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# Colour Removal of Malachite Green Dye Solution using Stainless Steel Electrodes via Electrocoagulation

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***Abstract: Electrocoagulation is one of the effective techniques for removal of pollutants from the waste water. This method combines electrochemical processes with conventional chemical coagulation. Electrocoagulation was applied for the colour removal of solution containing Malachite Green Dye. The experiment involved iron, stainless steel and their combinations as an electrode for the electrocoagulation process. The experiment involved reactor of capacity 1 litre and the solution to be treated was 500 ml. The experiment was performed at***

***different initial concentration 25mg/l, 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l, 300 mg/l. The current density was 4.47 m/cm$^2$ with inter electrode distance***

***Keywords: Electrocoagulation, Malachite Green Dye, Sacrificial Anode, Colour Removal Efficiency, Electrolysis time.***

## I. INTRODUCTION

Water which has been affected by humans are termed as Wastewater. Domestic wastes, agricultural and commercial wastes as well as industrial wastes are collectively fall in the category of wastewater. It consists of many physical, chemical and biological pollutants. Household activities such as bathing, cooking, toilet flush, dishwashing, cleaning produces wastewater.[8]

### *A. Textile Wastewater*

The textile industry is one of the major and most intricated industrial chains in manufacturing industry. The manufacture of a textile entails numerous phases of mechanical treating such as spinning, knitting, weaving, and garment production, which likely to be insulated from the wet treatment processes like sizing, desizing, scouring, bleaching, mercerizing, dyeing, printing and finishing operations, but there is a sturdy interconnection between dry processes and succeeding wet treatments. The textile industry discharges a wide range of contaminants from all phases in managing of fibers, fabrics and garment production.

The textile wastewater produced from textile industry is tremendously polluted due to existence of reactive dyes which are not willingly cooperative to biological treatment. Color water causes inadequacy in the light which is crucial for the improvement of the aquatic organisms. As result, it is prime suspect for a discrepancy in the environment. To ease the treatment cost of the river water which is used the purpose of drinking; it should not have any color and toxic compounds. So, before discharge of textile wastewater into river, many treatment processes including physical, chemical, biochemical, hybrid treatment processes have been developed to treat it in a commercial and efficient way. [5]

### *B. Dyes*

By definition dyes can be said to be colored, ionizing and aromatic natural mixes which demonstrates an affinity towards the substrate to which it is being connected. It is commonly mixed in an aqueous solution. Dyes may likewise require a stringent to better the fastness of the dye on the material on which it is applied. The dyes were acquired from animals, vegetable or mineral inception with no or almost no preparation. By a long shot the best wellspring of dyes has been from the plant kingdom, eminently roots, berries, bark, leaves and wood, however just a couple have ever been utilized on a business scale.[2]

1) *Malachite Green Dye:* Malachite green dye is an organic chloride that is monochloride salt of malachite green cation. Utilized as green- shaded dye, as a counter stain in histology, and for its enemy of parasitic properties in aquaculture. It has job as a fluorochrome, a histological dye, an antifungal medication, a cancer-causing specialist, a teratogenic operator, an ecological contaminant and an antibacterial specialist. The leuco form of this dye was first made by the scientist named Hermann Fisher in 1877 by condensing benzaldehyde and dimethylaniline in the ratio of 1:2 in presence of sulfuric acid.[3]

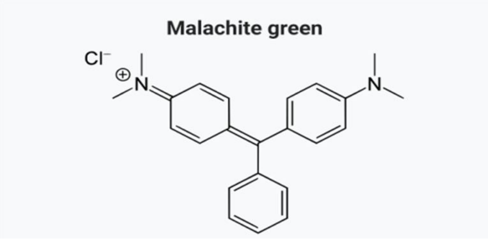

Figure 2. Malachite Green dye structure

### *C. Electrocoagulation*

Treatment of wastewater by EC has been drilled for the majority of the twentieth century with restricted achievement and fame. In the most recent decade, this innovation has been progressively utilized in South America and Europe for treatment of mechanical wastewater containing metals. It has additionally been noted that in North America EC has been utilized basically to treat wastewater from mash and paper businesses, mining and metal-handling enterprises. Also, EC has been connected to treat water containing staple squanders, oil squanders, colors, suspended particles, concoction and mechanical cleaning waste, natural issue from landfill leachates, defluorination of water, manufactured cleanser effluents, mine squanders and substantial metal-containing arrangement.[6]

