

**TOUGHNESS ENHANCEMENT OF POLYAMIDE 12 WITH NATURAL
RUBBER VIA NON-REACTIVE AND REACTIVE COMPATIBILIZATIONS**

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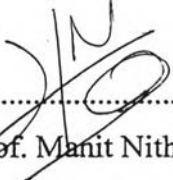

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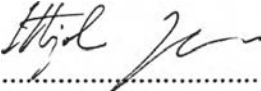

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ABSTRACT

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This research work studied toughness enhancement of polyamide12 (Nylon12) by adding natural rubber (NR) via melt blending process. Copolymers of polystyrene/natural rubber (PS/NR) and polystyrene/maleated natural rubber (PS/MNR) were used as non-reactive and reactive compatibilizers, respectively. The result revealed that the non-reactive compatibilizer improved the compatibility between Nylon12 and NR via physical linkage, leading to a good dispersion of NR domains in Nylon12 matrix and the enhancement of impact energy by a factor of 3. The reactive compatibilizer was then used to increase the interfacial adhesion between Nylon12 and NR via chemical linkage. However, different mixing procedures of PS/MNR copolymer as well as maleic anhydride loading affected to crosslinked NR (gel) content and MA grafting efficiency. The result showed that PS/MNR copolymer prepared by two-step mixing and low MA loading had a lower gel content and a higher MA grafting efficiency. The reactive compatibilizer with various contents also affected to the properties of Nylon12/NR blend. The formation of succinimide linkages via an imidization reaction at Nylon12/NR interfaces caused an increase of shear viscosity and a reduction of extrudate swell while viscosity ratio approached to 1 with increasing PS/MNR content up to 7 phr. The rubber particle appeared to be spherical with diameter and interparticle distance less than 0.5 and 0.3 μm , respectively. The compatibilized blends showed the enhancement of mechanical properties especially impact energy increased by a factor of 5.

บทคัดย่อ

สราวลี แสงทวีป: การเพิ่มความเหนียวของพอลิเอไมด์สิบสองด้วยยางธรรมชาติโดยผ่านความเข้ากันได้แบบไม่มีและแบบมีปฏิกิริยา (Toughness Enhancement of Polyamide 12 with Natural Rubber via Non-Reactive and Reactive Compatibilizations) อ. ที่ปรึกษา : รศ. ดร. รัตนาวรรณ มกรพันธุ์ และ ศ. ดร. ชัดสาน ชี จานา 244 หน้า

งานวิจัยนี้ศึกษาเกี่ยวกับการเพิ่มความเหนียวของพอลิเอไมด์สิบสอง (ไนลอนสิบสอง) ด้วยการเติมยางธรรมชาติโดยผ่านกระบวนการผสมแบบสภาวะหลอมเหลว โดยมีพอลิเมอร์ร่วมของพอลิสไตรีนกับยางธรรมชาติและพอลิเมอร์ร่วมของพอลิสไตรีนกับยางธรรมชาติมาเลเอตทำหน้าที่เป็นสารเชื่อมประสานทั้งแบบไม่มีปฏิกิริยาและแบบมีปฏิกิริยาตามลำดับ ผลพบว่าสารเชื่อมประสานแบบไม่มีปฏิกิริยาปรับปรุงความเข้ากันได้ของไนลอนสิบสองและยางธรรมชาติโดยผ่านการเชื่อมโยงทางกายภาพ นำไปสู่การกระจายตัวที่ดีของยางธรรมชาติในไนลอนสิบสอง เมทริกซ์และการเพิ่มขึ้นของพลังงานการกระแทกประมาณ 3 เท่า สารเชื่อมประสานแบบมีปฏิกิริยาถูกใช้ต่อมา เพื่อเพิ่มการยึดติดที่พื้นผิวระหว่างไนลอนสิบสองและยางธรรมชาติโดยผ่านการเชื่อมโยงทางเคมี อย่างไรก็ตามกระบวนการผสมพอลิเมอร์ร่วมของพอลิสไตรีนกับยางธรรมชาติมาเลเอตที่แตกต่างกัน (การผสมแบบขั้นตอนเดียวและสองขั้นตอน) รวมทั้งปริมาณมาเลอิกแอนไฮไดรด์ มีผลต่อปริมาณการเชื่อมโยงของยาง (เจล) และประสิทธิภาพการกราฟต์มาเลอิกแอนไฮไดรด์ ซึ่งผลพบว่าพอลิเมอร์ร่วมของพอลิสไตรีนกับยางธรรมชาติมาเลเอตที่เตรียมโดยใช้กระบวนการผสมแบบสองขั้นตอนและมาเลอิกแอนไฮไดรด์ในปริมาณต่ำ มีปริมาณเจลน้อยกว่าและมีประสิทธิภาพการกราฟต์มาเลอิกแอนไฮไดรด์สูงกว่า นอกจากนี้ปริมาณของสารเชื่อมประสานแบบมีปฏิกิริยาที่แตกต่างกันมีผลต่อสมบัติต่างๆ ของพอลิเมอร์ผสมระหว่างไนลอนสิบสองและยางธรรมชาติด้วย ซึ่งการสร้างการเชื่อมต่อซัคซิโนไมด์โดยผ่านปฏิกิริยาอิมิไดเซชันที่ส่วนต่อประสานของไนลอนสิบสองและยางธรรมชาติ เป็นสาเหตุของการเพิ่มขึ้นของค่าความเหนียวแบบเหนียวและการลดลงของการบวมตัว ขณะที่อัตราส่วนความเหนียวมีค่าใกล้เคียงหนึ่งเมื่อเพิ่มปริมาณสารเชื่อมประสานจนถึง 7 ส่วนในร้อยส่วนพอลิเมอร์ อนุภาคของยางจึงมีลักษณะเป็นทรงกลมด้วยขนาดและระยะห่างระหว่างอนุภาคที่น้อยกว่า 0.5 และ 0.3 ไมโครเมตรตามลำดับ พอลิเมอร์ผสมที่ถูกรับปรุงความเข้ากันได้จึงแสดงสมบัติเชิงกลที่ดีขึ้น โดยเฉพาะอย่างยิ่งค่าพลังงานการกระแทกเพิ่มขึ้น 5 เท่า

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ABBREVIATIONS

ATR-FTIR	Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy
DCP	Dicumyl Peroxide
DSC	Differential Scanning Calorimetry
MA	Maleic Anhydride
NR	Natural Rubber
PA12	Polyamide 12 (Nylon12)
PS	Polystyrene
PS/MNR	Polystyrene/Maleated Natural Rubber Copolymer
PS/NR	Polystyrene/Natural Rubber Copolymer
SEM	Scanning Electron Microscopy
TGA	Thermogravimetric Analysis

LIST OF SYMBOLS

T_g	Glass Transition Temperature
T_m	Melting Temperature
T_c	Crystallization Temperature
χ_c	Degree of Crystallinity
τ	Shear Stress
$\dot{\gamma}$	Shear Rate
η	Viscosity
n	Power Law Index
K	Flow Consistency Index or Viscosity Coefficient Index
T	Temperature
R	Universal Gas Constant
E_a	Flow Activation Energy
D	Diameter
D_{ip}	Interparticle Distance
ϕ_c	Volume Fraction of Continuous Phase
ϕ_d	Volume Fraction of Disperse Phase
ϕ_r	Volume Fraction of Rubber Phase