

**PREPARATION AND CHARACTERIZATION OF NOVEL  
POLYBENZOXAZINE-BASED POROUS STRUCTURES AND THEIR  
TRANSFORMATION TO CARBON FORM**

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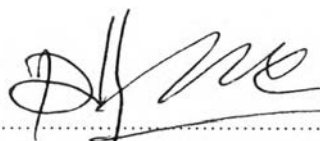
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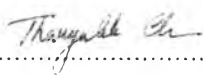


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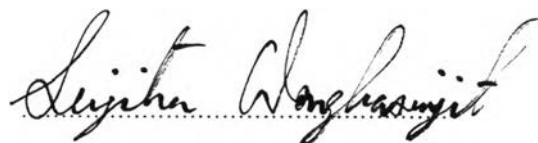
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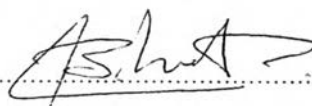
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**ABSTRACT**

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New organic aerogel and organic foam were successfully prepared from a new class of phenolic resins called polybenzoxazine synthesized via a simple thermal curing reaction without the use of any catalysts unlike the conventional phenolic precursors. Polybenzoxazine organic aerogel was cost-effectively prepared by using xylene as a solvent. Without the need for solvent exchanging and using supercritical conditions to remove the solvent during the process, carbon aerogel with high specific surface area, low bulk density, high proportion of micropore volume and micropore surface area, was obtained with a much shortened time. Besides, we further investigated the thermal degradation behaviors of both bulk polybenzoxazine and polybenzoxazine aerogel. Here, the organic foam derived from polybenzoxazine was also successfully prepared with a noncomplex and economical foaming method by using azodicarbonamide as a foaming agent. The influence of foam density on the physical and mechanical properties of the foams was studied. In addition, the polybenzoxazine foam was further transformed into carbon foam by carbonization under an inert atmosphere, and its properties were examined. Furthermore, this work also presents the influence of glass reinforcing fiber on mechanical, physical, and thermomechanical properties of polybenzoxazine foam composite.

## บทคัดย่อ

ภาควิชาเคมี: การเตรียมและการวิเคราะห์สมบัติของพอลิเบนซอกซาซีนที่มีโครงสร้างเป็นรูพรุนและศึกษาการเปลี่ยนรูปร่างเหล่านั้นให้เป็นคาร์บอน (Preparation and Characterization of Novel Polybenzoxazine-based Porous Structures and Their Transformation to Carbon Form)  
 อ. ที่ปรึกษา : รองศาสตราจารย์ ดร. สุจิตรา วงศ์เกษมจิตต์, ศาสตราจารย์ ดร. Alexander M. Jamieson และ ดร. ธีญญลักษณ์ นายสุวรรณ 132 หน้า

งานวิจัยนี้นำเสนอการสังเคราะห์วัสดุที่มีโครงสร้างเป็นรูพรุน ได้แก่ แอโรเจลและโฟมจากสารประกอบอินทรีย์ชนิดใหม่ที่มีชื่อว่าพอลิเบนซอกซาซีน เนื่องจากพอลิเบนซอกซาซีนสามารถเกิดปฏิกิริยาเชื่อมโยงได้ โดยการให้ความร้อนเพียงอย่างเดียวและไม่จำเป็นต้องใช้ตัวเริ่มหรือตัวเร่งปฏิกิริยา ทำให้กระบวนการผลิตวัสดุที่มีโครงสร้างเป็นรูพรุนดังกล่าว สะดวกและรวดเร็วกว่าขึ้นเมื่อเปรียบเทียบกับการใช้สารตั้งต้นที่นิยมใช้กันอยู่ในปัจจุบัน โดยในกระบวนการสังเคราะห์แอโรเจลโดยใช้พอลิเบนซอกซาซีนเป็นสารตั้งต้นนั้นจะไม่จำเป็นต้องทำการแลกเปลี่ยนตัวทำละลายและทำให้แห้งภายใต้สภาวะเหนือวิกฤติ ทำให้ระยะเวลาที่ใช้ในการบวนการสังเคราะห์พอลิเบนซอกซาซีนและคาร์บอนแอโรเจลสั้นลงมาก โดยคาร์บอนแอโรเจลที่สังเคราะห์ได้นั้นจะมีพื้นผิวสูง มีความหนาแน่นต่ำ และมีสัดส่วนของรูพรุนที่มีขนาดเล็กกว่า 2 นาโนเมตรมากกว่า คาร์บอนแอโรเจลที่สังเคราะห์จากสารตั้งต้นอื่นที่ใช้กันในปัจจุบัน นอกจากนี้ยังได้ทำการศึกษาพฤติกรรมการสลายตัวโดยความร้อนที่มีความแตกต่างกันระหว่างพอลิเบนซอกซาซีนและพอลิเบนซอกซาซีนแอโรเจลด้วย อีกทั้งในงานวิจัยนี้ยังได้นำเสนอการสังเคราะห์พอลิเบนซอกซาซีน โฟม ผ่านกระบวนการที่ง่ายและมีต้นทุนต่ำโดยใช้ สารเอโซไดคาร์บอนเอไมด์เป็นสารตั้งต้น โดยทำการศึกษาความสัมพันธ์ระหว่างความหนาแน่นของโฟมที่สังเคราะห์ได้กับสมบัติทางกายภาพและสมบัติทางกลของโฟมเหล่านั้น รวมถึงเปลี่ยนรูปพอลิเบนซอกซาซีน โฟมที่ได้ให้เป็นคาร์บอนโฟม โดยการเผาภายใต้บรรยากาศเฉื่อย และทำการทดสอบสมบัติของคาร์บอนโฟมที่ได้ ทั้งนี้ยังได้ทำการศึกษาอิทธิพลของเส้นใยแก้วเสริมแรงที่มีต่อสมบัติทางกลและสมบัติทางกายภาพของโฟมคอมพอสิตที่ได้อีกด้วย

