Preparation and characterization of Pt nanowire by electrospinning method for methanol oxidation

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1. Introduction

Pt nanoparticles, which are used as catalysts in various chemical/electrochemical reactions, are generally prepared by means of chemical impregnation or reduction methods [1–3]. Recently, a series of studies on metal particles supported on graphite/carbon nanofibers and nanotubes [4–6] and the preparation of metal or metal oxide in the shape of nanotubes or nanowires [7–10] have been reported. As in other types of nanostructures, it is expected that if the diameter of a metal nanowire or nanotube shrinks, there will be a dramatic increase in the surface-area-to-volume (mass) ratio as well as the ratio of exposed atoms on the surface [11]. The use of unsupported metal nanowires/tubes as catalytic materials for fuel cells can be beneficial because of their higher electron conductivity [12,13]; moreover, the catalyst degradation that normally occurs due to corrosion of the carbon support can be avoided [11].

Metal nanowires are generally prepared by template synthesis [10,12], a wet-chemical method that employs a carbon nanosphere [14], galvanic displacement [15], and the electrospinning method [13,16–18]. Of these, electrospinning has proven to be a simple and stable method to prepare polymer fibers that have a uniform diameter in the range of a nanometer scale. The physical properties of electrospun fibers can be controlled through the maintenance of certain parameters such as polymer concentration, dissolution temperature, spinning voltage, and spinning rate [19–22].

The conventional electrospinning method that is normally used to prepare polymer fibers uses polymer solutions, whereas metal–polymer hybrid wires [23,24] or metallic nanowires are prepared by electrospinning a polymer solution blended with the metal precursors [13,16,17]. Working along these lines, Bognitzki et al. [25] prepared copper nanowires with a size of 215–270 nm using a mixture containing polyvinylbutyral (PVB) polymer and a Cu precursor. Kim et al. [13] prepared electrospun PtRh and PtRu nanowires using a Pt precursor–polyvinyl pyrrolidone (PVP) mixture and used the same for the MOR. In their study, the PVP was burnt out by means of a heat treatment carried out at 300 °C for 3 h in air, followed by treatment at 100 °C in a H2 atmosphere in order to reduce Pt. They also prepared hybrid PtRu nanoparticles/nanowires using the electrospinning method, and used the hybrid materials as electrocatalysts in a DMFC and in a polymer electrolyte membrane fuel cell (PEMFC) [16]. They were able to achieve a power density of approximately 35 mW/cm2 using a 2.5 mg/cm² hybrid catalyst in the anode and pure oxygen in the cathode of a DMFC, at an operating temperature of 70 °C. Although the above studies have explored the possibilities of using the electrospinning technique to prepare Pt and Pt alloy nanowires as