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Electrocoagulation of Navy Blue 3G Dye Wastewater: A Batch Study

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Abstract: ***Electrocoagulation treatment of simulated dye wastewater using aluminium electrode material has been studied in this paper. The effect of current density, electrolysis time and dye concentration has been investigated. Before these investigations effect on initial influent pH and NaCl dose on the EC process has also been investigated and further work was carried at optimized initial pH and NaCl dose. The results show that at highest studied current density, aluminium electrode showed complete removal of dye concentration after 90 min of treatment time.***

Keywords: Navyblue 3G, electrocoagulation, current density

1. Introduction

Coagulation is a conventional physico-chemical method of phase separation of pollutant from wastewater before its discharge in environment, where coagulating ions (Fe^{+3} or Al^{+3}) are added from outside. Electrochemical treatment technique can produce similar ions and effect by means of electrocoagulation method [1-5]. EC uses current to dissolve Fe, steel or Al sacrificial electrode submerged in polluted water. Current gives rise to different metal ion species (Fe^{+2}, Fe^{+3} or Al^{+3}) along with the release of hydroxide ion (OH^-) [4,6]. These species are coagulants or destabilizing agents that bring about charge neutralization for pollutant separation from the wastewater. The coagulated particles can also be separated by electroflotation when they are attached to the bubbles of H_2 gas evolved at the cathode and transported to the top of the solution where they can be separated [3,4].

High COD concentration, high pH,, temperature, strong color and lower biodegradable nature makes dye /textile wastewater disposal more challenging [7]. Adsorption, oxidation, conventional coagulation, biological treatment and flocculation are common treatments applied to dye wastewater [7]. All these conventional treatments have their own disadvantages. Coagulation can increase burden on sludge disposal, adsorption needs extra cost for regeneration of adsorbent, microbial treatments are inefficient for dye wastewater due to complexity and toxicity of waste. On the other hand EC process has been used successfully by several researchers during last one and half decade.

Current density, electrolysis time, initial dye concentration are the major process variables in EC process, along with these process variables initial pH of influent has significant effect on process. Thus, the aim of the study was to understand effect of all the variables and process variables on EC process. Effluent Dye concentration and color removal (%) are the two criteria taken into consideration.

2. Materials and Method

The experiments were performed on Navy blue 3G dye solution with varying initial concentrations from 50 mg/L to 150 mg/L. the working volume of dye solution was 500 mL. 115 mm x 100 mm x 100 mm acrylic reactor was used with Aluminium electrode of 90 mm x 75 mm x 5mm size. Interelectrode spacing was kept at 50 mm. one anode-one cathode assembly was used in a convention electrocoagulation cell. Effect of initial pH was investigated on varying initial pH from 1-9. While effect of NaCl dose was studied on varying it from 0-1000 mg/L. Effect of initial pH and NaCl dose were assessed based on color removal. While effect of current density was studied in a range from 1-10 mA/cm2 with electrolysis time from 0-90 min, effluent dye concentration (mg/L) and % color removal were taken as response parameters.

3. Results and Discussion

3.1 Effect of initial pH

Initial pH of the dye solution was varied from 1 to 9 as shown in Fig. 1, it has been observed that maximum color removal was achieved at initial pH 5, hence all further experimentation work was carried at 5 initial pH. Similar results have been obtained by Kobya et al, 2003 [8] for textile wastewater, where it has been mentioned that Al electrode works better under pH <6.

3.2 Effect of NaCl dose

On optimizing initial pH, further effect of electrolyte addition (NaCl) was studied as shown in Fig. 02. It is observed that maximum removal was achieved when, NaCl dose was absent and with increase in dose of electrolyte reduction in col

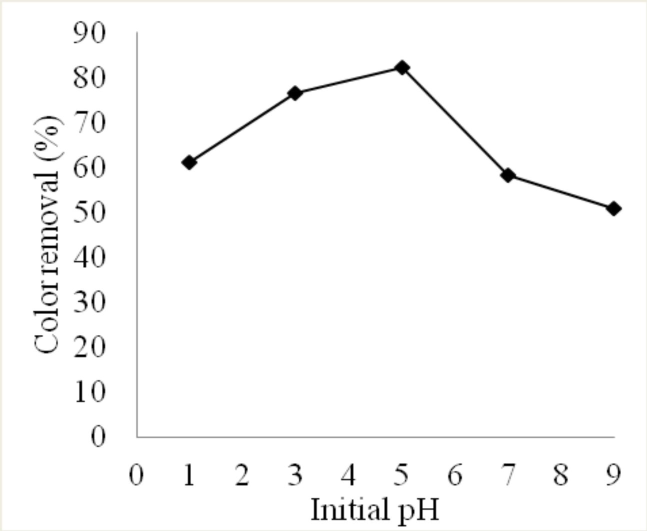


Figure 1: Effect of initial pH on color removal (%) (initial dye concentration: 50 mg/L, interelectrode distance: 50 mm, current density: 5 mA/cm^2)

or removal has been observed hence all further experimentation work was carried without adding NaCl dose. Literature reports good effect on NaCl addition on biodegradable pollutant removal efficiency due to formation of HOCl and OCl^- in the solution which are oxidizing agents [3]. While here reverse trend has been observed due to complexity of dye waste.

