



Photocatalytic Degradation of Acetaminophen in Water Via Ultraviolet Radiation And Titanium Dioxide Thin Films

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Motivation and Relevance



Fig. 1 Cookeville Waste Water treatment plant

Ref.Cookeville-tn.gov

Objective and Advantage

- Eliminate tedious and costly filtration steps in water treatment with TiO₂.
- Discover possible degradation pathways of this compound.
- Develop Simple and efficient preparation methods for TiO₂ thin films.

Model Treatment

Acetaminophen (N-(4-Hydroxyphenyl) acetamide is an over-the-counter analgesic drug for relieving minor aches and pains associated with backache, headache, arthritis etc.

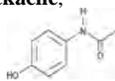


Fig 2. N-(4-Hydroxyphenyl) acetamide

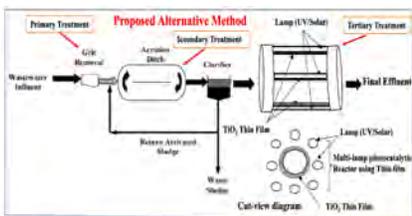


Fig 3. Cookeville Wastewater Treatment Plant Proposed Scheme (Modified to include tertiary treatment process)

Materials and Methods

- Multiple layers of TiO₂ Thin films (6, 8,10) were prepared and deposited onto glass slides via sol-gel methods and characterized by SEM and XRD analysis.
- Four and six TiO₂ deposited thin film glass slides were inserted on UV-Photocatalytic reactor in order to determine photocatalytic degradation of Acetaminophen under different pH conditions (acidic, basic, and neutral).
- The degradation rate of acetaminophen was observed by UV-Vis Spectrophotometer at the wavelength of 243nm, While the recorded absorbance was converted to concentration by using Beer- Lambert's Law.



Fig. 4, & 5. TiO₂ thin film coating insert on UV Photocatalytic reactor using aluminum rods

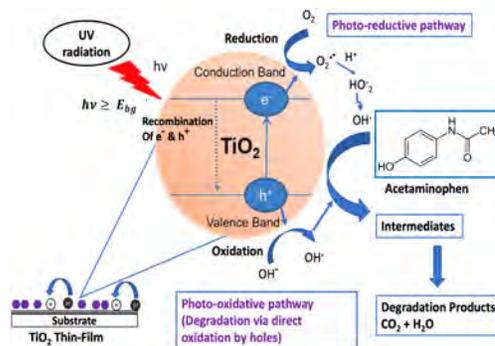


Fig 6. Schematic of Photocatalytic Degradation Mechanism on the Surface of Thin-Film

Results and Discussion

Comparison with Different Elemental Composition(Average Wt %) on Different Layers of Thin-Film Coatings

Elements	Plain glass (Wt. %)	1- layer coating (Wt. %)	2- layer coating (Wt. %)	3- layer coating (Wt. %)	4- layer coating (Wt. %)	6- layer coating (Wt. %)	8- layer coating (Wt. %)	10- layer coating (Wt. %)
Si	31.12	16.71	9.41	6.8	1.81	1.95	1.27	2.26
Ti	NA	24.79	36.64	38.90	43.72	50.75	53.8	54.3

Thin Film Based Studies of Acetaminophen Photocatalytic Degradation

4 TiO ₂ Thin Film Slides			6 TiO ₂ Thin Film Slides		
Number of Thin Film layers	Degradation 10- Min.	Degradation 90-Min	Number of Thin Film layers	Degradation 10- Min.	Degradation 90-Min
6	10.8%	35.7%	6	11.3%	41.0%
8	13.3%	38.2%	8	16.8%	42.3%
10	15.6%	40.2%	10	16.9%	43.8%

Discussion

It was found that Acetaminophen degradation was affected by various factors including pH ranges, initial concentration of Acetaminophen, the amount of photocatalyst deposited on the slides, and the irradiation sources. The highest degradation was achieved during the 90-minute interval with 43.8% degradation on the neutral medium with ten layers of TiO₂ photocatalyst coating on 6-glass slides.

Future Work

- Doping a suitable metal with TiO₂ would help to increase the degradation rate, which will help to reduce the band gap and harness visible light. This will not rule out sunlight as a potential energy source for photodegradation. This will also reduce the high recombination rate of the photogenerated electron-hole pairs and eliminate the low quantum efficiency.
- Detailed studies on microstructure of TiO₂ thin films and their interactions with other materials are crucial to increase the photocatalytic process. The photocatalytic activities of thin films depends upon the crystal phase structure, thickness, and porosity. In order to analyze these properties, more work on characterization of coated thin film would be beneficial.

Acknowledgement

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Reference

Okoye, N.H., Master Science Thesis, Tennessee Technological University, 2011