

1. ABSTRACT

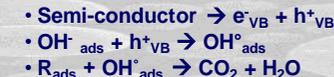
Photocatalysis with TiO₂ is a method used to degrade various organic pollutants. The drawback with TiO₂ is that it utilizes only 3-5% of the total solar spectrum. By decreasing the band gap of TiO₂ the effective utilization of the solar spectrum can be achieved. It has been reported that nanoparticles and lattices can affect the band gap. In this work, spray drying was used to fabricate TiO₂ hollow particles and coated glass spheres, and then employed in an attempt to photocatalyze methylene blue.

2. OBJECTIVE AND BACKGROUND

The objective of this research was to use spray drying to synthesize both titania particles and continuous coatings on hollow glass microspheres in order to study their photocatalytic activity.

Titania was chosen because of its high photocatalytic activity and non-toxicity. Glass spheres were used as a substrate because of its non-reactivity, low density and its commercial availability in a wide range of sizes. Spray drying was chosen because it is a common, industrially-friendly method for producing powders.

Fundamental photocatalysis equations:



where R_{ads} represents the adsorbed impurity radical to be oxidized

3. EXPERIMENTAL PROCEDURE

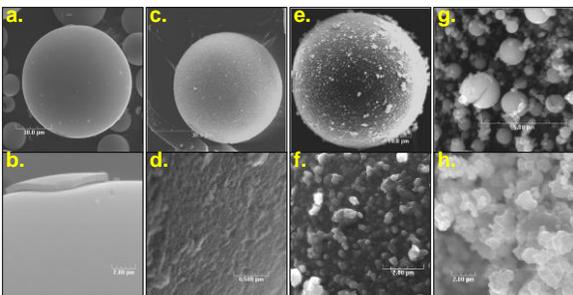
Synthesis of TiO₂ Coatings and Particles:

Two chemical methods were used to prepare Ti precursor solutions. Both used titanium isopropoxide dissolved in anhydrous isopropanol. To this solution a modifier (Method 1 \rightarrow acid modifier, Method 2 \rightarrow hygroscopic modifier) was added and dissolved. Glass spheres were then added to the solution and stirred. Then the suspension was filtered with filter paper and allowed to hydrolyze in open atmosphere. After hydrolysis the suspension was then spray dried using a (Buchi B-290) mini spray dryer. Titania particles were synthesized by a similar method as the coating, with the exclusion of glass spheres and filtration.

Photocatalysis:

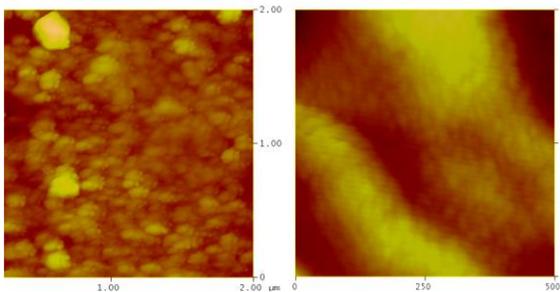
A fixed quantity of the treated glass spheres or titania particles were added to a Methylene blue (MB) solution (10⁻⁵ M). The suspension was irradiated with either UV light of $\lambda=254\text{nm}$, or simulated solar light (AM1.5), filtered with filter paper, transferred to a cuvette, and analyzed with a UV-Vis spectrometer. For comparison, the same procedure was carried out for samples with no irradiation.