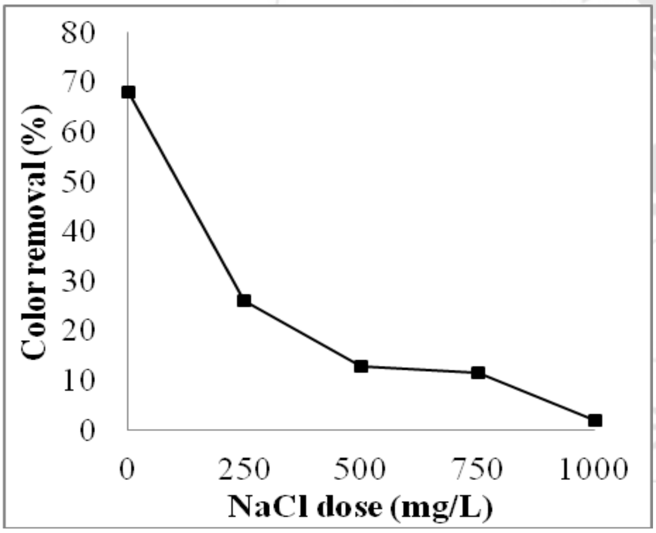
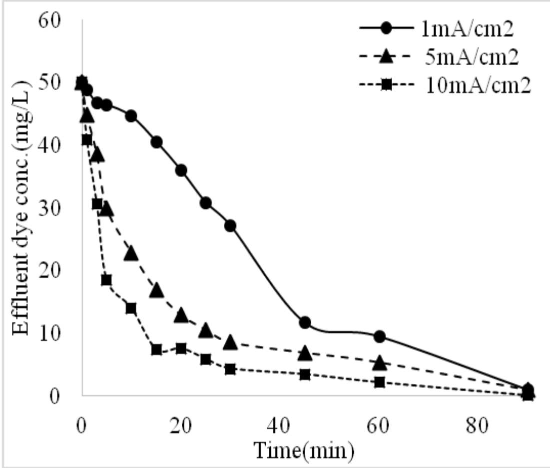


Figure 2: Effect of NaCl dose on color removal (%) (initial dye concentration: 50 mg/L, interelectrode distance: 50 mm, initial pH: 5, current density 5 mA/cm^2)

3.3 Effect of current density and time on dye and color removal

Fig. 03 and Fig. 04 show effect of current density and time on effluent dye concentration and color removal (%) respectively. At 50 mg/L initial dye concentration after 30 min electrolysis time 27.2 mg/L, 8.5 mg/L and 4.5 mg/L dye was observed in treated effluent for 1, 5 and 10 mA/cm^2 current density respectively. At 100 mg/L initial dye concentration



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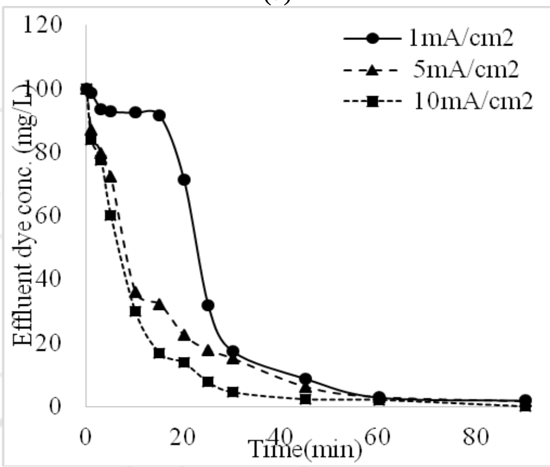

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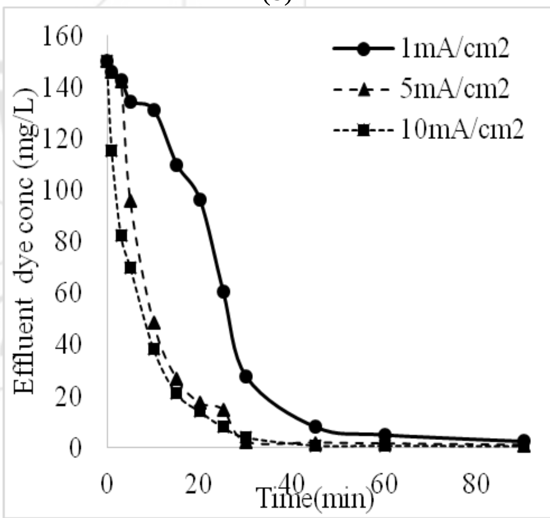

