Influence of various aromatic derivatives on the advanced photo Fenton degradation of Amaranth dye

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ABSTRACT

The photo degradation of Amaranth (AR) dye by advanced photo Fenton process in the presence of symmetrical peroxides like hydrogen peroxide (H₂O₂) and ammonium persulfate (APS) are investigated. The influence of various reaction parameters like the effect of iron dosage, concentration of H₂O₂/APS, initial dye concentration, effect of pH and the influence of various aromatic derivatives were studied and optimum conditions are reported. The efficiency of the oxidant was strongly influenced by the nature of aromatic photoproduits formed during the course of the degradation reaction. To study their effect on the rate of degradation these aromatic derivatives were added in known concentration (10 ppm). The influence of various aromatic derivatives on the degradation kinetics shows the following order: hydroquinones→chlorophenol→chlorobenzene→aromatic carboxylic acids→aniline→nitrophenol. The addition of these derivatives did not influence the degradation pathway although it altered the reaction rate. The percentage COD and TOC removal were determined in presence of aromatic derivatives to evaluate the complete removal of the pollutant. Based on the intermediates obtained in the UV–vis and GC-MS spectroscopic techniques probable degradation mechanism has been proposed.

1. Introduction

Zero-valent metallic iron (ZVMI) has been used as a potential catalyst for the efficient production of hydroxyl radicals in Fenton/photo-Fenton process to degrade many pollutants [1–6]. The homogeneous Fenton and photo Fenton process have also been widely used for the degradation of organic contaminants [7–11]. Many researchers have investigated the applications of iron incorporated zeolites (sodium-alumino silicates) [12], ferihydrate, crystalline goethite [13] and semi crystalline Iron oxide [14] as catalytic material for the oxidation of organic pollutants. Lucking et al. [15] tested the catalytic properties of iron powder, graphite and activated carbon for the oxidation of 4-chlorophenol in aqueous solution with hydrogen peroxide. They concluded that fine metallic iron powder could be used to replace the iron salts as a catalyst in the Fenton reactions. From the environmental point of view, the advantage of using ZVMI instead of iron salts is that, the concentration of the iron ions in the wastewater after the treatment can be significantly reduced. Moreover, use of ZVMI as catalyst instead of iron salts prevents the additional anion loading in the treatment of wastewater. The residual iron powder can be easily removed after the treatment and can be easily recycled [10].

The efficiency of the Fenton process critically depends on the regeneration of ferrous ions in the solution. Any reaction that promotes the reduction of Fe³⁺ ions would accelerate the Fenton reaction. In this regard, ZVMI is used as a source of Fe²⁺ ions in the photo Fenton process. The higher activity of ZVMI was attributed to the faster reduction of Fe³⁺ ions on the iron surface [16,17]. The addition of oxalic acid and aromatic derivative like hydroquinone was found to have catalytic action for the reduction of Fe³⁺ ions (Eq. 1) thereby accelerating the reaction [18–20]. Since most of the dye waste water contains various aromatic phenolic compounds, a detailed study of their influence on the photo Fenton process would be of great importance. In view of this, we report the degradation of Amaranth (AR) influenced by the presence of various kinds of aromatic phenol derivatives, the effect of oxidant concentration, catalyst loading, effect of pH, influence of hydroxyl radical scavenger and the initial concentration of the dye on the degradation rate using ZVMI as the catalyst in the Photo-Fenton process. Though H₂O₂ is extensively used in Fenton’s process, very few attempts have been made towards the use of peroxy disulfate as an oxidant. In view of this, the main focus is on two aspects i) influence of aromatic derivatives on the rate and mechanism of photodegradation of AR, and ii) utilization of ammonium persulfate (APS) which is also a symmetrical peroxide like hydrogen peroxide in the Fenton’s and photo-Fenton’s process.

2. Materials and methods

2.1. Materials

Amaranth (AR), iron powder (100 mesh size, electrolytic), ammonium persulfate (APS), hydrogen peroxide (50%), NaCl, Na₂SO₄, Catechol (CH), Resorcinol (RH), Hydroquinone (HQ), p-chloro phenol...