Development of a Metallic Bipolar Plate using Nano Material Coating for PEM Fuel cell Application

Submitted By

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M.Sc. (Chemistry) 2007

To

Chemistry Department, Faculty of Science

Ain Shams University

For

Ph.D. degree in Chemistry

2014

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INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 37 (2012) 7677–7688

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/he

Ni–P and Ni–Co–P coated aluminum alloy 5251 substrates as metallic bipolar plates for PEM fuel cell applications

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ARTICLE INFO

Article history:
Received 7 December 2011
Received in revised form
24 January 2012
Accepted 29 January 2012
Available online 3 March 2012

Keywords:
Bipolar plate
Polymer electrolyte membrane fuel cell
Ni–P
Ni–Co–P
Interfacial Contact resistance

ABSTRACT

This study is aimed to replace graphite bipolar plates in PEM fuel cells with surface modified aluminum alloy. To improve the surface characteristics of aluminum alloy 5251 (AA5251) substrate, Ni–P and Ni–Co–P coatings were deposited using electroless and electroplating deposition techniques (power supply and chronoamperometry). Surface morphology and chemical composition of prepared coatings have been investigated using scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) techniques. The corrosion behaviour of Ni–P and Ni–Co–P coated AA5251 was studied in (0.5 M H_2SO_4 + 2 ppm HF) solution by potentiodynamic polarization technique. Lower corrosion current densities and more positive corrosion potentials were gained after coating AA5251 with Ni–P and Ni–Co–P deposits. Much better corrosion resistance was shown by coatings containing cobalt. Potentiostatic tests were carried out at +160 mV (MMS) in air-saturated solution to simulate cathode environment in PEM fuel cells. The current density of Ni–Co–P (1:1)/AA5251 was stabilized at a value lowered by 4 times relative to that at bare AA5251 substrate. Interfacial contact resistance values between coated substrates and carbon paper were measured. Ni–P and Ni–Co–P coatings prepared by electroless method showed ICR values, twice that at ones prepared by electroplating power supply technique.

1. Introduction

In recent years, renewable energy has become an increasingly important issue in terms of mitigating global warming and preventing the depletion of fossil fuels. There is a great potential to apply fuel cells for the generation of electricity. As an electrochemical device that converts chemical energy into electric power by means of catalytic electrochemical reaction, the main advantages of fuel cells are relatively simple mechanisms, silent operation, high efficiency and flexible scaling between power and capacity [1]. Out of various fuel cells currently under development, direct methanol fuel cell (DMFC) is one of the most promising candidates for use as a substitute power source in portable applications, such as cellular phones and laptops [2].

In a typical PEMFC, the key components include a proton exchange membrane, catalyst, gas diffusion layer and bipolar plate. Bipolar plates constitute the backbone of a hydrogen fuel cell power stack. They conduct current between cells, facilitate water and thermal management,

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0360-3199/$ – see front matter
doi:10.1016/j.ijhydene.2012.01.145

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 37 (2012) 10807–10817

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/he

Study of different aluminum alloy substrates coated with Ni–Co–P as metallic bipolar plates for PEM fuel cell applications

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ARTICLE INFO

Article history:
Received 14 February 2012
Received in revised form
30 March 2012
Accepted 12 April 2012
Available online 19 May 2012

Keywords:
Electroplating
Ni–Co–P
Aluminum
Metallic bipolar plate
Polymer electrolyte membrane fuel cell

ABSTRACT

Pure Al and some of its alloys [Al alloy 6061 (AA6061), Al alloy 3004 (AA3004) and Al alloy 1050 (AA1050)] were coated with Ni–Co–P using electroplating power supply technique. Scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) techniques were applied to study the surface morphology and chemical composition of coated aluminum substrates. Their performance against corrosion was examined using potentiodynamic polarization technique in (0.5 M H_2SO_4 + 2 ppm HF) solution. Corrosion potential values were shifted in the positive direction at all aluminum substrates after their coating with Ni–Co–P. Corrosion current density values at coated pure Al and AA1050 were decreased by ~18.6 times, compared to those at bare substrates. The stability of coated aluminum alloys was investigated during long-time operation under cathodic environment in PEMFCs using potentiostatic polarization test at +160 mV (MMS) in air-saturated solution. Ni–Co–P/AA3004 substrate showed a high corrosion rate after short time, while coated AA6061 one slowly corroded. Interfacial contact resistance (ICR) values between metallic bipolar plates and gas diffusion layer were measured. Coating AA1050 with Ni–Co–P reduces its ICR value by 13 times. Accordingly, electroplated Ni–Co–P/AA1050 substrate can be chosen as an efficient bipolar plate material in PEMFCs.

1. Introduction

Increased demand to oil fuel for transportation applications with its continuous decreased supply and increased environment pollution had paid attention to develop fuel cells [1–4]. In relation to the internal combustion engines, polymer electrolyte membrane fuel cells (PEMFCs) offered high power density, low emissions and can operate at low temperatures [5–8]. However, the high cost of their constituents, mainly bipolar plates, impedes the commercial application of PEMFCs. Bipolar plates represent the backbone of the cell. They transfer the electric current from the electrodes to the load circuit and distribute reactant and product gas flow streams.

Bipolar plates can be mainly made of two types of materials; namely graphite and metals. Graphite is the most used one as a result of its low bulk resistance, excellent chemical stability and corrosion resistance [9]. However, graphite is

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doi:10.1016/j.ijhydene.2012.04.066

Acknowledgment

I would like to express my thanks to ***Prof. Dr. Eglal Myriam Raymond Souaya***, Chemistry Department, Faculty of Science, Ain Shams University for her continuous help and support.

My thanks are also to ***Prof. Dr. Kamel Mohamed Mahmoud El-khatib***, Chemical Engineering and Pilot Plant Department, National Research Center for his continuous help, suggesting the points investigated and valuable supervision, in addition to his interest in my work.

My gratitude and indebtedness are to ***Dr. Randa Mohamed Abdel-Hameed*** Assistant Prof. of physical chemistry, Cairo University for her great effort that was done through this thesis.

The Author cannot find words to express her deep feelings of gratitude to her colleagues ***Miss/Rabab Sayed Amin*** Assistant Researcher at Chemical Engineering and Pilot Plant Department, National Research Center for her sincere co-operation.

TO

MY

FAMILY

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