Removal of Dyes and Color from Textile Waste Water by Using Electro Fenton Process

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ABSTRACT

Dye is colored substance has an affinity to substrate to which it is being applied. Dyes appear to be colored because they absorb some wavelengths of light more than others. The presence of dye materials greatly influences the quality of water and the removal of this kind of pollutant is of prime importance. Dyes (Textile) are among the most industrial that release colored wastewater containing dye that become major environmental concern. The disposal of dye wastewater without proper treatment can cause harm for the aquatic species and environment. EF has good efficiency of color and dyes removal from the waste water. EF efficient technique of removal of the color and dyes from the textile waste water. Cost of this type of process is lowest than the conventional method. Analysis of the removal of color and dyes from textile waste water at various pH, Contact Time and the Concentration of color and dyes shows the optimum values of all parameters. Color and dyes can easily adsorb from textile waste water by EF and high efficiency. The percentage of color and dyes adsorbed increases with the pH. The percentage of each metal adsorbed as function of the pH. The maximum adsorption of color and dyes occurs at pH range between 5 and 6. As per observation the efficiency of color and dyes adsorption is related with the contact time as contact time increase percentage of color and dyes reduction increase. The maximum adsorption is noticed between time of 120-150 min for color and dyes at concentration of 5-10 ppm with pH value 5-6. After these optimum value removal of color and dyes are constant. As concentration increases % removal decrease at particular stage after that rate of adsorption constant. As concentration increases % removal decrease at particular stage after that rate of adsorption constant. The optimum value of concentration of dyes between 5-10 ppm. The maximum dyes removal from textile waste water up to 90 % between contact time 120 min, 5 ppm and pH value 5-6.

Keywords – Dyes Wastewater Treatment, Advanced Oxidation Process, Electro Fenton Process, Color and Dyes Reduction.

1. INTRODUCTION

A dye is a colored substance that has an affinity to the substrate to which it is being applied. Dyes appear to be colored because they absorb some wavelengths of light more than others. Several physical, chemical and biological de-colorization methods such as coagulation / flocculation treatment, biodegradation processes, oxidation methods, membrane filtration and adsorption have been reported to be investigated for the removal of dyes from industrial effluents.

Application of Advanced Oxidation Process

1. Chemical Industry
2. Pharmaceutical Industry
3. Pulp and Paper Industry
4. Textile Industry
5. Food Industry
6. Landfill Leachates
7. Dye-Process Industrial Waste
8. Pre-treatment to Wastewater
9. Organic Pollutant destruction
10. Toxicity, Odor and Color Removal

Types of Fenton Process

1. Fenton (Fe^{2+} or Fe^{3+}/H_2O_2)
2. Electro Fenton
3. Photo-Fenton (Fe^{2+} or $Fe^{3+}/H_2O_2/UV$)

Classification of Textile Dyes

1. Based on Application

Based on its application characteristics such as acid, basic, mordant, reactive, direct, disperse, Sulphur dye, pigment, vat, azo insoluble.

2. Based on Chemical Structure

Based on its chemical structure such as nitro, azo, carotenoid, acridine, quinoline, indamine, diphenyl methane, xanthene Sulphur, anthraquinone, indigoid, amino- and hydroxy ketone, phthalocyanine, inorganic pigment, etc.

3. Anionic, Nonionic and Cationic

Dyes on the basis of the general structure. The major anionic dyes are the direct, acid and reactive dyes.

Textile Organic Dyes Environmental Hazards

1. High concentration of dyes in water bodies stop oxygenation capacity of receiving water and cut of sun light.

2. The blue, green or brown colors of water courses is accepted by public but red and purpose colors in water bodies make people concern.

3. Polluting effects of these dyes is also due to their non-biodegradability and keep on accumulating in the sediments, in fishes or other aquatic life forms.

4. Decomposition of dyes into pollutants in carcinogenic or mutagenic compounds causing allergies, skin irritation, or different tissue changes.

5. Azo dyes which aromatic compounds cause high potential health risk by adsorption of azo dyes and their breakdown products.

6. Azo dyes cause damage of DNA which leads to malignant tumors.

7. Azo dyes have linked to bladder cancer in humans, splenic aromas, hepatic carcinomas.

8. Dyes which made from known carcinogens such as benzidine and aromatic compounds.

9. Anthraquinone based dyes fused aromatic ring structure are resistant to degradation.

2. LITERATURE REVIEWS

Advanced oxidation processes (AOPs) have led the way treatment of aqueous waste and rapidly becoming the chosen technology for many applications. COD reduction of textile industry wastewater by electro-Fenton (EF) oxidation at batch experimental conditions. The wastewater samples with a COD of 590 mg /l in average taken from outlet of an equalization tank of a textile industry. Wastewater samples treated in a batch reactor equipped with two iron electrodes. [2]

The EF tests were conducted at different H_2O_2 doses such as 313, 626, 940 and 1253 mg /l and constant electrical power of 24 W and pH of 3. The highest treatment efficiency was attained at 313 mg/l of H_2O_2 by which more than 85% of COD removed within 10 min of reaction time. EF process best method for textile wastewater treatment. [2]

