

การเตรียมคอมพอลิตของออกไซด์ฐานไทเทเนียมและท่อนาโนคาร์บอนสำหรับตัวเก็บประจุ

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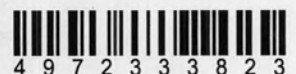
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PREPARATION OF TITANIUM - BASED OXIDE AND CARBON NANOTUBE
COMPOSITES FOR CAPACITOR

Mr. Narabhandhu Laohawich

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

Faculty of Science

Chulalongkorn University

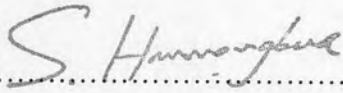
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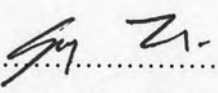
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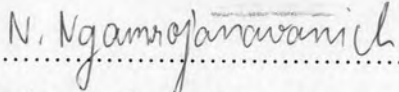
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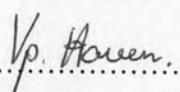

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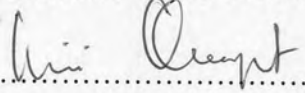
THESIS COMMITTEE


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..... Advisor
(Associate Professor Orawon Chailapakul, Ph.D.)


..... Examiner
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..... Examiner
(Assistant Professor Voravee Hoven, Ph.D.)


..... External Examiner
(Winai Oungpipat, Ph.D.)

นราพันธ์ เลาหวิช : การเตรียมคอมพอสิตของออกไซด์ฐานไทเทเนียมและท่อนาโนคาร์บอนสำหรับตัวเก็บประจุ (PREPARATION OF TITANIUM - BASED OXIDE AND CARBON NANOTUBE COMPOSITES FOR CAPACITOR)
 อ.ที่ปรึกษาวิทยานิพนธ์หลัก : รศ. ดร. อรวรรณ ชัยลภากุล, 102 หน้า.

งานวิจัยนี้เป็นการสังเคราะห์โลหะออกไซด์สองชนิด ได้แก่ เหล็กออกไซด์และนิกเกิลออกไซด์ ร่วมกับวัสดุคอมพอสิตของท่อนาโนคาร์บอนผนังหลายชั้นกับไทเทเนียมไดออกไซด์ เพื่อใช้เป็นขั้วตัวเก็บประจุ โดยทั่วไปวัสดุคอมพอสิตดังกล่าวสามารถสังเคราะห์ด้วยวิธีทางเคมีจากสารประกอบเกลือของโลหะ และท่อนาโนคาร์บอนซึ่งผ่านการดัดแปรผิวหน้าด้วยกรดที่มีความเข้มข้นสูง แล้วจึงทำการศึกษาลักษณะโครงสร้างผลึกและสัณฐานวิทยาของวัสดุคอมพอสิตด้วยเทคนิคการเลี้ยวเบนของรังสีเอ็กซ์ (เอ็กซ์อาร์ดี) กล้องจุลทรรศน์อิเล็กตรอนแบบส่องกราด (เอสบีเอ็ม) และกล้องจุลทรรศน์อิเล็กตรอนแบบส่องผ่าน (ทีอีเอ็ม) การเตรียมขั้วเพื่อใช้ในการทดสอบสมบัติทางเคมีไฟฟ้าของวัสดุคอมพอสิต เริ่มจากการนำวัสดุคอมพอสิตดังกล่าวผสมร่วมกับตัวทำละลายโดยผ่านกระบวนการอัลตราโซนิคอย่างต่อเนื่องเป็นเวลา 30 นาที ทำให้สารละลายที่ได้มีลักษณะเป็นเนื้อเดียวกัน จากนั้นสารละลายดังกล่าวจะถูกพ่นเป็นละอองตามแนวแรงไฟฟ้าสถิตไปยังแผ่นรองรับซึ่งมีอุณหภูมิ 150 องศาเซลเซียสด้วยเทคนิคอิเล็กโทรสพรายด์โพลีชัน (อีเอสดี) ซึ่งก่อให้เกิดขั้วของวัสดุคอมพอสิตที่มีลักษณะเป็นแผ่นฟิล์มบาง เพื่อใช้ในการศึกษาลักษณะทางเคมีไฟฟ้าด้วยเทคนิคไซคลิกโวลแทมเมทรี เทคนิคอิมพีแดนซ์สเปกโทรสโกปี และเทคนิคควาโนสตาติกในสารละลายกรดซัลฟิวริกที่ความเข้มข้น 1 โมลาร์ จากการศึกษาพบว่า ความสามารถในการเก็บประจุของวัสดุคอมพอสิตขึ้นอยู่กับปริมาณของโลหะออกไซด์ชนิดต่างๆที่ถูกสังเคราะห์ร่วมกับท่อนาโนคาร์บอน เนื่องจากโลหะออกไซด์มีลักษณะเฉพาะที่ดีในการเก็บประจุ ที่สำคัญยังพบว่าวัสดุคอมพอสิตฐานของออกไซด์ฐานไทเทเนียมที่มีนิกเกิลออกไซด์เป็นส่วนประกอบ จะมีค่าการเก็บประจุสูงถึง 180.40 ฟารัดต่อกรัม โดยที่ค่าดังกล่าวนี้สูงกว่าค่าการเก็บประจุของวัสดุคอมพอสิตฐานไทเทเนียมไดออกไซด์ และนอกจากนี้ยังสามารถใช้เป็นวัสดุคอมพอสิตชนิดใหม่เพื่อใช้เป็นขั้วเก็บประจุทางเคมีไฟฟ้า

