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Cationic Dye Degradation and Real Textile Wastewater Treatment by Heterogeneous Photo-Fenton, Using a Novel Natural Catalyst

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Abstract: A photo-Fenton process using a local iron oxide as a natural catalyst was compared to Fenton and UV/H_2O_2 advanced oxidation processes for degrading crystal violet (CV) dye in aqueous solutions. The catalyst was characterized by transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDX), Fourier transform infrared spectroscopy (FT-IR), Raman spectrum, X-ray diffraction (XRD), UV-vis spectroscopy, and Brunauer–Emmett–Teller (BET) analysis. The optical properties proved that the catalyst represents a good candidate for photocatalytic activity. The impact of different parameters (catalyst dose, initial CV concentration, initial H_2O_2 concentration, pH) on the photo-Fenton efficiency was evaluated. A photo-Fenton process operated under UVC light irradiation, at spontaneous pH, with 1.0 g/L of catalyst and 30 mg/L of H_2O_2 was the most effective process, resulting in 98% CV dye removal within 3 h. LC-MS and ion-chromatography techniques were used to identify demethylated organic intermediates during the process. Furthermore, a regeneration study of the catalyst showed its stability and reusability (after three treatment cycles, CV dye degradation decreased from 94% to 83%). Finally, the photo-Fenton process was tested in the treatment of real textile wastewater, and the effluent was found to be in compliance with standards for industrial wastewater disposal into sewerage.

Keywords: advanced oxidation processes; crystal violet dye; heterogeneous catalyst; iron oxide; regeneration; real wastewater

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1. Introduction

Dyes are organic compounds often utilized in the paper, plastic, pigment, cosmetic, and textile industries [1,2]. Textile factories produce wastewater characterized by a very low biodegradability, high amounts of surfactants, high chemical oxygen demand (COD), toxicity, highly fluctuating temperature and pH, and a strong color [3,4]. These textile effluents represent a serious problem for the environment, and even their degradation products may be toxic, thus threatening public health and aquatic organisms [5].

Several methods have been tested to remove dyes from water, including membrane separation [6], conventional coagulation/flocculation [7] and adsorption [8]. Unfortunately, these methods can only transfer pollutants from liquid to solid phase. Moreover, several dyes are not biodegradable, making a biological process alone not a suitable solution for textile wastewater treatment. Advanced oxidation processes (AOPs) are a possible solution for degrading bio-refractory pollutants. These processes promote the formation of highly reactive and non-selective oxidants species, such as hydroxyl radicals (•OH) that can degrade and mineralize recalcitrant compounds and eventually obtain non-toxic inorganic