

Treatment of Wastewater Containing Brilliant Orange H2R and Brilliant Red M5B by Electrocoagulation

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Abstract

Treatment of dyeing wastewater containing reactive Brilliant Orange H2R and Brilliant Red M5B dyes were investigated by using electrocoagulation process. The experimental results were analysed in terms of percent removal of dye with time. Electrocoagulation of dye containing wastewater was carried out in a two-electrode monopolar electrocoagulation cell using iron as sacrificial anode and 0.01 M NaCl as internal electrolyte in which the electrolyte concentration was maintained constant during the experiment. In electrocoagulation the effects of concentration of dye and applied current strength on dye removal efficiency were tested and found that both have significant effects on the electrocoagulation of dye from wastewater.

I. Introduction

Wastewaters from dyeing and finishing industries are significant sources of environmental pollution. The reactive dyes, which represent the largest class of dyes used in textile processing industries are mostly azo compounds. The azo compounds are formed with one or more several azo (N=N) bridges linking substituted aromatic structures. These dyes are chemically and photolytically stable, they exhibit a high resistance to microbial degradation and are highly persistent in natural environment. The release of these compounds into the environment is undesirable, not only for aesthetic reasons, but also because many azo dyes and their breakdown products are toxic and /or mutagenic for life.

Various physical, chemical and biological pre-treatment, main treatment and post-treatment techniques can be employed to remove color from dye-containing wastewaters¹⁻⁸. Physico-chemical techniques include membrane filtration, coagulation/flocculation, flotation, precipitation, adsorption, ion exchange, ion pair-extraction, ultrasonic mineralization, electrolysis, advanced oxidation (chlorination, bleaching, ozonization, fenton oxidation and photocatalytic oxidation) and chemical reduction. Biological techniques include bacterial and fungal biosorption and biodegradation in aerobic, anaerobic, anoxic or combined anaerobic/aerobic treatment process. Since many organic dyes are harmful to human beings, the removal of color from process or waste effluents becomes environmentally important. Due to the large degree of organics and stability of modern dyes, conventional physico-chemical and biological treatment methods are not completely effective for their removal. Furthermore, the treatment cost of the textile wastewater has been escalating fairly rapidly in recent years. Hence search for more cost effective treatment methods has always been an attractive area of research. One of the primary objectives of this study was to investigate the degradation of the two textile dyes Brilliant Orange H2R and Brilliant Red M5B by using in-situ electrocoagulation method with iron as 'sacrificial'

electrodes. Electrocoagulation technique is applied for treatment of inorganic as well as organic pollutants from wastewater. This is an innovative and inexpensive technique used for treatment of wastewater. With the proper technological design, EC can be applied to a broad spectrum of water and wastewater treatment systems. In the EC process, the coagulant is generated in situ by electrolytic oxidation of an appropriate anode material. In this process, charged ionic species- metals or otherwise – are removed from wastewater by allowing it to react (i) with an ion having opposite charge, or (ii) with floc of metallic hydroxide generated within the effluent.

II. Experimental

In the present research synthetic wastewaters containing two reactive textiles dyes Brilliant Orange H2R dye and Brilliant Red M5B were selected for investigations. The removal of dye from dye containing wastewater by electrocoagulation was carried out by using two electrode electrocoagulation cell (Fig. 1) containing Fe as 'sacrificial electrode (8 cm × 8 cm × 0.15 cm). This set up includes the electrode assembly, a DC power supply unit, a voltage stabilizer, a resistance box to regulate the current and a multimeter to read the current values. The concentrations of dyes in wastewater were determined spectrophotometrically. The iron-hydroxy adsorbent was produced in-situ to determine the % of dyes removed by electrocoagulation. The % of dye removed was calculated by using the following equation:

$$\% \text{ of dye removed} = (C_0 - C_t) / C_0 \times 100$$

where, C_0 and C_t are the initial concentration of the dye and concentration of the dye at time t after coagulation respectively. The experiments were carried out by varying the dye concentrations as well as by varying the current strength.