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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
List of Schemes	xvi
 <b>CHAPTER</b>	
<b>I INTRODUCTION</b>	<b>1</b>
 <b>II LITERATURE REVIEW</b>	 <b>4</b>
2.1 Benzoxazine Resin	4
2.2 Porous Materials	6
2.3 Introduction Aerogel	6
2.3.1 Type of Aerogel	7
2.3.2 Organic and Carbon Aerogel Background	9
2.4 Introduction to Polymeric Foam	12
2.4.1 Polymeric Foam Technology	13
2.4.2 Polybenzoxazine Foam Background	14
2.5 Objectives	15
 <b>III EXPERIMENTAL</b>	 <b>17</b>
3.1 Materials and Sample Preparation	17
3.1.1 Organic and Carbon Aerogel Preparation	17
3.1.2 Organic and Carbon Foam Preparation	17
3.2 Characterization of Polybenzoxazine Aerogel and Polybenzoxazine Foam	 18

<b>CHAPTER</b>	<b>PAGE</b>
3.2.1 Physical Analysis	18
3.2.2 Structural Analysis	19
3.2.3 Thermal Analysis	19
3.2.4 Mechanical and Thermomechanical Analysis	19
3.2.5 Electrical Analysis	19
3.2.6 Thermal Decomposition Investigation	19
3.2.7 Kinetic Analysis	20
<b>IV      SIGNIFICANT ENHANCEMENT OF THERMAL STABILITY IN THE NON-OXIDATIVE THERMAL DEGRADATION OF BISPHENOL-A/ANILINE BASED POLYBENZOXAZINE AEROGELS</b>	21
4.1 Abstract	21
4.2 Introduction	22
4.3 Experimental	23
4.3.1 Reaction Kinetic Theory	23
4.3.2 Materials	24
4.3.3 Polybenzoxazine and Polybenzoxazine Aerogel Preparation	25
4.3.4 Characterization of Polybenzoxazine and Polybenzoxazine Aerogel	25
4.4 Results and Discussion	26
4.5 Conclusions	35
4.6 Acknowledgements	36
4.7 References	36
<b>V      POROUS STRUCTURE OF POLYBENZOXAZINE-BASED ORGANIC AEROGEL PREPARED BY SOL-GEL PROCESS AND THEIR CARBON AEROGELS</b>	56
5.1 Abstract	56

<b>CHAPTER</b>	<b>PAGE</b>
5.2 Introduction	57
5.3 Experimental	58
5.3.1 Materials	58
5.3.2 Organic and Carbon Aerogel Preparation	58
5.3.3 Characterization of The Organic and Carbon Aerogels	59
5.4 Results and Discussion	60
5.5 Conclusions	66
5.6 Acknowledgements	66
5.7 References	67
<b>VI    PREPARATION OF POLYBENZOXAZINE FOAM AND ITS TRANSFORMATION TO CARBON FOAM</b>	<b>82</b>
6.1 Abstract	82
6.2 Introduction	83
6.3 Experimental	85
6.3.1 Materials	85
6.3.2 Organic and Carbon Foam Preparation	85
6.3.3 Characterization of The Organic and Carbon Foams	86
6.4 Results and Discussion	87
6.5 Conclusions	93
6.6 Acknowledgements	93
6.7 References	93
<b>VII   CHARACTERIZATION OF CHOPPED GLASS FIBER REINFORCED POLYBENZOXAZINE FOAM COMPOSITE</b>	<b>109</b>
7.1 Abstract	109
7.2 Introduction	110



