PHOTOCATALYTIC METHODS FOR CONTAMINANT DEGRADATION AND HYDROGEN PRODUCTION IN WASTE WATER USING SOLAR/UV RADIATION

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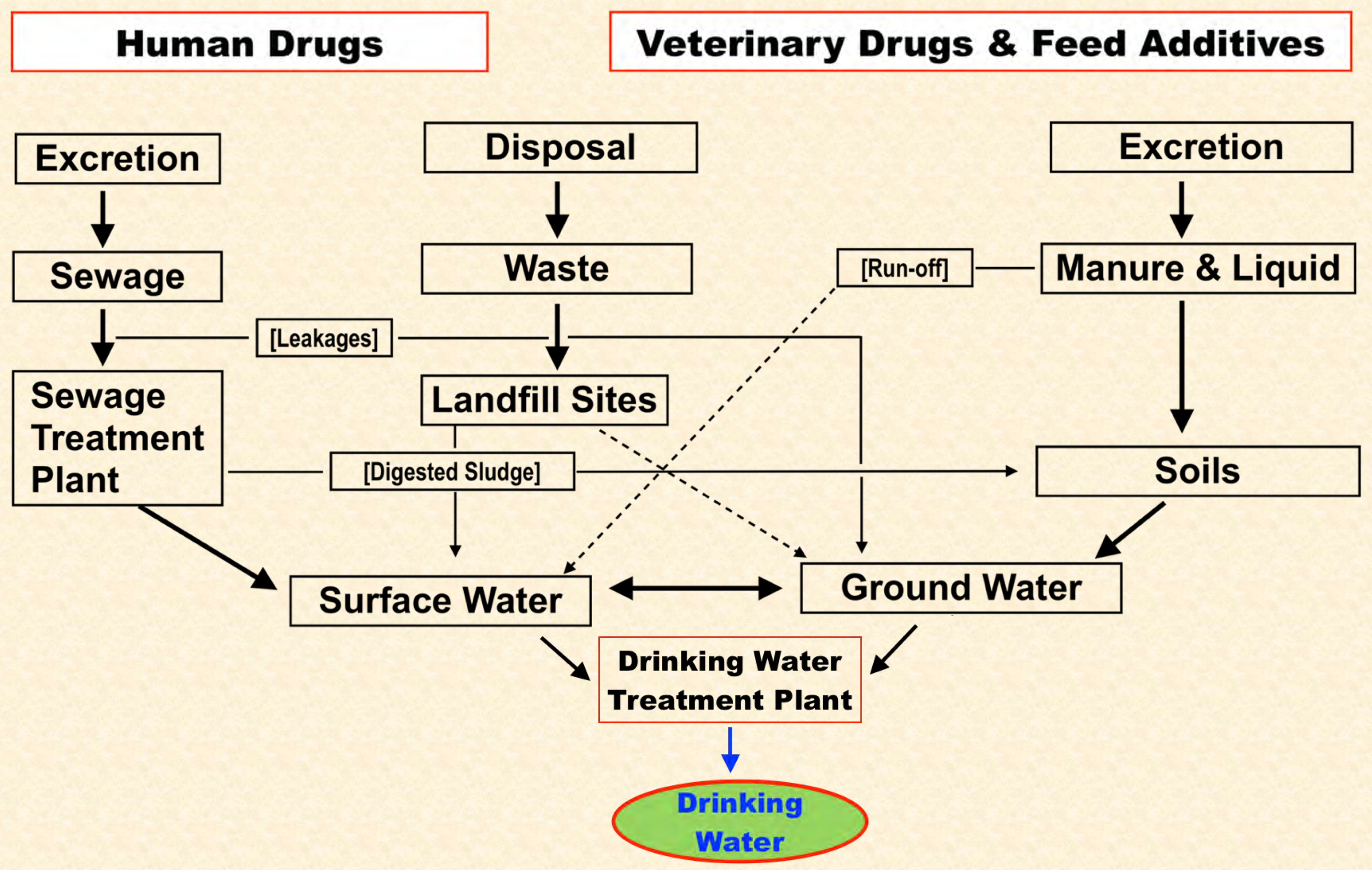
Motivation

