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Decolorization of Synthetic Dye Solution Containing Congo Red By Advanced Oxidation Process (AOP)

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ABSTRACT-*Decolorization of synthetic azo dye solution of Congo red dye, as an anionic dye was studied in a batch reactor using Advanced Oxidation Process (AOP). Congo red has been selected amongst azo dyes due to its high solubility in aquatic environment. AOP is effectively removing color in azo dye wastewater due to its strong oxidizing property by breaking down the functional group that impacting color on azo dye. AOP selected in this study was the ozonation. The effect of ozonation contact time on initial dye concentration, solution pH and the rate of decolorization were studied and the results were analyzed in terms of color removal efficiency. The color removal efficiency was found to increase with an increase the ozonation time and decrease with an increase in initial dye concentration of the synthetic dye solution. The result with Congo red synthetic dye solution showed that maximum decolorization around 90% was obtained at 25 min of ozonation.*

Keywords--decolorization; advanced oxidation process (aop); ozonation; batch reactor; congo red.

1, INTRODUCTION

Textile industry wastewater is considered as one of the major pollutant to the environment due to high discharge volume, organic/inorganic content and concentration of color and consumes large quantity of water and chemicals for various operations such as washing, drying, rinsing and finishing. The major pollutants in textile wastewater are Chemical Oxygen Demand (COD), Total Organic Compound (TOC), Biochemical Oxygen Demand (BOD), Suspended Solids (SS), Dissolved Solids (DS), pH, Chloride, Sodium, Sulphur and the colors caused by different dyes. Moreover, some chemicals including salts, acids, bases and buffers also find their way in the effluent [1-3]. The non-biodegradability of textile wastewater is due to the high content of dyestuffs, surfactants and other additives; it is difficult to treat by conventional technologies [4]. Advanced oxidation is one of the most powerful methods for decolorization of textile wastewater**.** Ozone is a strong oxidant which is able to form a more powerful, nonselective hydroxyl radical at high pH values due to its high oxidation potential [5-6].

The main objective of this manuscript is to explore the potential of Advanced Oxidation Process for the treatment of textile industry effluent, as a function of operating parameters for decolorization. In the present study, ozonation of Congo red azo dye solution was performed and the effect of ozonation contact time on initial dye concentration, solution pH and the rate of decolorization were studied and the results were analyzed in terms of color removal efficiency.

2, ADVANCED OXIDATION PROCESSES

Advanced oxidation processes (AOPs) have been proven to be powerful and efficient treatment methods for degrading recalcitrant materials or mineralizing stable, inhibitory, or toxic contaminants [7]. The main advantages of AOPs include the lack of byproducts of environmental concern, high process rate, efficiency and enhanced biodegradation [8-9]. Once generated the hydroxyl radicals can attack organic chemicals by radical addition (Eq. 1), hydrogen abstraction (Eq. 2) and electron transfer (Eq. 3). In the following reactions, R is used to describe the reacting organic compound.

$$R + HO\bullet \rightarrow ROH \quad (1)$$

$$R + HO\bullet \rightarrow R\bullet + H_2O \quad (2)$$

$$Rn + HO\bullet \rightarrow Rn\text{-}1 + OH^- \quad (3)$$

AOPs are capable of achieving desired color destruction of wastewater and it can completely oxidize organic pollutants to CO_2, water and salts [10]. Kang et al. (2000)[11] reported the removal of color from textile waters by •OH radical oxidation, markedly related with the amount of •OH formed at pH 3–5. Up to 96% of color was removed within 30 min.

Ozonation is one of the most attractive alternatives for decolorize dye wastewater. Ozone application generalized into two; a powerful disinfection and a strong oxidant to remove color and odor, eliminating trace toxic synthetic organic. Figure 1 shows the ozonation process. Ozone reacts in aqueous solution with various organic and inorganic compounds, either by a direct reaction of molecular ozone or through a radical type reaction involving the hydroxyl radical produced by the ozone decomposition in water. Ozonation is one of the most effective means of decolourizing dye wastewater and has been shown to achieve high color and effluent COD removal [12]. Ozonation can be useful for color removal and enhancement of biodegradability of ozonation byproduct [13].

