Nanotechnology Course/ Ph-457 Lecture 7

Chapter 4:
Application of Nanomaterials

By

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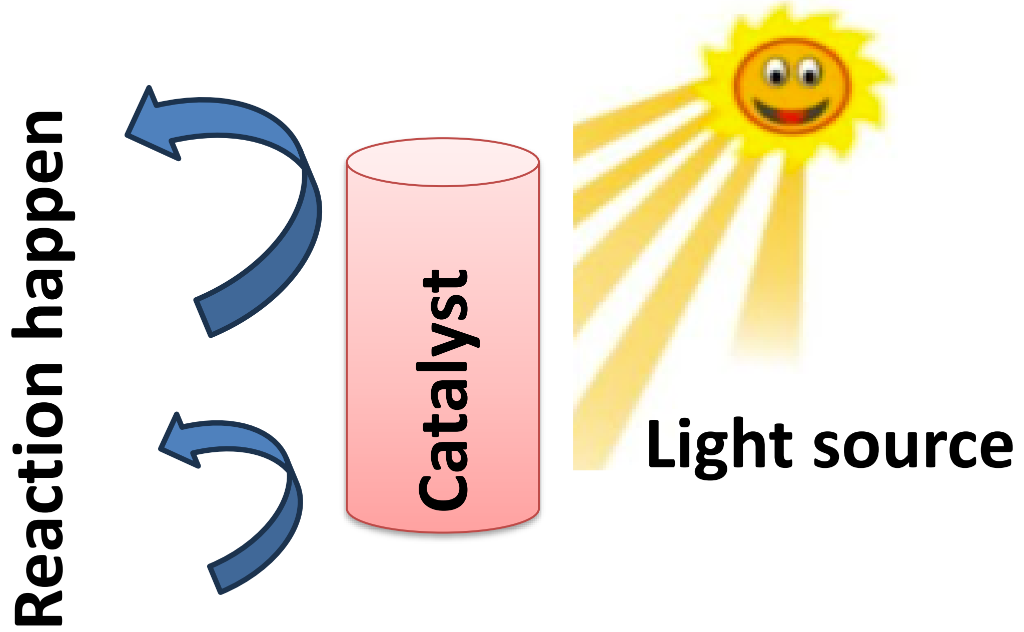
Application of Nanomaterials

- **Photocatalysis**

Photo ⟹ Energy in the form of light (UV or Visible)

Catalysis ⟹ Makes reaction faster (nanomaterials (catalyst))

- **Principle of photocatalysis**



Photocatalyst type

✓ Powder
✓ Thin films

Application of Nanomaterials

- **What is Photocatalysis?**

Photocatalysis is defined as the initiation of a chemical reaction under the action of light radiation in the presence of a substance.

- **Type of photocatalysis**

➢ Homogeneous photocatalysis

➢ Heterogeneous photocatalysis

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- Why photocatalyst?

✓ Photocatalysts are relatively cheap (Photocatalysts are made from inexpensive raw materials)

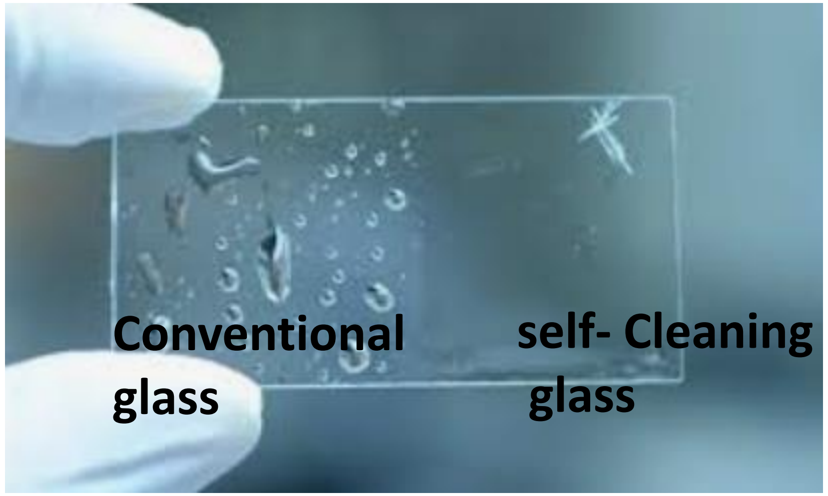
✓ Photocatalysts are saving (a UV or visible lamp can initiate the photocatalysis process)

✓ Photocatalysts are environmentally friendly (photocatalysts convert hazardous contaminants into harmless substance CO_2 and H_2O)

Application of Nanomaterials

- **Photocatalyst application**

- ❑ self- Cleaning Glass
- ❑ Pollutant treatment such as wastewater
- ❑ Photocatalytic water splitting (Hydrogen Production)
- ❑ Solar water disinfection
- ❑ crude oil decomposition



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- **Pollutant treatment (degradation pollution)**

➢ Pollution is defined as added substances harmful to the environment, such as organic and inorganic pollution or bacteria in water or air.