Electrocoagulation (EC) is a confounded procedure involving numerous substance and physical marvels that utilization consumable terminals to supply particles into the wastewater stream. In an EC procedure the coagulating particles are created 'in situ' and it includes three progressive stages:

1) Development of coagulants by electrolytic oxidation of the 'conciliatory terminal',
2) Destabilization of the contaminants, particulate suspension, and breaking of emulsions and
3) Conglomeration of the destabilized stages to frame flocs. The destabilization mechanism of the contaminants, particulate suspension, and breaking of emulsions have been portrayed in wide advances and may be abridged as pursues.[6]

The reactions involved in the electrocoagulation process are as follows.[5]

*a) At anode*

$$4Fe(s) \rightarrow 4Fe^{2+}(aq) + 8e^{-}$$
$$4Fe^{2+}(aq) + 10H_2O(l) + O_2(g) \rightarrow 4Fe(OH)_3(s) + 8H^{+}(aq)$$

*b) At Cathode*

$$8H^{+}(aq) + 8e^{-} \rightarrow 4H_2(g)$$

*c) Overall Reaction*

$$4Fe(s) + 10H_2O(l) + O_2(g) \rightarrow 4Fe(OH)_3(s) + 4H_2(g)$$

## II. MATERIALS AND METHODS

The experimental setup consists of magnetic stirrer, adjustable D.C. power supply, glass reactor of 1-liter capacity, electrodes. Setup was fabricated by putting two electrodes spaced few centimeters in a glass reactor. The dimension of electrodes was 19.5cm X 5cm X 0.2cm. The electrodes were connected to a DC power supply (LW-K3010D supplied by Longwei Instrument Co. Ltd., Hong Kong) to provide the electric current required for the electrocoagulation process. The entire arrangement of glass reactor and electrodes is kept over a hot plate magnetic stirrer which is used to stir the content of the reactor. The schematic diagram of experimental setup is shown in figure 1.

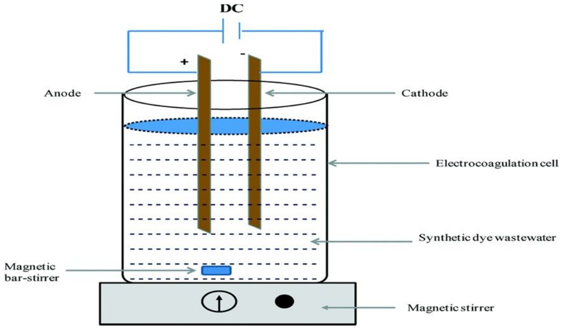

Figure 1. Schematic diagram of experimental setup

Malachite green dye of known weight was mixed with a liter of distilled water to make the stock solution of dye. Dye solution of different initial concentrations needed for the experiment such as 25 mg/l, 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l and 300 mg/l were prepared by diluting the stock solution. The dye solution (500 ml) of the above concentrations were taken in the reactor and its pH was adjusted to the desired level by adding $H_2SO_4$ or NaOH to it. After that around 2.7 gm of sodium chloride was added to this solution for providing electrical conductivity. Before beginning the electrocoagulation process the contents of reactor were stirred with the help of a magnetic stirrer and stirring kept continued during the entire process. The process of electrocoagulation begins with electricity supply from adjustable D.C. power supply. The electrolysis time was varied from 10-60 minutes to study the effect of time on color removal efficiency. Once the electrocoagulation process was over after the solution was allowed to settle for about 10 minutes to settle out the sludge. 10 ml of clear solution was taken out from the reactor and kept in sampling bottles for further analysis. The samples were analyzed in a UV-vis double beam Spectrophotometer for determining the concentration of dye present in the product samples. The wavelength used to find the absorbance was taken as 619 nm.
The color removal percentage of the treated dye samples was calculated using the following formula:

$$\%\ \text{Color Removal} = \frac{C_0 - C}{C_0} \times 100$$

Where $C_o$ are C are the initial and final dye concentrations in mg/l for the fresh and treated samples respectively.

## III. RESULTS AND DISCUSSIONS

The efficiency of electrocoagulation process was affected by the various process parameters such as initial concentration of dye, pH, current density, inter electrode distance and electrolysis time. To determine the effect of these process parameters the electrocoagulation was performed over a pair of electrodes. The best results were obtained for a dye concentration of 100 mg/l, at an interelectrode distance of 4 cm, 60 minutes of electrolysis time, at a pH of 5 and at a current density of 4.47 mA/$cm^2$ and the information is given elsewhere [11].

