

**POLYPROPYLENE/ORGANOCLAY NANOCOMPOSITE
INTELLIGENT PACKAGING**



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A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Master of Science
The Petroleum and Petrochemical College, Chulalongkorn University
in Academic Partnership with
The University of Michigan, The University of Oklahoma,
And Case Western Reserve University

2008

512037

Thesis Title: Polypropylene/Organoclay Nanocomposite Intelligent Packaging
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ABSTRACT

4872018063: Polymer Science Program

Natthira Ruangrit: Polypropylene/Organoclay Nanocomposite Intelligent Packaging.

Thesis Advisors: Assoc.Prof. Rathanawan Magaraphan, Asst. Prof. Hathaikarn Manuspiya, and Asst. Prof. Manit Nithitanakul xx pp.

ISBN xxx-xx-xxxx-x

Keywords: Polypropylene/ Clay / Nanocomposite / Intelligent Packaging/
PEDOT:PSS/ Cu²⁺/ Meat spoilage

PP/organoclay nanocomposite films with various clay contents were prepared by melt blending in a twin screw extruder and blow film extrusion machine and were investigated for their properties. The organoclay modified by ammonium salt was successfully prepared as confirmed by XRD, FT-TR, and TGA. PP/organoclay nanocomposite films containing organoclay 1-5 wt% show intercalated type of nanocomposites. The addition of organoclay does not affect the crystal structure of PP matrix; however, it enhances thermal stability, melting and crystallization behavior. The mechanical properties of the nanocomposite films show enhanced modulus by 10-20% over that of pure PP with the trade-off in tensile strength and elongation at break. The increased modulus reduces with organoclay content. SEM images show increase in aggregation of organoclay particles. This may result in inferior mechanical properties with organoclay content. However, oxygen barrier property is better by 6 times that of virgin PP films. Intelligent packaging films made of poly(3,4-ethylenedioxythiophene):poly(sodium-4-styrenesulfonate) (PEDOT:PSS)/poly(vinyl acetate) (PVA) and Cu²⁺/PVA spin-coated onto PP/organoclay nanocomposite films were successfully used for monitoring the freshness of chicken meat. The correlations between aerobic plate count (APC) and total volatile basic nitrogen (TVB-N) vs storage time at room temperature can be used to define the freshness of meat. PEDOT:PSS/PVA and Cu²⁺/PVA behave as both color sensors and electrical sensors to response to TVB-N. The results show that increasing thickness by reducing spin-coating speed, concentration of PEDOT:PSS and Cu²⁺ of the

sensor, amount of meat, and decreasing clay content of the nanocomposite film substrates lead to better response or higher in total color difference (TCD) values. Cu^{2+} sensors render better response through visible color change than PEDOT:PSS ones. However, it was estimated that at least chicken of 200 g is enough for clear color change of PEDOT:PSS detected by naked eyes. Leaching test shows that Cu^{2+} releases out less than the minimum allowance.

บทคัดย่อ

นักธีรา เรื่องฤทธิ์: บรรจุภัณฑ์ฉลาดพอลิพรอพิลีนเคลย์นาโนคอมพอสิต (Polypropylene/Organoclay Nanocomposite Intelligent Packaging) อ. ที่ปรึกษา: รศ.ดร. รัตนาวรรณ มกรพันธุ์ ผศ.ดร. หทัยกานต์ มนต์ปิยะ และ ผศ.ดร.มานิตย์ นิธิธนากุล xx หน้า ISBN xxx-xx-xxxx-x