The optimum pH in the study was identified as pH 5 and the highest percentage of color and COD removal 92.02% and 86.67%. The optimum current density is 0.28 A/cm^2 which gives 93.89% of color removal and 85.38% for COD removal. The optimum current density is 0.28A/cm^2 due to the decrease in percentage color and COD removal at the current density of 0.51A/cm^2. At 3 cm distances between electrodes 76.03% and 75.76% color and COD removal. [3]

Electrooxidation (EO) treatment using activated carbon cloth (ACC) electrodes on textile dye bath wastewater. ACC electrode pairs were used as anode/cathode for EO experiments. The effect of current density (50–150 A/m2), operating time (0–90 minutes) and solution pH (6-11) were tested for removal of chemical oxygen demand (COD), color and chloride as well as the changes in conductivity. 95.5% COD and color removal efficiencies were obtained at current density (CD) of 100 A/m^2 at solution pH of 10 for 90 minutes. The chloride concentration decreased from 4254 to 35.5 mg/L and solution conductivity decreased from 160 to 131 mS/cm at same conditions. [6]

The COD and color removal efficiencies changed in the range of 70 %–75 % and 20 % –80 % for 50–150 A/m^2 current density. The COD and color removal efficiencies increased in the range of 79.1%–95.5% and 80.6%–95.5% for solution pH of 6–11 respectively. High COD and color removal efficiencies (95.5%) were achieved at the current density of 100 A/m2 and solution pH of 10 for 90-minute electrolysis time. [7]

The color degradation can still occur when using the catalyst concentration of 4, 6 and 8 g/l. The highest color degradation (99%) occurs when using the catalyst concentration of 8 g/l after 12 hours of irradiation. The catalyst concentration of 6 g/l has been able to degrade the color to be clear (98% of degradation). The highest COD reduction obtained when using the catalyst concentration of 8 g/l (62%) after 12 hours of irradiation. COD highest degradation were reached by using the highest catalyst concentration of TiO_2 8 g/l. [8]

Fenton oxidation performed at dye concentrations of 50, 500, 100 and 1000 mg/L, hydrogen peroxide concentrations of 0, 10, 30, 60 and 120 mg/L, iron (II) concentrations of 0, 3, 5, 20 and 50 mg/L and pH levels of 3, 5, 7 and 10 for durations of 5, 10, 20, 30, 60 and 180 minutes. Optimal condition at dye concentration of 20 mg/L, hydrogen peroxide concentration of 120 mg/L, iron concentration of 100 mg/L, pH of 3 and duration of 30 minutes. Maximum dye removal rate 88.98%. DR81 decomposed and removed by Fenton oxidation. Removal of Direct Red 81 (DR81) depends on dye concentration, reaction time, concentrations of H and iron and pH. [9]

The performance of Fenton Process has been Optimized to minimize damage of acrylic yarn dye-house wastewater to environment regarding operating conditions, Fe (II) and H_2O_2 dosages, pH and reaction time using response surface methodology method over chemical oxygen demand (COD), color and total organic carbon (TOC) measurement parameters. Fenton Process determined as Fe (II) dosage for wastewater sample. Optimization efficiencies by 82.8%, 96.2% and 75.6% obtained for COD, color and TOC removal by means of Fenton process. [10]

pH and H_2O_2 plays important role in removal of phenol. H_2O_2 concentrations from 0.0125 to 0.025 M increased removal efficiency from 74 to 100 %. Maximum removal at pH=3. Increasing the pH to 9 lead to reducing removal efficiency to 9.8%. Increasing of current density removal efficiency increased. As increasing initial concentration of phenol removal efficiency reduced. Effectiveness of electrocoagulation process was sound suitable with 99.7% phenol removal in optimum condition. [11]

Experimental Analysis

Chemicals and Raw Materials

1. Phenolic Red Dye

2. 0.1 N NaOH or 0.1 N H_2SO_4

3. Distilled Water

4. Al and Fe Electrode

5. DV Adopter 12 V and 2 amp

Preparation of Dye Solution

Preparation of Dye Solution

1. 5 mg of phenolic red dye add in 1 L distilled water to make 5 ppm solution.

2. Stirring the solution for complete mixing of dye.

3. Similarly we can make synthetic water of various concentrations solution.

4. After addition dye color of solution Change.

5. Measure pH of solution should be maintaining between 5-7 using 0.1 N NaOH or 0.1 N H_2SO_4 for maximum adsorption.

6. Similarly we can make 5, 10, 15, 20 and 25 ppm solution.

Experimental Process

Experimental Process for Contact Time

1. Take 1-2 L synthetic waste water sample. (5 ppm)
2. Measure Absorbance/concentration unit by colorimeter/spectrophotometer.
3. Transfer sample in reaction vessel and stirred for mixing.
4. Dip the electrode in reaction vessel.
5. Add catalyst H_2O_2 and $Feso_4$ 1 ml/l each in solution in single step.
6. Start DC current supply. (Readings can take at different DC supply 12 V 2 amp)
7. Take sample each 30 min time of intervals up to 120 min reaction time.
8. Settlement achieved for 10 minutes and then withdrawal each sample.
9. Measurement of absorbance/concentration unit for each sample.
10. Finally, by comparing the initial and experimental values calculate % reduction of dyes from synthetic wastewater.