SEM Micrographs



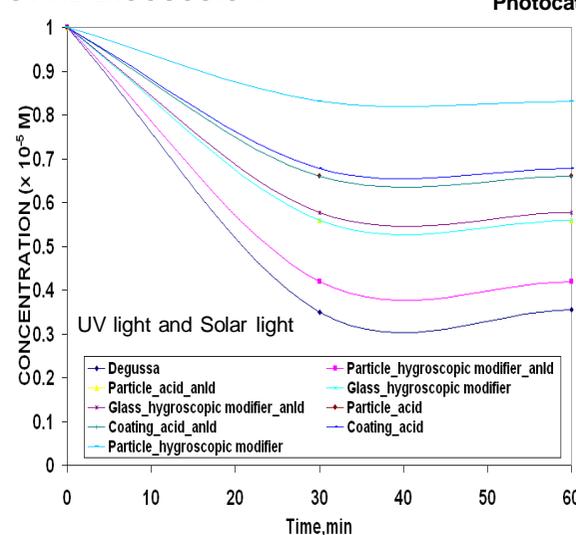
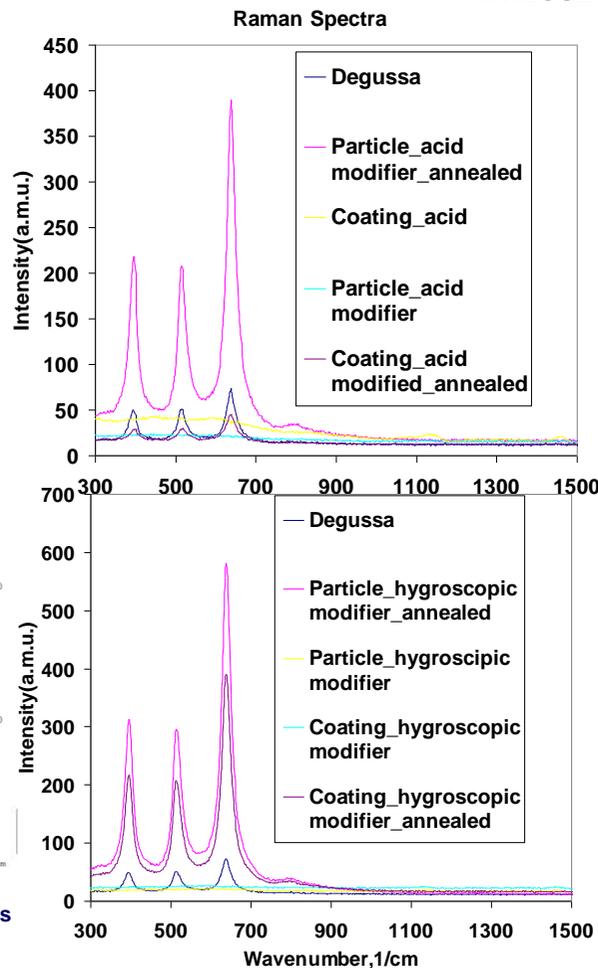
SEM pictures of relatively smooth surface of untreated glass (a&b). Dense continuous coatings were obtained using Method 1 (c&d), whereas a more porous and rough-looking coating was obtained using Method 2 (e&f). Without the glass spheres, Method 1 resulted in spherical hollow particles ranging in size from 0.2 to 5 microns (g). Method 2 resulted in particles that were spherical and doughnut shaped (h).

AFM Scans

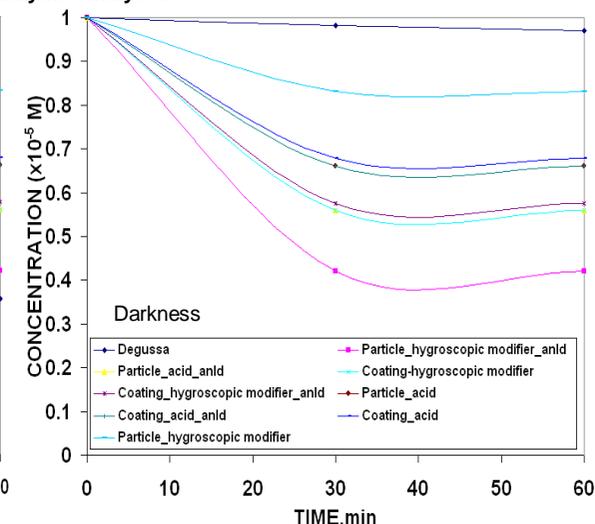


The titania coating on glass spheres by Method 1 has average roughness of 9nm. Method 2 produces coatings with two levels of roughness (10 nm and 1 μm).

4. RESULTS AND DISCUSSION

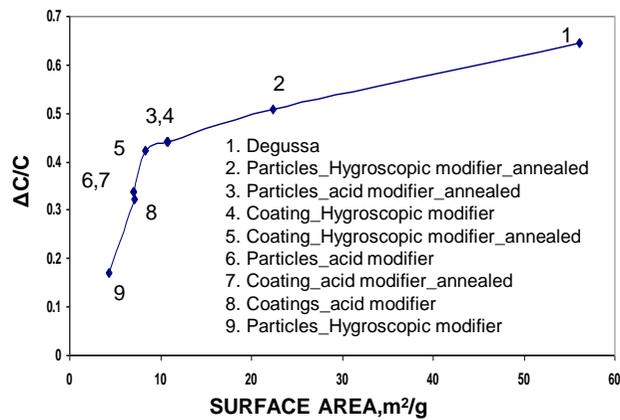


Photocatalysis Analyses



Raman spectra show that the as-sprayed products from both methods were amorphous. Annealing led to crystallization, as revealed by strong anatase peaks.

For experimental samples, UV-Vis analyses show that MB degradation was similar under all conditions (even without light exposure) suggesting that photocatalysis is not the principal mechanism. The change in MB concentration appears to hold constant after 30 min of exposure. Only the commercial nano-anatase (Degussa P-25) exhibited a significant difference between exposed and unexposed. In any case, the degradation of MB increases with increase in surface area. For experimental samples, the annealed titania particles by Method 2 has highest surface area and largest drop in MB concentration.



5. CONCLUSION

- Titania hollow spheres and coatings on glass microballoons, were synthesized by a sol-gel spray process. Primary particle size was in the nanometer range.
- Degradation of Methylene Blue occurred with all samples, regardless of exposure. The mechanism is believed to be adsorption with no significant photocatalytic activity.

REFERENCES

- K.D.Kim, H.T.Kim, Powder Technology 119(2001)164-172
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