Advanced Oxidation Applied to Water Contaminant Degradation and Energy Recovery

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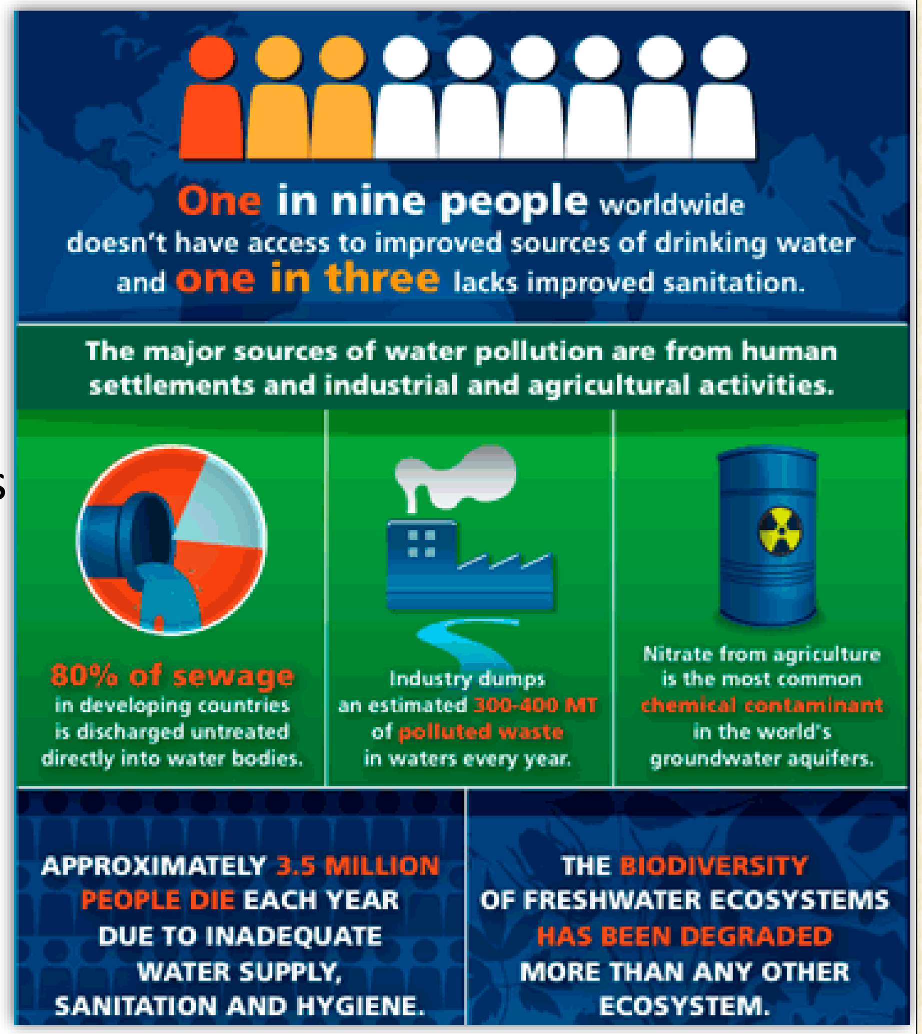
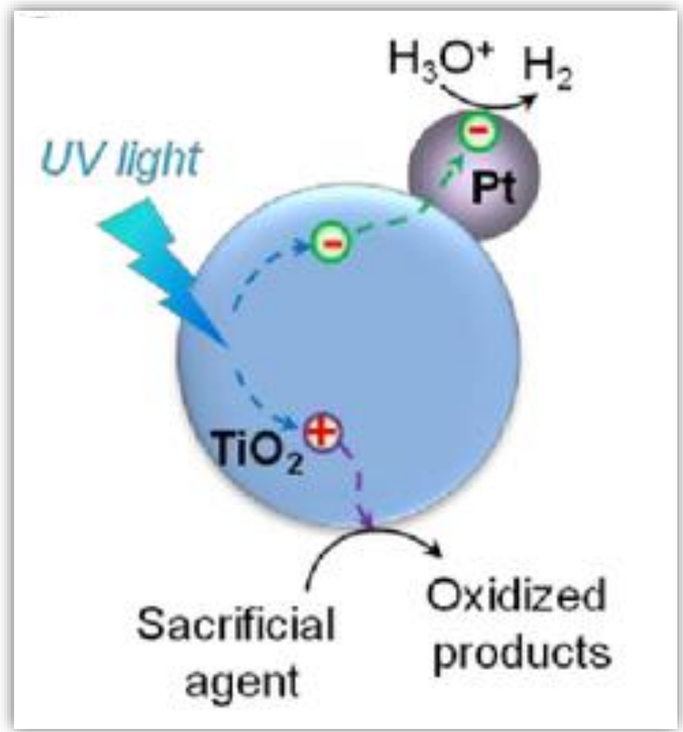
Motivation and Relevance of Research

