RESEARCH ARTICLE

Design and Test of Electrochemistry of Electrodes Catalysis for an Alkaline Fuel Cell

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ABSTRACT

This paper was aimed to design an alkaline fuel cell from anode and cathode mesh electrodes. The electrodes were coated with nickel oxide nanocatalysts. The outer wall of the cell consists of organic glass sheets. Also, which carries electrically charged molecules from one electrode to another and stimulates, accelerating interactions in the electrodes. Hydrogen is the primary fuel, produces from an electrolyser, Nickel oxide nanocatalysts was prepared by Chemical deposition, The Structural characteristics was studied through of X-ray diffraction (XRD) of the prepare for determining the yielding phase, Also the sample will test using an atomic force microscope to find the roughness of the prepared surface, Voltages were also obtained at 1.74 volts and current at 3.01 A of an alkaline fuel cell. In addition, study the characterization of the electrochemical parameters.

Key words: an alkaline fuel cell, nickel oxide nanocatalysts, Chemical deposition, electrolyser.

INTRODUCTION

Fuel cells are electrochemical devices that convert chemical energy to interact directly into electrical energy. Depending on the type of fuel cells used in electricity was classified into different groups. Each fuel cell has two electric electrodes, named, respectively the negative electrode and the positive electrode. An electrolyte membrane also, which carries the charge of molecules electrically from one electrode to the other and a catalyst [1]. The oldest fuel cells that were carefully developed and made possible electricity generation of hydrogen using KOH complex liquid electrolytes were alkaline fuel cells (AFCs) [2], Nano particles attracted wide interests because of their good properties namely optical, electronic, magnetic, thermal, mechanical properties, battery use for electrodes, gas sensors, electrochemical films, photoelectric devices[3]. The introduction of nanotechnology, which contributes significantly to sustainable economic growth. Nanotechnology is a generic term used to describe materials and phenomena on a nanometer. Specifically, it means not only minimizing but also the subtle changes in atoms and molecules to design and control the properties of nonmaterial. With an emphasis on the energy field, nanotechnology has the potential to significantly reduce Of the impact of energy production, Storage and use An already sustainable energy system, the scientific community is considering further development of nanotechnology for energy [4], The researcher Yasuhiro Mizukoshi and Katsumi Yamada evaluated the electrochemical properties of NiO/Au. High-velocity electrochemical changes was obtained within one second by improvements in penis length and film thickness for the NiO film[5], The researcher Tomokazu Sakamoto and his group NIO/Nb2O5/C, NIO/C, and Ni/C catalysts was manufactured for electro-hydrazine electrooxidation by evaporation drying method followed by thermodynamic nano materials have been extensively tested in recent decades because of their high surface area, which severely affects their physical properties. And on reported nanostructure shapes [6], The researcher Eileen Hao Yu, and his group studied new catalysts. And anion exchange membranes. In addition, alkaline fuel cell systems and new configurations were studied[7], The researcher István Bakos and his group used a layer of nano particles to partially cover Ni thin-film to provide the most effective use of the HOR catalyst. The Pd / Ni electrodes were prepared by spontaneous and electrolytic deposition of Pd on nickel-pure polycrystalline surfaces [8].

MATERIALS AND METHODS

Preparation of NiO nanoparticles

1 g of NiCl2 (6H2O) powder and add 10 mL ammonia gradually (Approx. 15 min) to under the strong stirring to produce Ni + 2 solutions. Due to the NiCl2 exothermic reaction with ammonia, ammonia slowly added to the precursors. The temperature of the solution was 75 ° C, and the pH was in a range to nine. Then add the deionized water as a precipitating agent while continuing under the strong stirring solution until the green sediment was formed. The resulting precipitates were filtered and washed twice with deionized water and ethanol. For the production of black NiO nanoparticles. And dry at 105 ° C for 90 minutes in the oven. As shown in 'Figure 1a'

