the air–water interface and the bulk liquid	90
<b>APPENDIX</b>		
A1	Surface tension of SDS solution with various concentrations of added NaCl at 25 °C to 27 °C	119
A2	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added NaCl at 25 °C to 27 °C	120
A3	Surface tension of SDS solution with various concentrations of added $\text{NaNO}_3$ at 25 °C to 27 °C	121
A4	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added $\text{NaNO}_3$ at 25 °C to 27 °C	122
A5	Surface tension of SDS solution with various concentrations of added $\text{Na}_2\text{SO}_4$ at 25 °C to 27 °C	123

<b>TABLE</b>		<b>PAGE</b>
A6	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added $\text{Na}_2\text{SO}_4$ at 25 °C to 27 °C	124
A7	Surface tension of SDS solution with various concentrations of added $\text{KNO}_3$ at 25 °C to 27 °C	125
A8	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added $\text{KNO}_3$ at 25 °C to 27 °C	126
A9	Surface tension of SDS solution with various concentrations of added $\text{Mg}(\text{NO}_3)_2$ at 25 °C to 27 °C	127
A10	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added $\text{Mg}(\text{NO}_3)_2$ at 25 °C to 27 °C	128
A11	Surface tension of SDS solution with various concentrations of added $\text{Ca}(\text{NO}_3)_2$ at 25 °C to 27 °C	129
A12	Surface tension of SDS solution with added $\text{Cd}(\text{NO}_3)_2$ concentration of 10 mg/L and various concentrations of added $\text{Ca}(\text{NO}_3)_2$ at 25 °C to 27 °C	130

## LIST OF FIGURES

<b>FIGURE</b>		<b>PAGE</b>
<b>CHAPTER II</b>		
2.1	Schematic of a surfactant molecule.	5
2.2	Formation of foam.	7
2.3	Plateau border at point of meeting of three bubbles.	7
2.4	Structure of foam.	8
2.5	Schematic of foam structure in a column.	8
2.6	Surface elasticity of foam film.	10
2.7	Reduction of foam film drainage by particle trapped in the plateau border.	11
2.8	(a) Surfactants at the air–liquid interface in the absence of thin film drainage. (b) Surface tension gradient on the surface is created as the surfactants are displaced due to the bulk viscous drag force in the presence of drainage. (c) The Marangoni effect results in a decrease in the net drainage rate.	13
2.9	Classification for the adsorptive bubble separation methods.	15
2.10	Principle of foam fractionation.	17
2.11	Material balance around foam phase.	17
2.12	Dependence of normalized bulk liquid transport on foamate volumetric ratio as described by Equation 2.12.	19
2.13	Dependence of % surfactant recovery on foamate volumetric ratio and normalized adsorptive transport as described by Equation 2.13.	20
2.14	Schematic of bubble caps tray.	21
2.15	Co-adsorption of surfactant and metal mechanism for ion separation in ion foam fractionation.	24

<b>FIGURE</b>	<b>PAGE</b>
2.16 A conceptual diagram of foam fractionation of ions integrated with the recovering unit (FF-Electrolysis).	26
<b>CHAPTER III</b>	
3.1 (a) Schematic of a multi-stage foam fractionation unit and (b) schematic of a base of a tray (top view).	35
3.2 Boundaries of the operational zone of the studied foam fractionator at a feed SDS/ Cd molar ratio of 7/1, a foam height of 60 cm, a feed Cd concentration of 10 mg/L, and the number of trays equal to 5.	37
3.3 Surface tension isotherms of SDS with various concentrations of Cd(NO <sub>3</sub> ) <sub>2</sub> and NaNO <sub>3</sub> at 25 °C to 27 °C.	38
3.4 Adsorption density as a function of concentration of SDS and SDS with 10 mg/L of Cd <sup>2+</sup> at 25 °C to 27 °C in the absence of NaNO <sub>3</sub> .	39
3.5 Correlations between Cd and SDS concentration (a) in the foamate and (b) in the effluent at a number of stages equal to 5 with different feed flow rates, air flow rates, and feed SDS/Cd molar ratios ( $\geq 2$ ).	43
3.6 Effect of feed SDS/Cd molar ratio on (a) % SDS recovery and Cd removal, (b) enrichment ratios of SDS and Cd and foamate volumetric ratio ( $V_f/V_i$ ), (c) residual factors of SDS and Cd, (d) effluent concentrations of SDS and Cd, (e) molar ratios of SDS/Cd in the foamate and effluent, and (f) separation factors of SDS and Cd at an air flow rate of 60 L/min, a feed flow rate of 40 mL/min, a foam height of 30 cm, a feed Cd concentration of 10 mg/L, and the number of trays equal to 5.	44

