

**DEVELOPMENT OF POLYOXYMETHYLENE BASED
NANOCOMPOSITE AND NANOFIBER MATERIALS**



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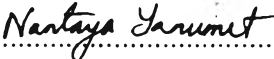
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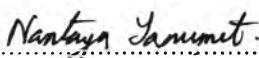
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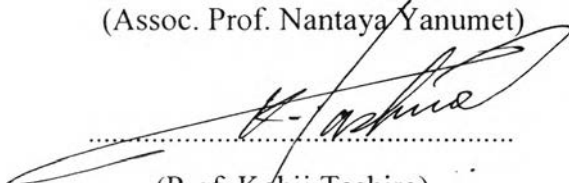
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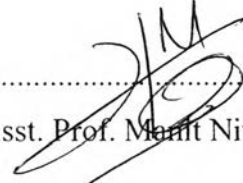
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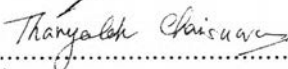

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บทคัดย่อ

ชวลตรี กองคลัง: การพัฒนาพอลิออกซิเมทิลีนเพื่อการใช้เป็นวัสดุนาโนคอมพอสิตและ วัสดุเส้นใยนาโน (Development of Polyoxymethylene based Nanocomposite and Nanofiber Materials) อ. ที่ปรึกษา: รองศาสตราจารย์ ดร. สุวบุญ จิรชาญชัย 104 หน้า

วิทยานิพนธ์ฉบับนี้มุ่งประเด็นไปที่การพัฒนาพอลิออกซิเมทิลีนและโคพอลิเมอร์ของพอลิออกซิเมทิลีนสำหรับวัสดุนาโนคอมพอสิตและวัสดุเส้นใยนาโน ส่วนแรกเกี่ยวข้องกับกาพิสูจน์ ทราบผลของสารลดแรงตึงผิวสำหรับการปรับปรุงแร่ดินเหนียว (clay) ต่อ การแทรกของสายใยพอลิเมอร์ในชั้นแร่ดินเหนียวและคุณสมบัติของวัสดุนาโนคอมพอสิตที่ได้ สารลดแรงตึงผิวประเภทควอเทอร์นารีแอมโมเนียม (quaternary ammonium) ก่อให้เกิดโครงสร้างแบบผสมระหว่าง อินเตอร์คาเลทและฟล็อกโคเลท (intercalated/flocculated nanocomposite) ในขณะที่สารลดแรงตึงผิวประเภทไพร์มาลีแอมโมเนียม (primary ammonium) ก่อให้เกิดโครงสร้างแบบเอ็กซ์โฟลีโอท (exfoliated nanocomposite) พร้อมกับสมบัติเชิงกลที่ดีขึ้นและการด้านการแพร่ผ่านของแก๊สที่สูงขึ้นอย่างเห็นได้ชัด งานส่วนที่สองเป็นการพิจารณาเทคนิคอิเล็กโตรสปินนิงเพื่อผลิตเส้นใยนาโนที่มีคุณสมบัติพิเศษ เส้นใยนาโนพอลิออกซิเมทิลีนสามารถเตรียมได้สำเร็จด้วยการใช้ตัวทำละลาย เฮกซะฟลูออโรไอโซโพรพานอล (hexafluoroisopropanol, HFIP) โดยการควบคุมเงื่อนไขในการปั่นเส้นใยซึ่งได้แก่ความแรงของสนามไฟฟ้าสถิตและความชื้นสัมพัทธ์ และสมบัติของสารละลายพอลิเมอร์ซึ่งได้แก่ปริมาณของโคพอลิเมอร์และความดันอากาศของตัวทำละลาย โครงสร้างแบบรูพรุนในระดับนาโนเมตรเกิดขึ้นอย่างหลีกเลี่ยงไม่ได้และถูกพัฒนาขึ้นจากปัจจัยหลักของกลไกการแยกเฟสด้วยความร้อน (thermally induced phase separation) และการแยกเฟสด้วยความดันอากาศ (vapor induced phase separation) โดยการควบคุมปริมาณศักย์ไฟฟ้าและความเร็วของการปั่นเก็บเส้นใย โครงสร้างผลึกจะเกิดการเปลี่ยนแปลงระหว่างโครงสร้างผลึกแบบสายโมเลกุลตเรียง (extended chain crystal, ECC) และโครงสร้างผลึกแบบสายโมเลกุลม้วน (folded chain crystal, FCC) สมการการจัดเรียงตัวแบบเฮร์แมน (Herman's orientation function) และอัตราส่วนไดโครอิก (dichroic ratio) นำเราไปสู่ข้อสรุปว่า (1) การจัดเรียงตัวของโมเลกุลของเส้นใยนาโนขนานกับแกนเส้นใยทั้งแบบกระจายอย่างทั่วถึงกัน (isotropic) และแบบกระจายในทิศทางใดทิศทางหนึ่ง (anisotropic) ของเส้นใยนาโนพอลิออกซิเมทิลีน และ(2) เส้นใยนาโนหนึ่งเส้นประกอบด้วยกรวมกลุ่มกันของนาโนไฟบริล (nanofibril assembly) ขนาด 60–70Å และเอียงทำมุมกับแกนเส้นใยในระดับหนึ่ง

