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Synthesis of platinum–polyaniline composite, its evaluation as a performance boosting interphase in the electrode assembly of proton exchange membrane fuel cell

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ABSTRACT

Platinum formed on polyaniline (PANi) is used as the interlayer between porous gas diffusion layer and the catalyst layer with the aim to reduce the thickness of the ordinary gas diffusion layer and provide a performance boosting electrostatic layer. The doping tendency of PANi is utilized to incorporate platinum(IV) ion in its matrix by chemisorption followed by its reduction to metallic platinum. Platinum is deposited on polyaniline by a simple wet chemistry method. PANi is prepared by the chemical oxidative polymerization of aniline by ammonium persulphate while Pt deposition on PANi is achieved by a phase transfer method (water–toluene) to yield Pt nanoparticles on PANi. The composite is characterized by XRD, Scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDX), IR spectroscopy, cyclic voltammetry (CV), AC impedance studies, density and conductivity measurements. The Pt/PANi composite is assessed in the proton exchange membrane fuel cell (PEMFC) using H_2/O_2 gases at ambient pressure. The performance of the PEMFC with Pt/PANi composite interphase on cathode side of the gas diffusion layer (GDL) shows improvement at high current densities which is attributed to the increased capacitative current of Pt/PANi layer in the presence of O_2 thereby improving the kinetics of subsequent reduction of O_2.

1. Introduction

Proton exchange membrane fuel cell (PEMFC) is considered to be the most attractive energy technology for the future due to its advantages such as increased efficiency, high power density, ultra low emissions of environmental pollutants, low weight, compact construction, and its ability to operate at lower temperatures (<100 °C) [1]. The PEMFC has undergone active developments over the recent years due to its very wide range of mobile applications, transportation applications and also in combined heat and power (CHP) systems. But commercially, the PEMFC still has a few hurdles to overcome such as reducing the material and catalyst costs, enhancing per weight use of platinum catalyst, and improving the performance of the membrane electrode assembly.

Efforts are going on for enhancing the performance of platinum catalyst in PEMFC. This may be done by increasing the surface area of the catalyst through homogeneous distribution on a high surface area support material or by miniaturization of the particle size of the catalyst at the nanoscale [2]. A wide variety of catalyst support materials having large surface area have been studied extensively for various applications. These include polymer nanocomposites [3], polyaniline (PANi) [4–6], multi-walled carbon nanotubes (MWCNTs) [7], single-walled carbon nanotubes (SWCNTs) [8], alumina (Al_2O_3) [9], nitrogen-doped magnetic carbon nanoparticles (N-MCNPs) [10], graphitized carbon nanofibres [11], nitrogen containing activated carbon fibre, polyamidoamine (PAMAM) dendrimers [12], etc. There has been a growing interest in research on conducting polymers because of the double advantages of being an organic conductor and highly conjugated polymeric structure, thus exhibiting attractive physicochemical properties for application in PEMFCs. The emeraldine salt form of polyaniline (PANi) [13], which is electrically conductive, can be synthesized in bulk and the cost of raw materials is very less. The unique properties of PANi are its good mechanical strength, tunable electronic and electrical conductivity, high chemical stability for use below 100 °C, large surface area, and simple and low cost manufacturing process. Platinum supported PANi prepared by various methods have been studied for their catalytic properties in redox reactions [14–17]. Composite of PANi and multiwalled carbon nanotube with immobilized Pt particles have been assessed for their redox characteristics [18].

With regard to the synthesis of platinum nanoparticles (Pt NPs), the literature reports various routes such as electrodeposition [19], sol–gel [20], micro-emulsion techniques [21], polyol process [22],

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