NOVEL ELECTROSPUN TITANIUM (IV) OXIDE COMPOSITE HOLLOW FIBERS AS ANODE IN LITHIUM-ION BATTERIES

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ABSTRACT

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Nanostructured transition metal oxides have been developed as electrode materials in Lithium-ion Batteries (LIBS) due to their ability to provide high capacity and improved cycling performance. Among these types, titanium oxide (TiO_2) has attracted considerable interesting owing to its high lithium intercalation property, minimal toxicity and small volume change during cycling. TiO_2, however, has low ionic and electronic conductivity. Therefore, this present work will focus on the structural modification of TiO_2 nanofibers to improve their efficiency. Accordingly, the hollow ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers will be prepared through coaxial electrospinning of the colloidal solution consisting of Titanium (IV) isopropoxide/ Poly (vinyl acetate)/ Zn particles and Ag particles in case of Ag_2O-TiO_2 fibers, followed by calcination in air at 500 °C 1 h. Both of added Zn and Ag particles are employed as seeds to generate the growth of ZnO and Ag_2O crystals on the surface of TiO_2 using the hydrothermal treatment at various times and temperatures. The average diameter of both types of the products obtained after hydrothermal treatment increased with increasing time and temperature of hydrothermal treatment. XRD patterns revealed well crystalline features of anatase TiO_2 with ZnO, and Ag_2O. Additionally, the surface area of the obtained hollow fibers was observed by BET surface area. Among the hydrothermally treated ZnO-TiO_2 composite hollow fibers, the fibers which were treated at 115 °C 0.5 h provided the highest surface area (25.164 m^2g^{-1}) compared to the other hydrothermally treated ones. But in case of Ag_2O-TiO_2 composite hollow fibers, the fibers which were treated at 110 °C 1 h provided the highest surface area (44.960 m^2g^{-1}).

บทคัดย่อ

ธนัชพร ศิริเมฆานนท์ : วัสดุโครงสร้างเส้นใยกลวงเชิงประกอบ ไททาเนียม ออกไซด์ชนิดใหม่สำหรับการประยุกต์ใช้เป็นขั้วแอโนดในลิเธียมไอออน แบตเตอรี (Novel Electrospun Titanium (IV) Oxide Composite Hollow Fibers as Anode in Lithium-ion Batteries) อ. ที่ปรึกษา : ศ. ดร. พิชญ์ ศุภผล และ ดร. กรกช สมบัติมั่นคง 117 หน้า

โครงสร้างระดับนาโนของ ทรานซิชัน เมทัล ออกไซด์ ได้รับการพัฒนาอย่างต่อเนื่องในการทำเป็นอิเล็กโทรดในลิเธียมไอออน แบตเตอรี โดย ไททาเนียม ออกไซด์ (TiO_2) ได้รับความสนใจอย่างมาก เนื่องจากมีโครงสร้างผลึกที่เหมาะสมในการให้ลิเธียมไอออนแทรกตัวในปริมาณสูง, ความเป็นพิษต่ำ, และเกิดการเปลี่ยนแปลงทางปริมาตรน้อยระหว่างกระบวนการให้และคายประจุ แต่อย่างไรก็ตาม ไททาเนียม ออกไซด์ มีความสามารถในการนำไอออนและอิเล็คตรอนต่ำ ดังนั้นงานวิจัยนี้จึงมุ่งศึกษาวิธีการปรับปรุงลักษณะพื้นผิวเส้นใยไททาเนียม ออกไซด์ เพื่อปรับปรุงประสิทธิภาพการนำไฟฟ้า โดยเส้นใยกลวงซึ่งเป็นวัสดุเชิงประกอบของซิงค์ ออกไซด์-ไททาเนียม ออกไซด์ และ ซิลเวอร์ ออกไซด์-ไททาเนียม ออกไซด์ ถูกเตรียมจากสารละลายคอลลอยด์ของ ไททาเนียม ไอโซโพรพอกไซด์ (TIP)/ พอลิไวนิล อะซิเตท (PVAc)/ อนุภาคของซิงค์ (Zn particles) และ ซิลเวอร์(Ag particles) ตามลำดับ ผ่านเทคนิค การปั่นเส้นใยด้วยไฟฟ้าสถิตย์แบบร่วมแกน (coaxial electrospinning) ตามด้วยกระบวนการเผา (calcination) ที่ 500 องศา เป็นเวลา 1 ชั่วโมง โดยอนุภาคของซิงค์ และ ซิลเวอร์ที่เติมลงไป จะถูกใช้เพื่อเหนี่ยวนำให้เกิดการเติบโตของผลึกซิงค์ ออกไซด์ และ ซิลเวอร์ ออกไซด์ บนผิวของเส้นใยกลวงผ่านกระบวนการให้ความร้อนด้วยน้ำ (hydrothermal treatment) ที่สภาวะต่างๆ จากผลการทดลองพบว่าขนาดเส้นใยเฉลี่ยของวัสดุทั้งสองชนิดเพิ่มขึ้นตามเวลาและอุณหภูมิ ภายใต้กระบวนการให้ความร้อนด้วยน้ำ จากผลเอกซเรย์ดิฟแฟรกชัน (XRD) พบว่าเส้นใยกลวงทั้งสองชนิดประกอบโครงสร้างผลึกของอะนาเทส ไททาเนียม ออกไซด์ ร่วมกับ ซิงค์ ออกไซด์ และ ซิลเวอร์ ออกไซด์ นอกจากนี้ พื้นที่ผิวของวัสดุโครงสร้างเส้นใยกลวงเชิงประกอบ ไททาเนียม ออกไซด์ทั้งสองชนิดได้ถูกตรวจสอบโดยเซอร์เฟส แอเรีย อะนาไลเซอร์ (BET) ผลการทดสอบพบว่าวัสดุโครงสร้างเส้นใยกลวงเชิงประกอบของซิงค์ ออกไซด์- ไททาเนียม ออกไซด์ที่สภาวะ 115 องศา 0.5 ชั่วโมง ให้ค่าพื้นที่ผิวสูงสุด ส่วนวัสดุโครงสร้างเส้นใยกลวงเชิงประกอบของซิลเวอร์ออกไซด์-ไททาเนียม ออกไซด์ที่สภาวะ 110 องศา1 ชั่วโมง ให้ค่าพื้นที่ผิวสูงสุด

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