ABSTRACT

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Keywords: Polyoxymethylene/ Nanocomposites/ Clay/ Electrospinning/ Nanofiber/ Pore formation/ Crystal structure/ Molecular orientation/ Chain aggregation

The present work focuses on the development of polyoxymethylene (POM) and its copolymer based nanocomposite and nanofiber materials. The first part involves clarification of the effects of surfactants used for modifying of clay on the intercalation of the polymer chain and the properties of the nanocomposites obtained. A quaternary ammonium surfactant induces the mixture of intercalated/flocculated nanocomposite structure while a primary ammonium surfactant induces an exfoliated structure of the nanocomposites, together with an improvement in mechanical properties and a significant gas barrier property. The second part considers electrospinning technique to produce nanofiber with unique properties. An electrospun POM nanofiber using a hexafluoroisopropanol (HFIP)-based solvent is successfully prepared by controlling the spinning conditions, i.e. electrostatic field strength and relative humidity and the polymer solution properties, i.e. copolymer content and vapor pressure of the solvent. Nanoporous structure is inevitably formed and is mainly induced via thermally induced phase separation (TIPS) and vapor induced phase separation (VIPS) mechanisms. By controlling the voltage and rotating velocity of disc rotator, the crystalline morphology changes between an extended chain crystal (ECC) and a folded chain crystal (FCC). Herman's orientation function and dichroic ratio lead us to a conclusion that (i) molecular orientation is parallel to fiber axis in both isotropic and anisotropic POM nanofibers and (ii) a single nanofiber consists of nanofibril assembly with 60–70 Å in size and tilting at a certain degree.

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TABLE OF CONTENTS

	PAGE
Title Page	i
Abstract (in English)	iii
Abstract (in Thai)	iv
Acknowledgements	v
Table of Contents	vii
List of Tables	ix
List of Figures	x

CHAPTER

I INTRODUCTION	1
II THEORETICAL BACKGROUND AND LITERATURE REVIEW	
2.1 Crystal Morphology and Molecular Conformation	3
2.2 Specific Properties for Potential Applications	6
2.3 Polymer/Clay Nanocomposites	7
2.4 Polyoxymethylene/Clay Nanocomposites	13
2.5 Electrospinning	14
2.6 Points of the Present Work	25
III ROLE OF PRIMARY AMINE IN POLYOXYMETHYLENE (POM) /BENTONITE NANOCOMPOSITE FORMATION	
Abstract	26
Introduction	27
Experimental Section	28
Results and Discussion	31
Conclusion	43

