

SYNTHESIS OF IRON/TITANIA PHOTOCATALYSTS

R. García Alamilla^{1*}, B. B. Zermeño Resendiz¹, E. Moctezuma Velázquez.²

¹ División de Estudios de Posgrado, Instituto Tecnológico de Ciudad Madero, Cd. Madero Tamps. México.

² Centro de Investigación y Estudios de Posgrado, Facultad de Ciencias Químicas, Universidad Autónoma de San Luis Potosí, San Luis Potosí S.L.P. México.

*rgalamilla@yahoo.com.mx

INTRODUCTION

There are more than eighteen million chemical compounds that are used extensively around the world and at least 300 substances are discovered or synthesized every day [1]. They are used as solvents, fuels, pesticides and raw materials to produce polymers or other industrial products. Other chemical substances are used as detergents, cosmetics and drugs. Therefore, industrial and domestic residual water can be contaminated with a diverse number of toxic organic compounds that can not easily degraded by traditional water treatment plants [2]. But, the advance oxidation processes (AOPs) are a new alternative to degradate and mineralize the recalcitrant organic compounds by oxidation with HO• radicals generated by photochemical, photocatalytic, ultrasound and gamma ray induced reactions. Semiconductor catalysts illuminated with UV light produce free electrons (e⁻) and positive holes (h⁺) that react with adsorbed water molecules or OH⁻ to produce the HO• radicals, which in turn react with the organic molecules. Unfortunately, the recombination reaction is very fast and effective. An oxidant gas or any other electron acceptor must be added to the reaction mixture to avoid recombination. Some authors [3] have reported that Ag⁺, Fe³⁺ and other metallic ions in solution are reduced by the free electrons and accelerate the degradation of organic compounds. It has been reported that metal-doped TiO₂ catalyst can be activated with lower energy radiation. However, the quantum yield of the photocatalytic reaction is not improved because the recombination reaction is still very fast. Therefore, new generations of Fe/TiO₂ semiconductor catalysts have been synthesized in our laboratories trying to reduce the energy of forbidden band and the recombination reaction rate.

EXPERIMENTAL

All the catalysts are prepared by the sol-gel method using titanium butoxide, absolute ethylic alcohol and Fe³⁺ salts. The reaction mixture is hydrolyzed for 2 hours at 60 °C with continuous reflux. The gel is dried at 80 °C and calcined at 500 °C under pure oxygen atmosphere. Pure Titania and doped catalysts are characterized by UV-vis spectroscopy and XRD.

Photocatalytic degradation experiments were carried out in a home reactor system. This unit is configured with a Pyrex glass tube reactor irradiated with four UV light lamps (Cole-Parmer E-09815-55, λ_{max} = 365 nm). For each set of experiments, 250 mL of a phenol standard solution are placed inside the glass reactor and slurried with 0.2 g of solid catalyst. Pure oxygen can bubbled through the system at a constant rate of 100 mL/min. For the determination of phenol and some of the intermediate organic compounds, the samples were analyzed by high performance liquid chromatography (HPLC) in a 600E Waters instrument.

RESULTS AND DISCUSSION

The catalysts were labeled as indicated in the following table according to the preparation methods:

Table 1. Fe/TiO₂ catalysts prepared by the sol-gel method.

Label	Precursors	pH
C8	Titanium butoxide IV, 1-butanol, water, (0.15 g) FeCl ₃ , HNO ₃ (1/16)	3.0
C10	Titanium butoxide IV, 1-butanol, water, (0.10 g) FeCl ₃ , HNO ₃ (1/16)	3.0
C11	Titanium isopropoxide, 1-butanol, water, HNO ₃ (1/16), Fe (NO ₃) ₃ •9H ₂ O (5%)	3.0

The results of the XRD and UV-vis characterization are presented in figure 1.

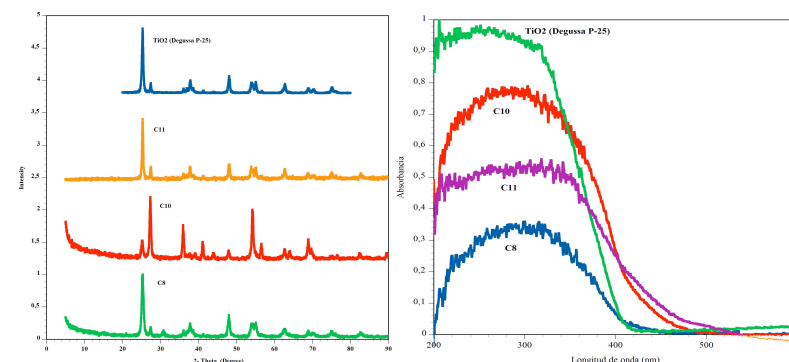


Figure1. Catalysts characterization by: a) Xs ray diffraction. b) Uv-Vis difusse reflectance spectroscopy.

As expected, XRD indicate the formation of anatase and rutile fases of the titania catalysts. But the presence of small amounts of iron oxides can not detected by this technique. The DR UV-vis spectroscopy results clearly indicate that iron ions displace the energy of the forbidden band to the visible region. The photocatalytic degradation experiments indicate that Fe/TiO₂ catalysts are as active as pure TiO₂ catalysts.

References

1. Kabra K., Chaudhary R., Rameshwar L.S., *Ind. Eng. Chem. Res.*, 7683, 7696 (2004).
2. Konstantinou K.I., Trintafyllou A., *Appl. Catal. B: Environ.*, 319, 335 (2003).
3. Wei T., Wang Y., Wan Ch., *Photochem. Photobiol. A: Chem.*, 115, 120 (1990).
4. Araña J., González O., Saracho M., Rodríguez D., Herrera M., Pérez P., *Appl. Catal. B: Environ.*, 3113, 124 (2002).