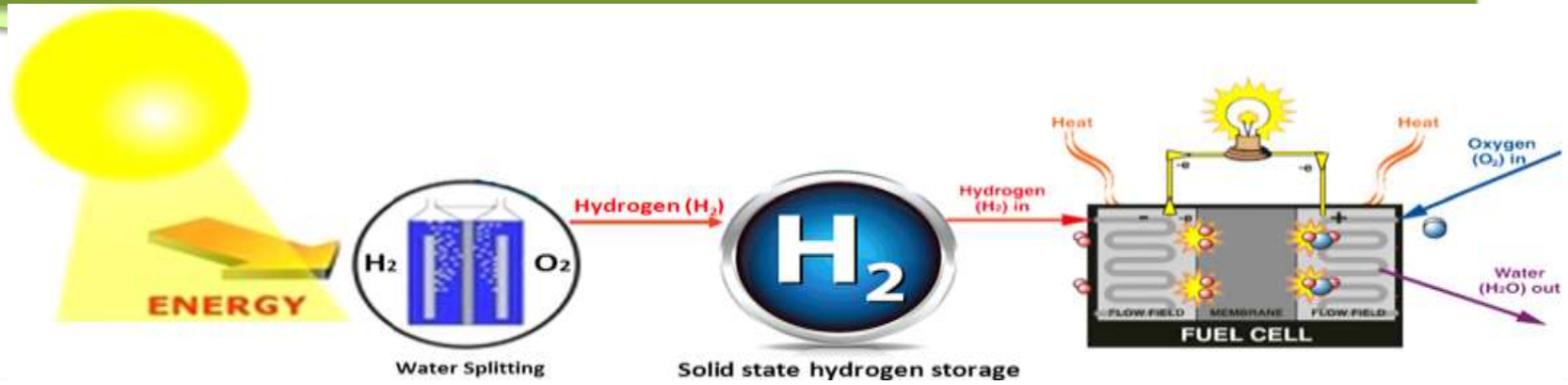
بسم الله الرحمن الرحيم

السلام عليكم ورحمة الله وبركاته

The Application of Nanotechnology in the Field of Renewable energy (Hydrogen and Fuel Cells)

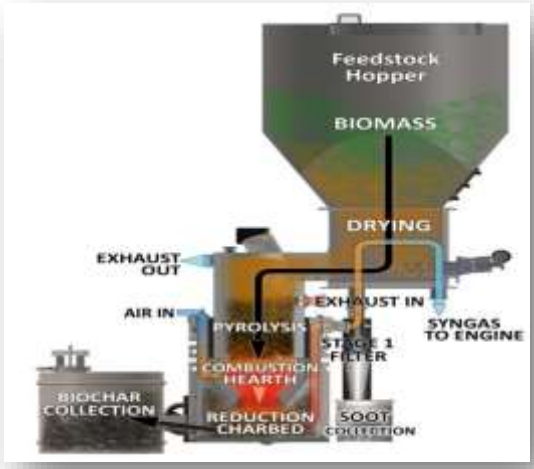


Dr. Haleemah J. Mohammed
Ministry of Science and Technology

Hydrogen Production Processes:

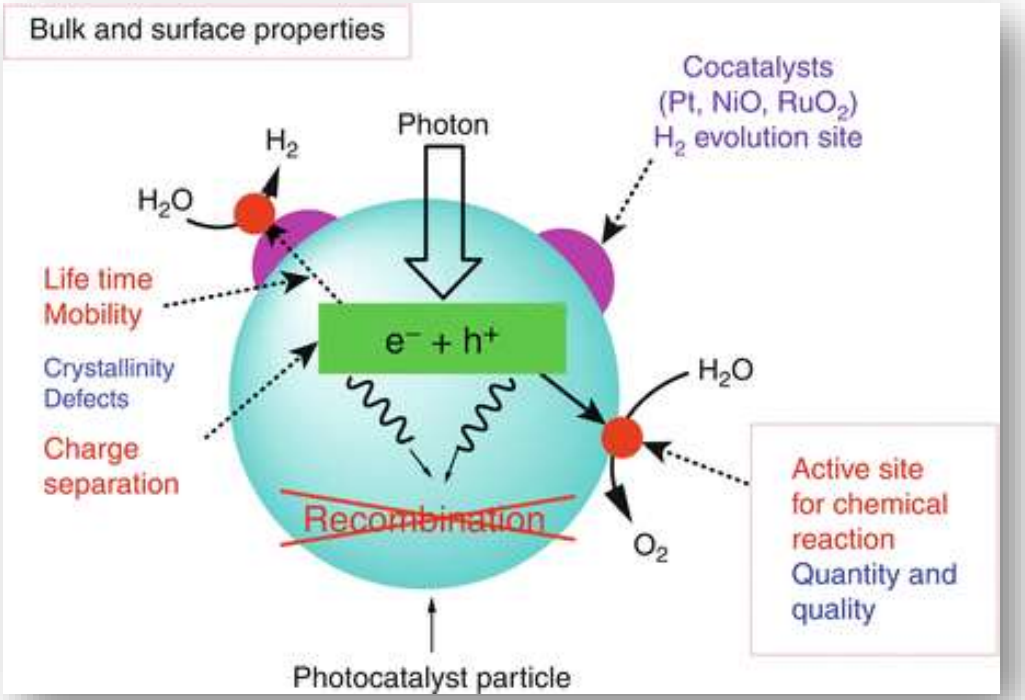
-1-Thermal Processes

- Gasification
- Renewable Liquid
- Natural Gas Reforming



2- Photolytic Processes

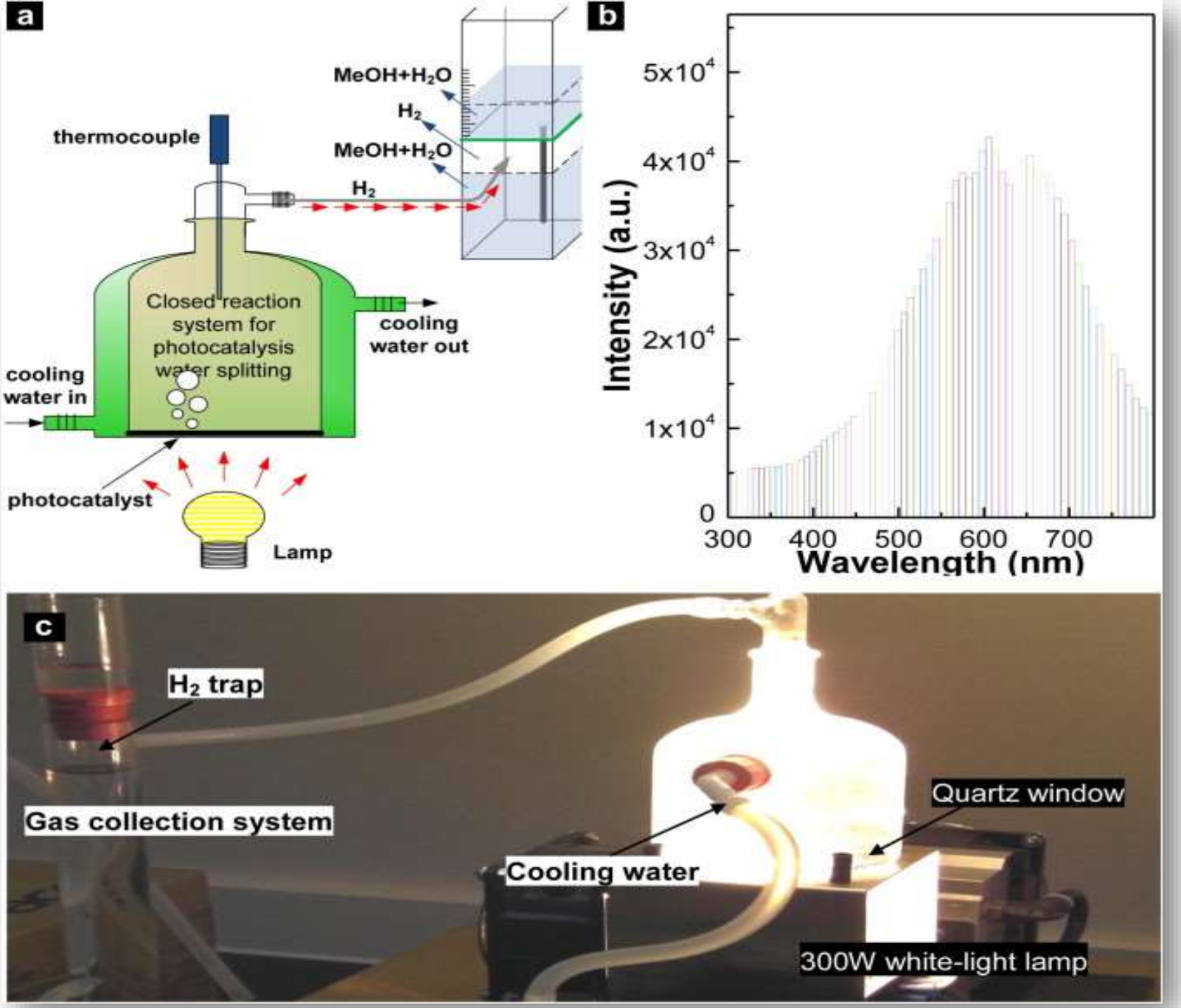
Uses light energy to split water into hydrogen and oxygen offer the possibility of hydrogen production which is cost effective and has a low environmental impact



Photocatalysis

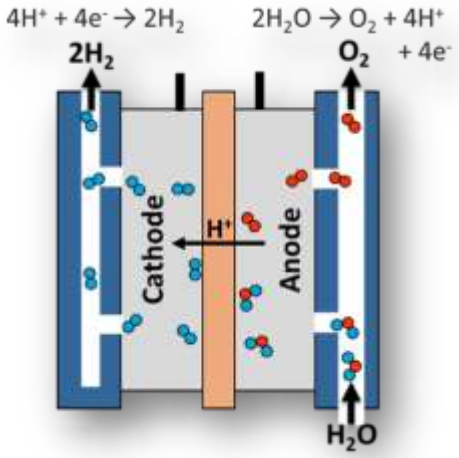
- Photocatalysis is defined as the chemical reaction induced by photoirradiation in the presence of a catalyst, or more specifically, a photocatalyst. Such material will facilitate chemical reactions without being consumed or transformed.

- Photocatalysts can be divided into homogeneous photocatalysts (photocatalyst in the same phase with the reactant materials like liquid with liquid or gas with gas) and heterogeneous photocatalysts (photocatalyst in more than one phase like liquid with gas) . first stape in improving new photocatalyst with high efficiency

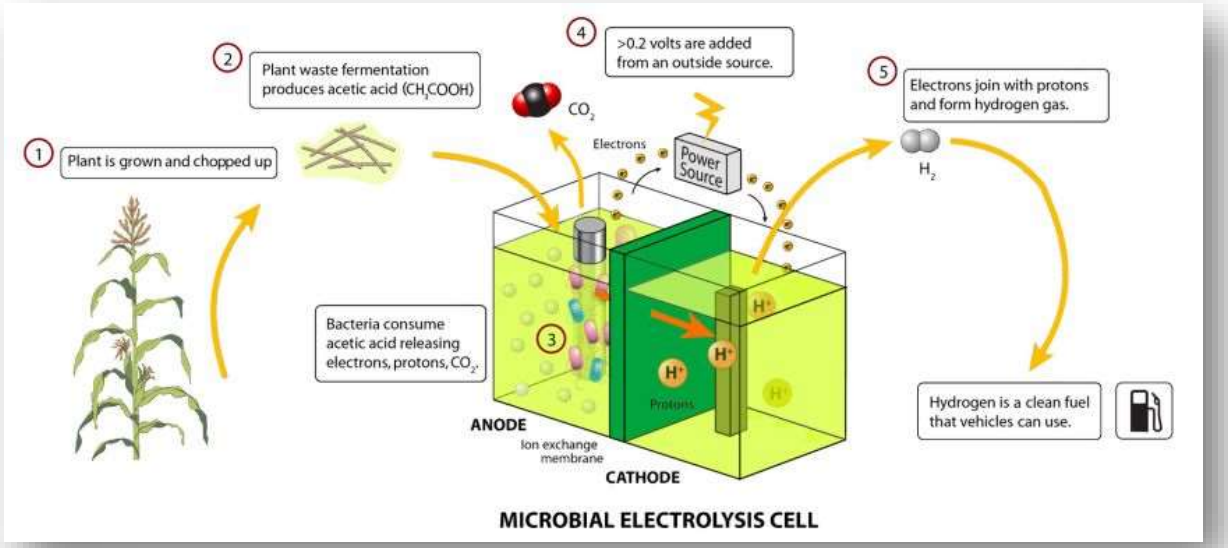

a
MeOH+H2O
H2
MeOH+H2O
H2
thermocouple
Closed reaction system for photocatalysis water splitting
cooling water out
cooling water in
photocatalyst
Lamp
b
Intensity (a.u.)
5x10^4
4x10^4
3x10^4
2x10^4
1x10^4
0
300
400
500
600
700
Wavelength (nm)
c
H2 trap
Gas collection system
Cooling water
Quartz window
300W white-light lamp