CHAPTER	PAGE
Acknowledgements	44
References	44
IV ELECTROSPUN POLYOXYMETHYLENE: SPINNING CONDITIONS AND ITS CONSEQUENT NANOPOROUS NANOFIBER	
Abstract	46
Introduction	47
Experimental Section	48
Results and Discussion	50
Conclusion	67
Acknowledgements	68
References	68
V ELECTROSPINNING METHOD AS A NEW TECHNIQUE TO CONTROL THE CRYSTAL MORPHOLOGY AND MOLECULAR ORIENTATION OF POLYOXYMETHYLENE NANOFIBER	
Abstract	72
Introduction	72
Experimental Section	75
Results and Discussion	76
Conclusion	90
Acknowledgements	91
References	91
VI CONCLUSIONS AND RECOMMENDATIONS	93
REFERENCES	95
CURRICULUM VITAE	103

LIST OF TABLES

TABLE		PAGE
CHAPTER II		
2.1	Schematic diagram of various electrospinning set-ups for multiple spinnerets to obtain various fibrous assemblies	23–24
CHAPTER III		
3.1	Bentonite based organo-modified clays used in the present work	29
3.2	Mechanical properties of POM and POM/organo-modified bentonite nanocomposites	37
3.3	Thermal properties and O ₂ permeability of POM and POM/bentonite based nanocomposites	43
CHAPTER IV		
4.1	Fiber diameter and specific surface area of electrospun POM nanofiber	54
4.2	Various properties of electrospun POM nanofibers as compared to POM resin	65
CHAPTER V		
5.1	FTIR band assignment of polyoxymethylene	78
5.2	Dichroic ratio ($A_{//}/A_{\perp}$) and thermal properties of POM nanofibers at various rotating disc velocity	83

LIST OF FIGURES

FIGURE	PAGE
CHAPTER II	
2.1 Chain conformation of polyoxymethylene	4
2.2 Schematic representation of (a) FCC, (b) ECC, and (c) model of cylindrical crystal	5
2.3 Structure of montmorillonite (MMT)	10
2.4 Comparison of the size of glass fiber (left) and montmorillonite (right)	10
2.5 Schematically illustration of three different types of thermodynamically achievable polymer/layered silicate nanocomposites	12
2.6 WAXD patterns and TEM images of three different types of nanocomposites	13
2.7 Schematic representative diagram of electrospinning process	16
2.8 Schematic of electrical spinning jet	17
2.9 SEM micrographs of electrospun nanofibers from different polymer concentration solutions	20
CHAPTER III	
3.1 WAXD patterns of (a) POM, NF5, and POM/NF5; (b) POM, NF9, and POM/NF9; (c) POM, KT, and POM/KT.	31
3.2 TEM micrographs of (a) POM, (b) POM/NF5, (c) POM/NF9, and (d) POM/KT. Arrows indicate silicate layers in the samples.	32
3.3 Polarizing optical micrographs of crystallized (at 138°C) neat POM (a,b) and POM/KT (c,d) at early crystallization stage (a,c) and final crystallization stage (b,d).	34
3.4 Number of nucleation (●) and crystallite growth rate (■) of POM and POM/organo-modified bentonite nanocomposites.	36

FIGURE	PAGE
3.5 Flexural strength (●) and elongation at break (■) of POM and POM/organo-modified bentonite nanocomposites as a function of number of nucleation. The results are an averaged value from five measurements.	38
3.6 Rheological properties of POM and POM/organo-modified bentonite nanocomposites.	39
3.7 TGA and DTG curves of (a) POM and POM/organo-modified bentonite nanocomposites, and (b) alkyl ammonium-treated bentonite.	40
3.8 TG-FTIR spectra of gases evolved during thermal degradation of (a) POM, (b) POM/NF5, (c) POM/NF9, and (d) POM/KT as a function of time.	41

