TiO_2 as a Catalyst in Thin Film Coatings of Glass Beads for Water Purification Purposes

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* *Research Experience for Undergraduates~2014*
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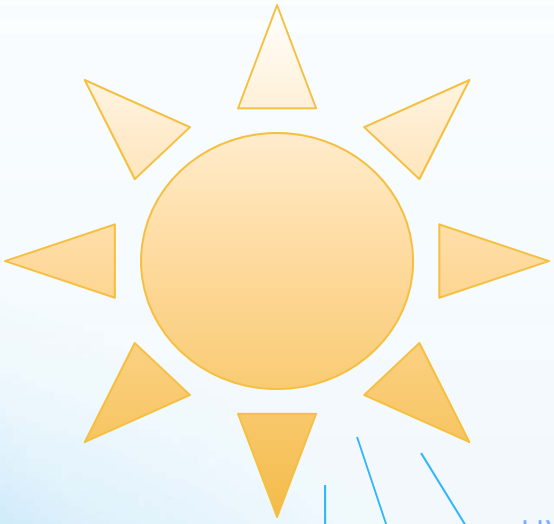
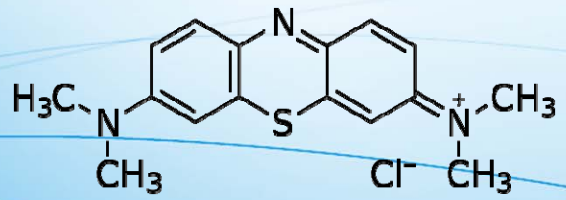
Background





Methylene Blue Dye

* The sun breaks down organic compounds using UV raise.
* TiO_2 is a catalyst for this reaction.

The Methylene Blue Dye is broken up into safe compounds.

CO_2, NH_4^+, NO_3^-, SO_4^{2-}

Why this Photocatalyst is Needed

Pharmaceuticals

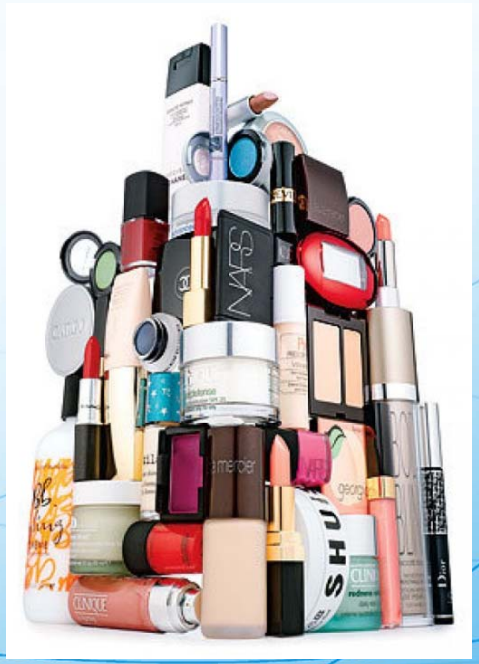
In 2011

- *4,020,000,000 prescriptions were written.*

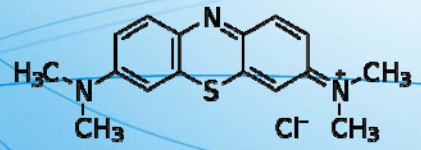
In 2013 a study found

- *70% take at least 1*
- *50% have at least 2*
- *20% are on 5 or more*
- *Over the counter drugs*