➢ Photocatalysts can be placed in contact with the reactants (pollutants)

➢ Organic pollution, such as dyes (Methylene Blue (MB), Methylene Orange (MO), Congo red, …)

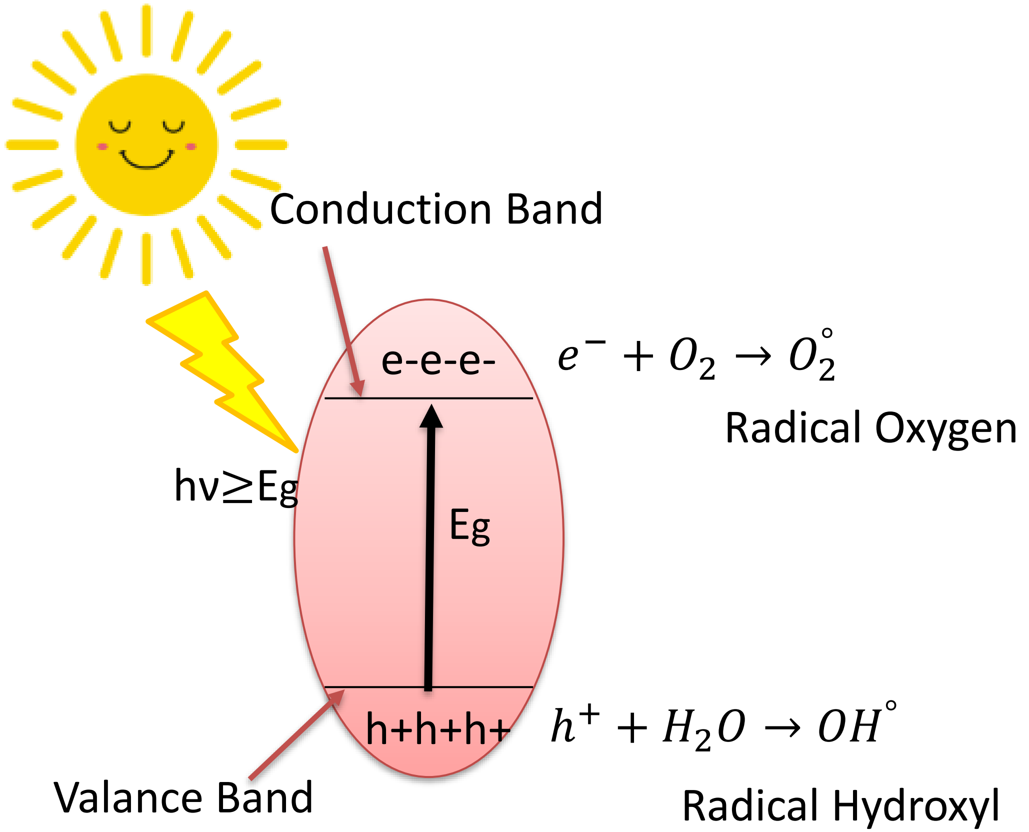
➢ Inorganic pollution, such as heavy metals (Arsenic, cadmium, chromium, copper, nickel, lead, and mercury)

➢ Photocatalysts such as semiconductors (such as ZnO) or modified semiconductors (such as Ag/ZnO, SnS/ZnO)

Application of Nanomaterials

- How does the mechanism of photocatalyst for treatment pollutants work?

- In general, when light is incident on the catalyst, the charge carriers in the Valence Band become excited and separate, and the electrons move to the Conduction Band, leaving behind holes.
- Photocatalyst reaction make radical oxygen (O_2°) and radical hydroxyl (OH°) with very strong oxidation power will destroy all bacteria and other contaminants into CO_2 and H_2O



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- **Photocatalytic efficiency**

Photocatalytic efficiency (PE%) is the number of degraded molecules formed per one quantum of light absorbed by the photocatalytic system.

$$PE\ \%=\frac{A_o-A_t}{A_o}\times 100\%$$

or

$$PE\ \%=\frac{C_o-C_t}{C_o}\times 100\%$$

Where A_o is initial absorbance, A_t is absorbance After time t, C_o is the concentration of initial, and C_t concentration after time t.

