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Decolorization of Rhodamine B by an Advanced Oxidation Process

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Abstract – Advanced oxidation process like; electro-fenton are promising technology for the treatment of wastewaters containing non-easily removable organic compounds. Rhoda mine B is a dye possess high toxicity and low degradability. The present study investigates the utility of electro-fenton process is one of the AOP Process for the degradation of Rhoda mine B from aqueous solution by the electro oxidation. Decolourization experiments were carried out under batch conditions with stainless steel as cathodes and RuO_2 coated titanium expanded mesh as anodes. Electrolysis was carried out with various current densities and flow rate using mediated electro chemical oxidation process with fenton mediator (Fe^{2+} / Fe^{3++} H_2O_2). Extent of decolourization was studied as a function of applied current, electrolysis time and concentration of ferrous ion. Remaining concentration of Rhoda mine B was found by spectrophotometry. The electrolysis was carried at optimised conditions to achieve efficiencies higher than 85%.

Keywords: Photo Catalytic Degradation, Rhoda Mine B, Electro-Fenton.

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1. INTRODUCTION

Environmental pollution has become a prime concern of scientists and researchers around the globe .Waste water discharged from different segments of society are one of the most prime causes of environmental pollution [1]. Industrial effluents from textile industry, dyes, pigment, leather, food, paper industries, etc., are the important source of water contamination. Disposal of dye pollutants mainly from the waste water generated by the textile industries is rated as one of the most polluting effluent among the entire industrial sectors [2]. It is estimated that 1–20% of the total world production of dyes is lost during synthesis and dying processes. Rhoda mine B dye is one the compound found in these industrial discharges at higher level. Rhoda mine B dye is non-biodegradable and can severe affect the human health as well as ecosystem.

The removal of Rhoda mine B dye from waste water has been given much attention in the last few decades by adopting different effective traditional and advance methods. Treatments methods include physical, chemical and biological treatment and Advance oxidation processes like H_2O_2/UV, H_2O_2/UV/O_3, H_2O_2/UV/TiO_2, H_2O_2/LED-UV, Fenton reaction, UV-Fenton and Microwave assisted photochemical and photo catalytic processes [3-8]. However, some advance techniques prove an efficient technique to remove some compounds but failed at higher level of contaminants.

Among the advanced oxidation processes (AOPs), electrochemical technologies are environment friendly, effective methods as they generate hydroxyl radicals (OH), either directly by anodic oxidation or indirectly at the cathode of an electro-Fenton process [8,9]. In the cathodic region, OH is formed according the following sequence.

$$O_2 + 2H^+ + 2e \rightarrow H_2O_2 \text{ (acidic)} \qquad 1(a)$$

O_2+2H_2 O+2e→H_2 O_2+2OH^- (neutral, basic) 1(b)

$$H_2O_2 + 2e \rightarrow 2 \cdot OH \qquad (2)$$

$$H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + \cdot OH \qquad (3)$$

The ·OH reacts unselectively with organic pollutants and mineralizes them into CO_2, H_2O and inorganic ions [10].

In this study, the degradation of Rhodamine B dye (200 ppm) by first type of electro-Fenton process, which uses Fe^{2+} and H_2O_2, photo-assisted electro Fenton process was done with using Fenton's reagent and mercury lamp.

2. MATERIALS AND METHODS

2.1 Raw materials and chemicals

All chemicals used here were analytical grade and without further purification. Rhoda mine B was supplied by S fine Chemicals Ltd. H_2O_2 (30 wt.%) was supplied by Merk india. The solution

pH was adjusted by using 0.1 M HCl or NaOH aqueous solution. Distilled water was used throughout the experiments. Stainless steel fiber felt ($Cr_{17}Ni_{14}Mo$) (10cm×10cm), used as cathode, was provided by Baosteel Group Corporation. RuO_2 electrode (5cm×8cm working area, on titanium mesh subtrate) was purchased from Northwest Institute of Non-ferrous Metal.

2.2 Experimental procedure

Experiments were carried out under galvanostatic condition at current density $1A/dm^2$, $2A/dm^2$, $3A/dm^2$ and $4A/dm^2$ using RuO coated titanium expanded mesh anodes and stainless steel as cathodes. Synthetic solution containing Rhoda mine B (150 ppm) is subjected to electrolysis in a batch recirculation reactor at fixed current density. Sodium sulphate solution (0.05 M) was used as an electrolyte solution. The fluid flow circuit consists of a reservoir, a magnetically driven self-priming centrifugal pump and an electrolytic cell. The electric circuit consists of a regulated DC power supply, ammeter and the cell with a voltmeter connected to the parallel to the reactor. The electrolyte was continuously stirred during the electrolysis using a magnetic stirrer. In order to generate the Fenton's reagent, the concentration of the mediator has been maintained at 0.25g/L and for the purpose of ºOH free radical, H_2O_2 was added at the rate of 1.5 mL/h. These experiments were carried out again in batch recirculation at different ferrous ion concentrations; namely 100 mg/L, 200mg/L, 300 mg/L, 400mg/L and 500mg/L.