Synthesis of catalysts

For the purpose of electrical insulation and control of the movement of ions electrons between the electrodes of the alkaline cell, the catalyst was prepared, and the electrodes are prepared for this purpose by placing, The desired electrode after attaching it to the negative electrode, the other carbon connected to the positive electrode of the power supply (5.6V and 0.90A) (1 L). The distance between the electrodes is 3 mm, the coating solution was added by taking 0.5 g of Nickel chloride salt (NiCl2•6H2O) and dissolved in 1 liter of deionized water, Where it is a clear solution green color in mixing a process to immerse the electrodes almost, and for three hours, until you a gray coating layer of NIO catalyst atoms was produced. After the coating was completed, it was cleaned with deionized water and dried. As shown in 'Figure 1 b,c'. The electrolysis cell consists of stainless steel plates of type 314 No. 2 isolated from each other, for the purpose of isolating each gas separately (hydrogen and oxygen), including a plate of organic glass. These electrodes are immersed in an electrolyte solution, prepared from distilled water and added to 28% of potassium hydroxide. The outer wall consists of organic glass to prevent leakage of gases (14.5 x 12) cm^2 from the 0,1 cm thick of and these electrodes were connected to a solar cell operating at 10 volts and a current of up to 3 shown in 'Figure 2'. A fuel cell alkaline consists of nano nickel oxide catalyst a porous anode and nano nickel oxide catalyst a porous cathode, with these two electrodes separated by is (KOH). An oxidant is fed to the cathode to supply hydrogen while is fed in the anode to supply hydrogen. The electrolyte supports the transfer of ions between an anode and cathode to support the reverse electrolysis reaction. The outer wall of the cell consists of organic glass sheets.

RESULTS AND DISCUSSION

The surface morphology of the nano NiO catalyst has been verified using AFM studies that are fully focused on the nano scale characterization. AFM images show nickel oxide prepared at a substrate temperature of 350 ° C with a uniform granular surface morphology, We have studied the surface morphology of the catalytic layers: a sponge-like structure is produced when the current density increases, where nano crystalline can be seen and distributed throughout the entire surface. As well as Analysis of the morphology of the catalyst Porous under varying current density conditions. In the low current density, the network was obtained very highly spaced, randomly oriented and highly correlated of pores. However, the increase in the current density of small pores showing forms, leading to a catalyst It was found that the particle size was 65 nm as shown in 'Figure 3 a, size, distribution, and morphology are closely related to the preparation techniques [3,9]. The XRD patterns indicate that the nano composite is well 'Figure 4 the obtained patterns are presented in Fig. 4, XRD analysis showed a series of diffraction peaks at 2θ of 27.21°, 42.08°, 61.82°, and 75.94° ° can be assigned to (111), (200), (220), (219) and (2 11) planes, The diffraction peaks show good crystalline nanoparticles and match very well with ideal lattice constants , n this paper , The XRD pattern shows that the samples are single phase and distinct diffraction peak except the characteristic peaks of FCC phase NiO was detected. This result shows that the physical phases of the NiO nanoparticles have higher purity prepared[10].

Organic glass plates were used in the outer surface of this cell, and electrodes were attached to the Stainless Steel Restaurant with Nickel oxide Plated Mesh (2) applied by electroplating process. Hydrogen gas was released from the dissolution of water molecules in electrolysis to analyze water to the cell through anode electrode Touch a layer of the nano-nickel oxide catalyst, which in turn separates the hydrogen molecules into atoms, and then the protons and electrons pass through an external load cycle accompanied by the movement of hydrogen ions (OH^{-1}) from the negative electrode through the electrolyte solution of the anode electrode, Oxygen molecules At the cathode, the electrode merges with the electrons that travel through the outer load circuit to form the water molecule again at the anode pole, accompanied by an increase in the valiant cell temperature to more than 70 ° C, to obtain a power of 1.74 volts and a current of 3.01 A. As shows 'Figure 5 , ' The amount of energy produced by the alkaline cell depends on the thickness and quantity of the plates. The atoms are the nickel oxide that stimulates the hydrogen molecules and converts them into electrons in the form of energy, As well as the purity and amount of hydrogen provided to the alkaline cell. The higher the purity, the higher the energy and the oxygen from the other electrode (cathode) This increases the energy and efficiency of the cell. In this paper, cell operation using oxygen from the electrolysis system was tested [11] [12]. Table 1 , The dimensions of mesh electrodes. And Table 2 shows increased electrical conductivity with an increase in the flow rate of hydrogen due to the amount of hydrogen gas.