FIGURE		PAGE
<b>CHAPTER IV</b>		
4.1	Schematic of a multistage foam fractionation unit.	56
4.2	Effect of foam height on (a) the enrichment ratios of Cd and SDS; (b) foamate volumetric ratio and molar ratio of SDS/Cd in foamate; (c) SDS recovery and Cd removal; (d) the residual factors of SDS and Cd; and (e) the separation factors of SDS and Cd; and (f) effluent SDS and Cd concentration at air flow rate = 60 dm <sup>3</sup> /min, feed flow rate = 40 mL/min, number of trays = 5, feed Cd concentration = 10 mg/L, and two feed SDS/Cd molar ratios of 8/1 and 10/1.	61
4.3	Effect of air flow rate on the enrichment ratios of Cd and SDS (a); foamate volumetric ratio and molar ratio of SDS/Cd in foamate (b); SDS recovery and Cd removal (c); the residual factors of SDS and Cd (d); and the separation factors of SDS and Cd (e) at foam height = 60 cm, feed flow rate = 60 mL/min, number of trays = 5, feed Cd concentration = 10 mg/L, and two feed molar ratios of SDS/Cd of 7/1 and 10/1.	65
4.4	Effect of feed flow rate on the enrichment ratios of Cd and SDS (a); foamate volumetric ratio and molar ratio of SDS/Cd in foamate (b); SDS recovery and Cd removal (c); the residual factors of SDS and Cd (d); and the separation factors of SDS and Cd (e) at two conditions. (Condition A (wet foam): foam height = 60 cm, air flow rate = 60 dm <sup>3</sup> /min, SDS/Cd = 10/1, feed Cd concentration = 10 mg/L, and number of trays = 5 and Condition B (dry foam): foam height = 90 cm, air flow rate = 60 dm <sup>3</sup> /min, SDS/Cd = 10/1, feed Cd concentration = 10 mg/L, and number of trays = 5).	68

<b>FIGURE</b>	<b>PAGE</b>
4.5 Effect of feed Cd concentration on the enrichment ratios of Cd and SDS (a); foamate volumetric ratio and molar ratio of SDS/Cd in foamate (b); SDS recovery and Cd removal (c); the residual factor of SDS and Cd (d); effluent Cd and SDS concentration (e); and the separation factor of SDS and Cd (f) at foam height = 90 cm, feed flow rate = 80 mL/min, air flow rate = 60 dm <sup>3</sup> /min, feed SDS concentration = 0.71 mM, and number of trays = 5.	71
4.6 The measured values of pC <sub>20</sub> (a) and the adsorption density of SDS (b) of SDS from surface tension isotherm in the presence of cadmium ion as a function of cadmium ion concentration.	73
<b>CHAPTER V</b>	
5.1 Schematic of a multistage foam fractionation unit.	83
5.2 Specie distribution diagrams of Cd in aqueous solutions having different Cd salts as a function of (a) nitrate, (b) sulfate, and (c) chloride concentration at total Cd concentration = 10 mg/L (0.09 mM), initial solution pH = 7, and temperature = 25 °C.	87
5.3 Surface tension isotherms of SDS at various concentrations of added NaCl (a), NaNO <sub>3</sub> (b), Na <sub>2</sub> SO <sub>4</sub> (c), KNO <sub>3</sub> (d), Mg(NO <sub>3</sub> ) <sub>2</sub> (e), Ca(NO <sub>3</sub> ) <sub>2</sub> (f) in the presence and absence of 10 mg/L of Cd at 25–27 °C as compared with that of pure SDS system.	88
5.4 Effect of type and concentration of counterion on surface tension reduction (pC <sub>20</sub> ) of SDS solution at 25–27 °C (pC <sub>20</sub> = 2.68 for the pure SDS system).	91

<b>FIGURE</b>	<b>PAGE</b>
5.5 Surface tensions of (a) SDS–Na, (b) SDS-K, (c) SDS-Mg, (d) SDS-Ca, and (e) SDS-Cd systems as a function of dodecylsulfate concentration at pH 7. The added cation counterions and dodecylsulfate were present in stoichiometric ratios.	94
5.6 Effect of counterion addition on (a) enrichment ratio, (b) foamate volumetric ratio, (c) residual factor, (d) recovery, and (e) separation factor of SDS at an air flow rate of 35 dm <sup>3</sup> /min, a feed flow rate of 60 mL/min, a foam height of 60 cm, the number of trays equal to 5, and a feed molar ratio of SDS/Cd of 10/1.	97
5.7 Effect of counterion addition on (a) enrichment ratio, (b) residual factor, (c) recovery of Cd, and (d) separation factor of Cd at an air flow rate of 35 dm <sup>3</sup> /min, a feed flow rate of 60 mL/min, a foam height of 60 cm, the number of trays equal to 5, and a feed molar ratio of SDS/Cd of 10/1.	100