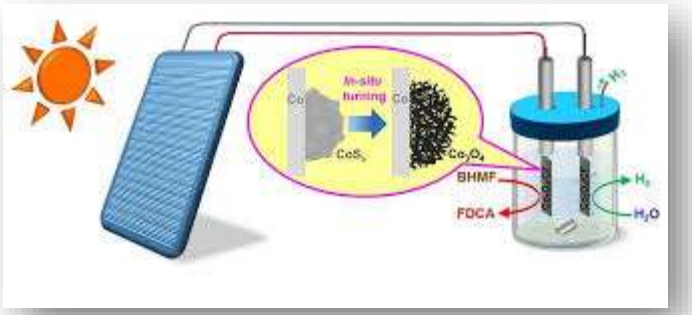
3-Electrolytic Processes

- **Electrolytic processes use an electric current to split water into hydrogen and oxygen**
- **The electricity required can be generated by using renewable energy technologies such as wind, solar, geothermal and hydroelectric power**



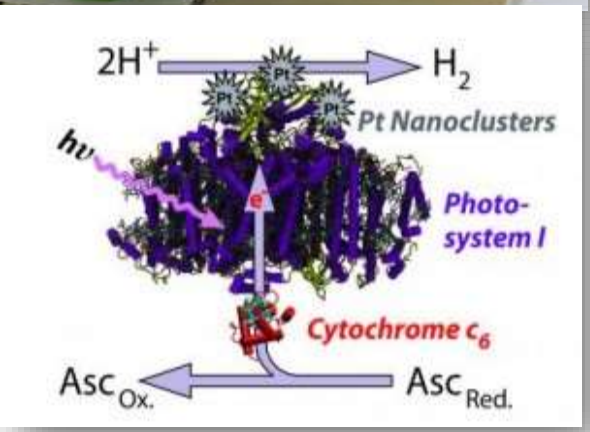
4-Biomass


1 Plant is grown and chopped up
2 Plant waste fermentation produces acetic acid (CH_3COOH)
3 Bacteria consume acetic acid releasing electrons, protons, CO_2.
4 >0.2 volts are added from an outside source.
5 Electrons join with protons and form hydrogen gas.
CO_2
Electrons
Power Source
H_2
H^+
Protons
ANODE
Ion exchange membrane
CATHODE
Hydrogen is a clean fuel that vehicles can use.
MICROBIAL ELECTROLYSIS CELL


In-situ turning
Co
CoS_x
Co_3O_4
BHMF
FDCA
H_2
H_2O

Hydrogen Production

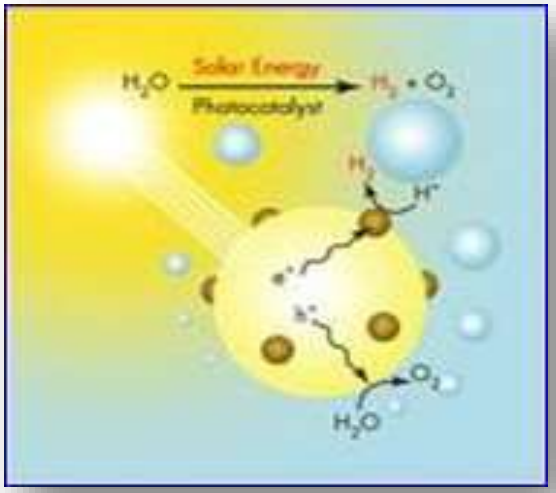
Bio-hydrogen
(Green algae)



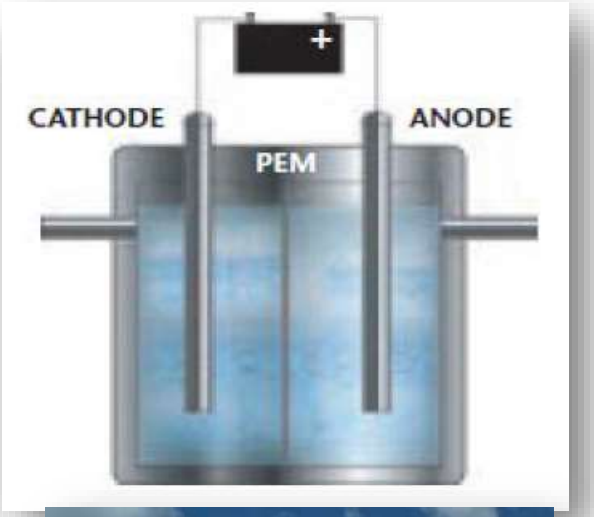
Barry D. Bruce

Oak Ridge National Laboratory
University of Tennessee

High-Temperature
water splitting

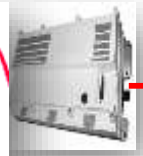


Electrolysis with renewable
energy



Wyoming

Wind Turbine
100kW



AC-DC Converter

Alkaline and PEM
Electrolyzers

Compressor
150psi-3,500psi

H2 Storage (85kg)

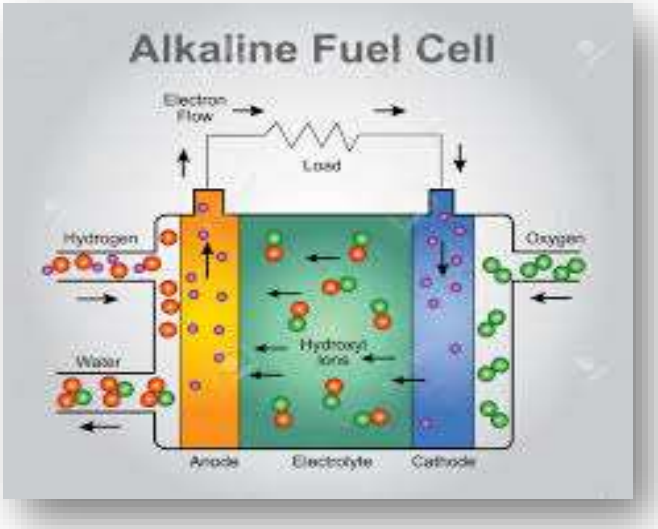
H2 Fuel Cell

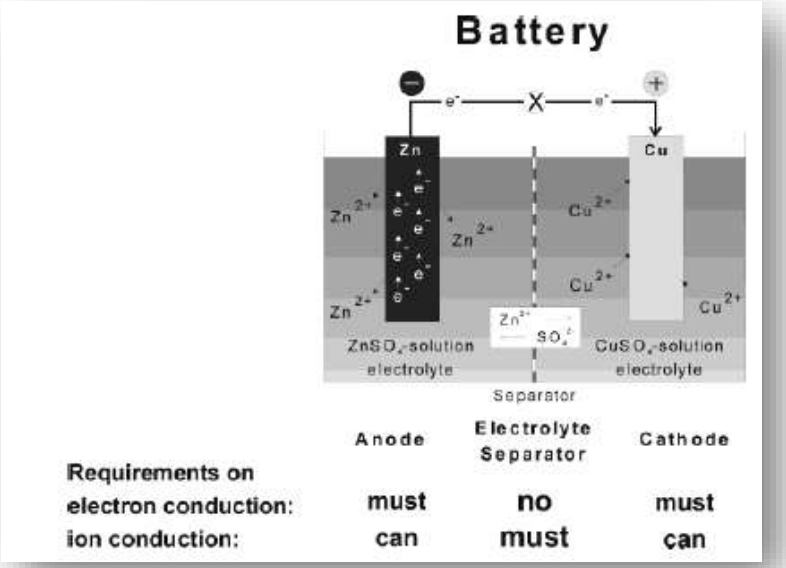
Utility Grid

H2 Fueling Station

Fuel Cells

- A fuel cell consists of two electrodes—a negative electrode (or anode) and a positive electrode (or cathode)—sandwiched around an electrolyte. Hydrogen is fed to the anode, and oxygen is fed to the cathode. Activated by a catalyst, hydrogen atoms separate into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. The protons migrate through the electrolyte to the cathode, where they reunite with oxygen and the electrons to produce water and heat



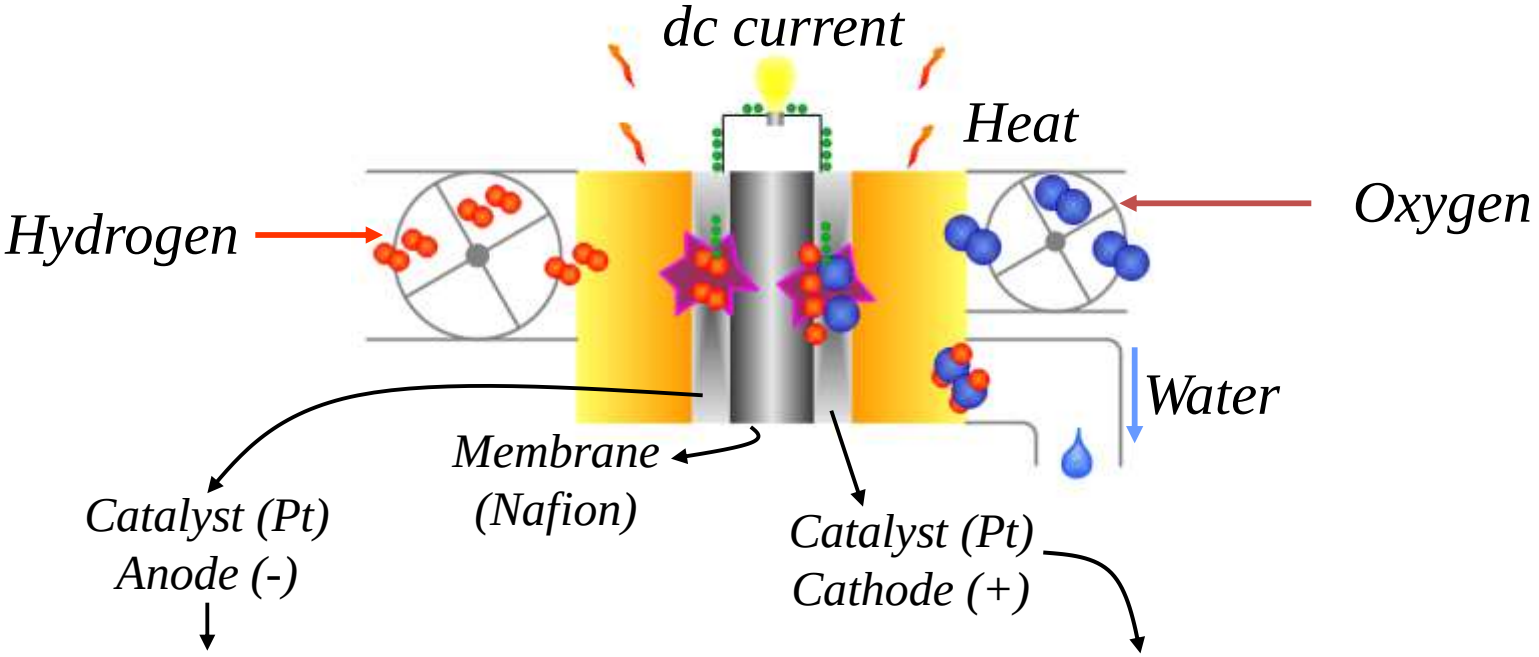


Fuel cells operation

Example: PEMFC•

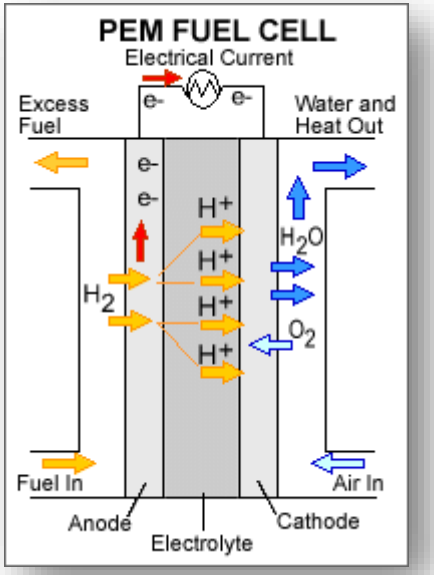
The hydrogen atom's electron and proton are separated at the anode.•

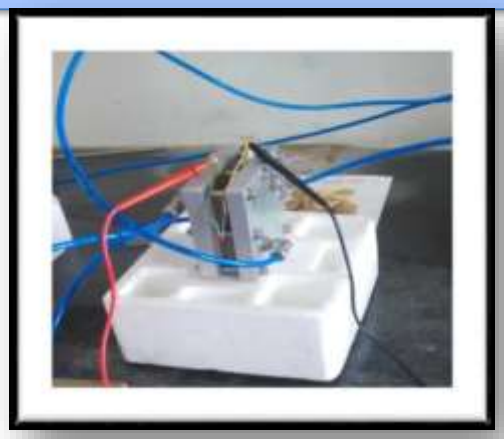
Only the protons can go through the membrane (thus, the name proton •
exchange membrane fuel cell).

