

สถาบันวิทยาและสมบัติเชิงกลของฟิล์มที่จัดเรียงตัวในสองทิศทางของ  
พอลิเอทีนที่นำมาเวีย่นทำไหม

นาย รุ่งโรจน์ สุกพันธุ์



สถาบันวิทยบริการ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต  
สาขาวิชาปิโตรเคมีและวิทยาศาสตร์พอลิเมอร์ หลักสูตรปิโตรเคมีและวิทยาศาสตร์พอลิเมอร์

คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2542

ISBN 974-333-951-5

ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

**MORPHOLOGY AND MECHANICAL PROPERTIES OF BIAXIALLY  
ORIENTED FILMS OF RECYCLED POLYETHYLENES**



**Mr. Roongroj Phoogpan**

**A Thesis Submitted in Partial Fulfilment of the Requirements  
for the Degree of Master of Science in Petrochemistry and Polymer Science  
Program of Petrochemistry and Polymer Science**

**Faculty of Science**

**Chulalongkorn University**

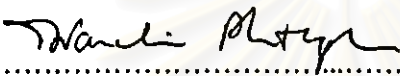
**Academic Year 1999**

**ISBN 974-333-951-5**

**Thesis Title** Morphology and Mechanical Properties of Biaxially Oriented  
Films of Recycled Polyethylenes  
**By** Mr. Roongroj Phoogpan  
**Department** Petrochemistry and Polymer Science  
**Thesis Advisor** Professor Suda Kiatkamjornwong, Ph.D.


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Accepted by Faculty of Science, Chulalongkorn University in Partial  
Fulfillment of the Requirements for the Master's Degree


  
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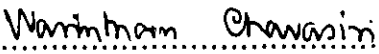
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รุ่งโรจน์ ผูกพันธุ์ : สัณฐานวิทยาและสมบัติเชิงกลของฟิล์มที่จัดเรียงตัวในสอง  
ทิศทางของพอลิเอทิลีนเวียนทำใหม่ (MORPHOLOGY AND MECHANICAL  
PROPERTIES OF BIAXIALLY ORIENTED FILMS OF RECYCLED  
POLYETHYLENE) อ. ที่ปรึกษา : ศ.ดร. สุดา เกียรติกำจรวงศ์, 150 หน้า. ISBN  
974-333-951-5.

งานวิจัยนี้เป็นการศึกษาการนำพลาสติกมาเวียนทำใหม่ (Recycling) เพื่อช่วยลด  
ปัญหาขยะซึ่งเป็นผลกระทบต่อสิ่งแวดล้อม และ ช่วยลดต้นทุนการผลิตในอุตสาหกรรมฟิล์ม  
โดยสัดส่วนของพอลิเอทิลีนชนิดความหนาแน่นสูง (HDPE) บริสุทธิ์ต่อเม็ดพลาสติกพอลิเอท  
ิลีนเวียนทำใหม่ มีผลต่อสัณฐาน (Morphology) และ สมบัติเชิงกล ของฟิล์มผสม สำหรับเม็ด  
พลาสติกพอลิเอทิลีนเวียนทำใหม่ได้จากลูกค้าที่ใช้ฟิล์ม HDPE, ขวด HDPE และ พอลิเอทิลีน  
ชนิดความหนาแน่นต่ำ (LDPE) จากการศึกษาโดยใช้ข้อมูลทางสถิติ เพื่อประเมินเม็ดพลาสติก  
เวียนทำใหม่ พบว่า เม็ดพลาสติก LDPE เวียนทำใหม่มีผลต่อสมบัติของฟิล์มทั้งสองที่กล่าวมา  
นอกจากนั้น ยังได้ศึกษาสมบัติทางความร้อน, สมบัติเชิงวิสโคอิลาสติก, และลักษณะการไหล  
ได้แก่ หาค่าดัชนีการไหล (น้ำหนัก 2.16 และ 5 กิโลกรัม/190 °ซ.) และ หาลักษณะการไหลของ  
พอลิเมอร์ผสม เพื่อนำไปประยุกต์ใช้ในงานฟิล์ม ความเค้นของแรงดึงที่จุดขาด, ความเค้น  
ของแรงดึง ณ จุดคราก และความยืดที่จุดขาด ของฟิล์มลดลงตามปริมาณของเม็ดพลาสติก  
LDPE มาเวียนทำใหม่ที่เพิ่มขึ้น ในขณะที่ ความยืดที่จุดคราก (ร้อยละ 14.00-16.67) ไม่มีผลต่อ  
สมบัติของฟิล์ม และสัณฐานวิทยาของฟิล์มผสม อันประกอบด้วยส่วนที่เป็นผลึกในลักษณะ  
สว่างและส่วนที่เป็นอสัณฐานในลักษณะทึบแคบ ซึ่งยืนยันโดยใช้วิธีเอกซเรย์ดิฟแฟรกชัน อัน  
เป็นการหาส่วนความเป็นผลึกและส่วนที่เป็นอสัณฐานโดยตรง และหาค่านี้โดยวิธีอ้อมด้วยการ  
คำนวณจากค่าความร้อนของการหลอมเหลวจากดิฟเฟอเรนเชียลสแกนนิ่งคาลอริเมตรี การหา  
ความเป็นผลึกและค่าความร้อนของการหลอมเหลวมีความสัมพันธ์โดยตรงต่อกัน นั่นคือ การ  
เพิ่มปริมาณเม็ดพลาสติก LDPE เวียนทำใหม่ ทำให้ร้อยละความเป็นผลึกของฟิล์มลดลงจาก  
ร้อยละ 78 ไปเป็นร้อยละ 67 และสมบัติของแรงดึง (ด้าน MD) ลดลงจาก 27 เมกะพาสคัล ไป  
เป็น 17 เมกะพาสคัล

