

# Parametric study on the effect of the ratios $[\text{H}_2\text{O}_2]/[\text{Fe}^{3+}]$ and $[\text{H}_2\text{O}_2]/[\text{substrate}]$ on the photo-Fenton degradation of cationic azo dye Basic Blue 41

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An experimental parametric study was carried out to investigate the effects of  $[\text{H}_2\text{O}_2]$ ,  $[\text{Fe}^{3+}]$  and  $[\text{H}_2\text{O}_2]/[\text{Fe}^{3+}]$  ratio on the photo-Fenton degradation of an azo dye Basic Blue 41 (BB41) in aqueous solution. This method consists of coupling between Fenton's reagent and UV irradiation in order to catalyze the *in situ* generation of hydroxyl radicals, a powerful oxidizing agent which leads to degradation of organic pollutants until total mineralization. The kinetics study of the reaction between BB41 and hydroxyl radicals showed that the degradation of BB41 follows the first-order kinetics. It was found that the concentration of  $\text{H}_2\text{O}_2$  and ferric iron as well as their ratio  $[\text{H}_2\text{O}_2]/[\text{Fe}^{3+}]$  are key factors governing the removal of BB41 in aqueous medium and that the optimal ratio  $[\text{H}_2\text{O}_2]/[\text{Fe}^{3+}]$  is equal to 10 for 0.2 mM  $\text{Fe}^{3+}$  concentration. The initial BB41 concentration and the  $[\text{H}_2\text{O}_2]/[\text{BB41}]$  ratio are also found as significant operating parameters on the mineralization efficiency. The optimization of the operating conditions permitted to obtain a quasi-total mineralization of synthetic BB41 aqueous solutions. When these optimal conditions were applied to the real wastewater, 90% of TOC removal was obtained after 8 h of irradiation time.

**Keywords:** Advanced oxidation process, photo-Fenton, azo dye, hydroxyl radicals, mineralization, TOC.

## Introduction

Azo dyes are characterized by the presence of one or more azo bonds ( $-\text{N}=\text{N}-$ ) and represent the most important group of the synthetic dyes,<sup>[1]</sup> used in textile-processing and other industries such as food, cosmetics and paper manufacturing. They are designed to convey high photolytic stability and resistance towards major oxidizing agents.<sup>[2]</sup> Large amounts of dyes are discharged into the natural water from dye manufacturing plants and textile dyeing process effluents. In many cases, the concentrations at ppm level can produce an obvious coloration of water which prevents the transmission of the light and consequently the photosynthesis thus resulting in ecological imbalance.<sup>[3]</sup> On the other hand, several dyes metabolites have been reported as substances having potentially carcinogenic, mutagenic and/or teratogenic effects on aquatic life and, through bioaccumulation, on human health.<sup>[4]</sup> Thus, the removal of the dyes

from aqueous effluents is of significant environmental importance.

Different conventional methods such as biological degradation,<sup>[5]</sup> chemical oxidation,<sup>[6]</sup> coagulation-flocculation,<sup>[7]</sup> adsorption and reverse osmosis,<sup>[8]</sup> were employed for treating dye-containing wastewaters. These methods are usually ineffective in removal of toxic and persistent pollutants.<sup>[9]</sup> Physical separative methods are not destructive. Biodegradation of dyes may be selective and/or incomplete. Some dyes having aromatic structure and/or their metabolites are often recalcitrant to biological processes. Moreover, some biodegradation products are even more toxic than the mother dye molecules.<sup>[10]</sup>

In recent years, there is a great interest for so-called advanced oxidation processes (AOPs) which constitute an attractive alternative to treating wastewater containing toxic and persistent pollutants. They are based on the *in situ* generation of a powerful non specific oxidizing agent, the hydroxyl radical ( $\cdot\text{OH}$ ) which is able to oxidize a broad range of organic pollutants quickly and non-selectively.<sup>[11]</sup> There are several methods for generating  $\text{OH}\cdot$ ,<sup>[12]</sup> such as Fenton's reagent,<sup>[13,14]</sup>  $\text{H}_2\text{O}_2$  photolysis,<sup>[15]</sup>  $\text{Fe(III)}$  photolysis,<sup>[16–18]</sup> anodic oxidation,<sup>[19,20]</sup> electro-Fenton,<sup>[21–24]</sup> and heterogeneous photocatalysis.<sup>[25,26]</sup> Among them, the photo-Fenton

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