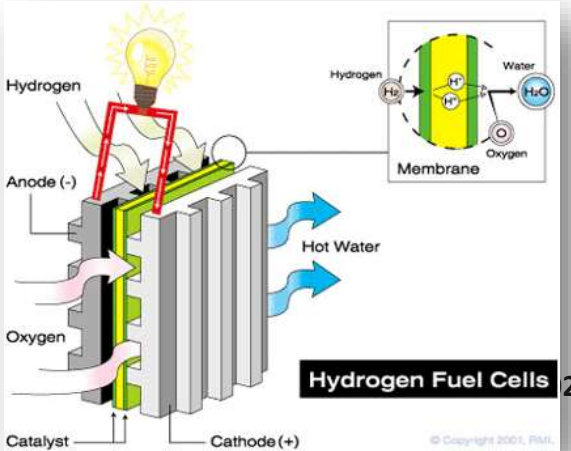


Types of Fuel Cell

- .Proton Exchange Membrane Fuel Cells (PEMFCs)
- 2- An .Alkaline Fuel Cells (AFCs)
- 3- Phosphoric Acid Fuel Cells (PAFCs)
- 4- Molten Carbonate Fuel Cells (MCFCs)
- 5. Solid Oxide Fuel Cells (SOFCs)



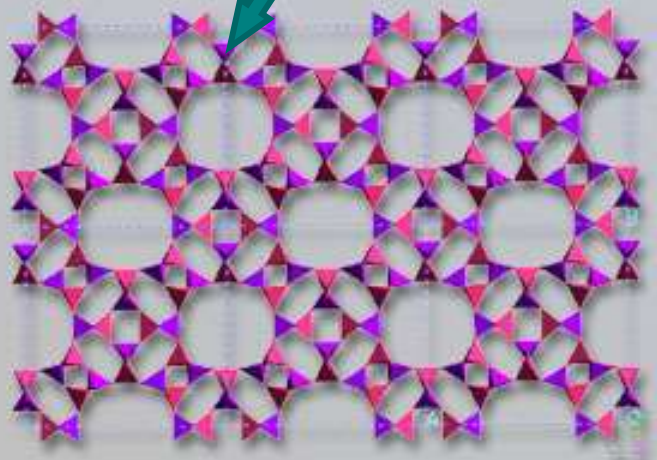




Hydrogen storage materials

High H-mass density
High H-volume density
Appropriate p,T stability
Reversible absorption/desorption

metal hydrides
carbon based materials
micorporous materials



Metal hydride forming elements
”Rule of 2 Å” for H-H separation

H_2 storage

- High pressure gas cylinders (up to 800bar)
- Liquid hydrogen in cryogenic tanks(at 21 K)

Fig. gas cylinders

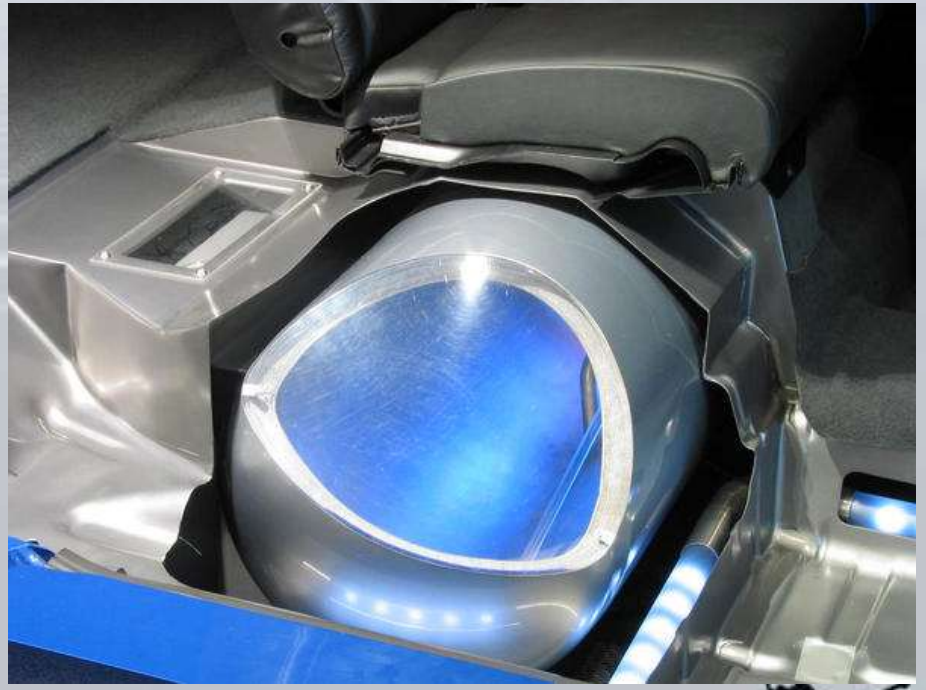
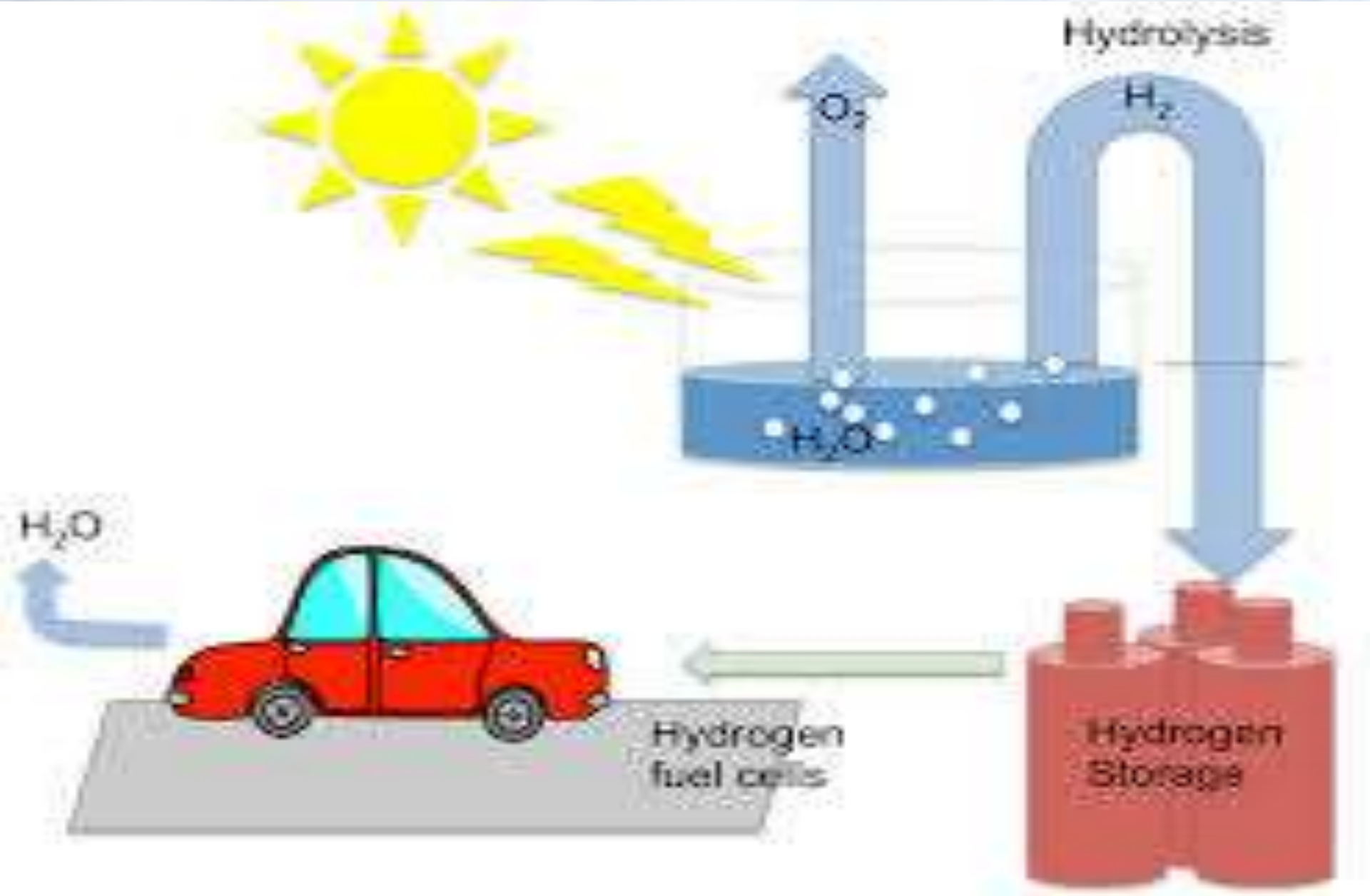


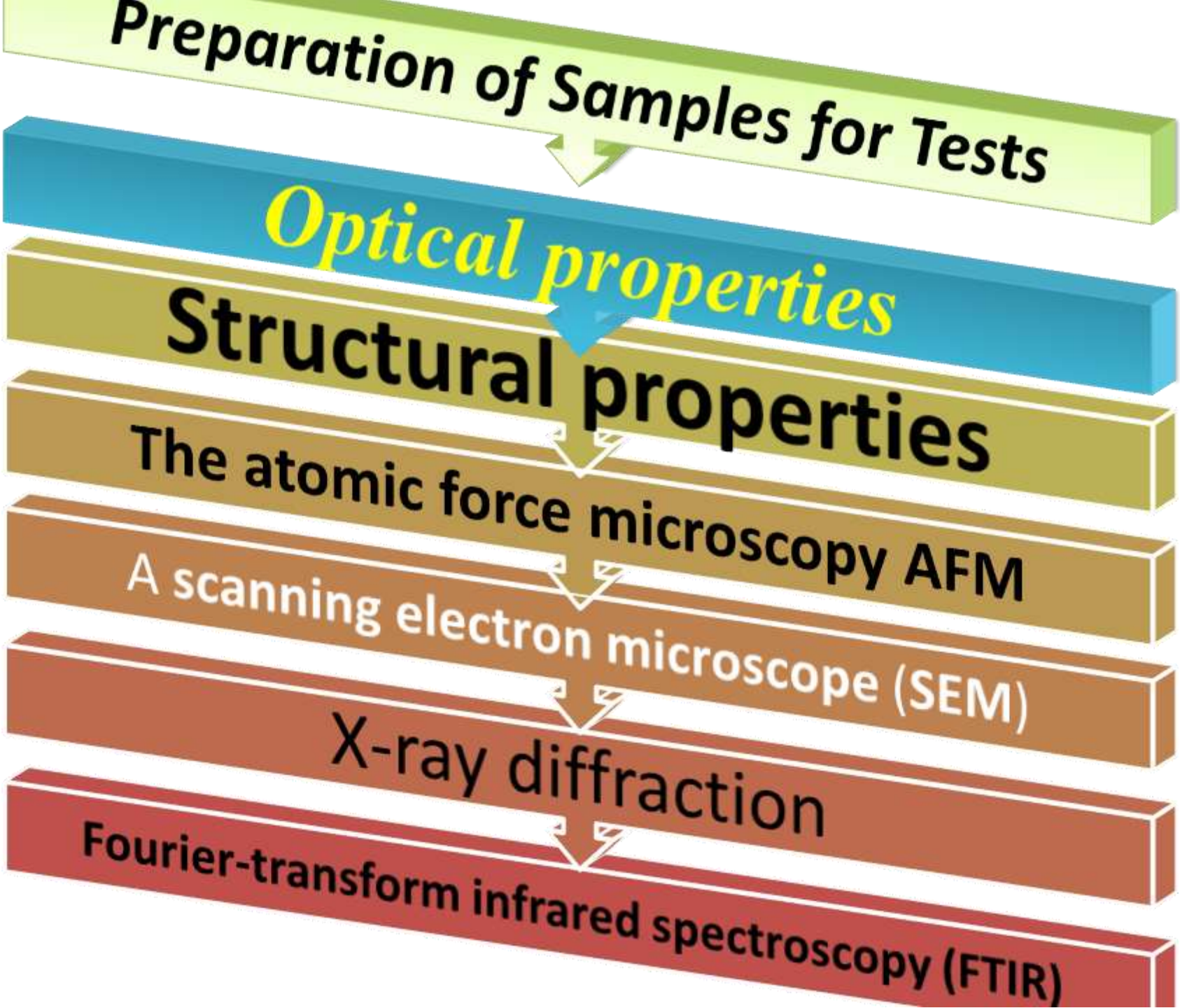
Fig. Liquid hydrogen tank for a hydrogen car


Hydrolysis
O_2
H_2
H_2O
H_2O
Hydrogen fuel cells
Hydrogen Storage

Nanostructured Materials

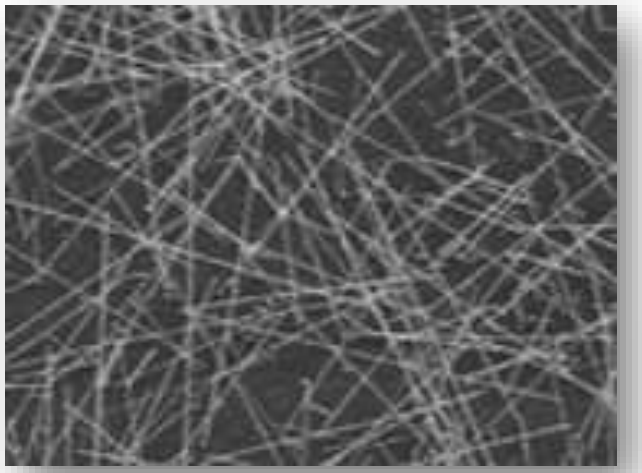
Nano materials are nano chemicals that are used with high quality in many applications. They contain many physical and chemical properties