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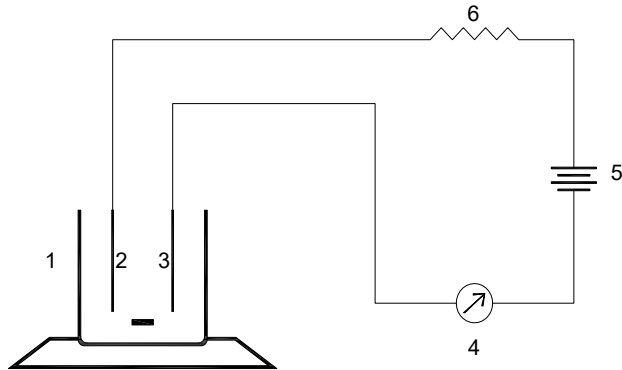


Fig. 1. Schematic diagram of the EC cell
 1. Pyrex beaker; 2. Anode; 3. Cathode;
 4. Ammeter; 5. D.C. source; 6. Variable resistance

III. Result and Discussion

In this series of experiments usually 200 mL of dye solution of definite concentration was used and 0.25 A current was applied. Sodium chloride (0.01 M) was used as internal electrolyte in all experiments. For Brilliant Orange H2R, the dye concentrations used were 10, 100, 200, 300 and 500 ppm and for Brilliant Red M5B the used concentrations were 300, 500 and 700 ppm. In the case of Brilliant Orange H2R two experiments were carried out by varying the current strength for 500 ppm. The results are shown in the Table 1

Table 1. Comparative data for the removal of Brilliant Orange H2R and Brilliant Red M5B with time.

[NaCl] = 0.01 M, Current = 0.25 A

Time/min	Percent removal						
	Brilliant Orange H2R				Brilliant Red M5B		
	200 ppm (pH=7.15)	300 ppm (pH=6.90)	500 ppm (pH=6.45)	500 ppm * (pH=6.45)	300 ppm (pH=4.29)	500 ppm (pH=4.18)	700 ppm (pH=3.68)
2	23.00	18.49	11.96	7.44	13.77	10.95	8.31
5	92.68	71.92	14.02	16.53	34.78	11.94	13.95
10	99.74	99.12	92.21	31.41	73.43	30.85	37.87
15	99.88	99.20	98.36	57.02	99.80	64.18	59.80
25		99.93	98.45	96.03	99.94	99.90	99.77
35			98.83	98.79		99.96	99.87
50			99.24	98.90		99.97	99.93

* Current used = 0.1 A

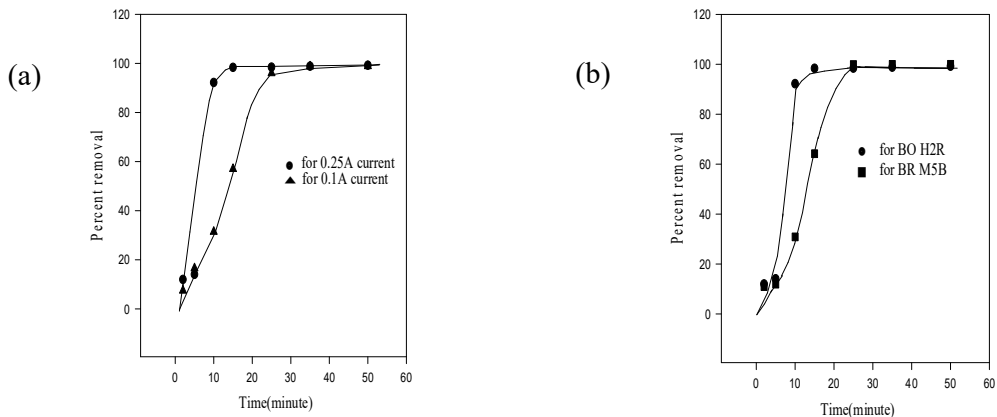
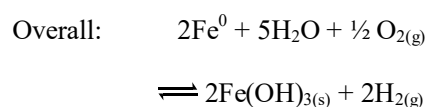
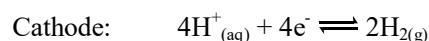
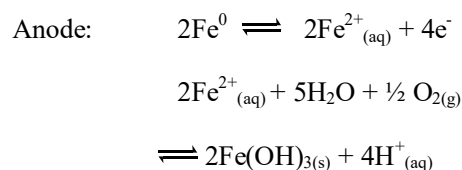