Note: $$\sigma = \frac{I*L}{V*W*T} \quad (1)$$

σ electrical conductivity I: current (A), L: sample length (cm) W: sample width (cm), T: sample and thickness (cm)

As shown in 'Figure 6'the voltage of fuel cell decreased with the current same flow rate. at 0.5 L/min flow rate of H2 gas ,It was drown using the Origin Lab program. As shown in 'Figure 7' electrical conductivity increases with in the current.Same in rate of hydrogen and oxygen gases, hydrogen has the highest energy density per unit weight than any other chemical fuel for many applications. It can be converted directly into electricity by cell in an electrochemical process. As shown in 'Figure8 the variation of cell voltage decreases with i increases current density (current/area) for the cell operating his voltage drop is the straightforward resistance to the flow of electrons through the material of the electrodes and the various interconnections, There are four major factors which contribute to the decrease in cell performance. The primary four sources of losses are fuel cross-over, ohmic polarisation and concentration hydrogen[14].

CONCLUSION

We have presented a simple chemical method for producing nano nickel oxide. In this research, Nano nickel oxide catalysts were synthesized successfully for Membrane for fuel cell application. Through this study found that the voltage of fuel cell decreased with the current same flow rate. While electrical conductivity increases with increasing in the current. As well as decreased with the voltage same flow rate. With increases current density. The alkaline fuel cell has been selected for its advantages. Operating temperature is a wide range, The composition of these cells is simple, Quick start, The cost is low because of the simplicity of the material.

REFERENCES

1. Khemraj Barhate , Madhuri Sharon , L.N. Singh and Maheshwar Sharon, 2011, "Development of Hydrogen Electrode for Alkaline Fuel Cell", Department of Physics, Babasaheb Ambedkar Technical University, Lonere, Maharashtra, The Open Fuel Cells Journal, 4. 30-33.
2. G. E. Evans an d K. V. Kordesch, 1967 , "Hydrazine Air Fuel Cells," vol. 158, pp. 1148 1152.
3. K. Anandan "and V. Rajendran,2012," Structural, optical and magnetic properties of wel dispersed NiO nanoparticles synthesized by CTAB assisted solvothermal process" Nanoscience and Nanotechnology: An International Journal Universal Research Publications. All rights reserve ISSN: 2278 -1374. http://www.urpjournals.com.
4. Elena Serrano a, Guillermo Rus b, Javier Garcı a-Martınez b, 2009,"Nanotechnology for sustainable energy University of Alicante, Carretera Alicante-San Vicente s/n, E-03690 Alicante, Spain b Dpt. Structural Mechanics, University of Granada, Polite´cnico de Fuentenueva, 18071 Granada, Spain Renewable and Sustainable Energy . Reviews 13 2373–2384.
5. Yasuhiro Mizukoshi and Katsumi Y amada ,2014, " Electrochromic Characteristics of NiO/Au Composite Nano-rod Array Membrane" Bull. Soc. Photogr. Imag. Japan. Vol. 24 No. 1: 12–17.
6. Tomokazu Sakamoto, Teruyuki Masuda, Koji Yoshimoto, Hirofumi Kishi, Susumu Yamaguchi, Daiju Matsumura, Kazuhisa Tamura, Akihiro Hori, Yousuke Horiuchi, Alexey Serov, Kateryna Artyushkova, ,Plamen Atanassov, and Hirohisa Tanak ,2017, " NiO/Nb2O5/C Hydrazine Electrooxidation Catalysts for Anion Exchange Membrane Fuel Cells' Journal of The Electrochemical Society,164(4) F229-F234 .
7. Eileen Hao Yu,*a Xu Wang,a Ulrike Krewer,bc Lei Lid and Keith Scotta ,2012," Direct oxidation alkaline fuel cells: from materials to systems" Energy Environmental Science Cite this: Energy Environ. Sci., 5, 5668 , www.rsc.org/ees.
8. István Bakos, András Paszternák, David Zitoun,2015," Pd/Ni Synergestic Activity for Hydrogen Oxidation Reaction in Alkaline Conditions" Electrochmica acta 176: 1074-1082 .
9. K.C. Liu, M.A. Anderson, 1996, " Porous nickel oxide/nickel films for electrochemical capacitors", J. Electrochem. Soc. 143 124–130.
10. D. Syamala Bai, R. Padma Suvarn, C. Bala Murali Krishna ,2016,'"Characterization and DC Conductivity Studies of NiO Nano Particle" Indian Journal of Advances in Chemical Science 4(1) 98-101.
11. A. Morozan, I. Stamatin, L. Stamatin, A. Dumitru, and K. Scott, 2007," Carbon electrodes for microbial fuel cells". Nano-SAE Research Centre, University of Bucharest, MG-38, 077125, Bucharest-Magurele, Romania School of Chemical Engineering and Advanced Materials, University of Newcastle upon Tyne, NE1 7RU, England, Journal of Optoelectronics and Advanced Materials Vol. 9, No. 1, p. 221 – 224, January .
12. Yongjun Leng, Lizhu Wang, Michael A. Hickner, and Chao-Yang Wang, 2015, "Alkaline membrane fuel cells with in-situ cross-linked ionomers", Electrochimica Acta 152 93–100.
13. Pakkanen, A., 2007, "Hydrogen fuel cell vehicle and a standalone renewable energy based re- fuelling station", masters degree of programmers in renewable energy, University of Jyvaskyla.
14. ung-Chou Lin, H. Russell Kunz, James M. Fenton, Suz anne S. Fenton, 2003," The Fuel Cell – An Ideal Chemical Engineering Undergraduate Experiment ' Revised as of July 14.