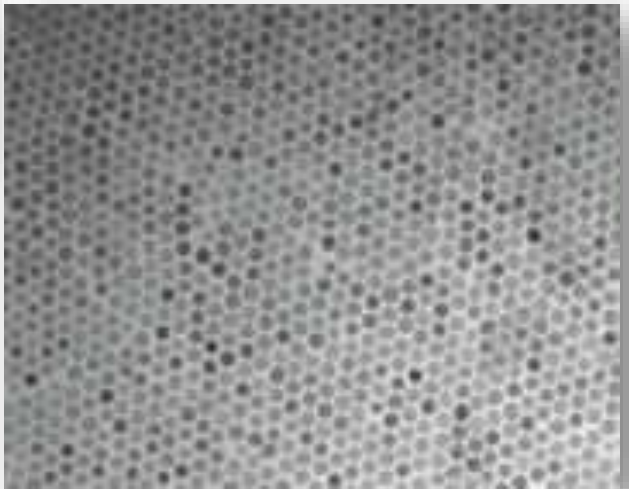
- **Preparation Methods of Nano material**
- **1- :physical methods**
- **2- chemical methods**
- **3- mechanical methods**
- **4- Electrochemical method**
- **5- Laser ablation method**
- **6- sputterings**

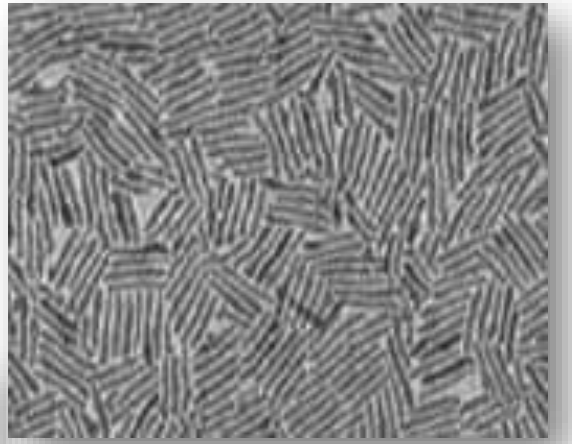

Preparation of Samples for Tests
Optical properties
Structural properties
The atomic force microscopy AFM
A scanning electron microscope (SEM)
X-ray diffraction
Fourier-transform infrared spectroscopy (FTIR)

Nanostructured Materials

- **Foundry processes / fabrication techniques enabling mass production of nanoparticles**
- **Broad range of functionality**

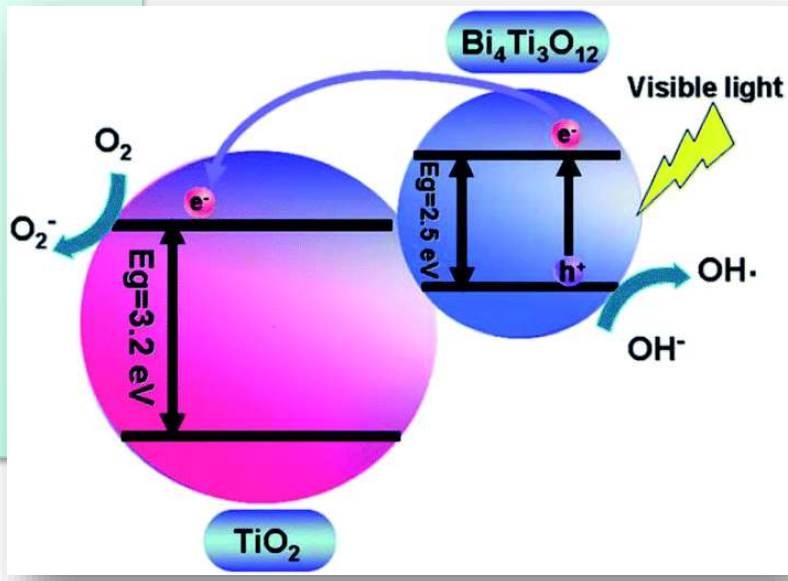






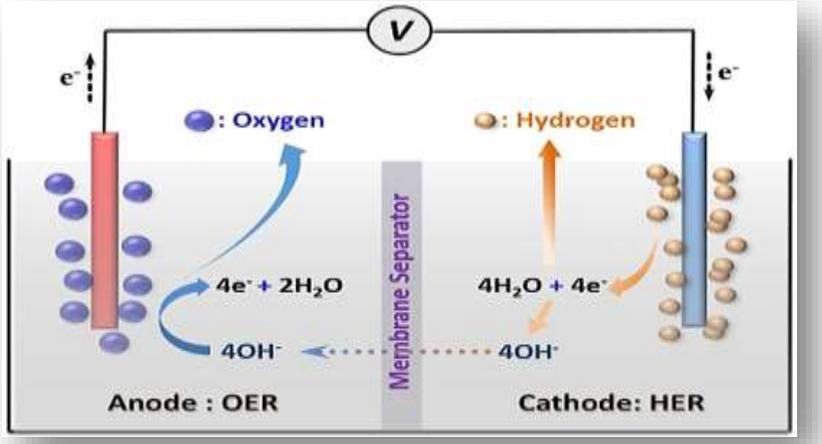
CATALYST CHARACTERIZATION

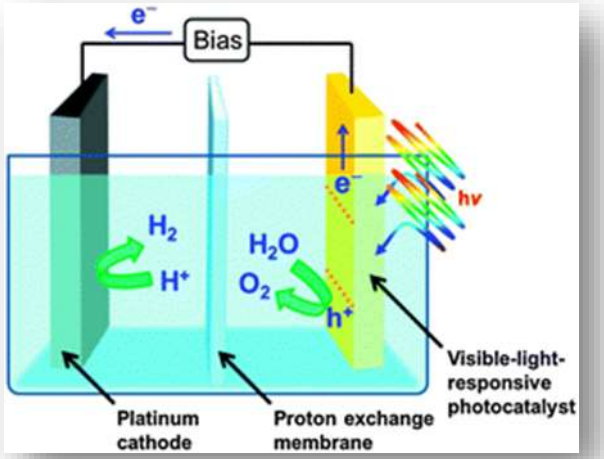
- Bulk Physical Properties
- Bulk Chemical Properties
- Surface Chemical Properties
- Surface Physical Properties
- Catalytic Performance

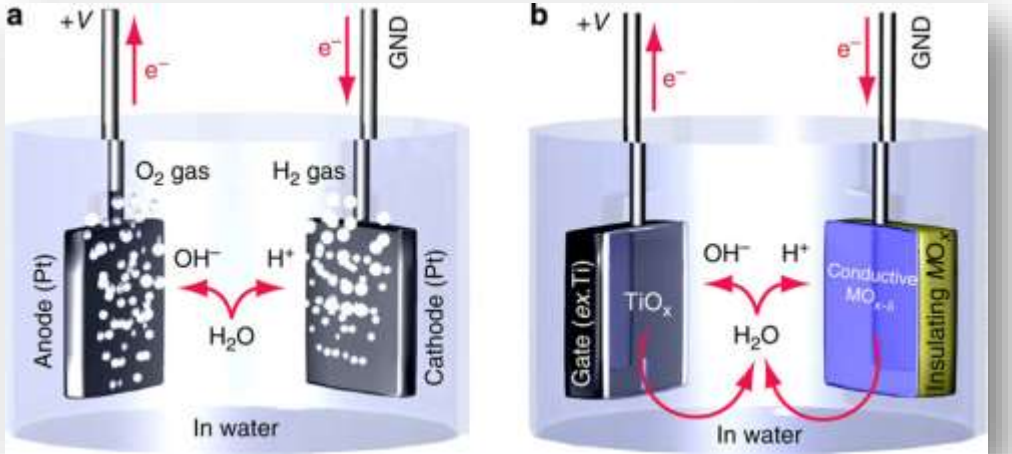


The Application of Nanotechnology

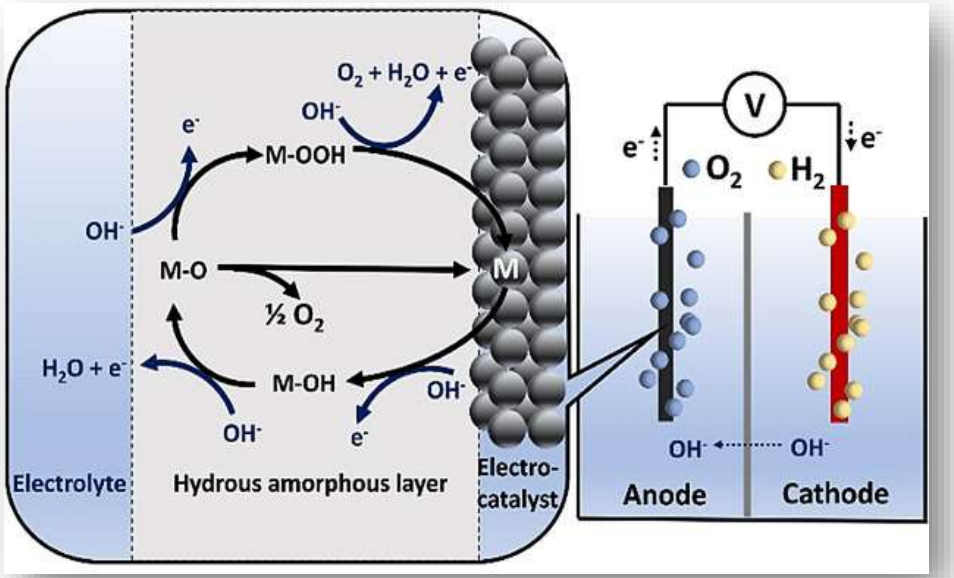
- 1-Electrolytic Processes



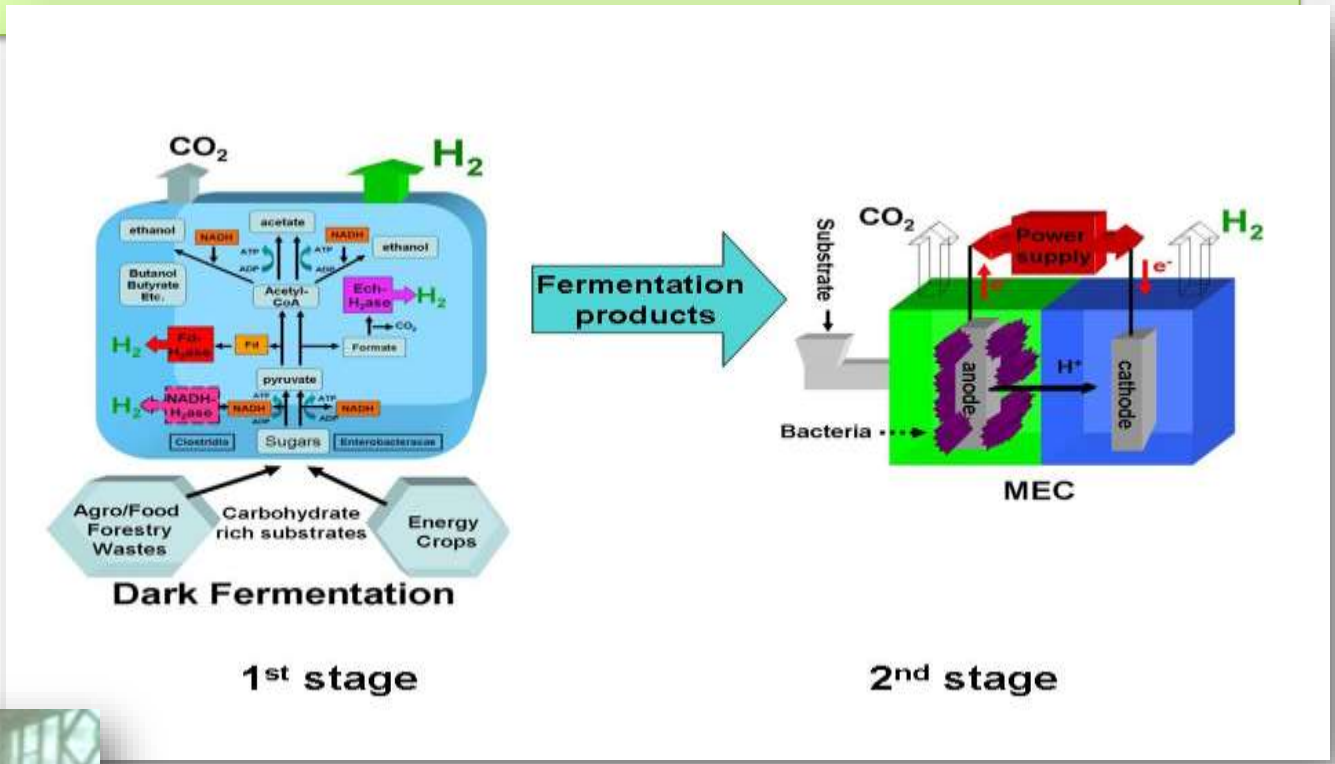




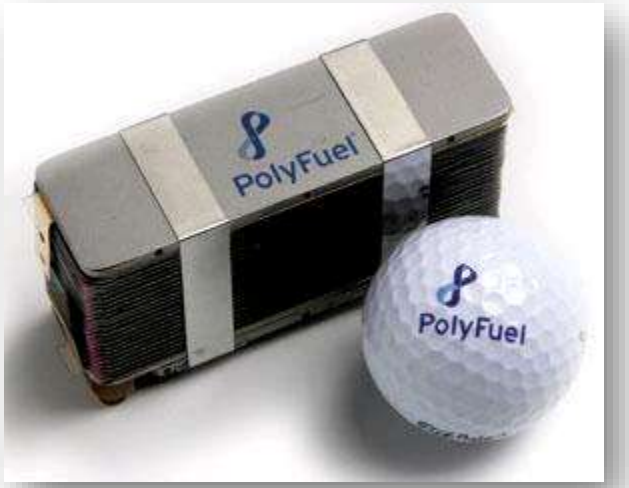
Principles of Water Electrolysis and Recent Progress in Cobalt-, Nickel-, and Iron-Based Oxides for the Oxygen Evolution Reaction