2.3 Experimental setup

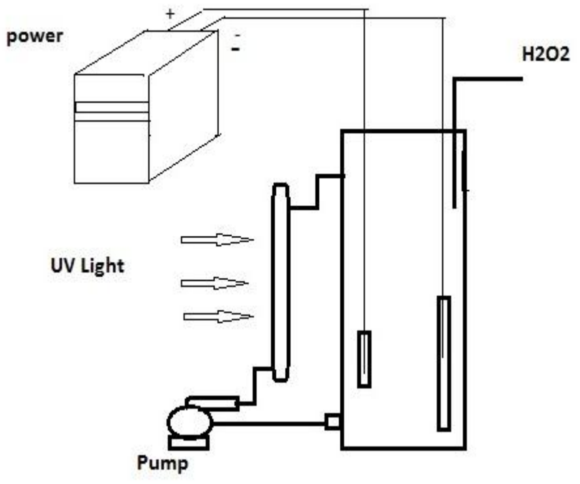

Figure 1: Schematic diagram of Electro-Fenton process.

2.4 Analytical methods

The remaining concentration of Rhoda mine B was determined for each sample by standard method and measuring the absorbance at 560 nm by UV-Vis Spectrophotometer (Nucon) and utilizing the calibration data. All the experimental run were repeated twice to maximize reliability of the data.

The degradation percentage was calculated by

$$y(\%) = \frac{C_0 - C_t}{C_0} \text{x}100 \qquad (4)$$

Where C_0 is initial and C_t is final concentration of Rhodamine B.

3. RESULTS AND DISCUSSION

3.1 Effect of electrical current

Effect of electrical current on Rhodamine B dye removal efficiency is shown in Fig.2. Apparently, the removal efficiency goes up when applied current increases from $1A/dm^2$ to $3A/dm^2$ indicating an enhancement on the degradation capacity. At higher current, the electro-regeneration of Fe is enhanced with the increasing of current, as a result, the efficiency of Fenton reactions and degradations of Rhodamine B are improved. However, further increase of electrical current to higher than $3A/dm^2$, causes lower dye removal efficiency, as we can see from Fig.2. When the current exceeds a certain value, it can be inferred that the competitive reactions on electrodes such as the evolution hydrogen at the cathode via reaction and the discharge of oxygen at the anode (Eq.1b) would become pronounced [11]. Consequently, the Rhodamine B degradation is inhibited at higher current intensity.

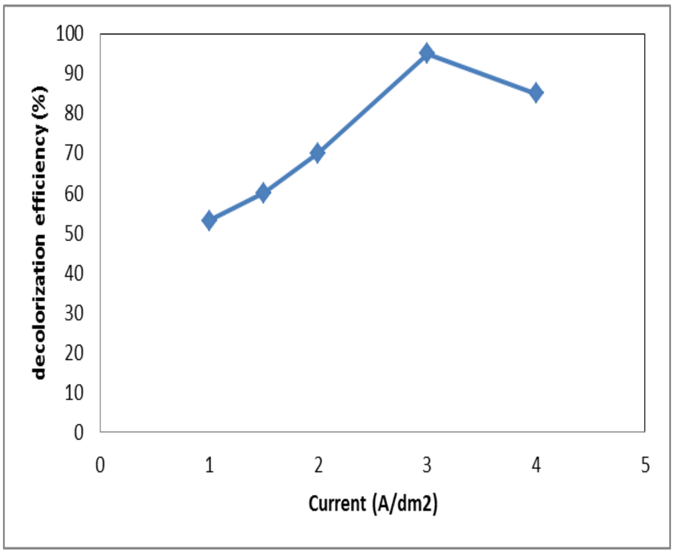

Figure 2: Effect of electrical current on decolorization efficiency.

3.2 Effect of electrolysis time

The degradation percentage always increases with increase in electrolysis time as can be seen from figure 2 and figure 3. Reaction time was investigated from 1 hr to 5 hr at all combination of concentration of H_2O_2 and catalyst dose. In all trial, increased percentage degradation was found. The reaction time reaches to its optimum at 6 hrs, thereafter no change in degradation efficiency was seen [12].

3.3 Effect of Initial Ferrous ion concentration

Catalyst dosage markedly influences heterogeneous Fenton reactions. Therefore, a series of experiments were carried out to investigate the influence of catalyst dosage on the decolorization of Rhodamine B, by varying the amount of ferrous ion from 100 mg/L, 200mh/L, 300 mg/L, 400mg/L and 500mg/L. In the electrolytic system, the Fenton reaction induced by the hydroperoxide and ferrous ions is the target reaction. However, the ferrous ions and ferric ions concentration are affected by both anodic and cathodic reactions. The results were shown in Fig. 3. The decolorization increased from 53.05% to 96.49% with the varying the catalyst. This phenomenon can be seen as increased Fenton's reagent concentration with increase in H_2O_2 flow rate. Hydroxyl radical can efficiently attack the chromospheres, thus increasing the decolorization rate of Rhodamine B [13].