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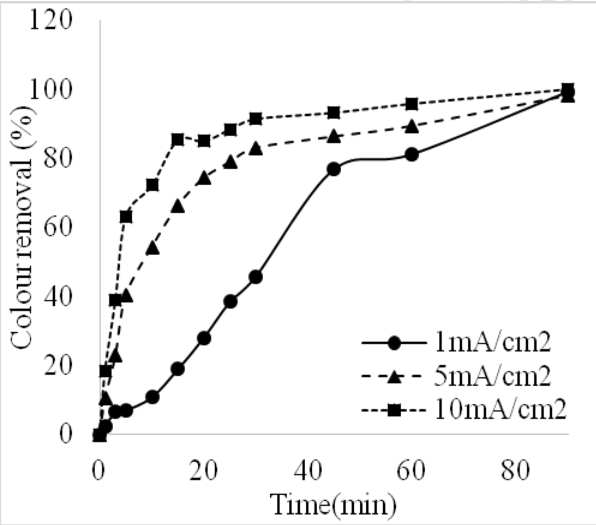
Figure 3: Effect of current density and time on effluent dye concentration for dye concentration of (a) 50 mg/L (b) 100 mg/L (c) 150 mg/L (interelectrode distance: 50 mm, initial pH: 5)

after 30 min electrolysis time 17.2 mg/L, 15.5 mg/L and 4.4 mg/L dye was observed in treated effluent for 1, 5 and 10 mA/cm^2 current density respectively. While at 150 mg/L initial dye concentration after 30 min electrolysis time 27.2 mg/L, 2.5 mg/L and 4.04 mg/L dye was observed in treated effluent for 1, 5 and 10 mA/cm^2 current density respectively. Similar trends were observed for color removal also. Increase in current density decreases effluent dye concentration for particular initial dye concentration and increases color removal for all the studied dye concentration (50-150 mg/L). Further increase in electrolysis time also showed similar effect. This is due to the fact that when more current is passed more metal ion get dissolved in solution and fastens the coagulation process. EC process involves two stages in pollution removal like destabilization of pollutant and then its aggregation. Hence when more time is given both the stages are satisfied and hence more removal can be observed. Hence the point to be noted is that; both insufficient and excess reaction times are undesirable as the former would result in reduced efficiency while the latter might increase the treatment costs associated with excess electrode dissolution, energy and sludge disposal [11]. Further another trend observed was increase in initial dye decreases effluent dye concentration; Similar trends were observed by [9] and [10] also. Hence initial dye concentration is also a significant process variable and thorough understanding for this variable should be developed before suggesting any technology.



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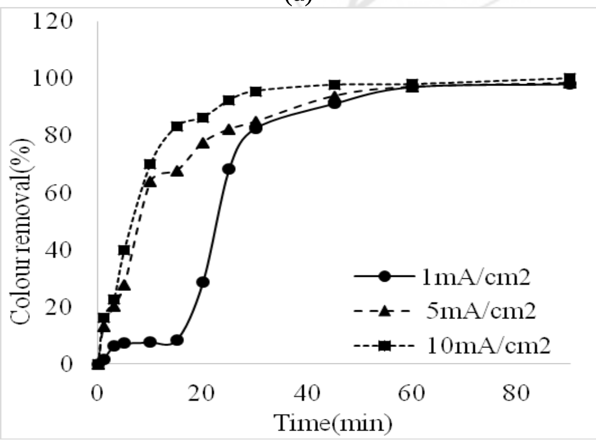

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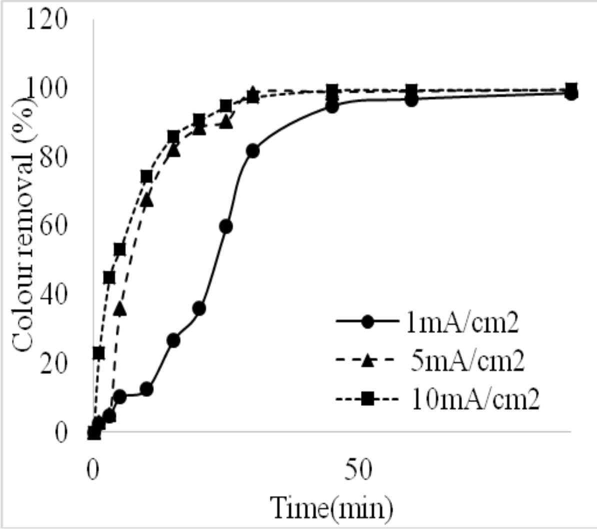

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Figure 4: Effect of current density and time Color removal (%) for influent dye concentration of (a) 50 mg/L (b) 100 mg/L (c) 150 mg/L (interelectrode distance: 50 mm, initial pH: 5)

4. Conclusion

EC of studied Navy Blue 3G dye reports 5 initial pH as the best for color removal. Further no effect of NaCl addition has been observed for Navy blue 3G dye solution electrocoagulation.

Current density and electrolysis time are most significant process variables, show direct increase in removal with their increase but excessive current and time will increase the process cost unnecessarily hence current density and time optimization are necessary to suggest economical technology.

Further increase in initial dye concentration, showed increase in removal hence proper knowledge for metal ion to pollutant load ratio should be developed to avoid wastage of sacrificial electrode with efficiency removal.

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