With the continued increase of human and industrial waste in our society, the treatment of wastewater is becoming a challenging task as the demand for more effective treatment methods and efficient technologies for water is higher than ever before. The number and flexibility of current water treatment practices have been found to be insufficient against a growing number of contaminants of concern, including pharmaceuticals and other industrial chemicals. Coupled with the need for cleaner water, the need for affordable, clean, and easily-produced energy is needed.



Methodology: Titanium Dioxide Thin Films + Pt Doping

Titanium dioxide (TiO_2) is an inexpensive semiconducting photocatalyst that has been proven to photodegrade both liquid solid-phase pollutants.



Preparation of TiO_2 Thin Film and Cleaning of Glass Slides with Ethanol

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Spray TiO_2 Solution on Glass Slide with Iwata Eclipse

- Air-Dry for 15 Minutes
- Calcination in oven at 500°C

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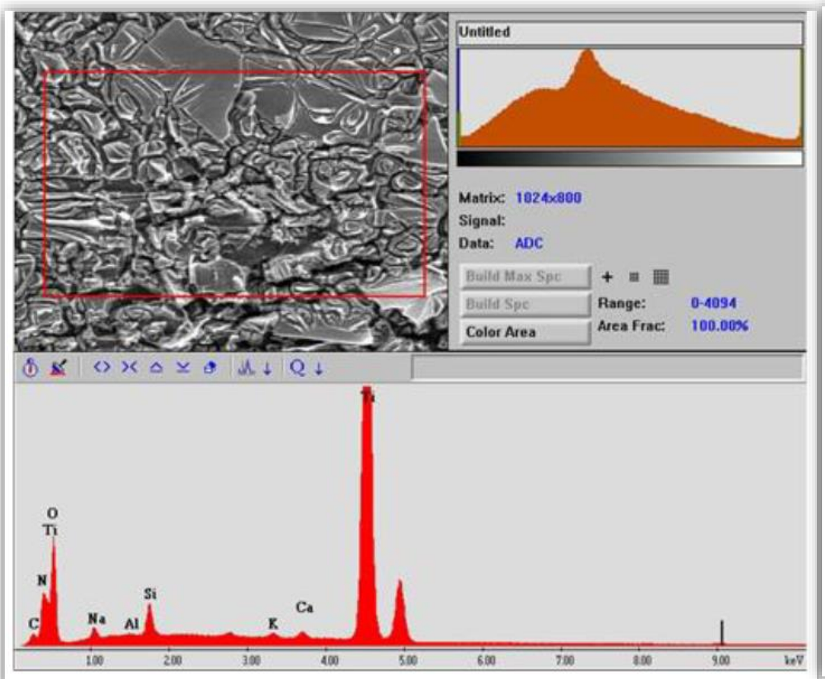
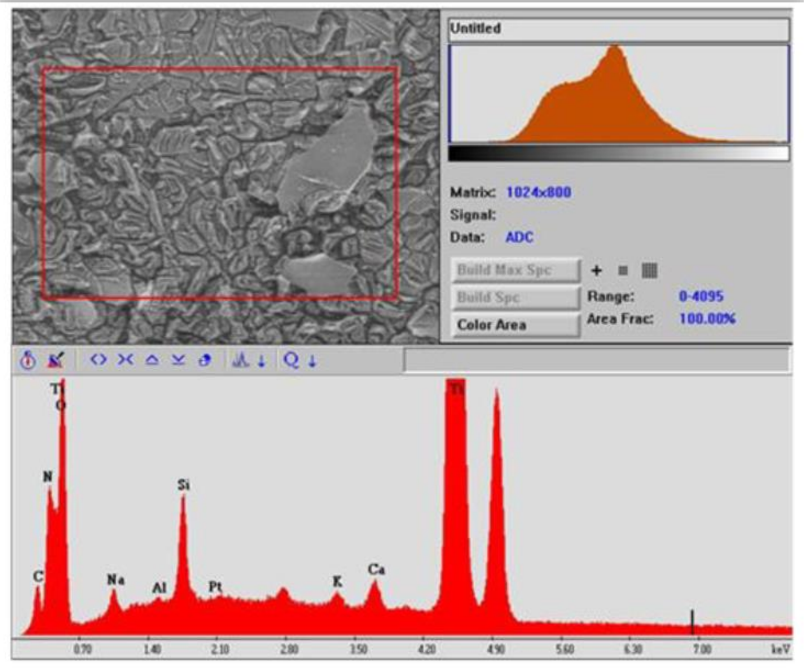
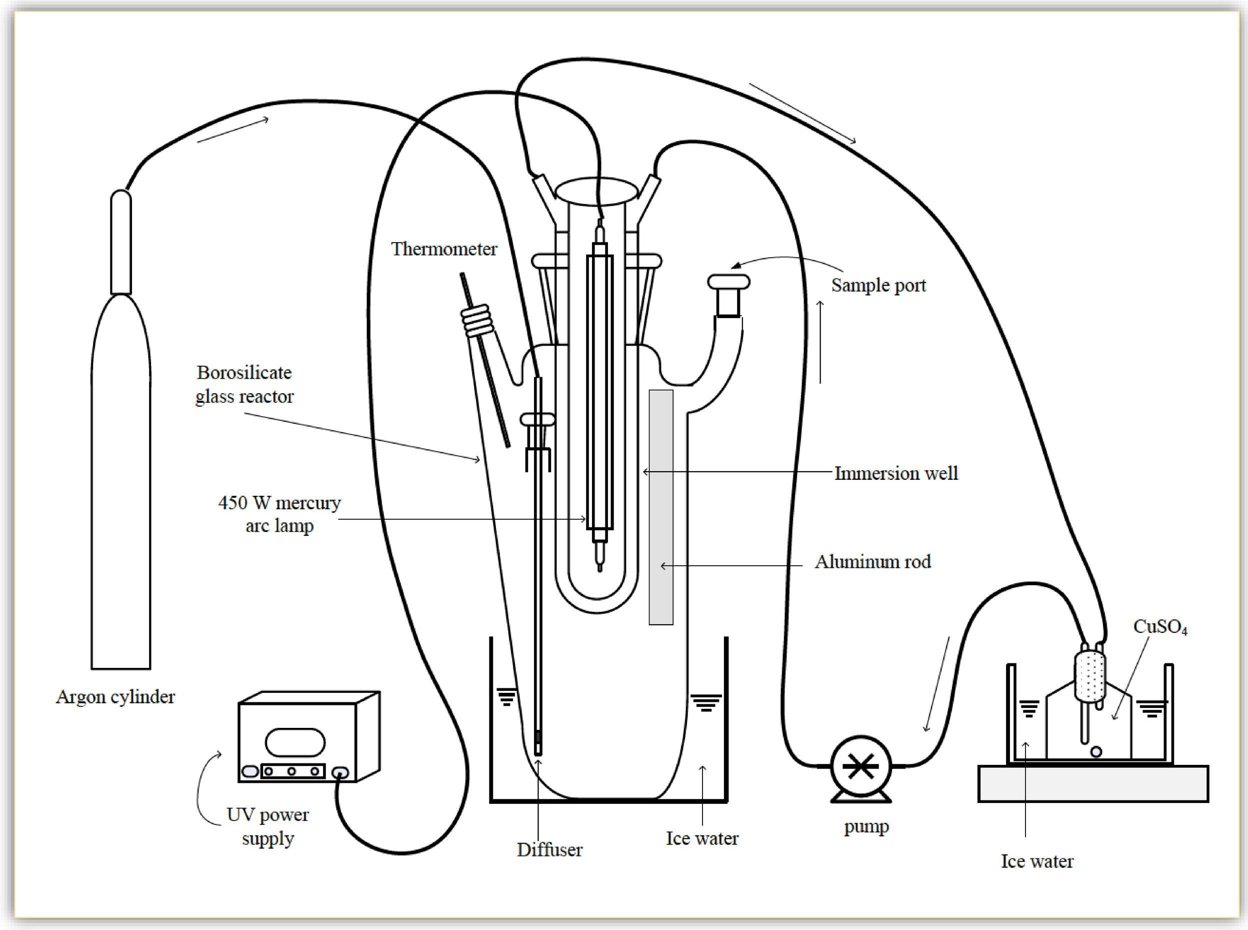
Deposition of Platinum (Pt) Salt → **Characterization (SEM and XRD)**





