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Degradation of Acid Blue 29 in visible light radiation using iron modified mesoporous silica as heterogeneous Photo-Fenton catalyst

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ABSTRACT

The evaluation of heterogeneous Fenton degradation on dye pollutant, Acid Blue 29 (AB29), has been investigated. The solid catalyst prepared by both sol–gel and incipient wetness impregnation methods was developed by occlusion of Fe^{3+} ions on synthesized mesoporous silica from sodium silicate. The prepared catalysts were characterized for their textural and surface morphology. High concentration of soluble metal precursor with 8.0 wt% Fe^{3+} can be easily deposited on silica. The results showed that the Fe-SiO_2 catalyst demonstrated good performance in the degradation of 50 ppm Acid Blue 29 (AB29) which was nearly completed in 100 min under visible light irradiation with optimum operating conditions at 0.4 g Fe-SiO_2/L, pH 3.0 and 10 mM H_2O_2. A possible mechanism on visible light irradiated Fenton process was proposed. The catalyst is reusable over four consecutive cycles and minimal leaching of iron ions (<0.5 ppm) was observed.

1. Introduction

There are a number of industrial textile chemical wastes which due to their negative effects on the environment and human health are worth mentioning in order to proffer suitable removal or treatment methods to safeguard both the aquatic and terrestrial life. Generally, the textile industry uses water as the principal medium for the removal of impurities in application of dyes and finishing agents during their mainstream operations. Thus, the main concern is about constant discharged of untreated dye effluent from the processing units to the surrounding water streams making it highly polluted with toxics and recalcitrant substances. This requires efficient wastewater treatment technology that is adequate to alleviate this problem and has attracted attention of many researchers in recent times. Advanced oxidation processes (AOPs) are capable of generating highly reactive radicals to disrupt a large number of hazardous pollutants without selection [1].

Homogeneous Fenton process (H_2O_2 in the presence of added iron ions), which also could generate highly reactive oxidising species >OH radicals has capability to destroy various pollutants present in the aqueous effluents discharges and its outstanding catalytic performance has been reported in the past decade [2]. However, catalyst loss due to formation of sludge as a result of the precipitation of iron hydroxide is often observed and also, operating at tight acidic pH range poses a major drawback [3]. These drawbacks can be overcome by using heterogeneous catalytic oxidation in the Fenton system, which often incorporates the iron ions or iron oxides into the catalyst support. In contrast to the homogeneous process, heterogeneous system provides the possibility to recover and reuse solid iron catalyst and operates in broader pH range [4].The criteria for the choice of catalyst support are mainly based on availability, cost and the composition of the support to be applied for the decomposition of H_2O_2 and for the pollutants to be degraded. To suit this purpose, various support materials such as zeolite [1,5], clay [6–8], silica [9], activated carbon [10], alumina [11], cation exchange resin [12], among others have been previously employed for the iron catalyst anchor in heterogeneous Fenton process.

In this work, silica was chosen as catalyst support to deposit the iron ions. Previously, tetraethyl orthosilicate (TEOS) or tetramethyl orthosilicate (TMOS) used as silica sources by many researchers [13–15] sussessfully desmostrated the higher catalytic activities; but the accompanied demerits in terms of solvent consumption among others make it rather complex. Similarly, when TEOS and TMOS are used, they are partly immiscible in the aqueous solution and require an intermediate medium such as alcohol or *n*-hexane and/or solvent modification in sol–gel preparation; this constitutes a lot of chemical wastages at the end of catalyst preparation process [14–16]. The current work studied an independent method to synthesize a mesoporous silica support using sodium silicate as silica precursor. A thorough review of literature revealed that the Fenton catalytic performance using this precursor and incorporation of iron ions into this silica to form composite silica matrix have not been reported. Thus, the development and performance of this

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