**Design and Construction of Proton**

**Exchange Pd Nanoparticle Membrane**

**Fuel Cell**

A thesis

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**ABSTRACT**

Nowadays, the Proton Exchange Membrane Fuel Cell (PEMFC) is

considered as one of the most promising sources of energy with zero

emissions. Therefore, maintaining the PEMFC system in its optimal

operating conditions is one of the most important research orientations in

the domain. In fact, the system's performance depends on the affective area

of the catalyst that separate hydrogen atom in to electron and ion, the

membrane ability to transfer hydrogen ions and the hydrogen flow rate to

operate the fuel cell stack.

In this work, the catalyst is Palladium nanoparticles which was

prepared at different precursor concentration (150 and 500 mg) with

reaction time of 60 minutes by Polyol method. Especially, the changing in

the precursor concentration cause changing the size of prepared palladium

nanoparticles were studied, also the optical and structural properties were

investigated. The X-Ray Diffraction (XRD) measurements appeared a

crystalline structure and face center cubic phase with crystalline orientation

(111) and (200). Atomic Force Microscope (AFM) results perceived that all

samples have nanoscale size and average diameter around (75-80) nm.

From AFM measurement, the particles size were proportional inversely

with precursor concentration. SEM images show a nanoscale particle size

range (64) nm, clustered shape can be distinguish ,this shape is important

in our work to diffused the hydrogen and oxygen gas throw it.

The membrane is a piece of (8 x 8) cm wrapping film immersed in

three heated paths of (H2O, H2O2, H2SO4) at 80oC respectively. The effect

of selphoric acid root (3

−) on membranes properties was further analyzed

as it is the responsible of H+ transportation, comparing the membranes with

different acid concentrations. From AFM measurement, it found that

membranes treated with high acid concentration rougher than the other, the

deposition of catalyst is better. Spraying the Pd nanoparticles on the both

surface of the membrane by using spraying system. It was necessary to

heat the membrane with 80oC to allow good adhesion of Pd nanoparticles

on the membrane surface.

microchannels with three size (350, 550, 810)μm ablated on the

surface of the fuel cell electrodes were made by using Q-switched Nd:YAG

laser 1064 nm wavelength, 10 Hz pulse repetition rate and 6 ns pulse

duration at 850 mJ/pulse as a maximum output energy. CNC machine

control the speed of motion while the laser pulses are rapidly ablate the

surface of the aluminum plate, there for it control the radius of fabricated

channel, three value of speed (50,60,75)mm per minute are used to gate

such channels .

All the above component are combined together with two gas gates,

two outer plates and bolts to construct single PEM fuel cell stake which is

feed to hydrogen generator that we made to test the performance of the

PEMFC at different operation temperature. The fuel cell performance was

evaluated from the polarization curves at operation temperatures from 20 to

80ºC ,the results shows that the best performance of the PEMFC when it

operate at 60oC, the maximum output power was (0.28) watt and the

efficiency was ( 68% ) .

**List of Symbols and abbreviations**

**Symbol Meaning**

FC Fuel Cell

H2 Hydrogen molecule

O2 Oxygen molecule

H+ Hydrogen ion

P Power (watt)

V Voltage (volt)

I Current (amp)

N Number of cells

A Area of an individual cell

AFCs Alkaline Fuel Cells

KOH Potassium hydroxide

PEM Proton Exchange Membrane

OH- Hydroxyl ions

PAFCs Phosphoric Acid Fuel Cells

MCFCs Molten Carbonate Fuel Cells

SPFC Solid Polymer Fuel Fells

DMFCs Direct methanol fuel cells

CH3OH Liquid methanol

PEMFCs Proton Exchange Membrane Fuel Cells

MEA Membrane Electrode Assembly

CHP Combined Heat and Power

TFE Tetrafluoroethylene

SO3- Sulphur trioxide

SO3H Sulfonic acid

Pt Plutonium

NSMs Nanostructured materials

nm Nanometer

ψ (x,t) Wave function

Ћ Reduced (normalized) Planck‟s constant

M Mass of particle

I Imaginary unit

t Time

V(x) potential energy

**List of Symbols and abbreviations**

**Symbol Meaning**

0-D Zero Dimentional

1-D One Dimentional

2-D Two Dimentional

3-D Three Dimentional

E.G Ethylene Glycol

SPR Surface Plasmon Resonance

NPs Nanoparticles

FCC Face-Center Cubic

Pd Palladium

PVP poly(vinyl pyrrolidone)

UV Ultra Violate

Wavelength

VIS Visible

IR Infrared

psec Picosecond

nsec Nanosecond

USLP Ultra Short Laser Plus

SEM Scanning Electron Microscope

XRD X-Ray Diffraction

AFM Atomic Force Microscopy

SEM Scanning Electron Microscopy

Nd:YAG Neodymium Yttrium Aluminum Garnet

Pd(NO3)2.2H2O Palladium nitrate dehydrate

Wt. Weight(gm)

Mwt Molecular weight

Rpm Round per minute

FWHM Full-Width-Half-Maximum

D Diameter

rms Root- mean-square

HHV Higher Heating Value

̇ flow rates ( moles/ second)

**List of Symbols and abbreviations**

**Symbol Meaning**

ΔH The standard enthalpy of reaction is symbolized by

ΔHº or ΔHºrxn (kJ/mol)

Efficiency

TEM Transmission Electron Microscope

N Real refractive index

Α Absorption coefficient

Afc active fuel cell area

**List of Figures**

**PAGE**

**No.**

**FIGURE TITLE OF FIGURE**

**NO.**

Figure (1.1) The Structure of Fuel Cell (FC) 3

A schematic Representation of Oxidization – 5

Reduction Processes at FCElectrodes

Figure (1.2)