3, MATERIALS AND METHODS

3.1. Preparation of Synthetic Azo Dye Solution

Congo red, as diazo dye used in this study was obtained from commercial market and used without any further purification. Congo red has been selected due to its high solubility in aquatic environment, which is difficult to decolorize by conventional coagulation/flocculation and physical adsorption processes. Congo red is a colored

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substance has complex chemical structures and high molecular weights ($C_{32}H_{22}N_6Na_2O_6S_2$; 696.66 g/mol). Figure 2 shows the chemical structure of Congo red. Initial dye concentration of synthetic Congo red dye solution was adjusted at 1500 mg/L at pH 10.

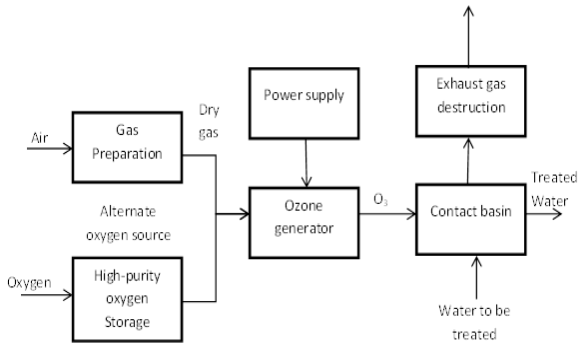

Figure. 1 The ozonation process.

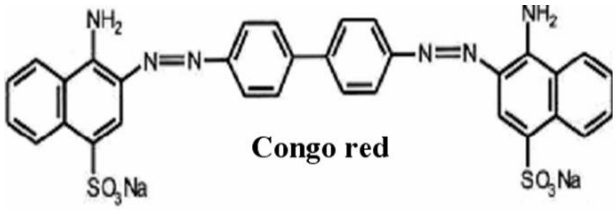

Figure. 2 Chemical structure of Congo red

3.2 Analytical Method

Ozonation of dye solution was carried out in a batch reactor. The ozone was produced by corona discharge type Ozone generator with flow rate of 5gm/hr from pure oxygen as feed gas. Oxygen was fed to the ozonator with a regulated pressure in the cylinder of 120 kg/cm^2, before entering the ozone generator cell. The oxygen gas was circulated through rotameter. Initial ozone concentration and ozone-oxygen flow rate was 55.5 mg/L and 1.5 LPM respectively. All the experiments were conducted at room temperature. Ozone concentration in feed gas was determined by KI starch titration method [14]. Decolorization of dyes sample were performed at certain time interval i.e. experiments were conducted consecutively for contact times of 5, 10, 15, 20, 25 minutes, and analyzed immediately. The synthetic dye samples were drawn at desired intervals to analyze the variations in pH, dye concentration and color, in the course of the experiments. Decolorization of dyes sample was measured with the aid of a UV-Vis Spectrophotometric analyses at the wavelength range of 200–700 nm were performed in order to measure the concentration of dye. The amount of ozone produced and consumed was determined by iodometric method describe in the Standard Methods for Examination of Water and Wastewater [15]. Color removal efficiency was determined by following equation:

$$R_{colour}(\%) = \left[\frac{C_{dye,\,o} - C_{dye,t}}{C_{dye,o}} \right] \times 100$$

Where C_{dye} (mg/L) is the dye concentration and 'o' and 't' correspond to initial time and sampling time, respectively.

4, RESULTS AND DISCUSSION

4.1 Ozonation effects on pH

In Figure 3 shows the variation in pH at 25°C with ozonation time for initial dye concentration of 1500 mg/L. This indicates that the initial pH values decreased rapidly with ozonation time, from 10±0.1 to 3.62 within 5 min and 3.61 to 3 in 25 min respectively. The variations in pH during ozonation are due to the formation of organic and inorganic acids. It can be noted that the generation of by-products of acidic nature (inorganic acids and organic anions), as a result of oxidation by ozone. The oxidation by ozone is directly affected by the solution pH observed by [16]. The pH is one of the major factors which affect treatment efficiency by ozonation.

