XXI Brazilian Meeting on Inorganic Chemistry
X Brazilian Meeting on Rare Earths
III Workshop on Theoretical Bioinorganic Chemistry
Belo Horizonte, September 12 - 15th 2024

TiO_2-SiO_2 HYBRID PHOTOCATALYST FOR TEXTILE EFFLUENT TREATMENT

Fernanda K. Silva [1], **Wagner E. Silva** [2] **and Mônica F. Belian** [2]

[1]Departamento de Química Fundamental, Universidade Federal de Pernambuco, Recife - PE, Brazil.
[2] Departamento de Química, Universidade Federal Rural de Pernambuco, Recife – PE, Brazil.
E-mail: fernandasilvakarol@gmail.com

Thematic Area: Materials Chemistry

Keywords: photocatalysis; titanium dioxide; silicon dioxide.

The contamination of surface waters by synthetic dyes in textile effluents constitutes a growing environmental problem and has intensified with the increase in jeans production. According to data from the Brazilian Association of the Textile Industry (ABIT), Brazil is the 5th largest producer and consumer of textiles globally. This large-scale production results in a considerable excess of textile effluent waste, raising concerns from a sustainable perspective. A practical solution for treating these effluents involves the application of photocatalytic materials. Among the central photocatalytic systems, titanium dioxide (TiO_2) stands out for being chemically stable and non-toxic; however, it has a high rate of recombination of photogenerated electron-hole pairs and a high band gap value (Eg = 3.2 eV), which implies the need for higher-cost energy sources, such as UV radiation, for its activation. A solution to the high recombination rates is the formation of hybrid species of TiO_2 with silicon dioxide (SiO_2), as its addition to the hybrid composition allows a reduction of the TiO_2 band gap to the visible region, enabling the use of energy from natural sources, such as solar energy, to reduce process costs. Therefore, this study aimed to synthesize a new hybrid material of TiO_2/SiO_2 in different proportions to treat wastewater from textile industries. The study of various proportions of titania and silica seeks to identify the most suitable proportion for the degradation of organic pollutants from the textile industries. The methodology of the work consists of producing hybrid photocatalysts of titanium dioxide and silicon dioxide synthesized in the molar proportion of 90:10, 80:20, 70:30, 60:40, and 50:50 (Ti:Si) using the sol-gel method, tested for their photocatalytic capacity through the degradation of the model dye, methylene blue. Pure TiO_2 and SiO_2 oxides were also synthesized and tested. The materials were characterized by Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD), which allowed verification of hybrid formation. FTIR data revealed bands at 425 cm^{-1}, characteristic of the Ti-O-Ti group, and a band at 650 cm^{-1} related to the Si-O-Si group. XRD showed standard peaks of TiO_2 in the anatase phase and the absence of the typical diffraction peak of the crystalline phase of SiO_2, suggesting that the species in the hybrid is in an amorphous form. The band gap values of the materials were calculated from UV-Vis diffuse reflectance spectroscopy data. Photocatalytic tests were conducted with methylene blue under solar radiation for 60 min, using nine transparent 10 mL penicillin vials, 5.3 cm in height and 2.5 cm in diameter, each containing 5 mL of 10^{-5} mol L^{-1} methylene blue solution, for each set of three vials, different masses of 5, 10, and 20 mg of the synthesized photocatalyst were added. The decolorization rate was evaluated by electronic absorption spectroscopy, analyzing the decrease in absorbance after the test. All obtained hybrid photocatalysts showed more significant activity compared to pure TiO_2. The highest activity was recorded for the Ti-Si (60:40) sample, with a decolorization rate of 95% after 60 min of testing. The tests demonstrated the photocatalytic efficiency of the synthesized materials, in addition to being active under solar radiation, leading to lower industrial costs by not requiring electric energy during the photocatalytic process.

Acknowledgments: UFRPE; UFPE; LaMTESA; FACEPE.