Table 1. The dimensions of mesh electrodes

Samples	Width, W(cm)	Length, L (cm)	Thickness (cm)
Mesh electrode	3	3.5	0.1

Table 2. Show the relationship between the Electrical conductivity with current and voltage

Electrical conductivity σ (S\cm)	Current (A)	Voltage (V)	Current density (A/cm²)
14.83	3.01	1.74	0.29
16.77	3.15	1.61	0.3
18.36	3.32	1.55	0.32
23.81	3.75	1.35	0.36
31.38	4.54	1.24	0.43
37.30	5.31	1.22	0.51
41.06	5.75	1.2	0.55

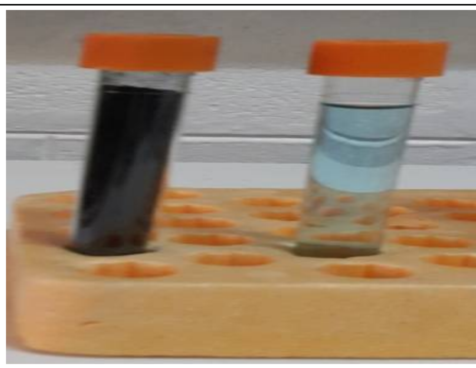

Figure 1a. Preparation of nano NiO

Figure 1b.Electroplating process

Figure 1c.the membrance

Figure 2.The electrolysis cell

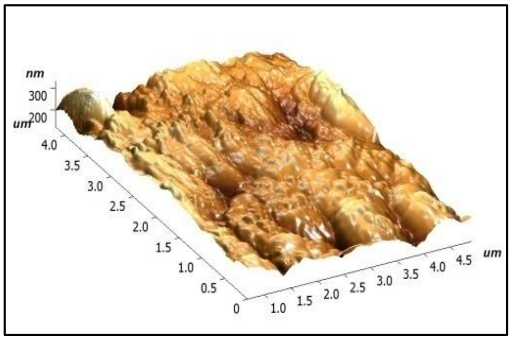