สาขาวิชา...ปิโตรเคมีและวิทยาศาสตร์พอลิเมอร์... ลายมือชื่อนิสิต..... นราพันธ์ เลาหวิช.....

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KEYWORDS : MULTI-WALLED CARBON NANOTUBES/ COMPOSITE ELECTRODE/ CAPACITOR/ CYCLIC VOLTAMMETRY/ IMPEDANCE SPECTROSCOPY/ ELECTROSTATIC SPRAY DEPOSITION

NARABHANDHU LAOHAWICH : PREPARATION OF TITANIUM - BASED OXIDE AND CARBON NANOTUBE COMPOSITES FOR CAPACITOR. ADVISOR : ASSOC. PROF. ORAWON CHAILAPAKUL, Ph.D., 102 pp.

In this work, the preparation of metal oxide (FeO and NiO) and titanium-based multi-walled nanotube (MWNTs) composites for capacitor electrodes was reported. The composite materials were synthesized via a chemical reduction method using metal salts and functionalized MWNTs. Structural and morphological characterizations of these composites were carried out via x-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The synthesized composites were dispersed in an aqueous solvent via sonication, and then the composite solutions were then electrostatically sprayed onto the Pt/Si substrates which were heated to 150⁰C. Cyclic voltammetry, impedance spectroscopy and galvanostatic technique were employed to characterize the electrochemical performances of the composite thin films. Electrochemical characterization shows that there is an almost linear dependence of structure-specific capacitance on the amount of metal oxides on the MWNTs surface due to the surface's pseudo-capacitive nature. From the results, the composite electrode obtained from NiO incorporated on TiO₂/MWNTs provides a markedly enhanced specific capacitance of 180.40 F/g in 1 M H₂SO₄. Such an enhanced capacitance, as well as the cost-effectiveness of the NiO on TiO₂/MWNTs composite, shows the advantages to the use of this composite as an effective alternative material for electrochemical capacitors.

Field of Study..Petrochemistry and Polymer Science.. Student's Signature.. *Narabhandhu L.*

Academic Year.....2008..... Advisor's Signature..... *Orawon Chailapakul*

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LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|-------------------------|---|
| CNTs | Carbon nanotubes |
| C_h | Chiral vector |
| SWNTs | Single-walled nanotubes |
| MWNTs | Multi-walled nanotubes |
| ECs | Electrochemical capacitors |
| EDLCs | Electrochemical double layer capacitors |
| $^{\circ}\text{C}$ | Degree celsius |
| % w/w | Weight by percent |
| μm | Micrometer |
| F/g | Farad per gram |
| g | Gram |
| mg | Milligram |
| mL | Milliliter |
| nm | Nanometer |
| cm^{-1} | Per centimeter |
| M | Molarity |
| mA | Milliampere |
| kV | Kilovolt |
| FTIR | Fourier transform infrared spectroscopy |
| XRD | X-ray diffractometry |
| SEM | Scanning electron microscopy |
| TEM | Transmission electron microscopy |
| SCE | Saturated calomel electrode |
| CV | Cyclic voltammetry |
| EIS | Electrochemical impedance spectroscopy |
| ESD | Electrostatic spray deposition |
| EWS | Ethanol-water system |
| NaOH | Sodium hydroxide |
| H_2SO_4 | Sulfuric acid |
| HNO_3 | Nitric acid |
| TiO_2 | Titanium dioxide |

| | |
|--------------------------------------|--------------------------------|
| FeO | Iron oxide |
| NiO | Nickel oxide |
| FeSO ₄ ·7H ₂ O | Iron (II) sulfate heptahydrate |
| KBr | Potassium bromide |