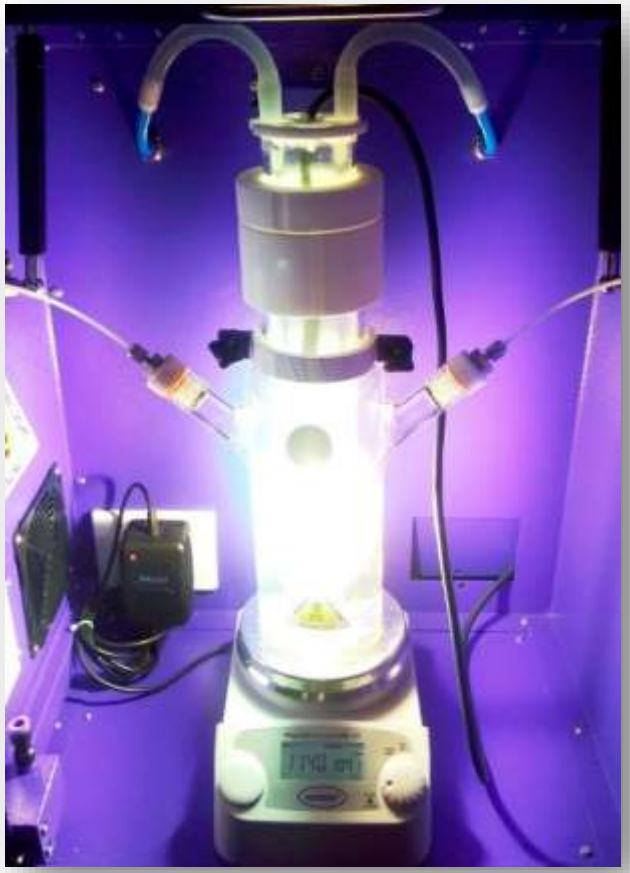
Microbial electrolysis cell (MEC)