Cosmetics



Dyes



Methylene Blue Dye

Pesticides & Herbicides

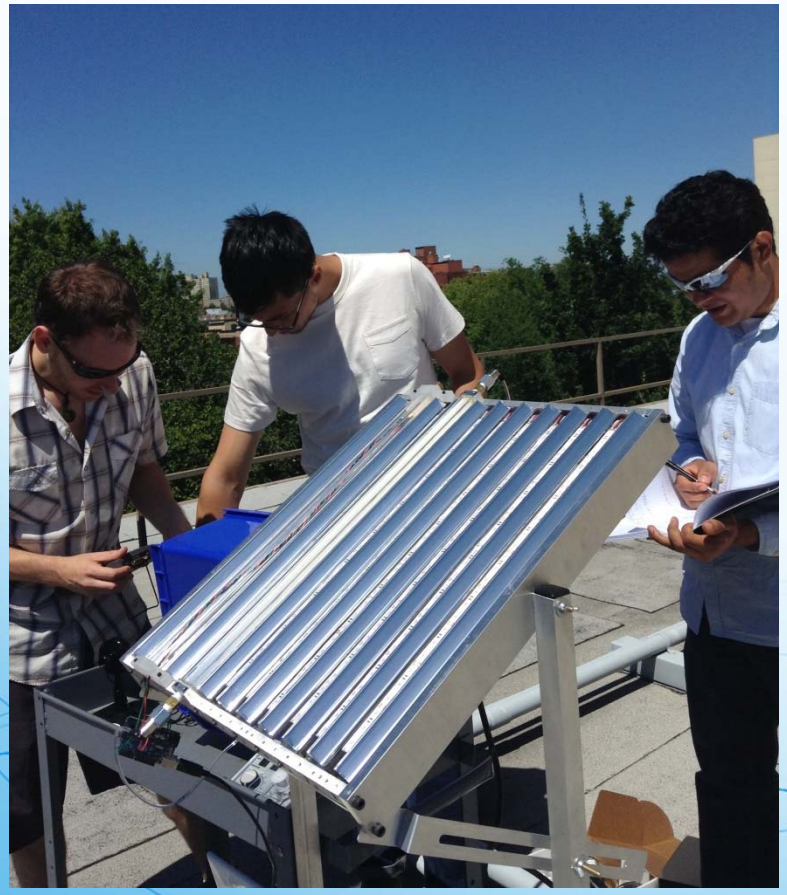
Current Techniques in Industry

* Bacteria
  - Contained in large pools
  - Large quantities of oxygen
  - A slow process

* Filtering Systems
  - Difficult to do
  - Leaves behind concentrated waste

* UV Producing Light Bulbs
  - Large pools of water
  - High energy costs

Research Group



* The Team
  - -Simon/ Physics
  - -Emilio/ Mechanical Engineering
  - -Esteban/ Chemistry
  - -Sydney (Me)/ Bioengineering
* The project that we are all working on is the prototype to the left.

My Research

* Borosilicate Glass Beads (1mm)
  - -performed synthesis trials
  - -dried the beads
  - -sintered the beads
  - -assessed their appearance
  - -SEM work on Tuesday nights
  - -degradation trials
  - -Raman tests

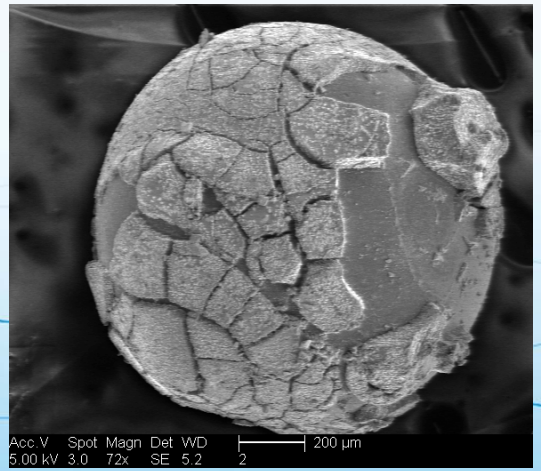
Drying Machines

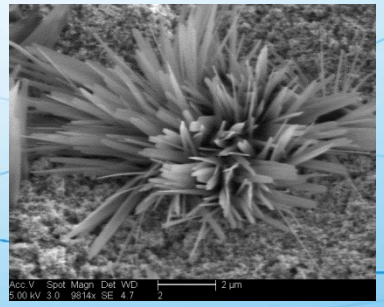
* Before baking the beads they must be dried at a low temperature.
* This decreases cracking or flacking off of the TiO_2 coating.