An effective and efficient treatment of the wastewater in the large commercial scale is becoming a challenging issue of the present. This status is due partially to the low efficiency of most of the practiced technologies in removing contaminants produced by human and industrial wastes. Therefore, the demand for an effective and efficient water treatment technology is of dire need to society. For example, the existing technologies are found to be insufficient as far as the treatment of a rapidly growing number of newer contaminants of pharmaceuticals, dyes, leachates, and several other industrial chemicals. In addition, a renewable and inexpensive method of energy production along with the contaminant degradation will be much beneficial optimized technology.

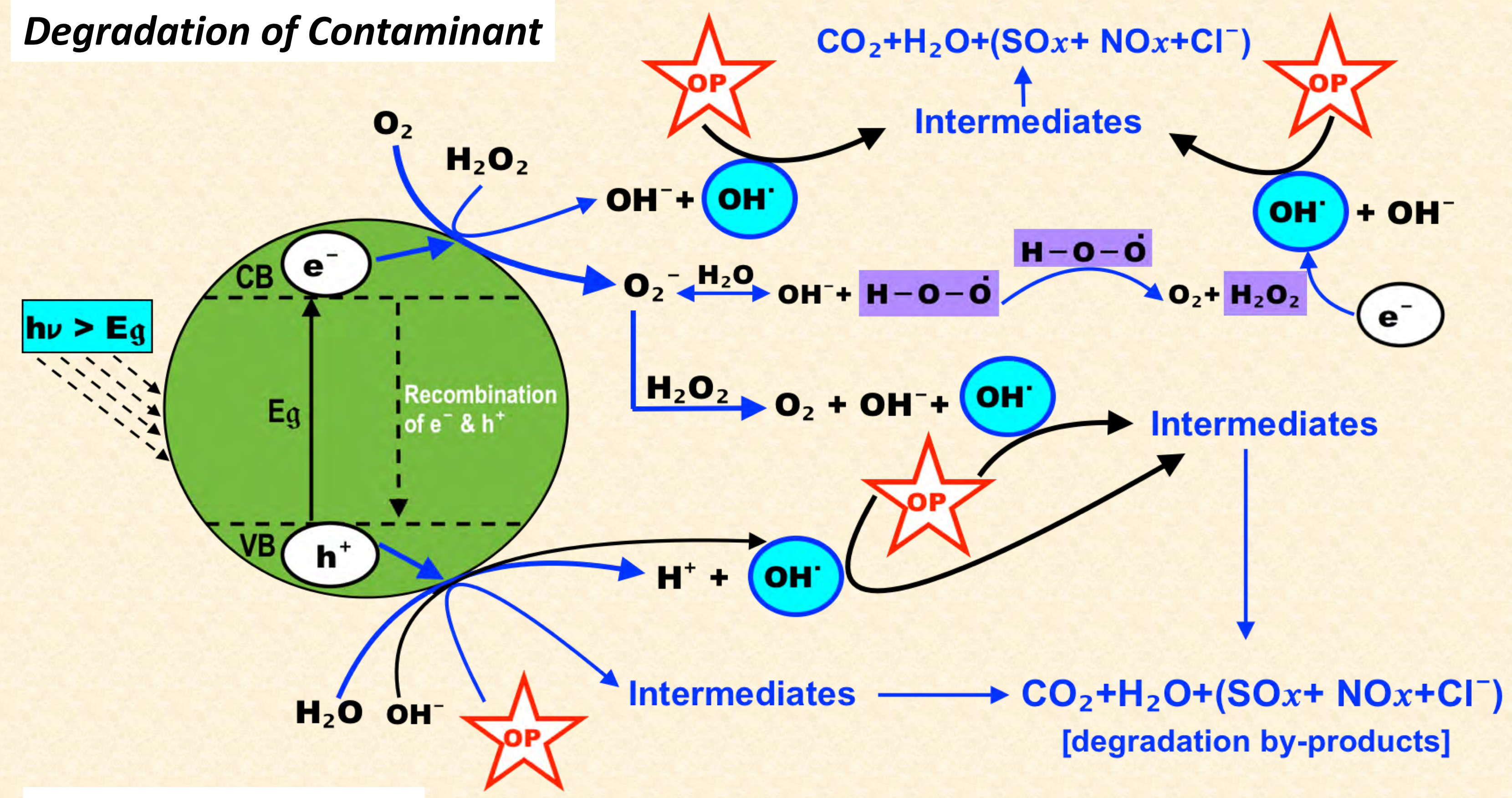


Project Objectives

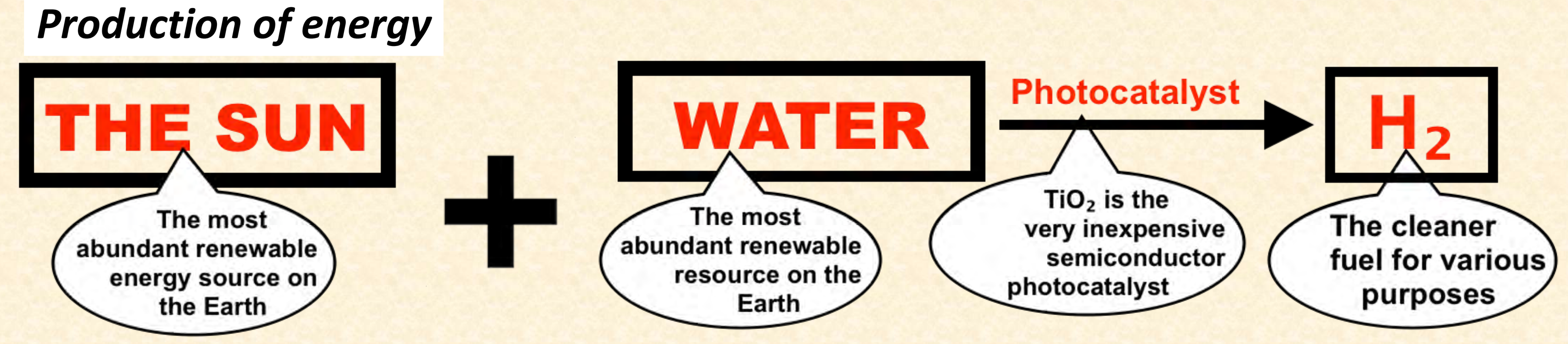
1	To develop a general technique to synthesize an effective and novel photocatalyst :	
1.1	Photocatalyst 1 for contaminant degradation purpose • Surface Characterization • Testing degradation rates under various experimental conditions	
1.2	Photocatalyst 2 for hydrogen production (renewable energy) • Surface Characterization • Testing H_2 production rates (by GC) under various experimental conditions	
1.3	Photocatalyst 3 for dual purpose • Surface Characterization • Testing degradation rates and H_2 production rates under various experimental conditions • Optimization between contaminant degradation versus H_2 production	
2	Proposing a general reaction mechanism and global kinetics for a model pharmaceuticals degradation and H_2 production	
3	Evaluation of overall efficiency of photocatalysts 1, 2, and 3 synthesized for above specified purposes	

