Photo-degradation of di azo dye Bismarck Brown by advanced photo-Fenton process: Influence of inorganic anions and evaluation of recycling efficiency of iron powder

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ABSTRACT

The present research work has demonstrated the usage of zero valent metallic iron (ZVMI) in the photo-Fenton process under UV light as a promising and novel technique for the complete degradation of di azo dye Bismarck Brown (BB) in aqueous medium. The influence of various reaction parameters like concentration of oxidant/iron powder and pH of the solution was investigated and optimum conditions are reported. Ammonium persulfate (APS) proved to be better oxidant in comparison with hydrogen peroxide for enhancing the degradation rate and effectively inhibited the precipitation of iron hydroxides at higher dosages of iron powder which is attributed to the acidity provided by APS which is crucial for Fenton process. The rate constant for the kinetics of degradation using various oxidation processes follows the order: Fe⁴⁺/APS/UV > Fe⁴⁺/H₂O₂/UV > Fe⁴⁺/APS/dark > Fe⁴⁺/UV > Fe⁴⁺/H₂O₂/dark > Fe⁴⁺/dark > H₂O₂/UV > APS/UV. The effects of inorganic anions that are commonly found in the industrial effluents like NaCl, KNO₃, Na₂SO₄, Na₂CO₃ and NaHCO₃ at different concentrations on the degradation rate were studied in detail. The degradation was followed by UV-vis and GC–MS techniques.

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1. Introduction

Pollution of water by dyes is a serious problem and the removal of these dyes from wastewater is a challenge to the related industries. These synthetic dyes are stable compounds and are difficult to remove by common treatments. For the treatment of wastewater containing dye, traditional methods such as flocculation, carbon adsorption, reverse osmosis and activated sludge processes have difficulties in the complete destruction of dye pollutants and has further disadvantage of generating secondary pollution. Photo-Fenton process based on the generation of hydroxyl radicals in situ is proved to be effective way for the removal of organic pollutants in wastewater treatment (Neamtu et al., 2003; Ntampegbiotis et al., 2006; Zhao et al., 2004). However the removal of sludge containing iron ions at the end of wastewater treatment is expensive and requires large amount of chemicals and needs extra manpower. Further, efficiency of the process is limited by the slow reduction of Fe₃⁺ to Fe²⁺ ions in the solution. Lucking et al. tested iron powder, graphite and activated carbon for the catalytic oxidation of 4-chlorophenol in aqueous solution with hydrogen peroxide (Lucking et al., 1998). They concluded that iron powder can be used to replace iron salts as a catalyst in the Fenton process which is commonly referred to as advanced photo-Fenton process (APFP).

In view of this, the present research focuses on the utilization of zero valent metallic iron powder (ZVMI) as the catalyst to mineralize synthetic dye Bismarck Brown (BB). However the disadvantage of using iron metallic powder is: (i) it requires acidic conditions; (ii) higher dosage of iron powder generates significant levels of Fe²⁺ ions which may cause secondary pollution; (iii) surface precipitation during the course of extended operation. To overcome these drawbacks, the present research aims at the use of low iron dosage and the experiments are designed to achieve complete mineralization of the BB in the desired time and thus avoiding the surface precipitation of the catalyst. The recycling efficiency of iron powder in the presence of hydrogen peroxide (HP) and ammonium persulfate (APS) is investigated.

It is well known that the dyeing processes requires the addition of inorganic salts to stabilize the color and these discharges from the dyeing baths and subsequent washing procedure contains both inorganic salts and residual dyes in the effluents. Since the reactive dyes have a lower affinity than direct dyestuffs, huge amount of inorganic salt is required when using reactive dyes in order to improve the affinity of the dyes and to enhance adsorption through “salting out” effect. The addition of these inorganic salts in the dye bath increases the pollution load in the effluent. In view of this, the influence of inorganic anions that are common in industrial effluents was explored at different concentrations.