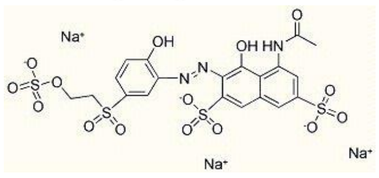
Photocatalytic Properties of TiO_2/[Metal]-Fly Ash Systems

Kyle Karinshak[1], Lakshitha Pahalagedara[2], Steven Suib[2]
[1]Department of Chemicals, Biological, and Materials Engineering, University of Oklahoma
[2]Department of Chemistry, University of Connecticut
VeruTek Corporation

Introduction:

- Fly Ash is a product of the combustion of coal and is composed mostly of SiO_2 and CaO along with trace heavy metals.[1]
- Health and environmental concerns necessitate ash ponds and recyclability of fly ash rather than ejection into the atmosphere.[2]
- Dyes interfere with the transmission of sunlight into water, while certain dyes are carcinogenic and damaging to the environment.[3]



http://www.chemicalbook.com/CAS%5CGIF%5C12226-38-9.gif

Structure of Remazol Brilliant Violet (left).

Market:

- The textile industry produces annually an average of 70 Billion tons of waste water the must be treated.[4]
- Numerous treatment processes exist, but are complicated, expensive and have varying degrees of success. [4]
- The development of simple, comprehensive treatment processes for waste water represent an opportunity to corner the market on textile waste water treatment.

Treatment of waste water such as that shown on the right provides a significant market opportunity

http://www.rsc.org/images/pink-sewage-300_tcm18-156872.jpg

Objective: Photocatalytic Degradation of Remazol Brilliant Violet in Aqueous Solutions by Titanium Oxide/ Metal-Doped Fly Ash Systems

Methods:

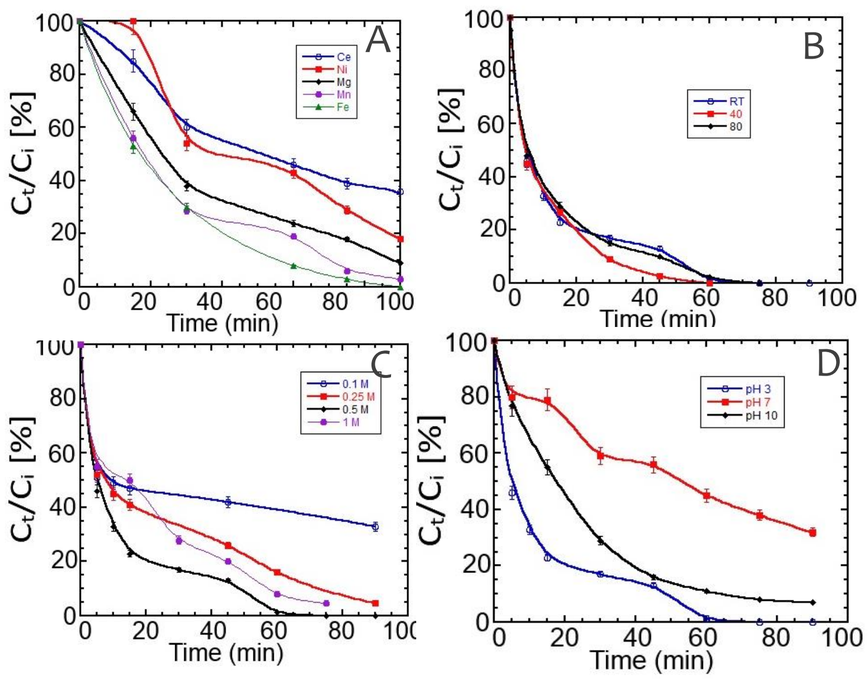
Metals were doped onto the Fly Ash; the solution was heated and aged for a week before it was calcined. Titanium Oxide was added to the mixture, gound together, and calcined a second, final time.