Materials and Method

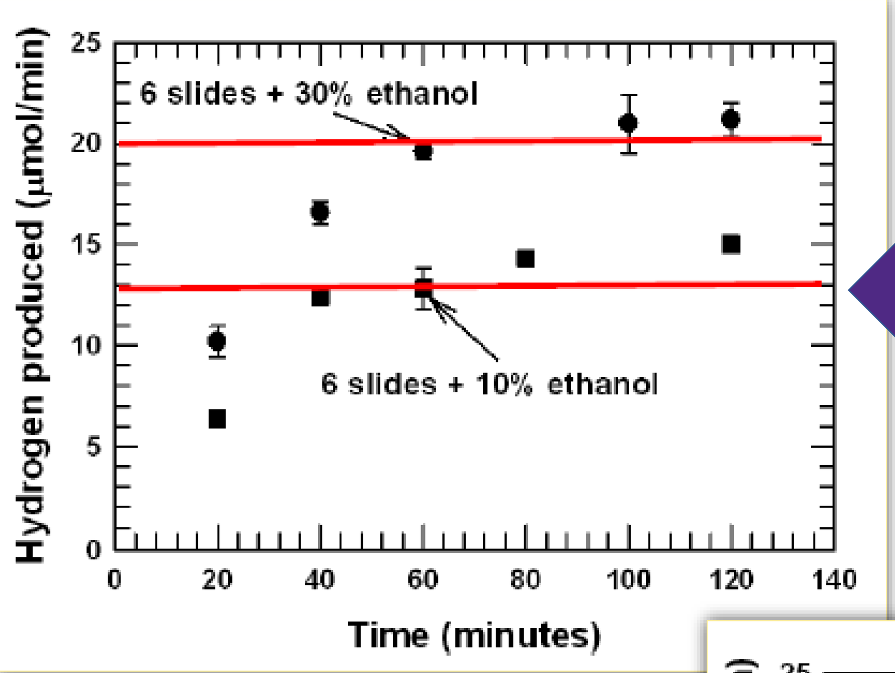
TN Tech Parabolic Reflector UV Reactor



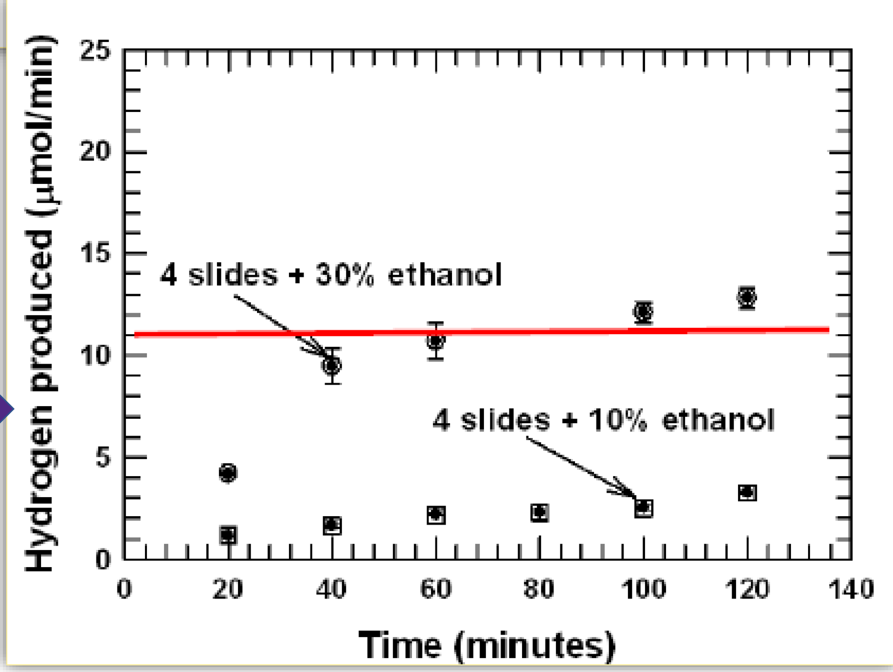
TiO_2 Reaction Mechanism With Methanol Example

