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Kinetics of tartrazine photodegradation by UV/H_2O_2 in aqueous solution

Petruta Oancea, Viorica Meltzer*

Department of Physical Chemistry, Faculty of Chemistry, University of Bucharest, Bd. Regina Elisabeta, 4–12, Bucharest 030018, Romania

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In the present work, kinetics of tartrazine decay by UV irradiation and H_2O_2 photolysis, and the removal of total organic carbon (TOC) under specific experimental conditions was explored. Irradiation experiments were carried out using a photoreactor of original design with a low-pressure Hg vapour lamp. The photodegradation rate of tartrazine was optimised with respect to the H_2O_2 concentration and temperature for the constant dye concentration of 1.035×10^{-5} M. Tartrazine degradation and the removal of TOC followed the pseudo-first-order kinetics. The much higher k_{obs} value for tartrazine degradation (7.91×10^{-4} s^{-1}) as compared with the TOC removal (2.3×10^{-4} s^{-1}) confirmed the presence of reaction intermediates in the solution.

Keywords: tartrazine, dyes, photodegradation, advanced oxidation process (AOP), water treatment

Introduction

Synthetic dyes are complex aromatic compounds that are rather difficult to degrade. These highly structured organic substances are widely used in textile and food industries. Azo dyes, characterised by the presence of one or more azo groups (R_1—N═N—R_2) (Khehra et al., 2006) represent about 60–70 % of all synthetic dyes produced worldwide. They are resistant to biodegradation under aerobic conditions (Pagga & Taeger, 1994). A wide range of methods for the removal of synthetic dyes from aqueous solutions, including physical adsorption, electrochemical oxidation, chemical oxidation, and chemical coagulation/precipitation, have been proposed (Daneshvar et al., 2002, 2003; El Qada et al., 2008). These methods are not destructive and they only transfer the pollutant from one phase to another. One promising method consists in the use of advanced oxidation processes (AOPs) involving the generation of highly reactive oxygen species ($HO^{\bullet}$) in sufficient quantities to oxidise the majority of organic compounds in waste water (Da Silva et al., 2011; Gupta et al., 2012a, 2012b).

Over the past 20 years, numerous publications recommended UV/H_2O_2 as an effective process for the removal of pollutants from aqueous solutions (El-Dein et al., 2003; Behnajady et al., 2004; Shu & Chang, 2005; Daneshvar et al., 2004). H_2O_2 is an environmentally friendly oxidant and the UV/H_2O_2 process has several advantages such as no sludge production, simplicity of operation, and low cost.

Tartrazine (known as E102, C.I. 19140, or FD&C Yellow 5) is a synthetic lemon yellow azo dye used as food colourant, in cosmetics and in the textile industry. Out of all azo dyes, tartrazine seems to cause the most allergic and intolerance reactions, particularly among asthmatic patients and those with aspirin intolerance (Alvarez Cuesta et al., 1981).

There are very few studies concerning tartrazine degradation. Salem and Gemeay (2000) examined the oxidation kinetics of tartrazine with peroxydisulfate in the presence and absence of Ag(I) and Fe(III) catalysts and observed higher tartrazine conversion in alkaline media. Fragoso et al. (2009) investigated the

*Corresponding author, e-mail: viomel@gw-chimie.math.unibuc.ro