Fig. 2. Percent removal of Dye vs. time showing (a) effect of current strength for the removal of BO H2R in case of 500 ppm solution, and (b) comparison of the removal of BO H2R and BR M5B for 500 ppm solution.

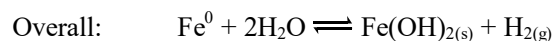
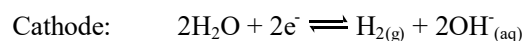
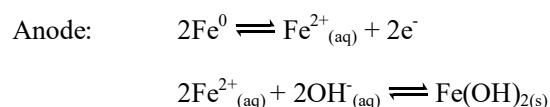
In the present experiments when EC was carried out for 200, 300 and 500 ppm Brilliant Orange H2R (BO H2R) it was observed that % removal of dye solution was increased with time and finally almost all dye was removed [Table 1]. This is because with time the rate of oxidation of anode material increase, so enhanced amount of coagulants formed in the solution become available for coagulation with dye molecules. When the EC experiments were carried out with 10 and 20 ppm BO H2R it was seen that almost all dye was removed within 2-5 minutes. But when the concentration was increased from 100 ppm to 200 ppm, the electrolysis period was exceeded to 10 minutes i.e. increasing the concentration of dye required increased electrolysis time for coagulation of BO H2R. The similar results were observed for 300 and 500 ppm BO H2R. The EC experiments were performed for 300, 500 and 700 ppm Brilliant Red M5B (BR M5B) keeping the EC condition unchanged and similar results were observed.

The mechanism of EC is not yet clearly understood, although it is believed that the coagulants in the present case are gelatinous suspension of $\text{Fe(OH)}_{n(s)}$ compound formed in-situ as a result of electrochemical process involving the 'sacrificial iron anode'. Two mechanisms have been proposed for the production of Fe(OH)_n ⁹⁻¹¹.

Mechanism I



Mechanism II



The $\text{Fe(OH)}_{n(s)}$ formed in the aqueous stream can remove the pollutants from wastewater either by complexation or by electrostatic attraction, followed by coagulation¹².

From the experimental results for 500 ppm BO H2R presented in Table 1, it was observed that when 0.1 A current was applied the removal efficiency of dye was much decreased with time interval in comparison to 0.25 A current [Fig. 2(a)]. The results indicate that with increasing current strength the coagulant formation rate increased and thus % removal of dye enhanced drastically. Finally from the comparative results for BO H2R and BR M5B with 500 ppm dye solution presented in Table 1 it was seen that in case of BO H2R removal efficiency was 11.96 % in 2 minutes and for BR M5B it was 10.95 % which is smaller in magnitude [Fig. 2(b)]. All other time intervals followed the same sequence. These results might be due to high concentration of BR M5B causing an altered range of pH for removal of BR M5B with coagulant¹³. These results showed that the removal of BO H2R was much easier than that of BR M5B.

IV. Conclusion

The treatment of reactive dyes Brilliant Orange H2R and Brilliant Red M5B by means of electrocoagulation was found to be affected by initial dye concentration and applied current strength during electrocoagulation. The results lead us to conclude that increasing the initial dye concentration require increased electrolysis time for electrocoagulation of dye and high current strength leads to an increase in percent removal of dye by electrocoagulation. Finally from the overall experimental results, taking into account the removal efficiency, electrocoagulation process can be considered as a promising process for reactive dye removal.

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