### *A. Colour Removal Efficiency For Different Initial Dye Concentrations*

Figure 3.1 shows the color removal efficiency vs electrolysis time for different dye concentrations. As evident from figure 3.1, the color removal efficiency increased with increasing electrolysis time at all dye concentration.

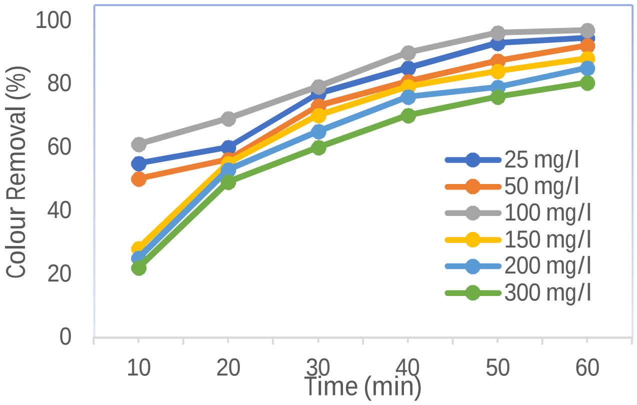

Figure 3. Color removal efficiency vs time plot for SS-SS electrode combination at different concentrations

It is clear that if we increase the electrolysis time than the amount of dye removed will also increase.
From the above graph it is clear that, the lower the dye concentration the better is the colour removal efficiency. This is due the reason that there is insufficient formation of iron hydroxide complexes by the electrode which coagulate large amount of dye molecules at higher concentrations.[8]

### *B. Selection Of Electrode Combination For Colour Removal Efficiency*

Literature shows that the iron and stainless-steel materials could serve as a potential electrode for the electrocoagulation process. Therefore, in order to know a suitable pair of electrode combination, the electrocoagulation process was conducted over three electrode combinations viz. SS-SS, Fe-Fe and Fe-SS (see Figure 3.2).

Among SS-SS, Fe-Fe and Fe-SS electrode combinations, SS-SS electrode gave higher colour removal efficiency and the maximum removal efficiency obtained was 97%.

This is because in stainless steel (SS-SS combination) there is partial direct oxidation at the anode and reduction at cathode which forms $Fe^{3+}$ ions. These ions adsorb the contamination present in the solution and these contaminations is removed by sedimentation or flotation.[4] There is no effect of pH on colour removal in case of stainless steel.[9]

For the iron electrodes (Fe-Fe combination) after 5 minutes, the solution to be treated changes its colour to greenish and after few minutes it again changes to brownish. The green colour is due to $Fe^{2+}$ ions present and brown colour is due to presence of $Fe^{3+}$ ion, since $Fe^{2+}$ can be easily oxidized to $Fe^{3+}$. $Fe^{3+}$ generally exists in the form of $Fe(OH)_3$ which is fine particles and hard to precipitate. So, iron is less suitable in this process.[7]

For the case of Iron and Stainless-Steel electrode (Fe-SS), since the pH was 5 i.e., acidic it will produce $Fe^{2+}$ ions. This ion is poor coagulant as it has lower positive charge and higher solubility of hydroxides due to which poor results are obtained.[10]

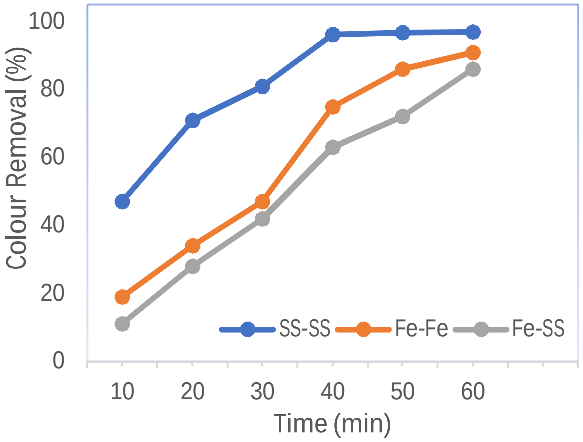

Figure 4. Electrode combination selection for color removal efficiency

## IV. CONCLUSION

The experiment performed is a study of electrocoagulation of Malachite green dye in aqueous solution using different electrode combination such as SS-SS, Fe-Fe, SS-Fe. This study summarizes about color removal.

