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Visible active metal decorated titania catalysts for the photocatalytic degradation of Amidoblack-10B

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HIGHLIGHTS

- Visible active photocatalysts with $E_g < 3.2$ eV were synthesised by simple technique.
- 100% decolourisation of dye was observed in shorter time for Ru/TiO_2 (1%).
- Optical response in visible region was found to be higher for M/TiO_2 than bare TiO_2.

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ABSTRACT

In order to get high degradation efficiency in the visible region, different concentrations of active transition metals such as nickel and ruthenium were impregnated over titania synthesised by sol–gel method. The physico chemical properties of the catalysts were studied by various instrumental techniques such as X-ray diffraction, UV–visible diffuse reflectance spectroscopy, BET surface area analysis, Transmission Electron Microscopy, FT-IR spectroscopy, Raman Spectroscopy and X-ray photoelectron spectroscopy. The photocatalytic decolourisation/degradation of a widely used dye namely Amidoblack-10B was studied over metal loaded titania under both UV and visible light irradiations and monitored by using UV–visible spectrophotometer/TOC analyser. Photocatalytic activities of bare and metal titania catalysts were compared. The optimised reaction parameters for the complete decolourisation of AB-10B over bare titania under UV irradiation were found to be: 0.15 g of TiO_2, 3×10^{-4} M [AB-10B] at its natural pH. Among the catalysts, Ni/TiO_2 (1%) and Ru/TiO_2 (1%) decolourised completely 100% at 330 min and 210 min with rate constant values of 9.39×10^{-3} min^{-1} and 2.3×10^{-2} min^{-1} respectively. Both nickel and ruthenium were found to be recyclable upto 3 cycles without any loss in their photocatalytic activities. The extent of degradation of Amidoblack-10B and its mineralisation were confirmed further by HPLC.

1. Introduction

Among one million tons of dyes produced worldwide every year, azo dyes —(N=N)— represent nearly half and hence these dyes are the largest and most important of all commercial dyes used in textile, leather, pharmaceutical, cosmetics and printing industries [1–4]. These industries release substantial amount of azo dyes during various processes posing potent toxic threat to both aquatic organisms and human health and hence is a major concern for the industries [5–9]. In the past two decades, increased attention has been paid to mitigate this ecological problem. To abate this problem several conventional methods have been employed and reported elsewhere but most of them are non-destructive leading to the production of secondary waste products [10–12]. Azo dyes are generally resistant to degradation under aerobic conditions [13–15]. Amidoblack-10B (AB-10B) is dark red to black in colour and highly soluble in water. Due to its intense colour and anionic in nature AB-10B has been employed widely in all the industries. Since the effluents from textile industries contain 10–100 mg of AB-10B, its destruction by a cleaner technique carries significance [16]. The structure and other chemical information about AB-10B is given in Table 1.

Advanced Oxidation Process (AOP) is the best alternative technique to mineralise dyes and other harmful organic compounds present in industrial effluents. Among the different AOPs, photocatalytic treatment using titania based catalysts is a preferred technique. Although titania photocatalyst is the best candidate due to its photo stability, oxidation abilities and availability, it requires ultraviolet irradiation to generate holes and electrons [17–21].

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