Effects of system parameters and inorganic salts on the photodecolourisation of textile dye Reactive Blue 19 by UV/H_2O_2 process

Miljana D Radović[1], Jelena Z Mitrović[1], Danijela V Bojić[1], Milan D Antonijević[2], Miloš M Kostić[1], Rada M Baošić[3], Aleksandar Lj. Bojić[1]*

[1]*Department of Chemistry, Faculty of Science and Mathematics, University of Niš, Visegradska 33, 18 000 Niš, Serbia*
[2]*School of Science, University of Greenwich, Chatham Maritime, Kent, ME4 4TB, UK*
[3]*Faculty of Chemistry, University of Belgrade, Studentski trg 12, 11000 Belgrade, Serbia*

ABSTRACT

The photodecolourisation of textile dye Reactive Blue 19 (RB 19), an anionic anthraquinone dye of the reactive class, was investigated using UV radiation in the presence of H_2O_2 in a batch photo-reactor with low-pressure mercury lamps. The effects of the system parameters: initial pH, initial dye concentration, concentration of peroxide and radiation intensity, as well as the presence of salts, (NaCl, Na_2SO_4, $NaNO_3$, NaH_2PO_4) on dye decolourisation was examined. Increasing the initial pH resulted in an increase in decolourisation efficiency. Results showed that with an increase of dye concentration from 10 to 100 mg·ℓ$^{-1}$, the efficiency of the process decreases. The highest decolourisation rates were noted at H_2O_2 concentrations of approximately 30 mmol·ℓ$^{-1}$. The increase of radiation intensity from 730 to 1 950 μW·cm^{-2}, linearly increases decolourisation efficiency. The inorganic ions investigated have inhibiting effects on RB 19 decolourisation by the UV/H_2O_2 process with inhibition intensities in the following order: $H_2PO_4^- > NO_3^- > SO_4^{2-} > Cl^-$. This study has shown that the UV/H_2O_2 process is a promising technology for degradation of RB 19 in water and wastewater.

Keywords: UV/H_2O_2 process, Reactive Blue 19, decolourisation, inorganic salts

INTRODUCTION

In the textile industry, the dyeing process produces large quantities of wastewater with intense colouration that has to be eliminated before release into the environment. Wastewaters from the textile industries contain different types of synthetic dyes, which are mostly toxic, mutagenic and carcinogenic (Zollinger, 2003; Song et al., 2008). There are many structural varieties of dyes, such as azo, anthraquinone, phthalocyanine, direct, reactive, dispersive, acid, basic, neutral and metal complexed. The three most commonly used groups of dyes are azo, anthraquinone and phthalocyanine (Ghodbane et al., 2010). There are a number of reasons why reactive dyes are the most often used in the dyeing process, e.g., good stability during washing, and relatively simple dyeing procedures (Kurbus et al., 2002; Muruganandham et al., 2004). These dyes are the most common in use today especially for dyeing of wool and cellulosic fibres such as cotton. Reactive dyes, which have good water solubility and are easily hydrolysed into insoluble forms, are extensively used in dyeing processes, and about 20–40% of these dyes remain in the effluent (Armagan et al., 2003). Thus, an effective and economical technique for removing reactive dyes from textile wastewater is needed.

In past decades, some techniques such as adsorption, membrane separation, coagulation, chemical oxidation, and electrochemical degradation have been investigated to treat dyeing wastewater. However, low removal efficiency or high cost in operation often limits their application (Wang et al., 2008). In recent years, advanced oxidation processes (AOPs) have been developed to treat the contaminants of natural water and industrial effluents. Earlier studies have shown that anthraquinone dyes can be removed by ozone (Kunc et al., 2002; Chen et al., 2009; Fanchiang et al., 2009), the combination of ozone and ultrasound, or electrochemical degradation in natural waters and effluents from the textile industry (He et al., 2008; Kim et al., 2002; Rajkumar et al., 2007). TiO_2 and TiO_2-based catalysts were used for the photodegradation of anthraquinone dyes (Saquib et al., 2002; Lizama et al., 2002). Colonna et al. (1999) reported that homogenous advanced oxidation processes employing hydrogen peroxide with UV light lead to complete decolourisation and mineralisation of sulphonated azo and anthraquinone dyes. This process is based on the generation of hydroxyl radicals (•OH), and a strong oxidising agent ($E^0 = 2.8$ V), which degrade a broad range of organic pollutants quickly and non-selectively (Muruganandham et al., 2004; Aleboyeh et al., 2005; Daneshvar et al., 2005). Reaction of hydroxyl radicals generated in the presence of an organic substrate may occur via one of three general pathways: (i) hydrogen abstraction; (ii) electrophilic addition and (iii) electron transfer (Daneshvar et al., 2005). The method is inexpensive and non-toxic for treatment of water (Bilgi et al., 2005).

For practical application of the UV/H_2O_2 process for treatment of dye-contaminated wastewater, it is important to determine the optimal experimental conditions. In this paper, the effects of initial pH, initial dye concentration, initial concentration of H_2O_2 and the presence of inorganic salts on decolourisation of reactive dye C.I. Reactive Blue 19 (RB 19) by UV radiation in the presence of hydrogen peroxide were examined.

* To whom all correspondence should be addressed.
☎ +381 63 106 40 16; Fax: +381 18 533 014;
e-mail: bojica@pmf.ni.ac.rs

Received 9 November 2012; accepted in revised form 25 June 2014.

http://dx.doi.org/10.4314/wsa.v40i3.21
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 3 July 2014
ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 3 July 2014