<b>CHAPTER</b>	<b>PAGE</b>
7.3 Experimental	111
7.3.1 Materials	111
7.3.2 Foam Composite Preparation	111
7.3.3 Characterization of Foam Composite	111
7.4 Results and Discussion	112
7.5 Conclusions	114
7.6 Acknowledgements	114
7.7 References	114
<b>VIII CONCLUSIONS AND RECOMMENDATIONS</b>	<b>121</b>
<b>REFERENCES</b>	<b>122</b>
<b>CURRICULUM VITAE</b>	<b>131</b>

**LIST OF TABLES**

<b>TABLE</b>		<b>PAGE</b>
<b>CHAPTER II</b>		
2.1	Summarized physical properties of carbon aerogels derived from various organic precursors	10
2.2	Physical properties of carbon aerogels derived from resorcinol-formaldehyde (RF) via ambient drying method	11
<b>CHAPTER IV</b>		
4.1	Summary of characteristics of individual DTG peaks derived using Peak fit software and associated activation energies obtained using the Kissinger method for bulk polybenzoxazine and polybenzoxazine aerogel	51
4.2	Percentage of each decomposition product generated from the entire carbonization process of bulk polybenzoxazine and polybenzoxazine aerogel under nitrogen atmosphere	52
<b>CHAPTER V</b>		
5.1	Density and pore texture of polybenzoxazine, polybenzoxazine aerogels and carbon aerogels	80
5.2	The calculated surface area, pore volume and pore size of the resultant carbon aerogels compared with that of carbon aerogels from other organic precursors	81
<b>CHAPTER VI</b>		
6.1	Physical and compressive properties of polybenzoxazine foams with different AZD contents	107

<b>TABLE</b>		<b>PAGE</b>
6.2	Physical and compressive properties of the resulting carbon foam	108

## **CHAPTER VII**

7.1	Physical, compressive, and thermal properties of polybenzoxazine foam composites with different fiber contents	120
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## LIST OF FIGURES

<b>FIGURE</b>		<b>PAGE</b>
<b>CHAPTER II</b>		
2.1	Monofunctional benzoxazine monomer synthesis.	5
2.2	Bifunctional benzoxazine monomer synthesis.	5
2.3	(a) Resorcinol-formaldehyde aerogel and (b) resorcinol-formaldehyde based carbon aerogel.	9
2.4	SEM photographs of polyurethane-based organic and carbon aerogels.	12
2.5	Idealized representation of (a) open cell foam structure and (b) close cell foam structure.	13
2.6	Solution quenching foaming method.	14
2.7	SEM photograph of polybenzoxazines foam and their specific properties.	14
2.8	SEM photographs of glass fiber reinforced polybenzoxazine foam and their specific properties.	15
<b>CHAPTER IV</b>		
4.1	Photographs of (a) bulk polybenzoxazine, (b) residual char from bulk polybenzoxazine, (c) polybenzoxazine aerogel, and (d) residual char from polybenzoxazine aerogel.	41
4.2	SEM micrographs of (a) polybenzoxazine aerogel and (b) bulk polybenzoxazine.	42
4.3	TGA and DTG thermograms of bulk polybenzoxazine and polybenzoxazine aerogel at a heating rate of 15°C/min.	43
4.4	DTG curves and associated individual peaks of (a) bulk polybenzoxazine and (b) polybenzoxazine aerogel at a heating rate of 15°C/min.	44

