Synthesis of a Mesoporous Silica/Titanium Dioxide Nanocomposite and Evaluation of Photoactivity

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There is considerable interest in the development of Advanced Oxidation Processes, especially those that use wide band gap semiconductors for photo-oxidation of pollutants in waste water streams. The photo-oxidation is a surface process and so the greatest photo-activity is displayed by colloidal particles. Unfortunately the particles do not settle from aqueous dispersions and so, to avoid a costly separations step, it is desirable to develop a supported form of the photo-catalyst.

We have encapsulated Degussa P-25 titanium dioxide into a thin film of mesoporous silica as a means of confining the photo-catalyst while retaining maximum access to the photo-catalyst for the aqueous solutes. Physical characterization of the medium was carried out by powder X-Ray Diffraction supplemented by Variable Angle Spectroscopic Ellipsometry. Chemical characterization focused on the photodecomposition of 2,4-dichlorophenol using 350 nm light. The photodegradation was monitored by both UV-vis and HPLC.

Tests showed that in the absence of a polymer template the silica/titanium dioxide film formed was not mesoporous. Such films were found to have very low photoactivity. On a per photon absorbed basis the mesoporous silica/titanium dioxide films were approximately 2/3rds as efficient as an aqueous dispersion of the same amount of P-25. The mesoporous silica has an hexagonal arrangement of 7 nm diameter pores. Experiments with other mesoporous structures; cubic and lamellar phases, showed much lower photoactivity, comparable to that of non-templated silica/P-25 composites.

Duty cycle experiments show that the photoactivity decreases for the first 50 hours of irradiation time, but then becomes steady at approximately 80% of the initial efficiency.