*A.* Among different electrode combinations SS-SS gave maximum color removal efficiency which is about 97%.
*B.* The result stated that when the dye concentration increased 25 mg/l to 300 mg/l the color removal efficiency increased with electrolysis time.
*C.* The optimum pH was 5. The optimum concentration was 100 mg/l at 20 V and current density 4.47mA/$cm^2$. At this concentration the color removal was maximum at 20 V for SS-SS combination.
*D.* It was observed during experiment that the sludge obtained was maximum in case of Iron-Stainless Steel combination followed by Iron-Iron and Stainless Steel-Stainless Steel combinations.

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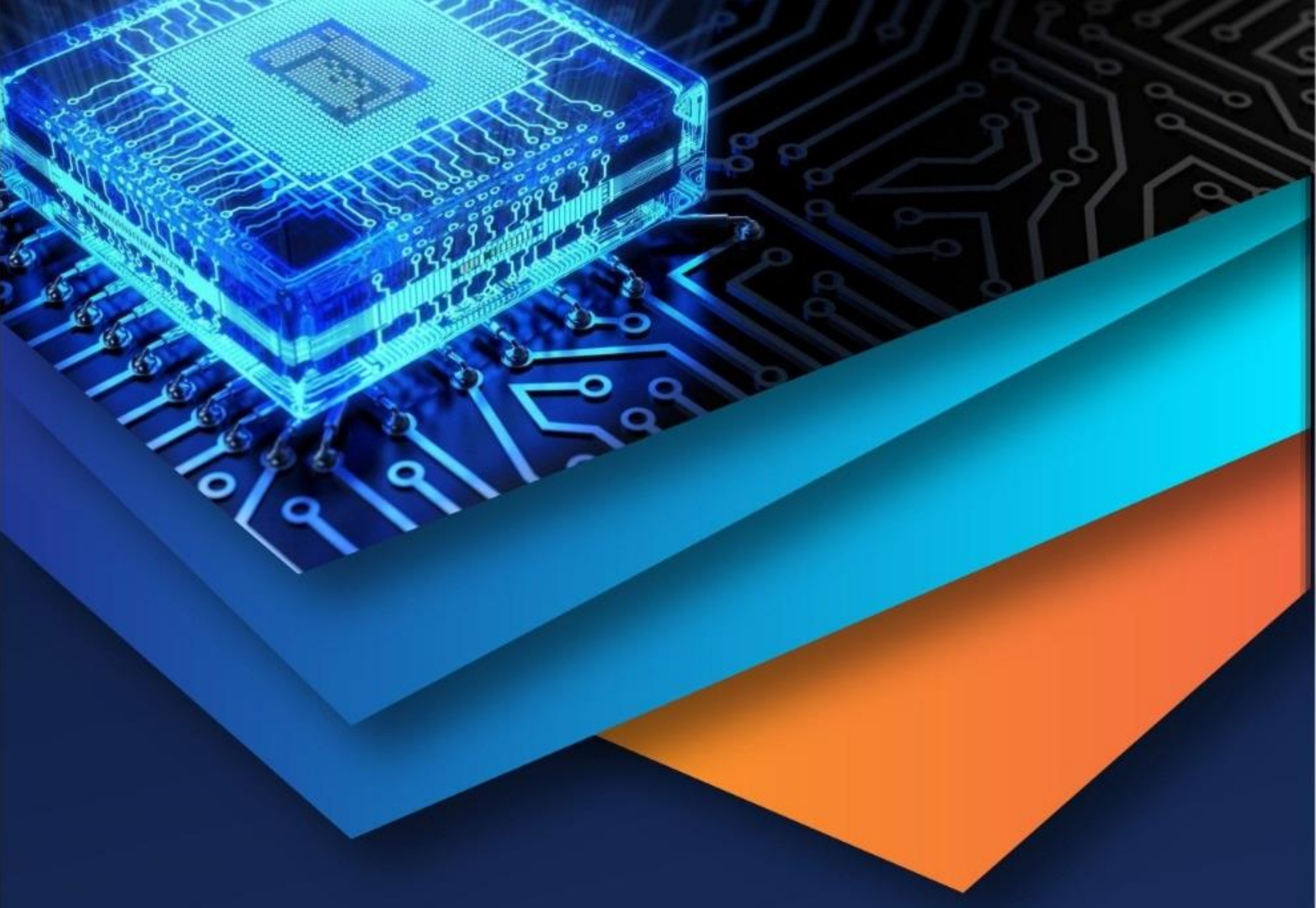

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