CHAPTER IV

4.1 Scanning electron micrographs and frequency distributions of electrospun POM13 nanofibers as a function of polymer concentrations: (a) and (d) for 3 wt%; (b) and (e) for 5 wt%; and (c) and (f) for 10 wt%. (Electrostatic field strength = 15kV/10cm and relative humidity = 75%).	52
4.2 Scanning electron micrographs of the electrospun POM nanofibers from an HFIP solution with copolymer contents of (a) 0 wt%, (b) 1.5 wt%, (c) 4.4 wt%, and (d) 13 wt%. (Electrostatic field strength = 15kV/10cm and relative humidity =75%).	53
4.3 Scanning electron micrographs of the electrospun POM4.4 nanofiber from (a) HFIP/DMF (94:6), (b) HFIP/Glu (90:10), and (c) and (d) HFIP/Toluene (70:30) where (d) is magnified to observe the surface morphology of (c). (Electrostatic field = 15kV/10cm and relative humidity =75%).	55

FIGURE	PAGE
4.4 Scanning electron micrographs of the electrospun POM13 nanofibers from an HFIP solution at 75% relative humidity, and pore size distributions as a function of electrical voltages: (a) and (e) for 4kV; (b) and (f) for 6kV; (c) and (g) for 10kV; and (d) and (h) for 15kV. (Tip-to-target distance = 10 cm).	58
4.5 Fiber diameters as a function of electric field strength.	59
4.6 Scanning electron micrographs of the electrospun POM13 nanofibers from an HFIP solution at 55% relative humidity, and pore size distributions as a function of electrical voltages: (a) and (e) for 4kV; (b) and (f) for 6kV; (c) and (g) for 10kV; and (d) and (h) for 15kV. (Tip-to-target distance = 10 cm).	61
4.7 Scanning electron micrographs showing a cross-section of POM13 nanofibers from an HFIP solution at 55% relative humidity, electrospun at (a) 4 kV and (b) 15 kV. (Tip-to-target distance = 10 cm).	62

CHAPTER V

5.1 Scanning electron micrographs and frequency distribution of electrospun POM nanofiber obtained from using the rotating disc collector with the velocity of (a,d) 0 m/min, (b,e) 630 m/min, and (c,f) 1890 m/min. Arrows indicate drawing direction.	77
5.2 FTIR spectra of POM obtained from (a) cast film, (b) as-spun nanofiber, (c) re-cast film, and (d) re-spun nanofiber.	80
5.3 Polarized FTIR spectra of electrospun POM nanofiber with linear velocity of (a) 0 m/min, (b) 630 m/min, and (c) 1890 m/min. — Electric vector of an incident IR beam perpendicular to the fiber axis (\perp). --- Electric vector of an incident IR beam parallel to the fiber axis ($//$).	81

FIGURE	PAGE
5.4 Two dimensional (2D) WAXD patterns for the 100 reflection of aligned POM nanofiber at (a) 630 m/min and (b) 1890 m/min.	84
5.5 Azimuthal-scan profiles for the 100 reflection for aligned POM nanofibers with linear velocity (a) 630 m/min and (b) 1890 m/min.	84
5.6 (a) Herman's orientation function (\circ) and dichroic ratio of $A_2(4)$ band at 900 cm^{-1} (\bullet), (b) crystallinity estimated from the enthalpy of melt of the 1 st heating (\square) and 2 nd heating (\blacksquare), and (c) crystallite size estimated from 100 reflection (Δ) and 009 reflection (\blacktriangle), as a function of linear velocity of the disc rotating collector.	86
5.7 (a) SEM micrograph of single POM nanofiber collected at 630 m/min, (b) Schematic representations of nanofibril existed in the single POM nanofiber, (c)–(e) Schematic representations of the crystal orientation of (c) POM at 0 m/min, (d) POM at 630 m/min, and (e) POM at 1890 m/min, (f) Crystal conformation of 9/5 helical structure of the POM chain.	89
5.8 Schematic illustration of (a) vibrationally in-phase domain and geometrically-coherent region and (b) existence of tie chains in between the neighboring crystallites.	90