<b>FIGURE</b>		<b>PAGE</b>
4.5	FTIR spectra of (a) benzoxazine monomer, (b) bulk polybenzoxazine, and (c) polybenzoxazine aerogel. The asterisks indicate peaks discussed in the text.	45
4.6	FTIR spectra of residual char derived from (a) bulk polybenzoxazine and (b) polybenzoxazine aerogel after carbonization at various temperatures at a heating rate of 15°C/min.	47
4.7	Possible bonding configurations of nitrogen atom in carbon ring.	48
4.8	TGA and DTG analyses of (a) bulk polybenzoxazine, and (b) polybenzoxazine aerogel at different heating rates.	49
4.9	Plots of $\ln(\beta/T_p^2)$ versus $1/T_p$ for each decomposition step at different heating rates from DTG analysis via the Kissinger method for (a) bulk polybenzoxazine and (b) polybenzoxazine aerogel.	53
4.10	FTIR spectra of the decomposition products of (a) bulk polybenzoxazine, and (b) polybenzoxazine aerogel generated during each decomposition step at a heating rate of 15°C/min.	54
4.11	TGA and DTG analyses of bisphenol-A/tetraethylenepentamine (TEPA) based bulk polybenzoxazine and its corresponding aerogel under nitrogen atmosphere at a heating rate of 15°C/min.	55
<b>CHAPTER V</b>		
5.1	DSC thermogram of the benzoxazine monomer with scanning rate of 1 °C/min.	71
5.2	TGA thermogram of the polybenzoxazine.	72

<b>FIGURE</b>		<b>PAGE</b>
5.3	FTIR spectra of <b>a</b> benzoxazine monomer, <b>b</b> uncured BA-20% derived aerogel, and <b>c</b> uncured BA-40% derived aerogel.	73
5.4	DSC thermograms of benzoxazine monomer, fully cured polybenzoxazine and polybenzoxazine aerogels.	74
5.5	FTIR spectra of <b>a</b> benzoxazine monomer, <b>b</b> fully cured polybenzoxazine, <b>c</b> fully cured BA-20% derived aerogel, <b>d</b> fully cured BA-40% derived aerogel, <b>e</b> BA-40% derived carbon aerogel.	75
5.6	SEM micrographs of <b>a</b> fully cured polybenzoxazine, <b>b</b> carbonized polybenzoxazine, <b>c</b> fully cured organic aerogel from 20 wt% monomer solution, <b>d</b> carbon aerogel from 20 wt% monomer solution, <b>e</b> fully cured organic aerogel from 40 wt% monomer solution, and <b>f</b> carbon aerogel 40 wt% monomer solution.	76
5.7	Adsorption and desorption isotherms of carbon aerogel from <b>a</b> 20 wt% monomer solution and <b>b</b> 40 wt% monomer solution.	77
5.8	Pore size distribution of carbon aerogels from different monomer concentrations	78
5.9	TEM morphology of carbon aerogel prepared from 40 wt% monomer solution.	79

## **CHAPTER VI**

6.1	DSC thermograms of the benzoxazine monomer, foaming agent, and monomer/foaming agent mixtures with a scanning rate of 1 °C/min.	97
6.2	TG and DTG analysis of polybenzoxazine.	98

<b>FIGURE</b>		<b>PAGE</b>
6.3	Measured densities of polybenzoxazine foams as a function of AZD content.	99
6.4	Comparison of the compressive strength and the density of polybenzoxazine foam derived from different fabrication techniques.	100
6.5	Compressive modulus of polybenzoxazine foams as a function of foam density.	101
6.6	Microscope images of polybenzoxazine foams at several densities (a) 407 kg/m <sup>3</sup> , (b) 378 kg/m <sup>3</sup> , (c) 339 kg/m <sup>3</sup> , (d) 306 kg/m <sup>3</sup> , and (e) 273 kg/m <sup>3</sup> .	102
6.7	Compressive stress–strain curves of polybenzoxazine foam with various densities at a strain rate of 2.5 mm/min.	103
6.8	XRD pattern of polybenzoxazine-based carbon foam.	104
6.9	Microscopic image of the resulting carbon foam.	105
6.10	Comparison between (a) stress-strain curve and (b) specific stress-strain curve of polybenzoxazine foam and the corresponding carbon foam.	106

## **CHAPTER VII**

7.1	Microscope images of polybenzoxazine foam composites with different fiber contents (a) SEM micrograph of 3wt% of fiber reinforced foam composite (b).	117
7.2	Compressive strength and modulus of polybenzoxazine foam composites as a function of fiber content.	118
7.3	Storage modulus (a) loss tangent (b) of polybenzoxazine foam composites with different fiber contents.	119

**LIST OF SCHEMES**

<b>SCHEME</b>		<b>PAGE</b>
<b>CHAPTER II</b>		
2.1	Polycondensation reactions of the well-liked precursors.	8
<b>CHAPTER IV</b>		
4.1	Mechanism for Schiff base formation from chain cleavage at Mannich bridge within polybenzoxazine.	46
<b>CHAPTER V</b>		
5.1	The precursors and polybenzoxazine synthetic reaction.	70