ภาควิชา.....ลายมือชื่อนิติ.....  
สาขาวิชาปีโทเคมีและวิทยาศาสตร์พอลิเมอร์.....ลายมือชื่ออาจารย์ที่ปรึกษา.....  
ปีการศึกษา.....2542.....ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

## C417323 : MAJOR PETROCHEMISTRY AND POLYMERS SCIENCE

KEY WORD: RECYCLED POLYETHYLENE / MECHANICAL PROPERTIES /  
MORPHOLOGY / HDPE FILM / CRYSTALLINITY

ROONGROJ PHOOGPAN : MORPHOLOGY AND MECHANICAL  
PROPERTIES OF BIAXIALLY ORIENTED FILMS OF RECYCLED  
POLYETHYLENE. THESIS ADVISOR : PROF. SUDA

KIATKAMJORNWONG, Ph.D. 150 pp. ISBN 974-333-951-5.

Recycling of polyethylene resins to reduce waste problems in environment and to save cost of the production in film industry was carried out. The effect of virgin high-density polyethylene (HDPE) / recycled polyethylene resin composition on the morphology and mechanical properties of the blended films was investigated. The recycled polyethylene resin was obtained from a post-consumer cyclate of HDPE film, HDPE bottle, and low-density polyethylene (LDPE) resin. Based on the statistical evaluation of the type of PE on tensile properties and morphology, it was found that the recycled LDPE affected both properties. In addition, the thermal properties, the viscoelastic properties and the flow behavior as melt flow index (load 2.16 and 5 kg/190°C.) and flow curve were investigated for film processability. The stress at break, stress at yield and elongation at break decreased with increasing the recycled LDPE amount while the elongation at yield did not affect the film properties significantly (14.00-16.67%). Morphology of the blended films is composed of the crystalline region shown as bright fibrils and the amorphous region as narrow dark fibrils. The whole region was confirmed by X-ray diffraction (XRD) which determined the crystalline and amorphous domains. Increasing the amount of recycling LDPE decreased % crystallinity. The amount of crystallinity was determined indirectly as heat of fusion by differential scanning calorimetry (DSC). The extent of crystallinity and heat of fusion are in a direct relation. Additionally, increasing the concentration of recycled LDPE decreased the crystallinity of plastic film from 78% to 67%, and tensile property (MD) decreased from 27 MPa to 17 MPa.

ภาควิชา..... นายมือชื่อนิติ.....  
สาขาวิชาปิโตรเคมีและวิทยาศาสตร์พอลิเมอร์..... นายมือชื่ออาจารย์ที่ปรึกษา.....  
ปีการศึกษา..... 2542..... นายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

## ACKNOWLEDGEMENTS



The author wishes to thank Professor Dr. Suda Kiatkamjornwong, his advisor, for her suggestion, guidance and encouragement during the research work and reviewing the thesis.

I am also grateful to Professor Dr. Pattarapan Prasassarakich, Professor Dr. Somsak Darmronglert, Associate Professor Dr. Wimonrat Trakampurk, and Assistant Professor Dr. Warintorn Chavasiri for serving as chairperson and members of thesis committee, respectively.

In addition, I would like to thank Thai Petrochemical Industry (Public) Co., Ltd., for donating the virgin HDPE (film grade); and Thai Bamroong Import Export Co., Ltd., for donating recycled polyethylene resins (recycled HDPE film, recycled HDPE bottle, and recycled LDPE). Special thank is extended to Chulalongkorn University and Mahidol University for library facilities. Furthermore, National Metal and Materials Technology Center (MTEC), Scientific and Technological Research Equipment Centre (STREC), and Professor Dr. Piyasarn Prasertam of the Petrochemistry Center of Chemical Engineering Department, Faculty of Engineering, Chulalongkorn University for accesses to research instruments. Without these institute supports this thesis could not be finished.

Finally, I wish to express my gratitude to my family for encouragements and moral supports. Many thanks are gone to my best friends and everyone, whose names are not mentioned here, who contribute suggestions and supports during the course of research.

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## ABBREVIATIONS

ANOVA	analysis of variance
HDPE	high-density polyethylene
LDPE	low-density polyethylene
LLDPE	linear low-density polyethylene
PE	polyethylene
PCR	Post-consumer recycled
HIC	Household/Industrial Container
MSW	Municipal solid waste
MFI	melt flow index
rpm	round per minute
$T_g$	glass transition temperature
$T_m$	melting temperature
$\sigma_y$	stress at yield
$\sigma_b$	stress at break
$\epsilon_y$	elongation at yield
$\epsilon_b$	elongation at break
DSC	Differential scanning calorimetry
SEM	Scanning electron microscopy
TEM	Transimission electron microscopy
DMA	Dynamic mechanical analysis
XRD	X-ray diffraction
$G'$	storage modulus
$G''$	loss modulus
$\tan \delta$	loss tangent

BUR	blow up ratio
FLH	frost line hight
DDR	draw down ratio
MD	machine direction
TD	transverse direction
$\Delta H_f$	heat of fusion
$\dot{\gamma}$	shear rate
$\eta$	viscosity
$\chi_c$	degree of crystallinity



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