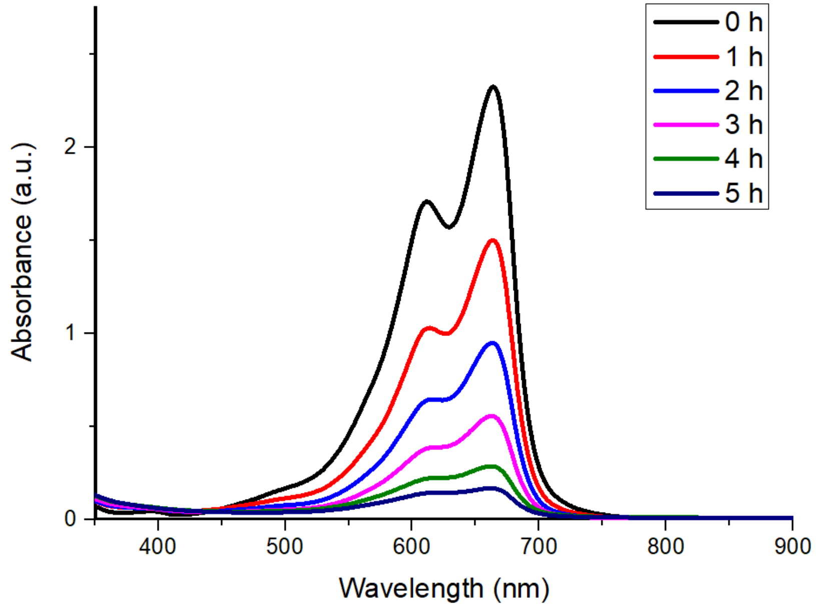

Figure: absorbance spectra of the photodegradation MB dye By using Au/SnS photocatalysts

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- **Ex:** Calculate photocatalytic efficiency (PE%) of the degradation Methylene Blue dye by using CdS NPs as catalysts when initial absorbance is 2.325 a.u and decreased to 0.313 a.u after 240 min

- Sol: $PE\ \% = \frac{A_o - A_t}{A_o} \times 100\%$

$$PE\ \% = \frac{2.325 - 0.313}{2.325} \times 100\%$$

$$PE\ \% = 86.5\%$$

- H.W: Calculate photocatalytic efficiency (PE%) of the degradation of Methylene Blue dye by using ZnO NRs for all times as shown in the following data:

t (min)	0	30	60	90	120
A (a.u.)	2.325	1.69	0.67	0.5	0.214

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Parameters Affecting the Photocatalytic Efficiency of the pollution:

1) Surface Morphology (thickness of film, grain size, porosity, surface roughness)
2) Band gap of photocatalysts
3) Rate recombination of excited electrons and holes.
4) Calcination and annealing temperature and temperature of the pollutants.
5) Pollution pH
6) Photocatalyst loading
7) Light intensity and wavelength
8) Dye type or type of pollution

Figure: Gumball in wastewater plant

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- **Water splitting (Hydrogen Production)**

➢ Water splitting is a process that enables hydrogen production by direct water decomposition in its elements.

➢ Photocatalytic water splitting is a promising option for hydrogen production, which is oriented toward reducing CO_2 emissions and using renewable resources such as water and sunlight.

Parameters Affecting the Photocatalytic Water Splitting

1) Size and morphology of the nanostructure Electrolyte temperature
2) Electrolyte pH
3) Particle size and defect and high crystallinity
4) Band gap energy > 1.23 eV
5) Intensity light and type

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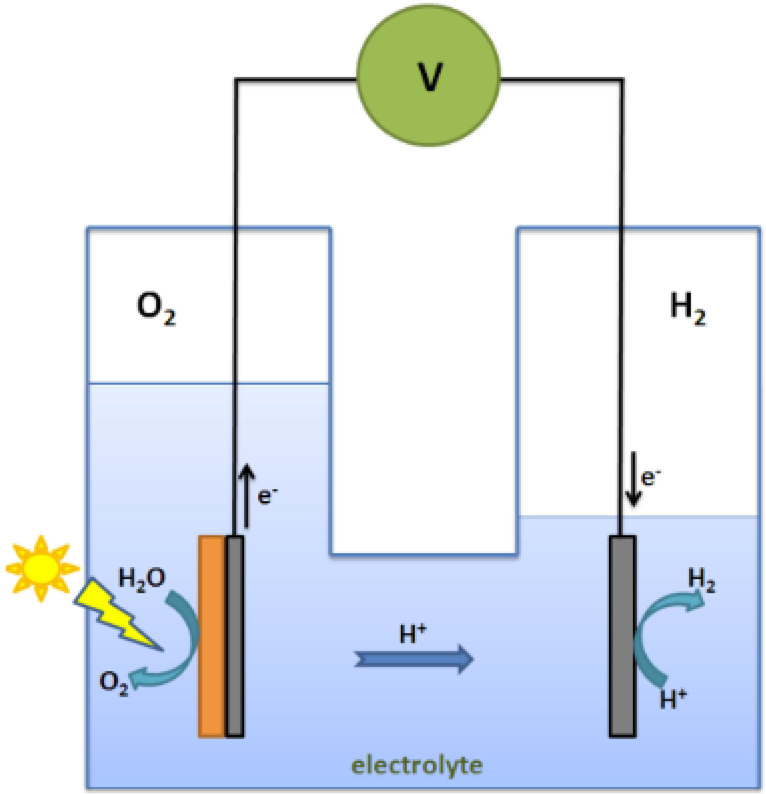
- **Mechanism of photocatalytic water splitting**
- generation of charge carrier (e-h) pairs upon light irradiation on the photo-anode.
- oxidation of water by photo-generated holes on the photo-anode surface to give O2 and H+
- transfer of photo-generated electrons through an external circuit to the cathode
- reduction of H+ by photo-generated electrons on the cathode surface to give H2



Catalysts 2012, 2(4), 490-516

THANK YOU