$$TiO_2 \rightarrow TiO_2(e^-, h^+)$$
$$H_2O_{(ads)} + h^+ \rightarrow \cdot OH + H^+$$
$$CH_3OH + \cdot OH \rightarrow HCHO + H_2O + \frac{1}{2}H_2$$
$$H^+ + e^- \rightarrow \frac{1}{2}H_2$$
$$HCHO + OH^- \rightarrow (H_2COOH)^- \rightarrow HCOOH + \frac{1}{2}H_2$$
$$HCHO \rightarrow CO + H_2$$

Results



Rate of hydrogen produced with 6 slides with 30% and 10% ethanol solution.



Rate of hydrogen produced with 6 slides with 30% and 10% ethanol solution.

Discussion: Quantum Yield

The quantum yield of the system is the measure of the efficiency of photon emission as defined by the number of photons emitted to the number of photons absorbed. Using the equation below, the quantum yield of the system was calculated to be 68%.

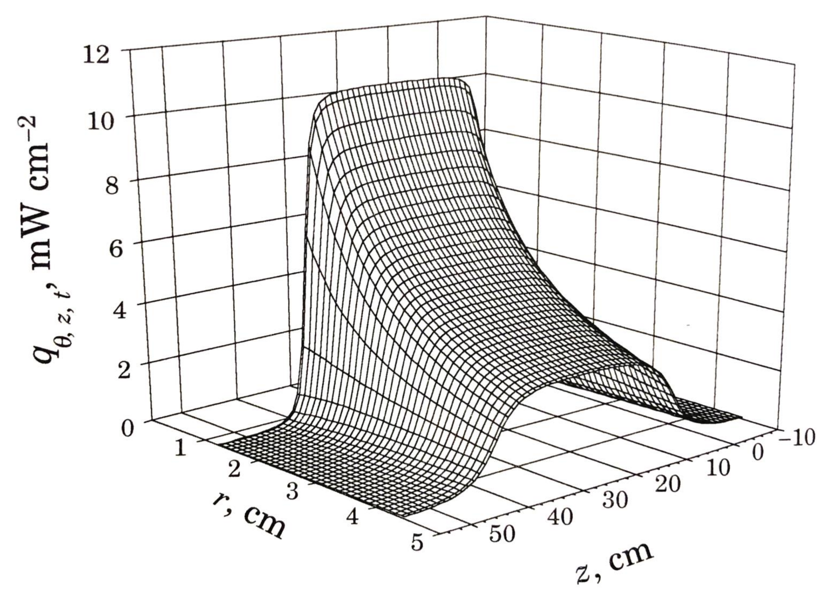
$$\varphi = \frac{moles\ of\ reactant\ consumed\ or\ product\ formed}{moles\ of\ photon\ absorbed} = \frac{n_e}{n_p}$$

where

n_e	$(2 * H_2$ Production Rate$)$x $(N/60$ electrons/s$)$
n_p	$Incident\ Power\ (J/s)\ x\ {}^{\lambda}/_{hC}$
N	Avogadro's Number
h	Planck's Constant
d	Speed of Light

Conclusions and Future Work

To make these processes available for use in industry, a mathematical-computational model will be developed to produce a scaled-up model of the reactor cell.



The mathematical model is based upon the Mass Conservation Equation for Laminar Flow *(1)* and the Radiation Conservation Equation *(3)*. The Reaction Rate Equation *(2)* couples equations *(1)* and *(3)* together. Solving these three equations simultaneously yields the concentration profile for the solution.

Mass	$-2\bar{v}_z\left[1-\left({}^{r}/_{R}\right)^2\right]\frac{\partial c_i}{\partial z} + \frac{1}{r}D_i\frac{\partial}{\partial r}\left(r\frac{\partial c_i}{\partial r}\right) + \Omega_i = 0$	***(1)***
Reaction Rate	$\Omega = kI_{r,z}C_A$	***(2)***
Radiation	$\frac{1}{r}\frac{\partial}{\partial r}(rI_r) = \pm I_r$	***(3)***

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