Figure (1.3) Polarization Curve of Fuel Cell 8

Figure (1.4) Schematic representation of alkaline fuel cell 9

Schematic representation of phosphoric acid 10

fuel cell

Figure (1.5)

Schematic representation of molten carbonate 11

fuel cell

Figure (1.6)

Figure (1.7) Schematic representation of solid oxide fuel cell 12

Schematic representation of direct methanol fuel 14

cells

Figure (1.8)

Schematic representation of polymer electrolyte 15

membrane fuel cell

Figure (1.9)

Figure (1.10) The component of PEMFC 17

Figure (1.11) Various Designs of Bipolar Plates 18

Figure (1.12) Chemical Structure of Nafion membrane 20

Representation of atomic, nano and bulk gold 25

nanoparticle is a bridge between atom and bulk

Figure (1.13)

Initiation of ionization with subsequent electron 29

avalanche

Figure (1.14)

Figure (2.1) Structure of polyvinylpyrolidone 38

Figure (2.2) The experimental set-up of Polyol method 40

Figure (2.3) Pd nanoparticals 40

Figure (2.4) Pd nanoparticles measurements 41

baths series (a)water (b) H2O2 44

(c) H2SO4 Figure (2.5)

Figure (2.6) Membrane coated with Pd nanoparticals 45

Figure (2.7) membrane measurements 46

Figure (2.8) Spray pyrolysis system 47

Figure (2.9) Mask for nafion coating 48

Experimental setup for laser ablation of 50

aluminum electrode.

Figure (2.10)

Figure (2.11) Nanosecond laser system 51

Figure (2.12) Mach3 programe to control the speed of motion 51

Aluminum Electrodes With The Microchannels 52

With Different Size

Figure (2.13)

Figure (2.14) Proton Exchange Membrane Fuel Cell 53

Construction (PEM)

Scam diagram summarized all the experimental 55

stapes that done to construct the PEMFC

Figure (2.15)

Figure (2.16) hydrogen generator components 56

Figure (2.17) hydrogen generator setup 57

Figure (2.18) The setup of the test station for the PEMFC 58

X-Ray Diffraction pattern of Pd=500mg 60

powder

Figure (3.1)

Figure (3.2) X-Ray Diffraction pattern of Pd=150mg powder 61

Two -dimensional AFM of images of Pd NPs 63

( A 150mg)and (B 500mg ) deposited on galas

plate

Figure (3.3)

Three -dimensional AFM of images of Pd NPs ( 63

A 150mg ) and (B 500mg ) deposited on galas

plate

Figure (3.4)

SEM image of Pd particles at 45 64 oC temperature.

The average size is 64 nm

Figure (3.5)

SEM image of Pd NPs at (150mg) precursor 65

concentration with 2 μm scale

Figure (3.6)

SEM image of Pd NPs at (150mg) precursor 65

concentration with 5 μm scale

Figure (3.7)

SEM image of Pd NPs at (500mg) precursor 66

concentration with 5 μm scale

Figure (3.8)

SEM image of Pd NPs at (500mg) precursor 66

concentration with 10 μm scale

Figure (3.9)

(A)Absorption spectrum of Pd NPs at 68

construction 150

(B): Absorption spectrum of Pd NPs at

construction 500

Figure (3.10)

)A): Energy gab of Pd 150mg 69

)B): Energy gab of Pd 500mg

Figure (3.11)

The absorption spectrum of Nafion with one 71

sulfuric acid bath

Figure (3.12)

The absorption spectrum of Nafion with two 72

sulfuric acid bath

Figure (3.13)

Three -dimensional AFM images of Nafion ( 72

A- one bath ) and (B- two bath )

Figure (3.14)

Three -dimensional AFM images of Nafion ( 73

A- one bath ) and (B- two bath )

Figure (3.15)

Channel size versus the CNC machine speed 74

with fixed laser energy

Figure (3.16)

Figure (3.17) The microchannel with channel size ( 810nm) 75

Figure (3.18) The microchannel with channel size ( 550nm) 76

7 Figure (3.19) The microchannel with channel size ( 350nm) 6

Effect of the operation temperature (20º -80º) C 78

on the polarization curves with channel

size(350μm)

Figure (3.20)

Effect of the different of channel size on the 79

polarization curves at (60ºC) operation

temperature

Figure (3.21)

power performance with the current density at 80

60o C operation temperature

Figure (3.22)

**List of Tables**

**PAGE**

**No.**

**TABLE TITLE**

**NO.**

Table (1.1) The properties of Pd bulk 26

Table (2.1) The main characteristics of Pd(NO3 )2.2H2O 37

Table (2.2) The main characteristics of PVP 38

Table (2.3) The properties of C2H6O2 38

Table (2.4) The Specification of the AFM. 43

The main characteristics of polymer electrolyte 44

membrane

Table (2.5)

Table (3.1) X-Ray Diffraction data for Pd = 500mg powder 60

Table (3.2) X-Ray Diffraction data for Pd = 150mg powder 61

Average grain size and surface roughness values for 62

Pd nano. with different precursor concentrations

Table (3.3)

The average particle size, absorption peak, 69

absorption magnitude, and different precursor

concentration for reaction of Pd NPs

Table (3.4)

Lists the experimental roughness values for Nafion 73

structure with the different bath number preparation

Table (3.5)

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my brothers

and

my sister

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