Figure 3a.Atomic force microscope of nano NiO catalyst

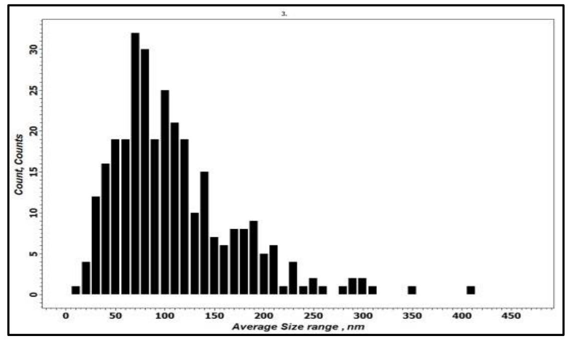

Figure 3b.Histogram of their size distribution of nano NiO catalyst

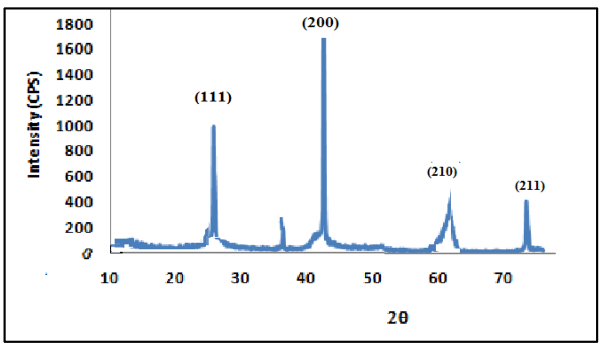

Figure 4. X-ray diffraction analysis of NiO nanoparticles

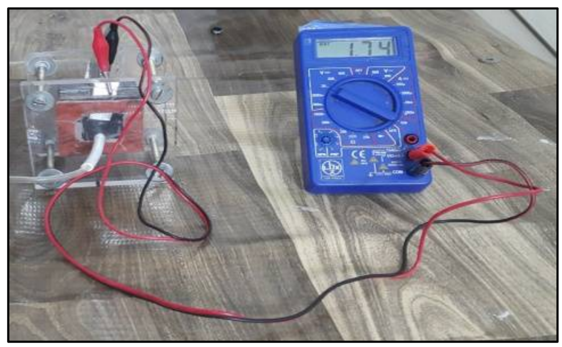

Figure 5.The fuel cell

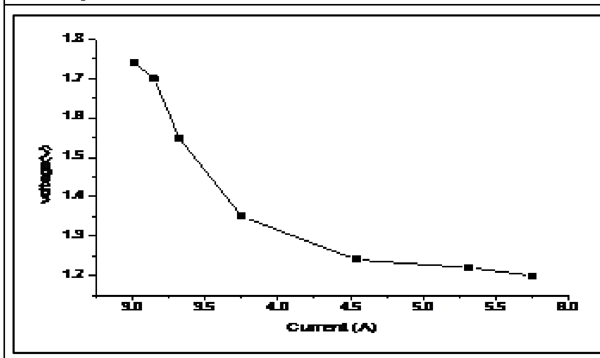

Figure 6.current-voltage at 0.5 L/min flow rate of H2 gas

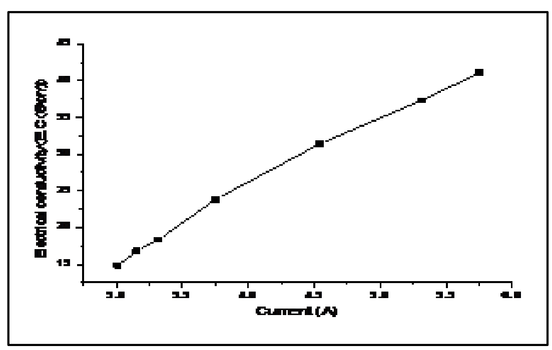

Figure 7. Electrical conductivity with current at 0.5 L\ min flow rate of H2 gas

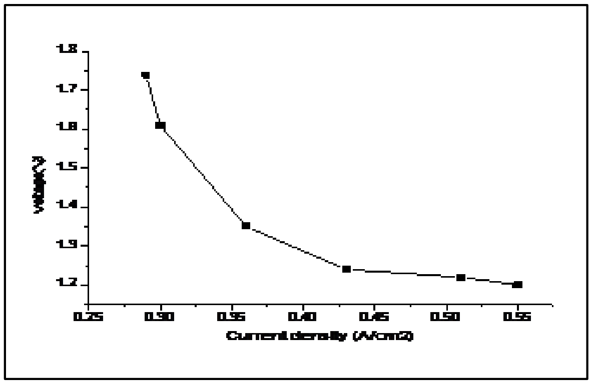

Figure 8.current density– Voltage at 0.5 L/min flow rate of H2 gas