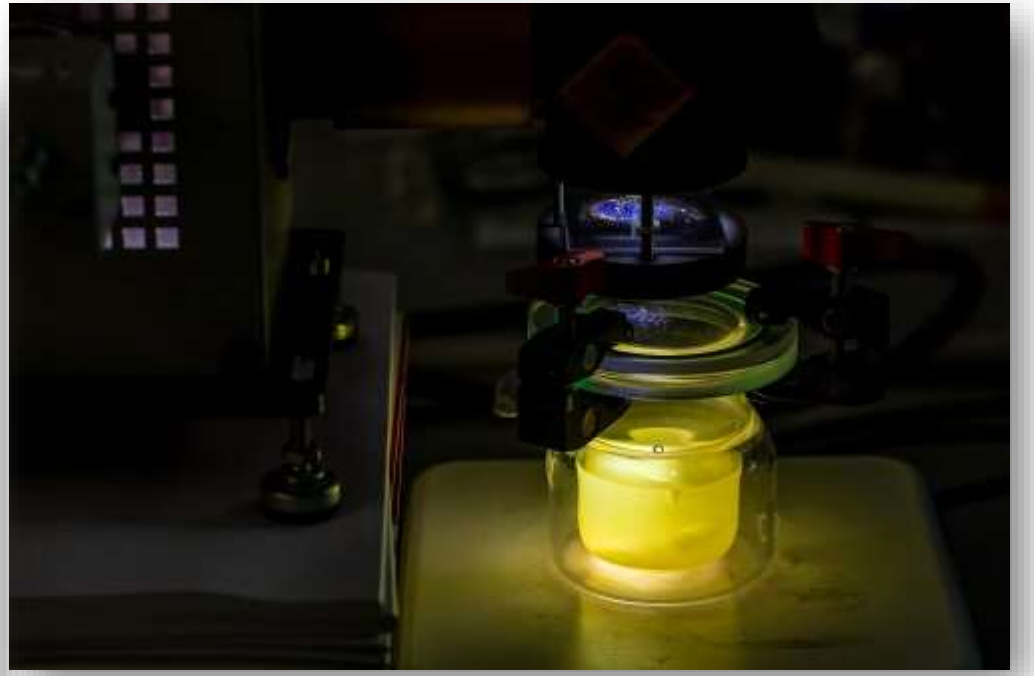


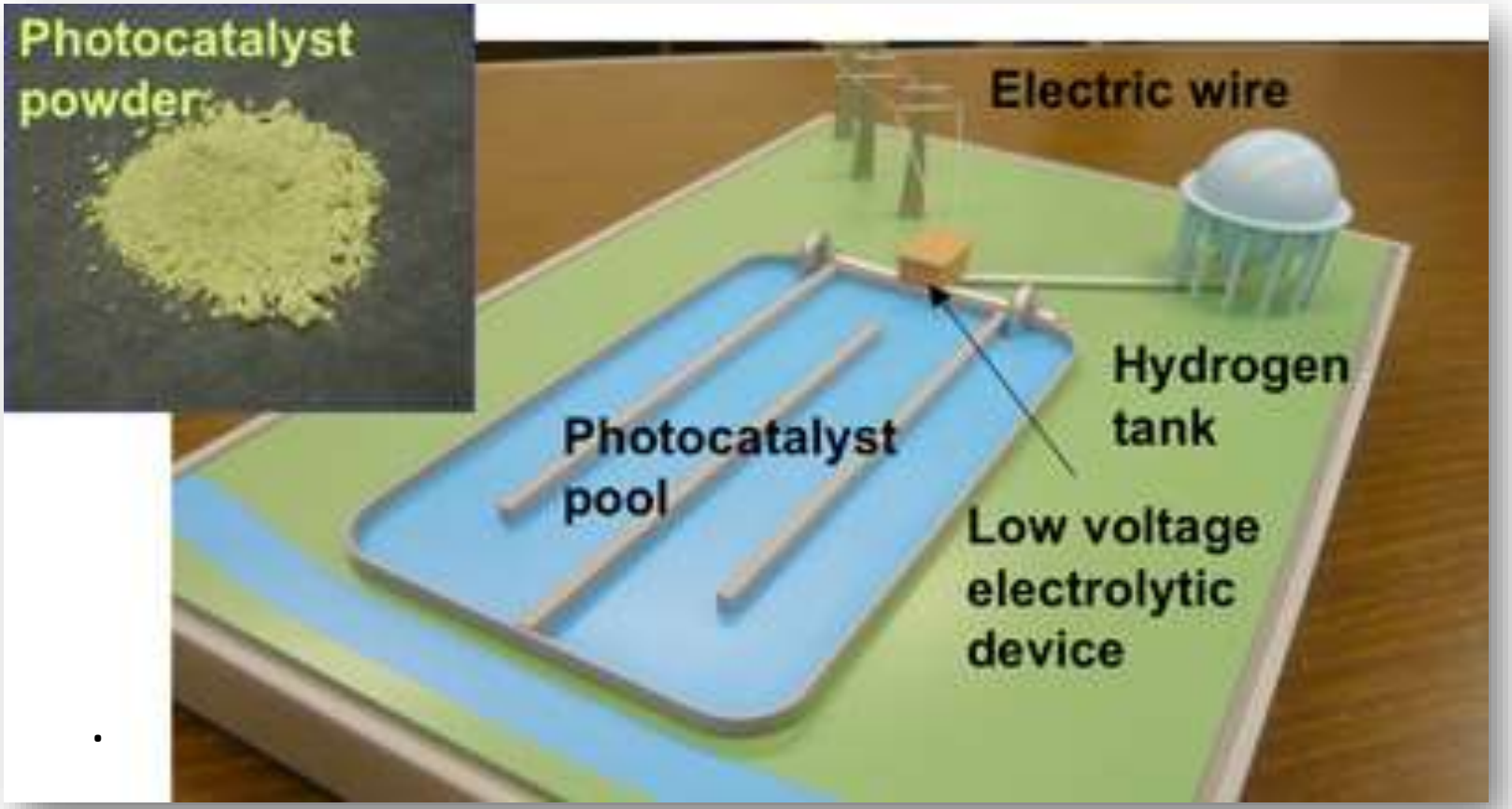

mobion

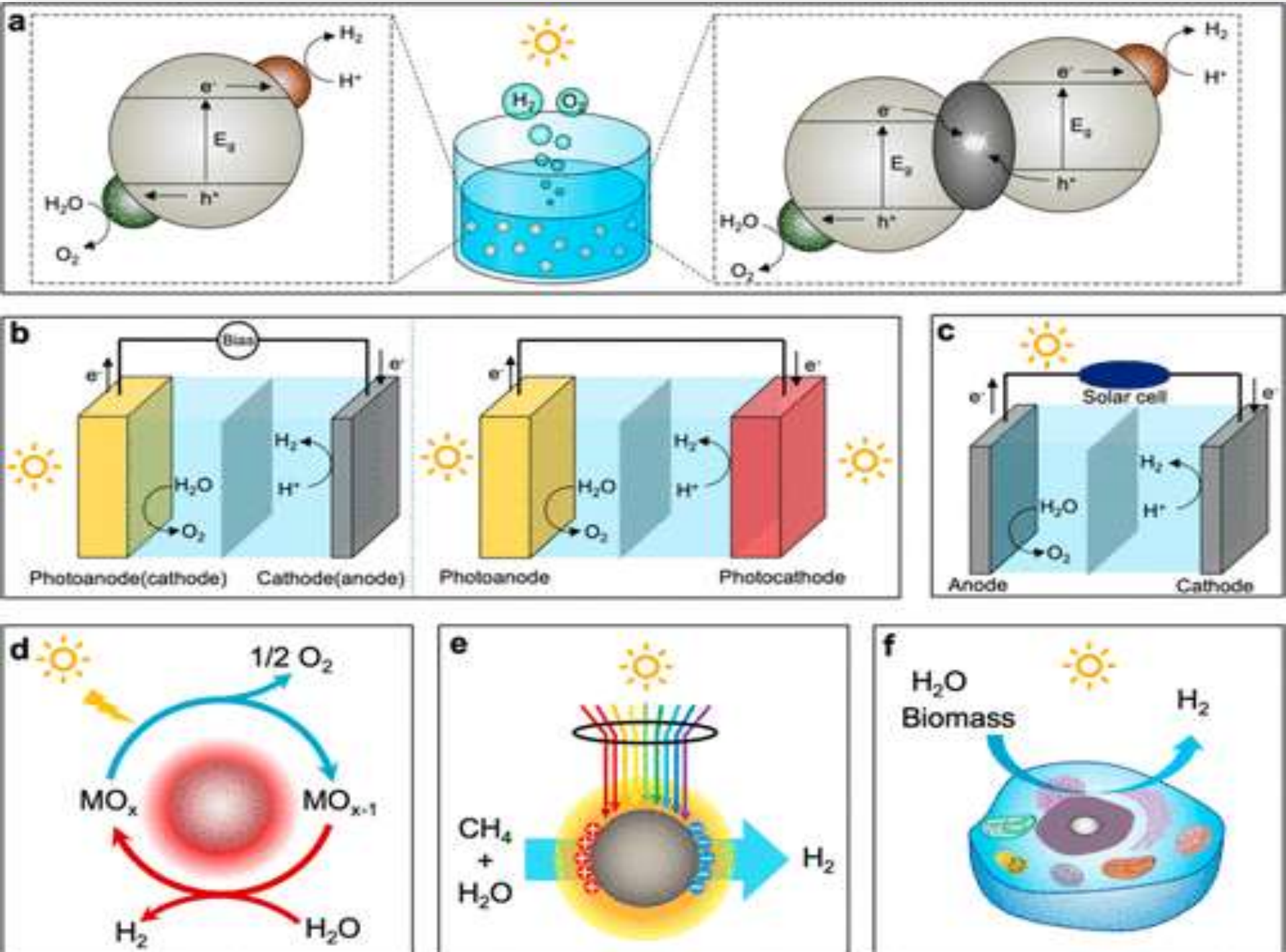

PolyFuel
PolyFuel

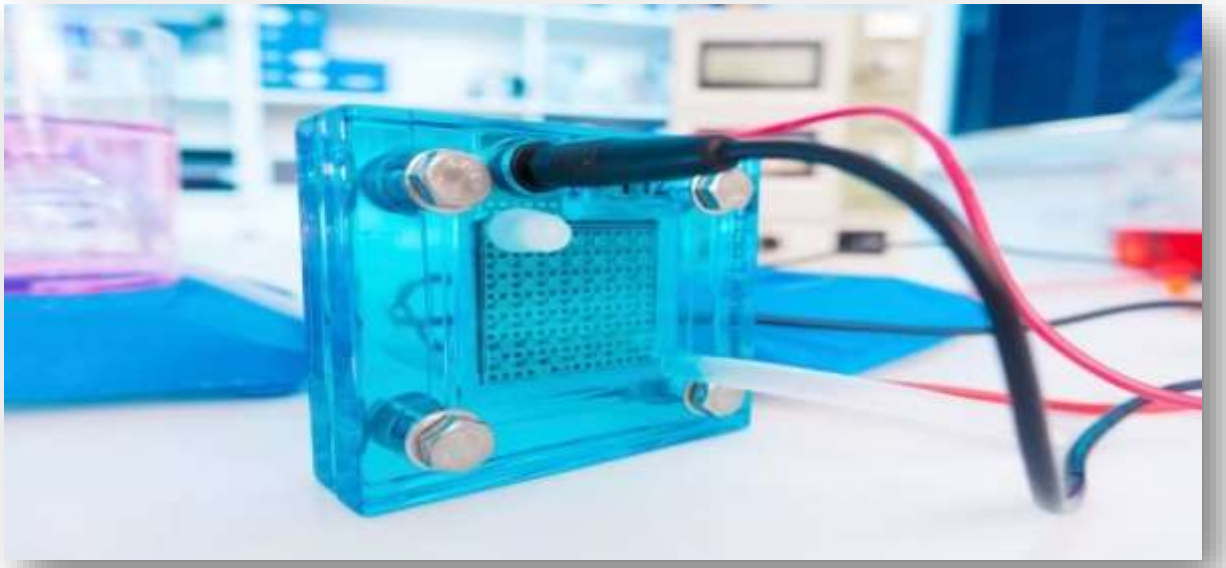
Nano Photocatalysis

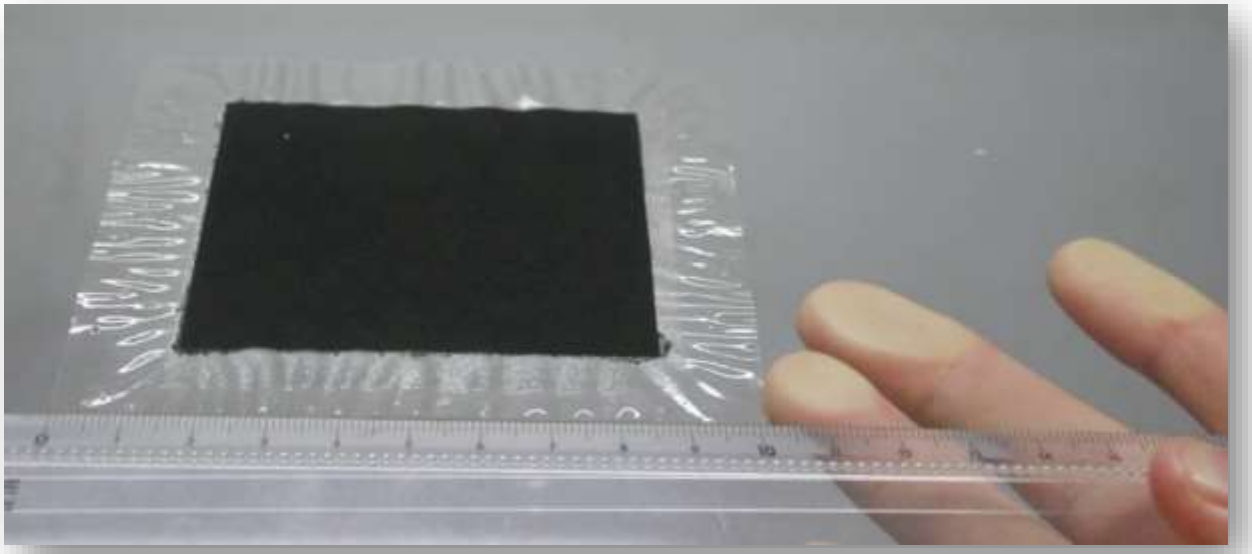


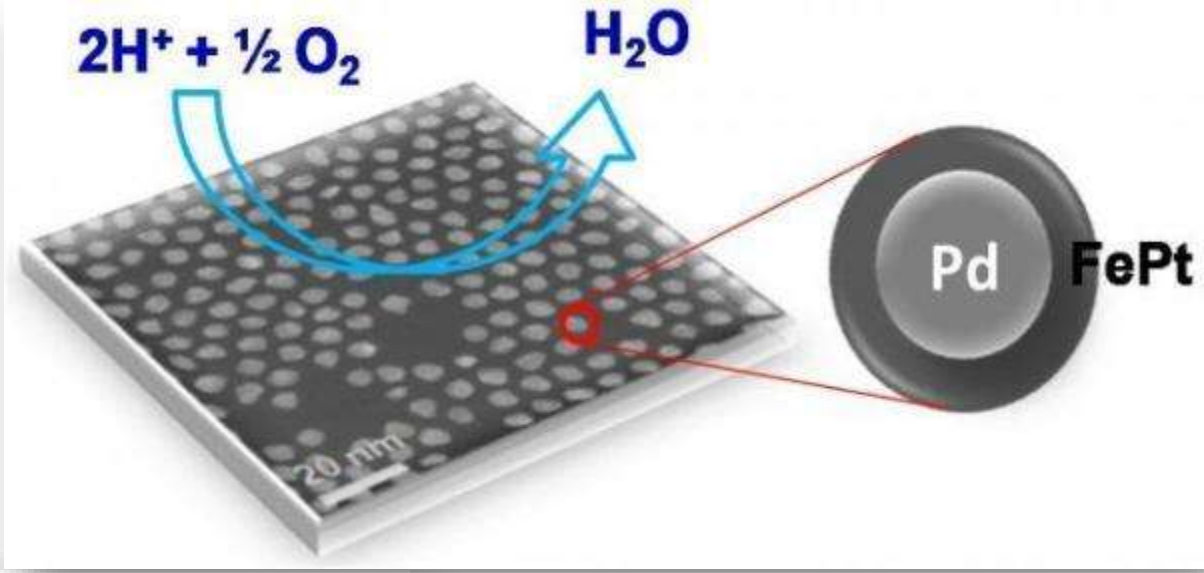


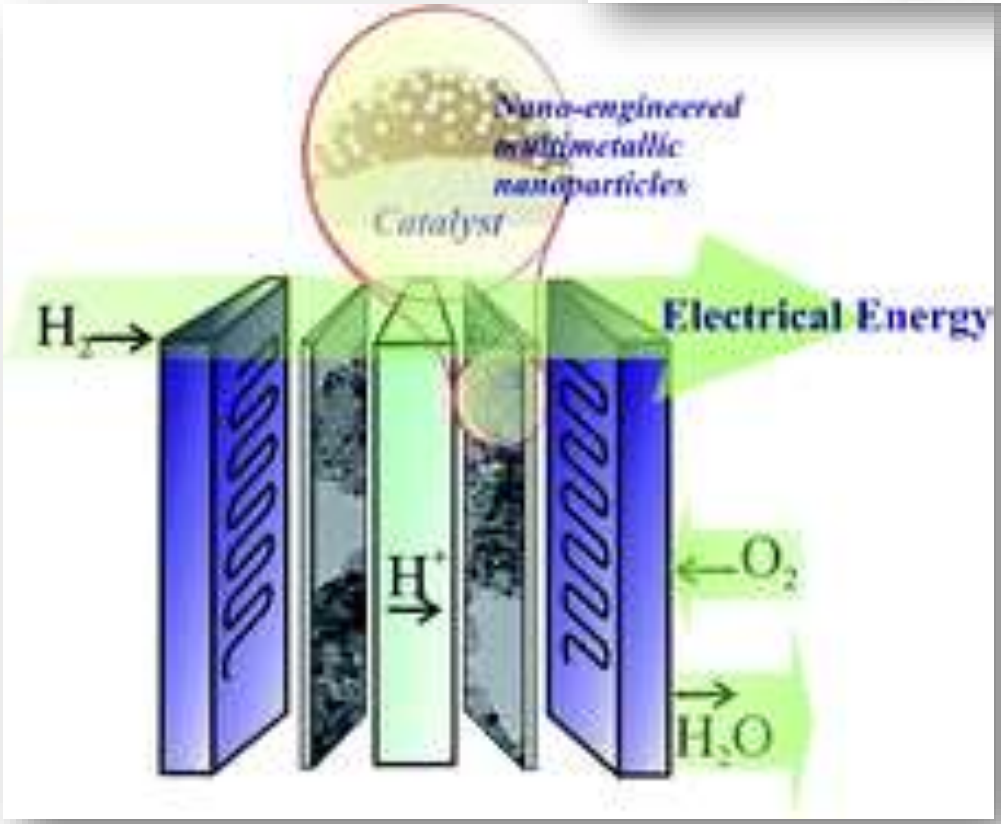

Photocatalyst powder
Electric wire
Hydrogen tank
Photocatalyst pool
Low voltage electrolytic device

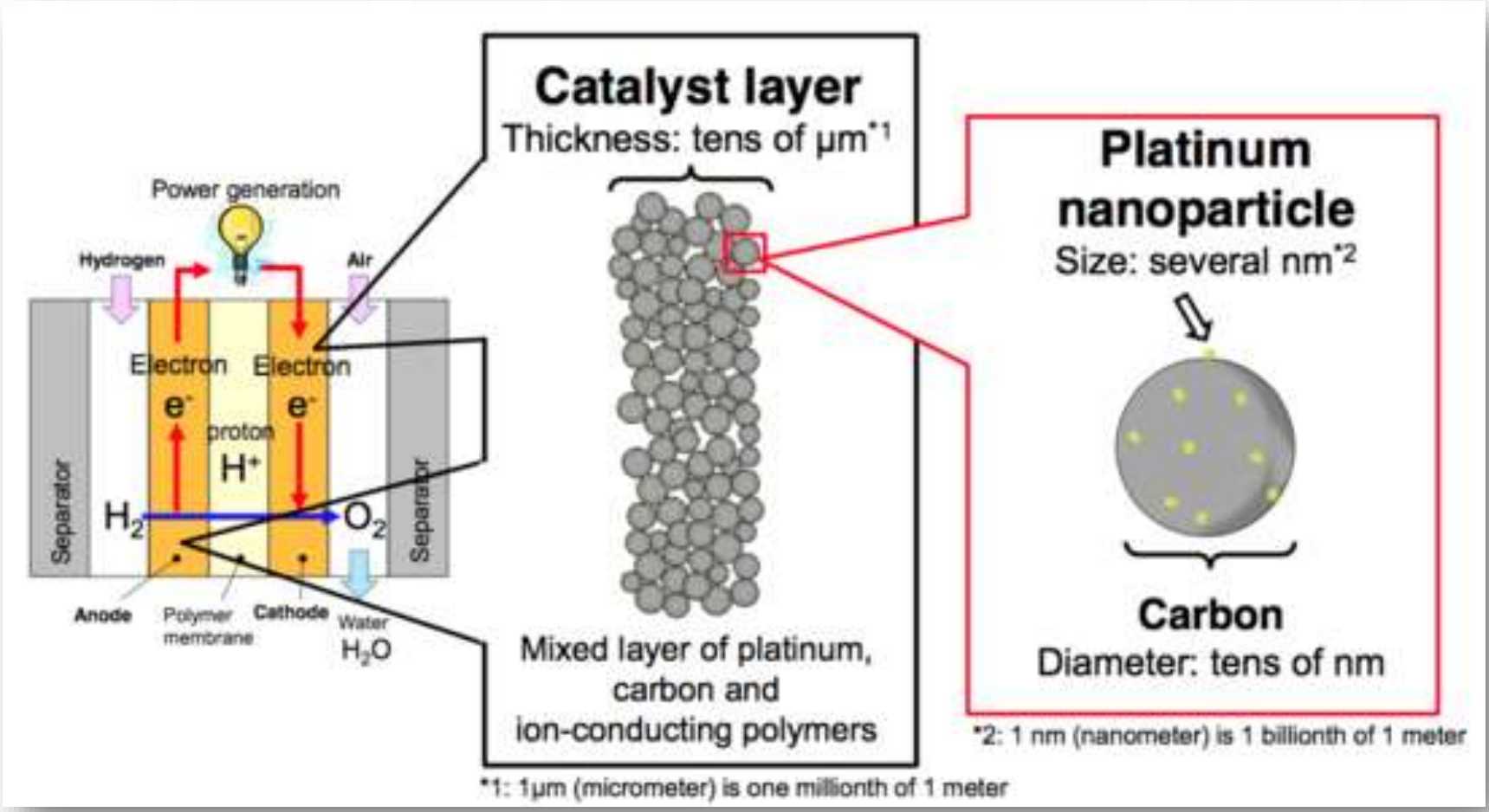

a
H2
H+
e-
Eg
h+
H2O
O2
b
Bias
e-
H2
H+
H2O
O2
Photoanode(cathode)
Cathode(anode)
Photoanode
Photocathode
c
Solar cell
e-
H2
H+
H2O
O2
Anode
Cathode
d
1/2 O2
MOx
MOx-1
H2
H2O
e
CH4
+
H2O
H2
f
H2O
Biomass
H2