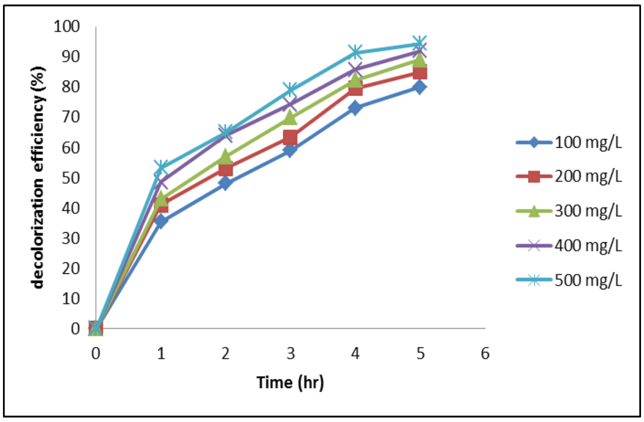

Figure 3: Effects of initial ferrous ion concentration.

4. CONCLUSIONS

From the study it can be concluded that electro-Fenton process is highly efficient in removal of Rhodamine B from aqueous solution. It has been found that, the extent of decolorization of Rhodamine B is a function of the applied current, electrolysis time and concentration of ferrous ion. The usage of electro-Fenton processes can be recommended for the decolorization of Rhodamine B at low concentrations, as the extent of degradation decreases when the concentration increases. The concentration of mediator was maintained at limited level in order to prevent the formation of stable complexes of ferrous ion with Rhodamine.

5. REFERENCES

[1]. N.K. Daud, B.H. Hameed, Decolorization of acid red 1 by Fenton-like process using rice husk ash-based catalyst, J. Hazard Mater. 176 (2010) 938–944.

[2]. X.C. Ruan, M.Y. Liu, Q.F. Zeng, Y.H. Ding, Degradation and decolorization of reactive red X-3B aqueous solution by ozone integrated with internal microelectrolysis, Sep. Purif. Technol. 74 (2010) 195–201.

[3]. L. Young, J. Yu, Ligninase-catalysed decolorization of synthetic dyes, Water Res.31 (1997) 1187–1193.

[4]. K. Tanaka, K. Padermpole, T. Hisanaga, Photocatalytic degradation of commercial azo dyes, Water Res. 34 (2000) 327–333.

[5]. W.Q. Gong, Q. Zhou, C.X. Xie, D.J. Yang, X.Q. Ling, X.A. Yuan, S.H. Chen, X.F. Liu, Removal of Neutral Red from aqueous solution by adsorption on spent cottonseed

hull substrate, J. Hazard. Mater. 185 (2011) 502–506.

[6]. A. Nezamzadeh-Ejhieh, Z. Banan, A comparison between the efficiency of CdS nanoparticles/zeolite A and CdO/zeolite A as catalysts in photodecolorization of crystal violet, Desalination 279 (2011) 146–151.

[7]. X.K. Wang, J.G. Wang, P.Q. Guo, W.L. Guo, C. Wang, Degradation of Rhodamine B in aqueous solution by using swirling jet-induced cavitation combined with H2O, J. Hazard. Mater. 169 (2009) 486–491.

[8]. Q.Q. Chen, P.X. Wu, Z. Dang, N.W. Zhu, P. Li, J.H. Wu, X.D. Wang, Iron pillared vermiculite as a heterogeneous photo-Fenton catalyst for photo catalytic degradation of azo dye reactive brilliant orange X-GN, Sep. Purif. Technol. 71 (2010) 315–323.

[9]. J. Farias, G.H. Rossetti, E.D. Albizzati, O.M. Alfano, Solar degradation of formic acid: temperature effects on the photo-fenton reaction, Ind. Eng. Chem. Res. 46 (2007) 7580–7586.

[10]. C.B. Molina, J.A. Casas, J.A. Zazo, J.J. Rodriguez, A comparison of Al–Fe and Zr–Fe pillared clays for catalytic wet peroxide oxidation, Chem. Eng. J. 118 (2006) 29–35.

[11]. S.F. Kang, C.H. Liao, M.C. Chen, Pre-oxidation and coagulation of textile wastewater by the Fenton process, Chemosphere 46 (2002) 923–928.

[12]. J.H. Ramirez, C.A. Costa, L.M. Madeira, G. Mata, M.A. Vicente, M.L. RojasCervantes, A.J. Lopez-Peinado, R.M. Martin-Aranda, Fenton-like oxidation of Orange II solutions using heterogeneous catalysts based on saponite clay, Appl. Catal. B-Environ. 71 (2007) 44–56.

[13]. J.H. Ramirez, F.J. Maldonado-Hodar, A.F. Perez-Cadenas, C. Moreno-Castilla, C.A. Costa, L.M. Madeira, Azo-dye Orange II degradation by heterogeneous Fenton-like reaction using carbon–Fe catalysts, Appl. Catal. B-Environ. 75 (2007) 312–323.