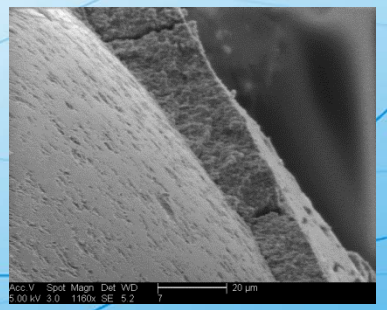
* Drying Techniques
  - air drying
  - ceramic oven (40°C)
  - tumble drying
* Tumble Dryer
  - repurposed a rock polisher
  - designed insert on AutoCAD (w/ Emilio)
  - bought marbles to move the beads

Scanning Electron Microscope

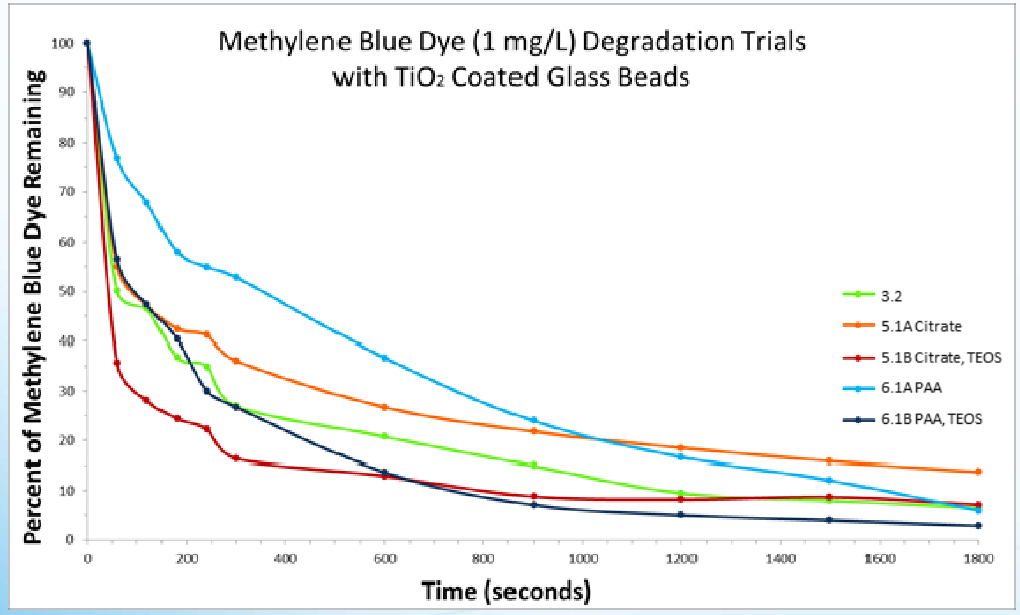
* SEM Tuesday Nights
* Surface Morphology
  - -cracking
  - -thickness
  - -contaminants
* Detector for Spectra



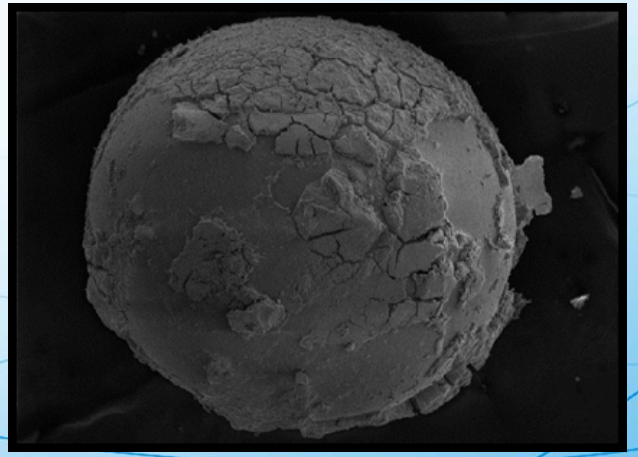




My Final Project



Ingredients	Original Synthesis	Trial 1	Trial 2	Trial 3
TiO_2(g)	4.0162	1.5010	1.4993	1.501
Water(mL)	7	11	15	13
TEOS(mL)	1.0	1.0	1.5	1.0
PAA(µL)	220	200	200	300
Glass Beads(g)	7.0063	20.095	20.006	20.003