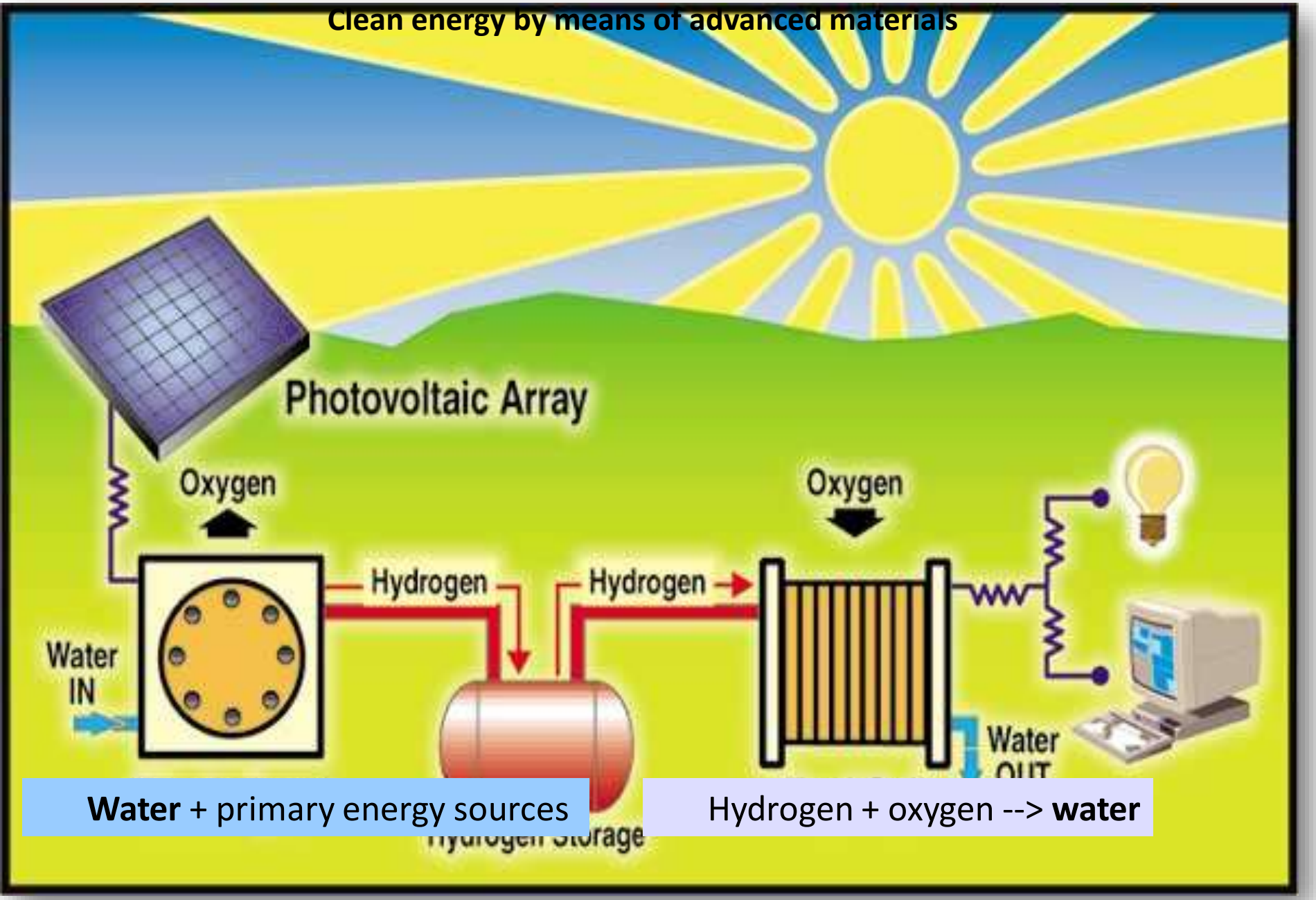



2H+ + ½ O2
H2O
Pd
FePt
20 nm


Nano-engineered
multimetallic
nanoparticles
Catalyst
H2
Electrical Energy
H+
O2
H2O

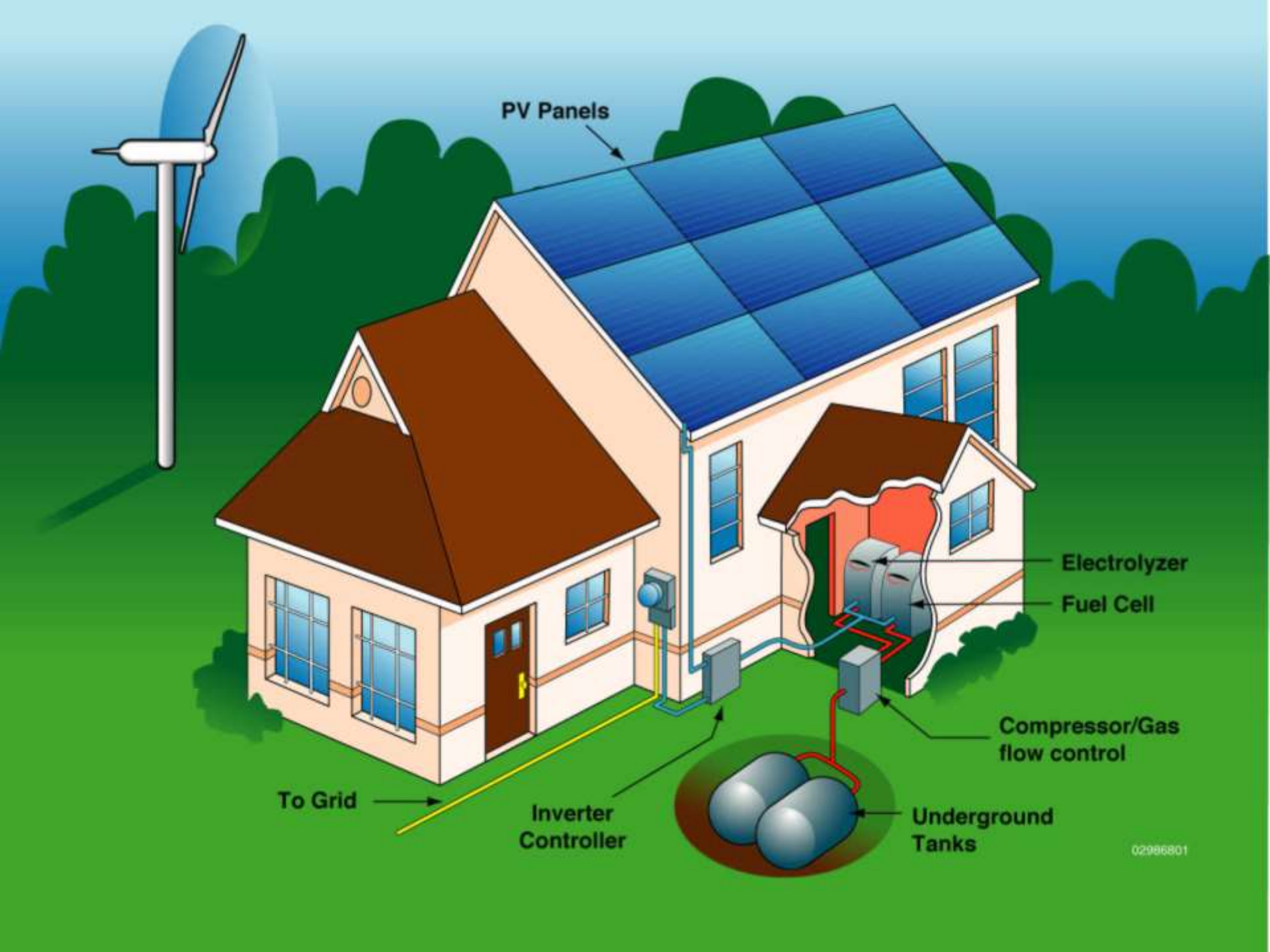

Power generation
Hydrogen
Air
Electron
Electron
e⁻
e⁻
proton
H⁺
Separator
Separator
H2
O2
Anode
Polymer membrane
Cathode
Water
H2O
Catalyst layer
Thickness: tens of μm*1
Mixed layer of platinum, carbon and ion-conducting polymers
Platinum nanoparticle
Size: several nm*2
Carbon
Diameter: tens of nm
*1: 1μm (micrometer) is one millionth of 1 meter
*2: 1 nm (nanometer) is 1 billionth of 1 meter

Clean energy by means of advanced materials



Water + primary energy sources

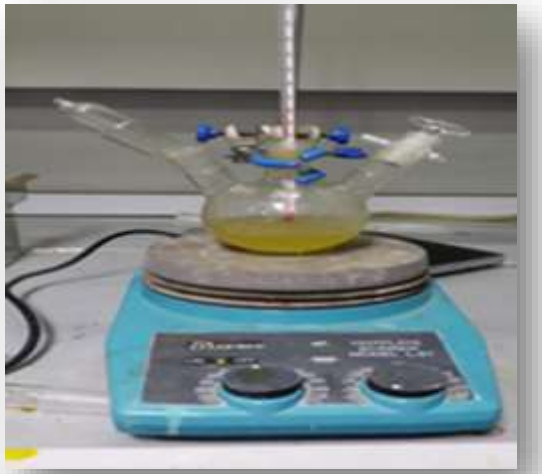
Hydrogen + oxygen --> **water**

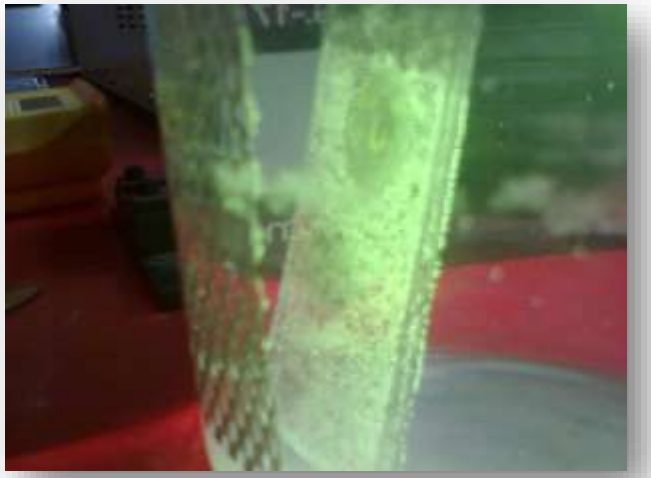

PV Panels
Electrolyzer
Fuel Cell
Compressor/Gas flow control
To Grid
Inverter Controller
Underground Tanks
02986801

انجازات : شعبة الهيدروجين: دائرة الطاقات المتجددة : وزاره العلوم والتكنولوجيا

- تم انجاز عدد من براءات الاختراع في هذا المجال
- تم نشر العديد من البحوث في مجلات المستوعبات اسكوباس والدوليه
- الحصول علئ عدد من الدروع والشهادات التقديريه
- المشاركة في المؤتمرات والمعارض الدولية

