Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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“Synthesis of Iron Doped Titania and its Application in Degradation of Organic Pollution in Water”

Department of Mechanical Engineering

Wednesday, December 6, 2017
2:00 P.M.
Engineering and Computer Science Building
Room 468

Supervisory Committee:
Dr. Rodney Herring, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Martin Jun, Department of Mechanical Engineering, Uvic (Co-Supervisor)
Dr. Rustom Bhiladvala, Department of Mechanical Engineering, UVic (Member)
Dr. Harry Kwok, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Bruno P. Azeredo, Department of Mechanical Engineering, Arizona State University

Chair of Oral Examination:
Dr. Timothy Iles, Department of Pacific and Asian Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies
Abstract

Anatase TiO2 has attracted a lot of attention due to its applications as a photocatalyst in water and air treatment technologies. However, its large band gap energy (≈3.2 eV) limits its application only to UV light. Also, anatase TiO2 suffers from high electron/hole recombination, which diminishes its photocatalytic activity. Therefore, different methods have been employed to decrease its band gap energy and reduce the recombination of the charge carriers. One of the methods is to incorporate impurities as dopants in its crystal lattice. Different metal and non-metal dopants have been studied for this aim. Among the different choices, Fe3+ has showed a great potential to improve the photocatalytic activity of TiO2 under visible light irradiation. Firstly, the d orbitals of Fe3+ interact with the 3d orbitals of Ti4+ generating intermediate band gap energy levels to facilitate excitation of electrons under visible light by a red shift in the absorption of light. Secondly, Fe3+ can interact with both electrons and holes to produce Fe2+ and Fe4+ trapping the charge carriers and reducing their recombination rate. Fe2+ and Fe4+ can release the electron and hole and revert back to the Fe3+. The released charge carriers migrate to the surface of the nanoparticles to initiate the photocatalytic reactions. However, it was found that the photocatalytic activity of Fe-TiO2 is not as high as expected. Therefore, in this research study I investigated the cause for its low photocatalytic activity and found methods to improve it. The Fe-TiO2 was synthesized using a facile sol-gel method and its structure and properties were characterized by different instrumental techniques. Using TEM and HRTEM an amorphous layer was seen on the surface of the nanoparticles. This layer characterized using XPS and EDX was composed of iron oxide layers. This layer was contaminating the surface of the nanoparticles where the photocatalytic reactions take place. Moreover, the contamination layer was acting as a recombination center for the electrons and holes. To the best of our knowledge, no previous study was conducted to investigate the effect of an iron oxide contamination layer on the photocatalytic activity of Fe-TiO2 nanoparticles. This layer was removed using a concentrated HCl solution confirmed using HRTEM and XPS. Also, using DRS it was shown that its
removal does not effect the optical properties of the Fe-TiO2 confirming that the acid
treatment process did not influence the doped Fe3+ in the TiO2 crystal lattice. The
degradation of methylene orange (MO), a representative pollutant, was increased from
25% to 98% under visible light irradiation. Also, in order to achieve the highest
performance of the photocatalyst, it was necessary to study the parameters of the
photocatalytic activity and the degradation efficiency. Therefore, experiments using a
phenol solution, another representative pollutant, were conducted to investigate and
optimize the effects of the catalyst load, reaction time, initial concentrating of the
pollutant and pH. The degradation efficiency of the phenol solution was found to
increase from 31% to 57% by the removal of the contamination layer and by controlling
the pH of the solution.