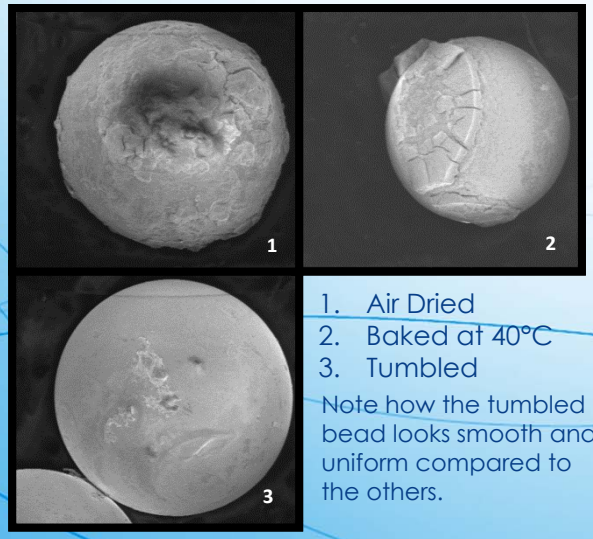


SEM photo of a bead from the original PAA & TEOS synthesis

Drying Process & Sintering Results

Drying

Drying Technique	Notes
Air Dried	-Visible cracking -Large rings formed where the bead sat
Baked at 40°C	-Dried faster -Visible cracking -Large rings formed where the bead sat
Tumbled w/ 14 Marbles	-Smooth surface -Thinner Coating -Takes longer to drying if not vented
	Method of Choice: Tumbling

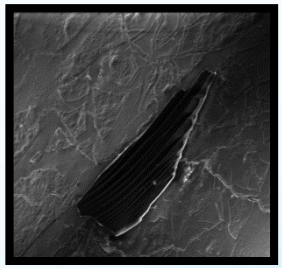


1. Air Dried
2. Baked at 40°C
3. Tumbled

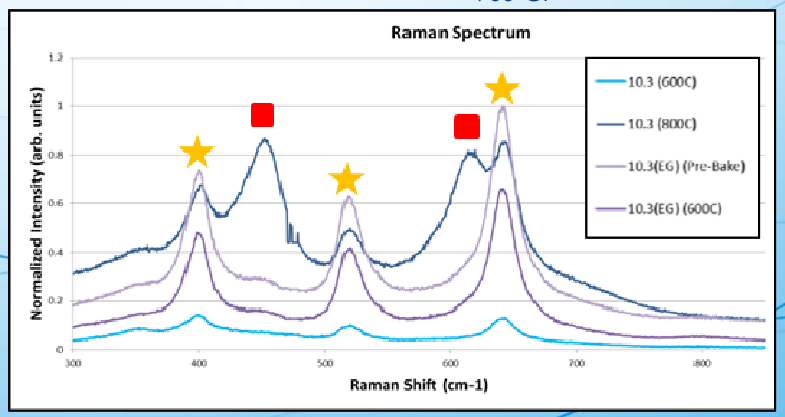
Note how the tumbled bead looks smooth and uniform compared to the others.

Sintering Temperatures

Trial 2 baked at each sintering temperature.



Piece of silicon wafer adhered to the TiO2 coating on a bead after being baked at 900°C.



The graph was normalized at the 635 1/cm peak.

Best Bead Coating

Process of Choice

Synthesis:

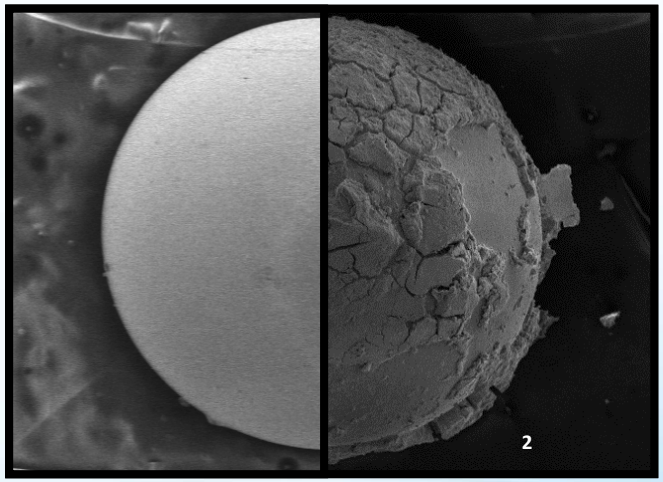
* Trial 3 (has more PAA)

Drying Technique:

* Tumbling

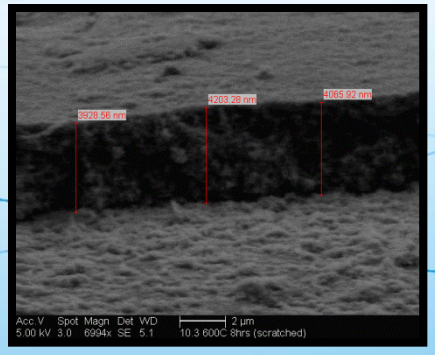
Sintering Process:

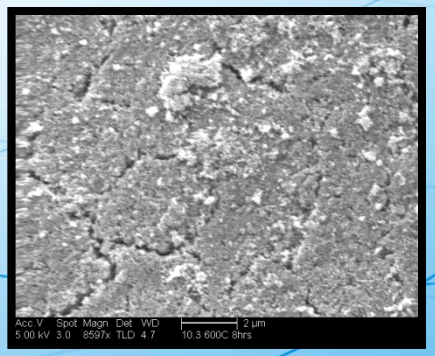
* 600°C for 8 Hours



Created

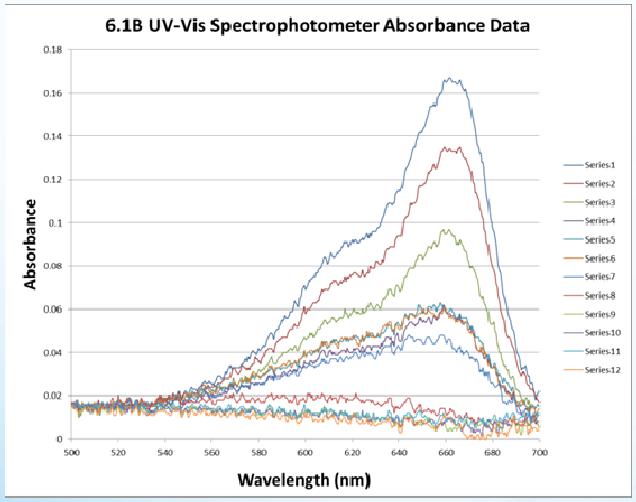
* 4 micron thin coating
* Small nanometer cracks
* No flacking





Degradation Results

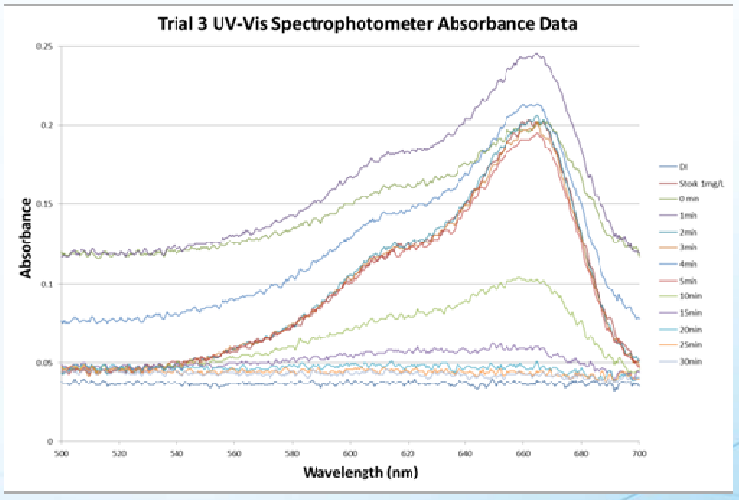
Before



The 6.1B degradation was done again at the same conditions as Trial 3.

* Light intensity AM 1.5
* 1miligram of methylene blue dye per liter
* 16mL of contaminated water per degradation trial

After



The stir bar was turned on after the 5 minute sample.

Top curves staying constant confirmed our assumption that circulation is important.

* more accurate reading
* brings the contaminants to the beads where they are degraded

Less TiO2 in the water

Potentially a faster degradation

Goal of The Group Project

* Create a more efficient way to clean water.
* A less expensive and more eco friendly solution.
* To create a product that is commercially viable.

Acknowledgments

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* Emilio & Esteban
* Lester Lampert
* Meaghan Corwin

References

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