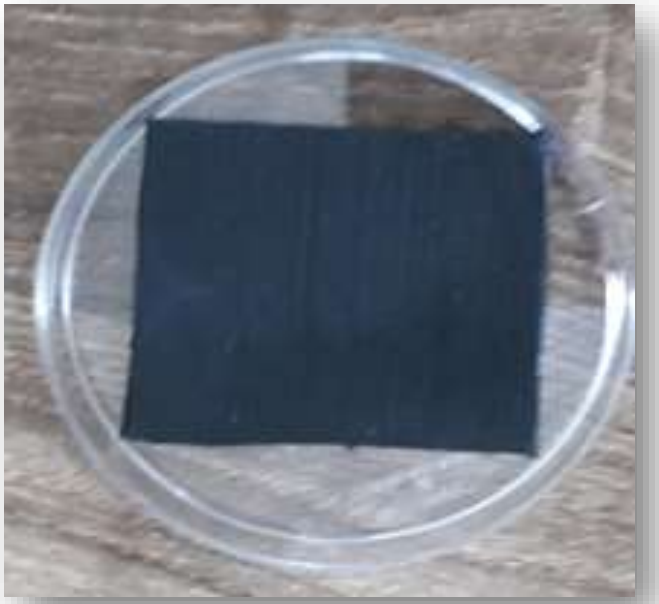
قسم من المشاريع المنجزة

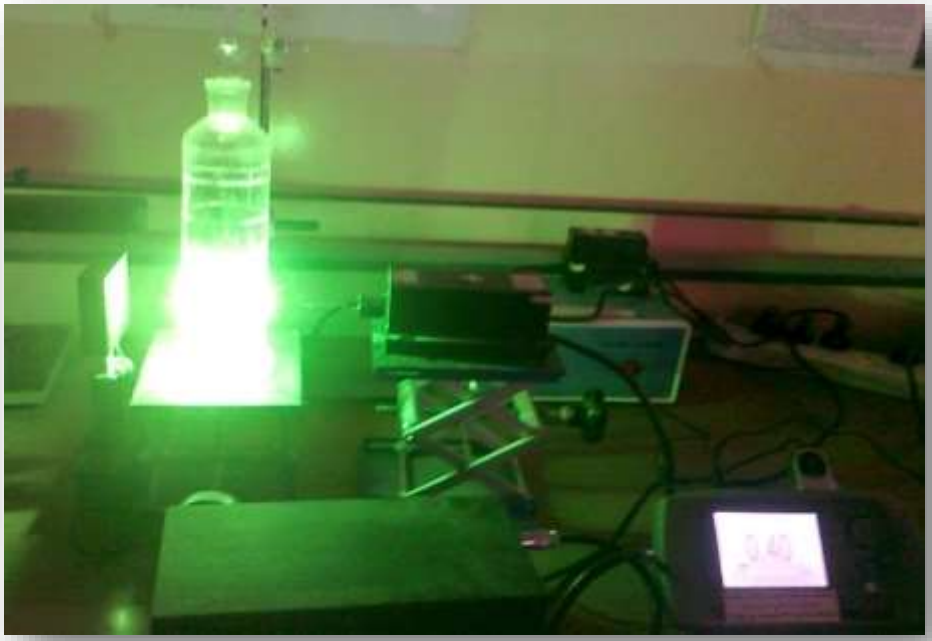


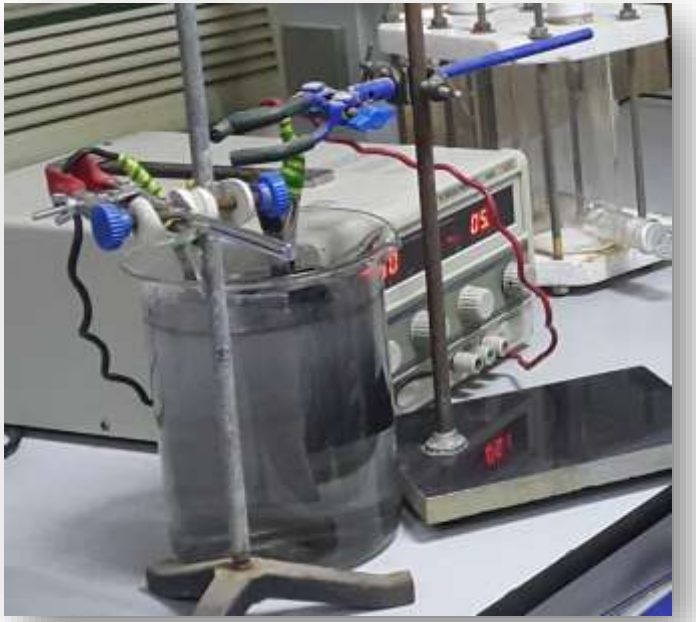


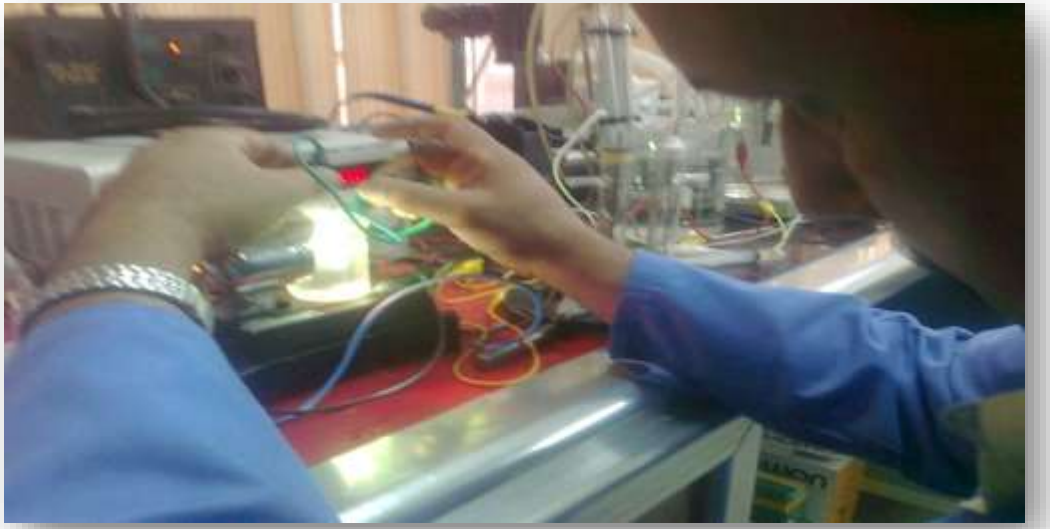

0.15

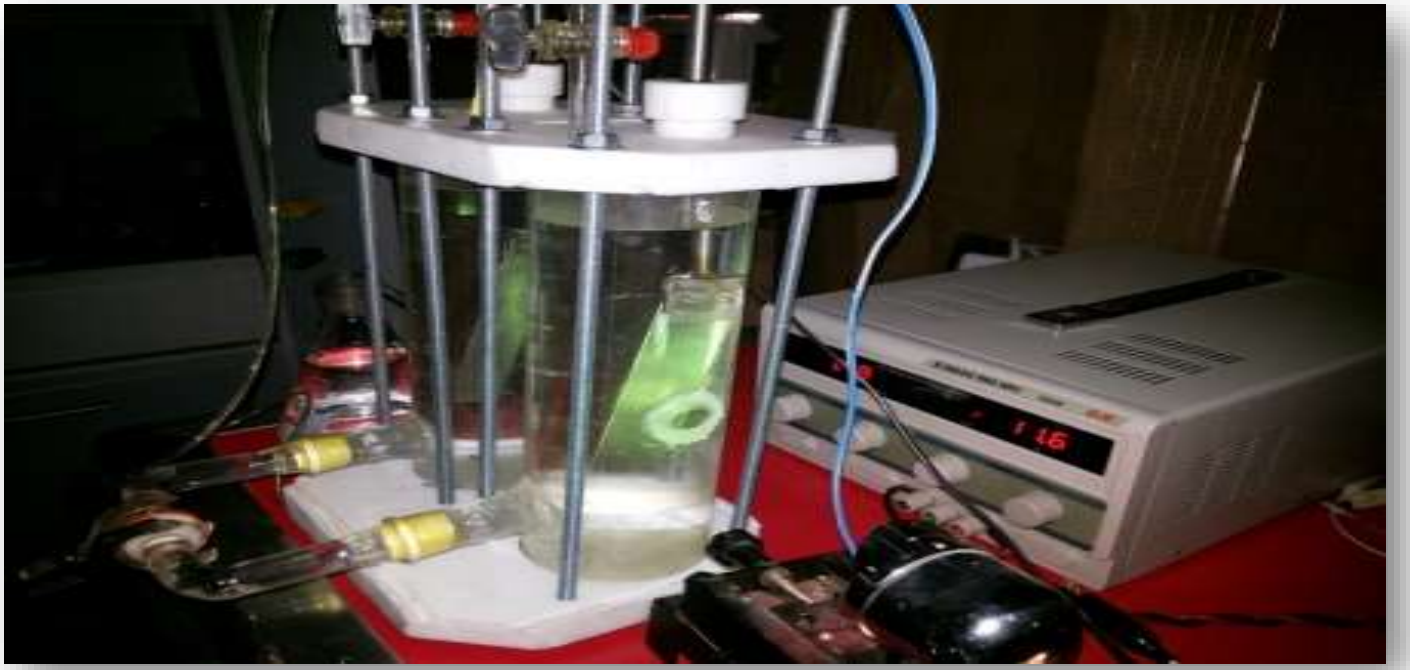

0.97

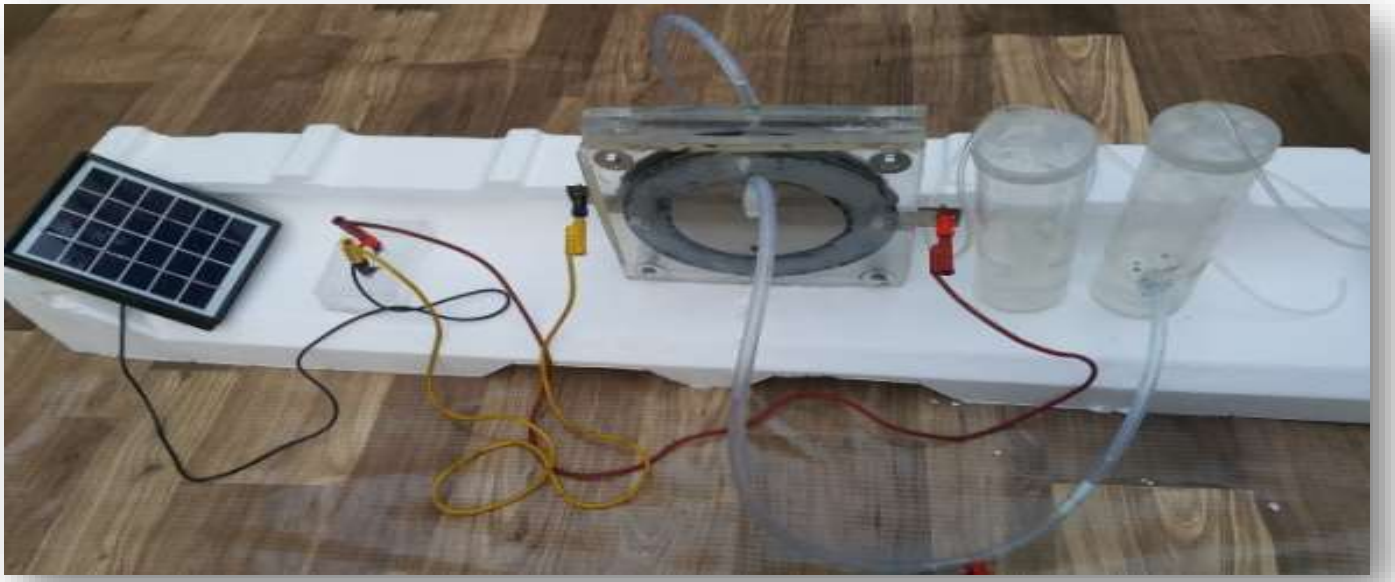


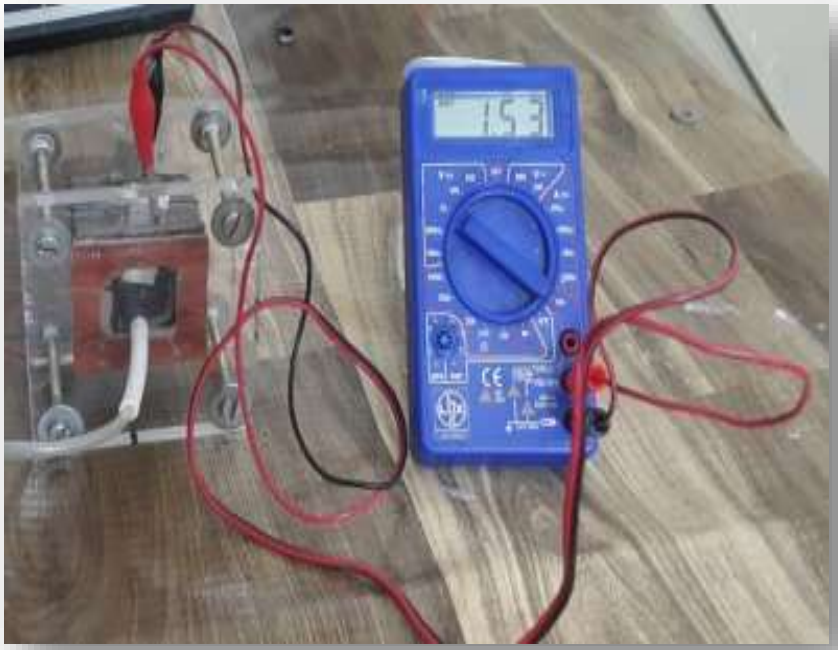


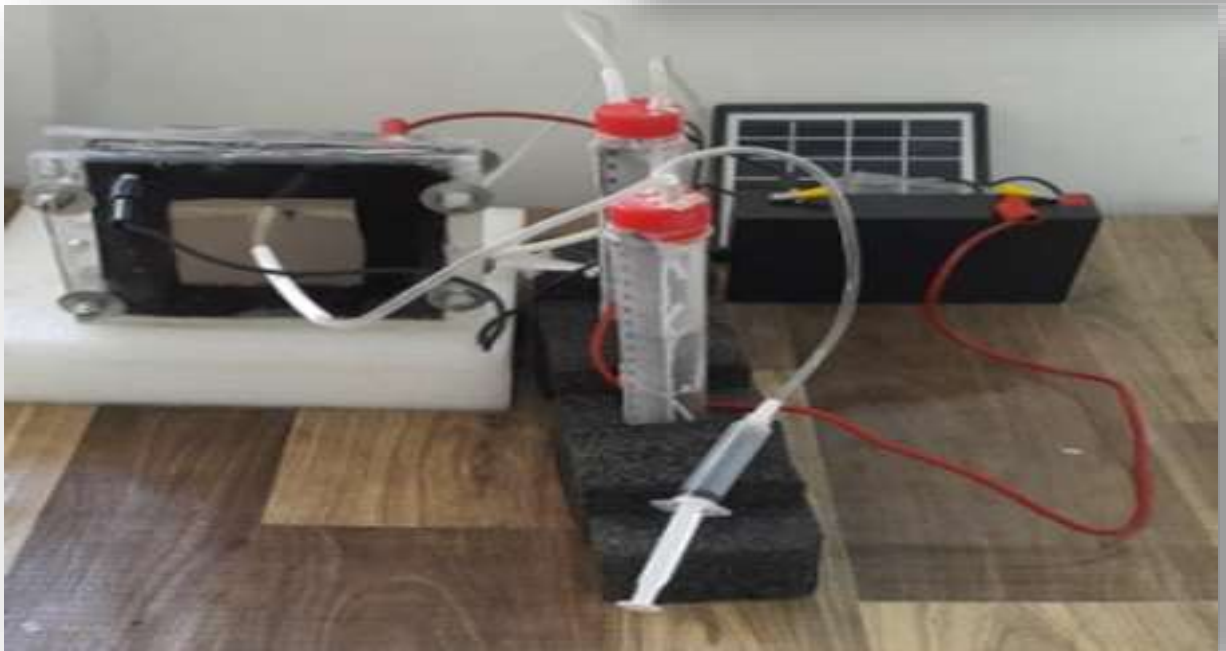












شكرا لحسن الاصغاء