**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

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my brothers

and

my sister

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