การวิจัยนี้ได้ศึกษาถึงสมบัติของแผ่นฟิล์มพอลิพรอพิลีน/ออร์แกโนเคลย์นาโนคอมพอสิตที่ปริมาณออร์แกโนเคลย์สัดส่วนต่าง ๆ โดยใช้เครื่อง twin screw extruder และ blow film extrusion machine ออร์แกโนเคลย์ได้ผ่านการปรับปรุงสมบัติด้วยเกลือของแอมโมเนียมก่อนนำไปใช้ พบว่า แผ่นฟิล์มนาโนคอมพอสิตที่เคลย์สัดส่วนต่าง ๆ เป็นชนิดอินเทอร์คาเลต การเติมออร์แกโนเคลย์ไม่มีผลต่อโครงสร้างผลึกของพอลิพรอพิลีน แต่มีผลทำให้ค่าทนความร้อน การหลอมเหลวและอุณหภูมิการตกผลึกสูงขึ้น สมบัติเชิงกล เช่น ค่า Young's modulus เพิ่มขึ้นประมาณ 10-20% แต่ค่า tensile strength และ elongation at break ลดลง ค่า Young's modulus ที่เพิ่มขึ้นนั้นลดลงเมื่อปริมาณเคลย์เพิ่มสูงขึ้น และภาพจาก SEM พบว่า มีการรวมตัวกันของเคลย์ ซึ่งอาจส่งผลกระทบต่อารลดลงของสมบัติเชิงกล อย่างไรก็ตามค่าการซึมผ่านของก๊าซออกซิเจนซึ่งสำคัญต่อบรรจุภัณฑ์อาหารมีค่าลดลงประมาณ 6 เท่า ในงานวิจัยนี้มีการผลิตบรรจุภัณฑ์ฉลาดที่ใช้สำหรับตรวจวัดความเน่าเสียของเนื้อไก่ โดยทำจากแผ่นฟิล์มพอลิพรอพิลีน/ออร์แกโนเคลย์นาโนคอมพอสิตที่เคลือบผิวด้วย poly(3,4-ethylenedioxythiophene): poly(sodium-4-styrenesulfonate) (PEDOT:PSS)/poly(vinyl acetate) (PVA) และ Cu^{2+} /PVA ซึ่งวัดความสดด้วยการนับจำนวนแบคทีเรียและการวัดปริมาณไอของสารประกอบไนโตรเจน จากผลการวิจัย พบว่า PEDOT:PSS/PVA และ Cu^{2+} /PVA สามารถใช้เป็นเซ็นเซอร์ตรวจวัดความสดของเนื้อไก่ โดยการเปลี่ยนสีและสังเกตได้ด้วยตาเปล่า รวมถึงการเปลี่ยนค่าทางไฟฟ้า โดยเมื่อเพิ่มความเข้มข้นและความหนาของเซ็นเซอร์ เพิ่มปริมาณเนื้อที่ใช้วัดความสด และลดปริมาณเคลย์ในแผ่นฟิล์มนาโนคอมพอสิต จะทำให้การตอบสนองของเซ็นเซอร์ดีขึ้น และพบอีกว่า Cu^{2+} /PVA สามารถตอบสนองได้ดีกว่า PEDOT:PSS/PVA แต่เมื่อเพิ่มปริมาณเนื้อเป็น 200 กรัม PEDOT:PSS/PVA ก็จะตอบสนองได้ดีขึ้น และสามารถมองเห็นได้ด้วยตาเปล่า จากการวัดการรั่วของเซ็นเซอร์ พบว่า มีปริมาณการรั่วออกมาน้อยมาก และอยู่ในค่าที่รับได้และไม่เป็นอันตราย

ACKNOWLEDGEMENTS

This work would not have been possible without the assistance of the following individuals.

First of all, the author would like to gratefully give special thanks to her advisors, Assoc. Prof. Rathanawan Magaraphan, Asst. Prof. Hathaikarn Manuspiya, and Asst. Prof. Manit Nithitanakul for their intensive suggestions, valuable guidance and vital help throughout this research. In addition, the author deeply thanks to Assoc. Prof. Ittipol Jangchud and Dr. Rattaporn Thonggoom for serving on her thesis committee.

The author is grateful for the partial scholarship and partial funding of the thesis work provided by the Postgraduate Education and Research Programs in The National Excellent Center for Petroleum, Petrochemicals, and Advanced Materials, National Research Council of Thailand (NRCT); and Polymer Processing and Polymer Nanomaterials Research Units.

The author would like to thank Thai Nippon Chemical Industry Co, Ltd.; for providing the raw materials to carry out this research and Tang Packaging Co., Ltd. for tubular blown film extrusion machine.

Special thanks go to all of the Petroleum and Petrochemical College's faculties who have tendered invaluable knowledge and the college staffs who willingly gave support and encouragement.

Finally, the author would like to take this opportunity to thank PPC Ph.D. students (especially, Ms. Nattaya Muksing and Mr. Wachiraphol Sinthavathavorn) and all her PPC friends for their friendly assistance, cheerfulness, creative suggestions, and encouragement. Also, the author is greatly indebted to her parents and her family for their support, love and understanding. Without them, this work wouldn't have been successful.

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ABBREVIATIONS

PP	Polypropylene
BTN	Bentonite
OBTN	Organommodified bentonite
Stepantex TM SP-90	Dipalmitoylethy hydroxyethylmonium methosulfate
Surlyn	Sodium-neutralized ethylene-co-methacrylic acid
EDOT	3,4-ethylenediethoxythiophene
PEDOT	Poly(3,4-ethylenediethoxythiophene)
PSS	Poly(sodium-4-styrenesulfonate)
TVC	Total viable count
APC	Aerobic plate count
TVB-N	Total volatile basic nitrogen
TCD	Total color difference