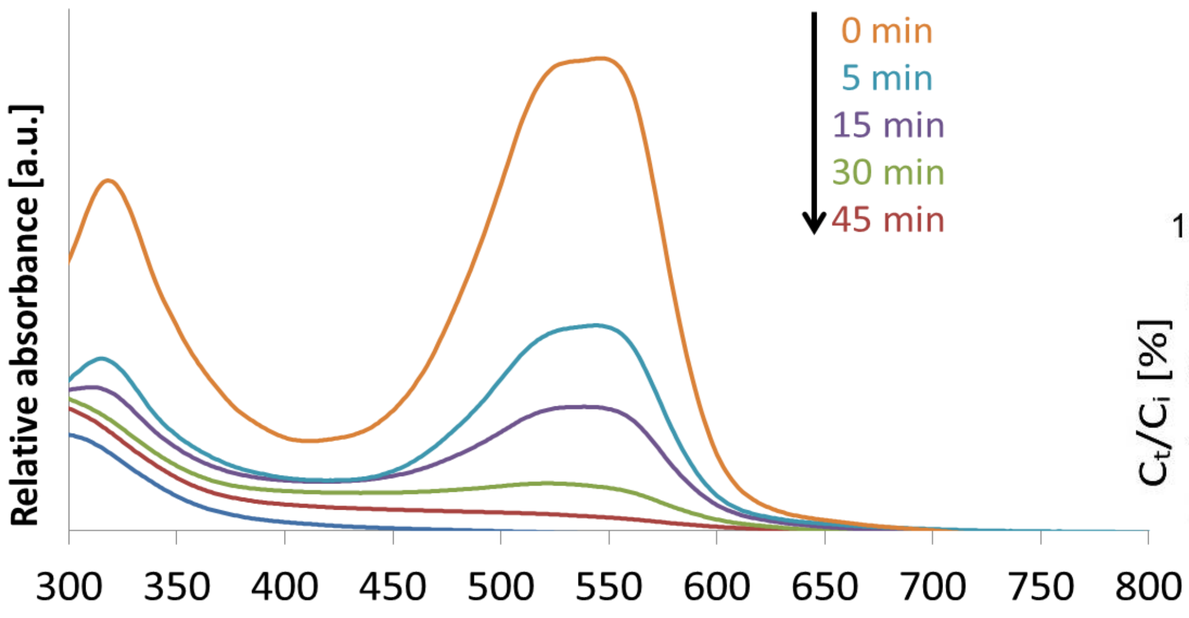
Reactions were carried out at room temperature in a UV reactor (above). 100 mg of catalyst was mixed into 100 mL of 20 ppm dye solution in a quartz beaker and agitated constantly throughout the reactions.

Results:

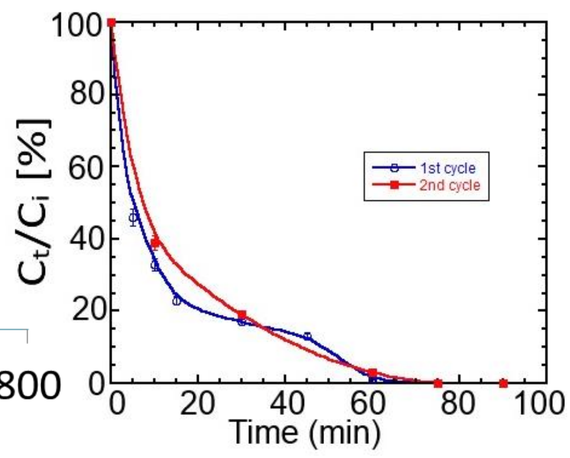
A: Effects of different doped metals.
B: Effects of calcination temperature.
C: Effects of molar concentration of Fe^{3+}.
D: Effects of pH.
In all cases the lowest line represents the best results.

Best results were found to be fly ash with Fe^{3+} ions doped at .5 M, calcined at 400° C with a solution pH of 3 (below). No by-products were observed.





Little change was shown in catalyst performance upon a second, identical reaction (below).



Conclusions:

TiO_2/ [Fe]-Fly ash is an effective catalyst for the degradation of Remazol Brilliant Violet. Optimal conditions for the degradation reaction were discovered and the recyclability of the catalyst was confirmed.

Further Research:

- Effects of temperature upon degradation need to be studied.
- Shifting activity of catalyst into the visible spectrum is a priority.
- Testing the effectiveness at the degradation of other compounds – e.g. diphenylthiolphene, a sulfur compound found in crude oils – and potential applications in other fields.

Acknowledgements:

National Science Foundation Research Experience for Undergraduates Program
Dr. Jeff McCutcheon
Dr. Steven Suib and the Suib Group

Citations: 1. http://www.sciencedirect.com/science/article/pii/S0016236105004643
2. http://pubs.acs.org/doi/abs/10.1021/cen-v087n008.p044
3. http://www.ncbi.nlm.nih.gov/pubmed/21421537
4. http://cdn.intechopen.com/pdfs/22395/InTech-Textile_dyeing_wastewater_treatment.pdf