Relevance to the Literature

Degradation of Contaminant



Production of energy



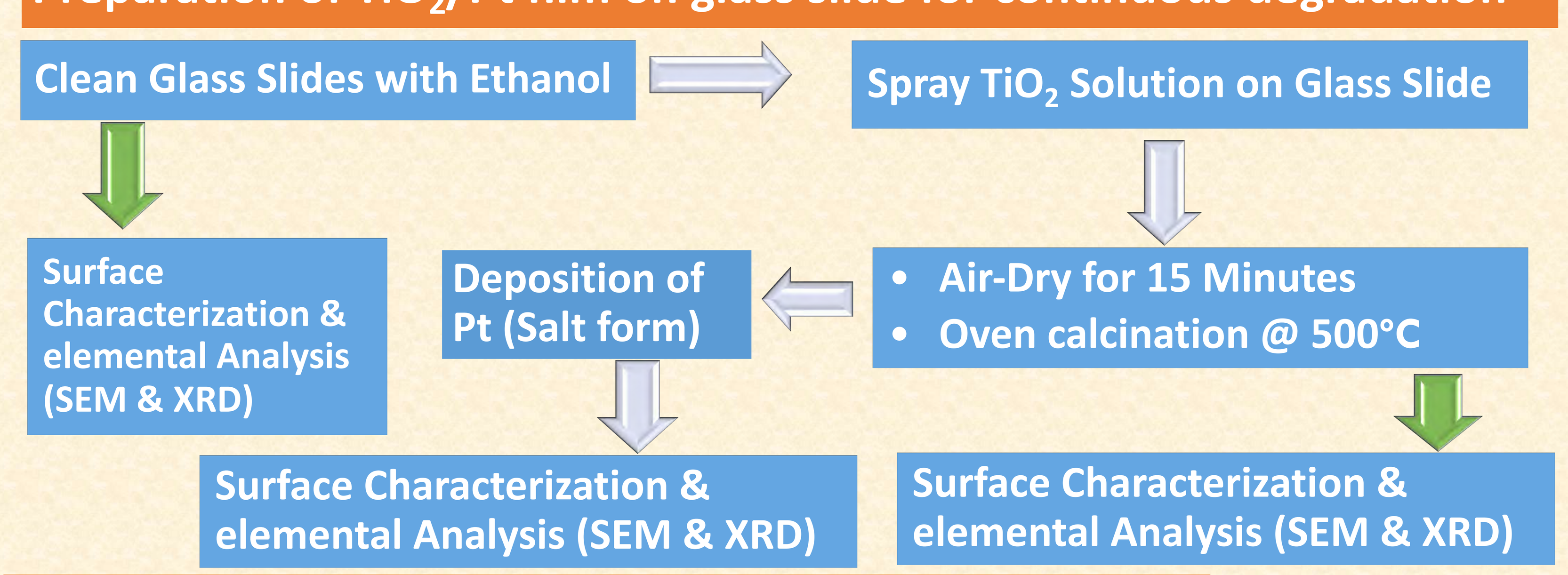
Photoelectrolysis: Honda-Fujishima effect, 1970s

- **Water photolysis with single crystal TiO_2 semiconductor (anode) & Pt (cathode)**

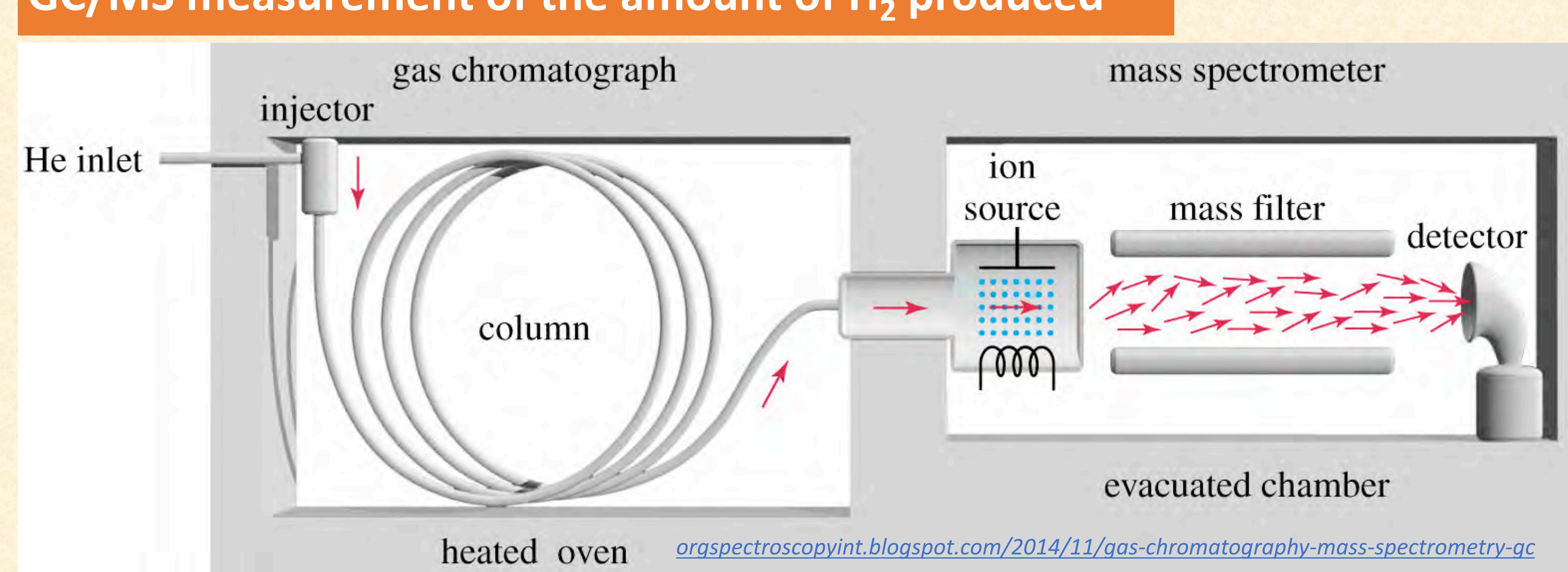
$$[\mathbf{TiO_2 + h\upsilon \rightarrow TiO_2(h^+_{vb} + e^-_{cb})}]\times 4$$
$$2H_2O + 4h^+_{vb} \rightarrow O_2 + 4H^+$$
$$[2H^+ + 2e^-_{cb} \rightarrow H_2]\times 2$$
$$2H_2O + 4h\upsilon \rightarrow O_2 + 2H_2$$