Experimental Process for Various Concertation

1. Take 1-2 L of 5 -25 ppm synthetic waste water sample.
2. Measure Absorbance/concentration unit by colorimeter/spectrophotometer.

3. Transfer sample in reaction vessel and stirred for mixing.
4. Dip the electrode in reaction vessel.
5. Add catalyst H_2O_2 and FeSO4 1 ml/l each in solution in single step.
6. Start DC current supply. (Readings can take at different DC supply 12 V 2 amp)
7. Take sample after 120 min reaction time for 5, 10, 15, 20 and 25 ppm solutions.
8. Settlement achieved for 10 minutes and then withdrawal each sample.
9. Measurement of absorbance/concentration unit for each sample.
10. Calculate % Reduction of Dyes.

Effect of Reaction Time Color and Basic Dyes

Sr. No.	Reaction Time in Min	% Reduction of Dye
01	30	52
02	45	58
03	60	68
04	75	76
05	90	80
06	105	86
07	120	90
07	150	92

Table Effect of Reaction Time on reduction of Dyes

Table shows the effect of contact time on removal of dye from synthetic waste water. As the value of contact time increase the % reduction of dyes increases up to 150 min. after that slightly change removal rate by adsorption process. For reduction of dyes optimum value for contact time will be 120 min. Maximum dyes removal from textile waste water up to 90 for contact time 120 min at 12 V 2-amp DC current.

Effect of Concentration on Dyes Removal

Sr. No.	Concentration ppm	% Reduction of Dye
01	5	88
02	10	72
03	15	56
04	20	48
05	25	42
06	30	38

Table Effect of Concentration on Dyes Removal

Table shows the effect of concentration on dye removal from textile waste water. As the value of concentration increase the % reduction of dyes decreases the removal rate by EF process. Max. dyes removal at 5 ppm which is up to 88 % resp.

Analysis of Effects of Various Parameters on EF Process

1. Effect of Current on Removal Efficiencies

The electrochemical reactor operated under different current density 12-30V and 2-5 amp current according to the concentration of dyes present in the waste water. Removal efficiencies depends on the concentration and solution conductivity affected when the current density increased. Removal efficiencies decreased when the applied current density reached up to 150 A/m^2. The optimum current density is 0.28 A/cm^2 and 12 V 2 amp for this experimental analysis.

2. Effect of Solution pH on Removal Efficiencies

The electrochemical reactor was operated under different pH (6, 8, 10, and 11) conditions. Removal efficiencies as well as variations of the chloride concentration and solution conductivity affected by changing the solution pH. Removal efficiencies increased for solution pH. The optimum pH in the study identified as pH 5-6 and the highest percentage of removal efficiency.

3. Effect of Distance between Electrodes (cm)

The distance between electrodes from 1cm, 3cm, 5cm and 7cm is taken into consideration to determine the optimum electrode distance. The distance of 3 -3.5 cm is optimized to be the best distance between the electrodes in the process for removal of dyes. The highest percentage obtained in 3-3.5 cm distances between electrodes.

4. Effect of Contact Time

The duration of electrochemical oxidation from 30- 150 min. The effects of time showed that the 120 minutes was the optimum time in which max. dyes removal.

CONCLUSION

EF has good efficiency of color and dyes removal from the waste water. EF efficient technique of removal of the color and dyes from the textile waste water. Cost of this type of process is lowest than the conventional method. Analysis of the removal of color and dyes from textile waste water at various pH, Contact Time and the Concentration of color and dyes shows the optimum values of all parameters. Color and dyes can easily adsorb from textile waste water by EF and high efficiency. The percentage of color and dyes adsorbed increases with the pH. The percentage of each metal adsorbed as function of the pH. The maximum adsorption of color and dyes occurs at pH range between 5 and 6. As per observation the efficiency of color and dyes adsorption is related with the contact time as contact time increase percentage of color and dyes reduction increase. The maximum adsorption is noticed between time of 120-150 min for color and dyes at concentration of 5-10 ppm with pH value 5-6. After these optimum value removals of color and dyes are constant. As concentration increases % removal decrease at particular stage after that rate of adsorption constant. As concentration increases % removal decrease at particular stage after that rate of adsorption constant. The optimum value of concentration of dyes between 5-10 ppm. The maximum dyes removal from textile waste water up to 90 % between contact time 120 min, 5 ppm and pH 5-6.

FUTURE SCOPE AND DEVELOPMENTS

Future Scope

- EF can be adopted to treat waste water.
- EF improve the efficiency of conventional method.
- EF can be used as an additional treatment to treat waste water.
- EF can make waste water for reusable as process water by removal of color and impurities from waste water.

Benefits

- Capital cost significantly less than convectional technologies.
- Operating cost significantly less than convectional technologies.
- EF made from waste material hence cost of production is low.
- EF is easy and it can adopt in laboratory.
- Minimal operator attention.
- Consistent and reliable results.

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