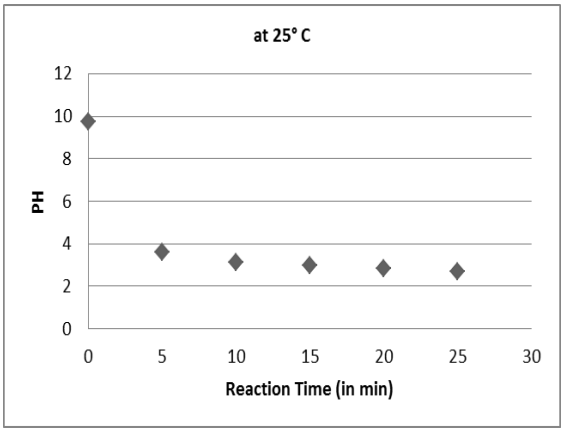

Figure. 3 The variation in pH at 25°C of Congo red dye solution

4.2 Ozonation effects on dye concentration

Figure 4 shows the results for the reduction in the dye concentration during ozonation of Congo red dye solution with an initial concentration of 1500 mg/L. it can be observed that for a longer ozonation times there is a greater reduction in the Congo red dye concentration. Ozonation times for 25 min an initial concentration of 1500mg/L result shows final dye concentrations of approximately 233mg/L are obtained, while for a shorter ozonation times less reduction in the dye concentration. For the degradation of high concentration Congo red dye molecules required longer ozonation time.

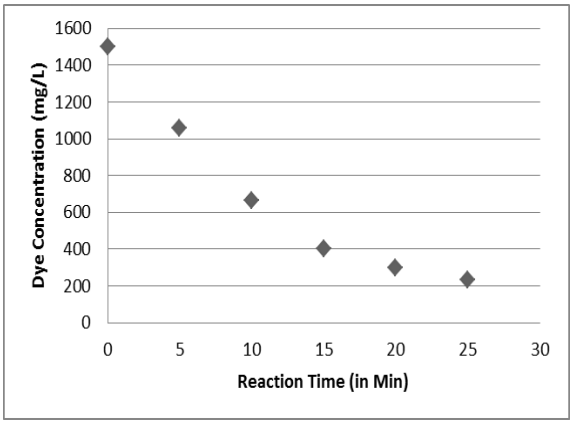

Figure. 4 Reduction of dye concentration of Congo red dye solution

4.3 Ozonation effects on the decolorization

Color removal efficiency of Congo red with ozonation contact time displayed in Figure 5. Analysis of the results indicated that ozonation contact time had a significant effect on color removal. It can be observed that the color reduction occurred very fast it achieving around 56% decolorization in 10 min. After 25 min treatment time, the color reduction reached up to 90%. On the other hand, in ozonation hydroxyl radical quickly oxidize color impacting functional group in azo dye, and consequently the azo dye is decolorized. The results obtained in the present study show that color disappears completely for Congo red dyes after 25 min of ozonation. So ozonation is a promising process for the degradation of the Congo red.

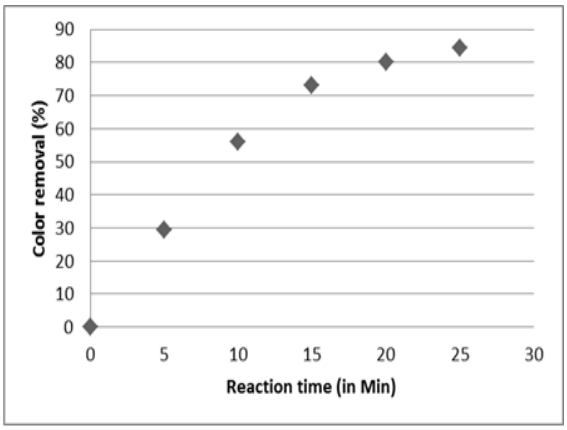

Figure. 5 Color removal rate of Congo red dye solution

V. CONCLUSIONS

Ozonation is one of the most effective treatment for decolorize dye wastewater. The conclusions from this study is that the initial pH values decreased with ozonation contact time, which is indicative of the generation of by-products with acidic nature (inorganic anions and organic acids) as a result of oxidation by ozone. Dye solutions with high dye

concentrations were found to decrease the color removal rate. The dyes concentration decrease with increase ozonation time. The maximum decolorization of Congo red takes place at alkaline condition, i.e., the indirect pathway of ozonation reaction. High color removal around 90% achieved at 25 min of ozonation.

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