Methodology

Preparation of TiO_2/Pt film on glass slide for continuous degradation



GC/MS measurement of the amount of H_2 produced



Results and Discussion

General Kinetics of photocatalytic degradation (radiation field effect)

- The degradation of a pollutant on the catalyst surface is described by Pseudo-first-order kinetics as given by Langmuir-Hinshelwood scheme:

$$R_A(C_A,T) = -\frac{dC_A}{dt} = \frac{K_{ad}k_rC_A}{1+K_{ad}C_A}$$

- Langmuir-Hinshelwood scheme is modified under the effect of radiation field. Therefore, the photocatalytic degradation of pollutant in water on the surface of TiO_2 film under the radiation field is :

$$R_A(C_A,T,\varphi) = -\frac{dC_A}{dt} = \frac{K_{ad}k_rC_A\varphi}{1+K_{ad}C_A}$$

- Pollutants are present in very low concentration in waste water (C_A<<1)

$$-\frac{dC_A}{dt} = K_{ad}k_rC_A\varphi$$

- This differential equation can be solved for C_A by integrating it

$$\int\frac{dC_A}{C_A} = -K_{ad}k_r\varphi\int dt \Rightarrow lnC_A = -K_{ad}k_r\varphi t + c$$

- Applying initial condition:@ t = 0, C_A= C_{A0} ⟹ c = lnC_{A0}

$$lnC_A = -K_{ad}k_r\varphi t + lnC_{A0} \Rightarrow ln\frac{C_A}{C_{A0}} = -k_{app}\varphi t$$
$$\Rightarrow ln\frac{C_A}{C_{A0}} = -k_{app}(I_0e^{-\mu r})t$$
$$\Rightarrow C_A = C_{A0}\,e^{-[k_{app}(I_0e^{-\mu r})t\,]}$$

R_A	initial rate of photocatalytic degradation	k_{app}= $k_r(T)*K_{ad}$	pseudo-first order rxn rate constant
C_A	pollutant concentration at time t	$\varphi = I_0e^{-\mu r}$	radiation intensity at the film surface
K_{ad}	equilibrium adsorption constant	I_0	Initial radiation intensity
$k_r(T)$	reaction rate constant	μ	Linear attenuation coefficient
R_A	initial rate of photocatalytic degradation	r	Position in the reactor

Conclusions and Future Work

- Suspension based photocatalytic degradation in a batch process versus coating-based continuous process can be compared.
- Coating-based continuous process for waste water treatment can be suggested for large scale commercialization.

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