Optimisation of electrochemical decolourisation of Fast Sulphon Black F dye solution

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Abstract : The removal of reactive dye from effluents by electrocoagulation has become an attractive method in recent years. This paper deals with the removal of the reactive dye Fast Sulphon Black F from an aqueous medium by the electrochemical method using platinised titanium, mild steel, aluminium, Copper and stainless steel electrodes. The effects of electrolyte concentration, initial pH, current density, electrode area, interelectrode distance, dye concentration, and treatment time on the decolorization efficiency have been investigated. The optical density of the dye solution was measured before and after electrolysis, and hence the decolourisation efficiency (DE) was calculated. UV spectroscopy has been used to investigate the nature of dye before and after decolourisation. The decolourisation efficiency is in the decreasing order Pt/Ti>Cu>SS>Mild Steel>Al.

Key words: Electrocoagulation, wastewater treatment, textile dye, Fast Sulphon Black F, decolourisation efficiency.

1. Introduction

In general, the wastewater generated from textile industries is found to contain high degree of pollutants with high total dissolved solids and suspended solids. The wastewater is highly colored and viscous due to dyestuff and suspended solids respectively. The textile industry is estimated to consume as much as two-third of the total annual production of dyes[1]. Azo dyes are the largest and most versatile class of dyes and are commonly used to dye various materials such as textiles leathers, plastics, cosmetics and food[2]. They are the major group of dyes used in the textile industry and contribute between 50-65% of the colours in textile dyes[1,3]. The inefficiencies in the dyeing process result in dyestuff losses between 2-50% to the waste water with the lower limit for basic dyes and the upper for azo dyes. Ultimately these dyes find their way to the environment and end up contaminating rivers and groundwater in the location of the industries[3]. Colours in water bodies reduce light penetration, alter the pH, increase the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and thereby make aquatic life difficult[4]. Dye house effluents are therefore of serious environmental concern. Several treatments of textile effluents to achieve decolourisation have been reported. These include physiochemical methods such as filtration, specific coagulation, use of activated carbon and chemical flocculation .Some of these methods are effective but quite expensive[5,6]. Although, biotreatment offers a cheaper and environmentally friendlier alternative for colour removal in textile effluents, it has its own demerits. Anaerobic decolourisation of azo dyes produces aromatic amines which are toxic to aquatic life[3] mutagenic to humans and cannot be degraded further under anaerobic conditions [7,8]. It has been reported that the only safe biodegradation method for azo dyes is combined aerobic treatment[9]. However, there are very few reports of aerobic bacteria that can grow with azo compounds[2]. Electrochemical methods can also be used to

decolourise dyes. Recently electrochemical methods[10,11] and chemical methods[12,13] have been used to decolourize various dye solutions. The present work is undertaken to decolourise an aqueous solution of Fast Sulphon Black F (**Scheme – 1**) dye by electrochemical methods using platinised titanium, mild steel, aluminium, copper and stainless steel as anodes and graphite as cathode
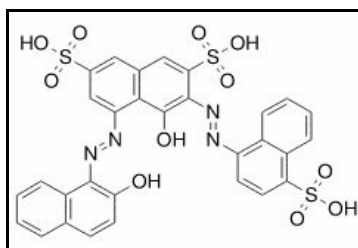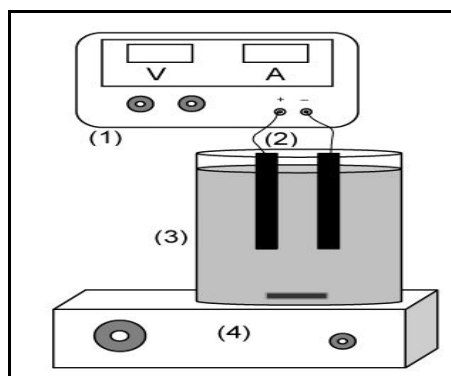

Scheme – 1: - Fast Sulphon Black F

2. Methodology

Dye solution: 50 ppm of Fast Sulphon Black F solution was used.

2.1. Decolourisation Process

The optical density of the dye solution before and after decolourisation was measured by the instrument Photoelectric Colorimeter -112.Graphite was used as cathode. Platinised titanium /Mild steel/ Copper/Aluminium /SS were used as anode. The electrolysis was carried out in an undivided cell with a stirring bar (**Fig- 1**). UV-Visible spectra were recorded in a Lamda 35 model.

Cathode	:	Graphite
Current Density	:	0.005 A/cm2
Volt	:	4 Volts
Duration of Electrolysis	:	5 mts
Initial OD	:	0.050
Electrolyte	:	3.75 gm of NaCl dissoluted in 100 ml of dye solution
pH of Dye solution Before electrolysis	:	3.5

1.Voltmeter and Ammeter, 2. Electrodes (Cathode and Anode), 3.Beaker with dye solution, 4.Stage.
Figure: 1 Schematic diagram of experimental setup

3. Results and Discussion

Decolourisation process was carried out in an undivided glass cell, provided with a stirring bar. 100 ml of the dye solution was taken (50 ppm of Fast Sulphon Black F. Graphite was used as cathode. One of the metal specimens (platinised titanium / Mild steel /Aluminium etc) was used as anode. 3.75 gm of sodium chloride was added. Current was passed for 5 minutes (4 volts; current density = 0.005 A/cm^2). The pH of the dye solution,

before and after decolourisation was measured. The optical density was measured before and after decolourisation. The decolourisation efficiency (DE) was calculated using the relation

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Percentage decolourization = [Initial O.D - Final O.D / Initial O.D] X 100

DE = [OD$_1$ - OD$_2$ / OD$_1$] X 100

Where
OD$_1$ = Optical Density before decolourisation
OD$_2$ = Optical Density after decolourisation
DE = Decolourization efficiency

The results are summarized in **Table 1**. It is observed that platinised titanium offers the maximum DE of 84%; Cu 66 %; SS 44%; Mild steel offers 36 % and Al 22%

**Table: 1 Decolourization efficiency of Fast Sulphon Black F solution**

S. No.	Anode	pH after electrolysis	NaCl 3.75 g	
			4 volt	
			OD After electrolysis	**DE**
1	Pt/Ti	3.3	0.008	84%
2	Cu	3.0	0.017	66%
3	Mild Steel	3.1	0.032	36%
4	Stainless Steel	3.4	0.028	44%
5	Al	3.2	0.039	22%

3.1 UV-Visible absorption spectra

UV-visible spectra for untreated (before electrolysis) and treated (after electrolysis) dye solution were recorded. The initial spectrum showed that the wavelength of the maximum absorbance (λ max) in the case of Fast Sulphon Black F (before decolourization) the three peaks were appeared at 218nm, 293nm, 480nm, 604nm **(Fig.2)**. After decolourization, only one peak was appeared at 205 nm **(Fig.3)**. It is revealed that the losing absorbing bands over the decolourisation process. This showed that decolourizattion of dye had taken place more effectively. The maximum efficiency of decolourization process is about 84%. The lonely peak in the region of 200-300 nm indicates that the aromatic structure is still there. The concentration is negligibly small. The destruction of the aromatic ring is not complete. That is why the decolourisation efficiency is not 100% but only 90%.
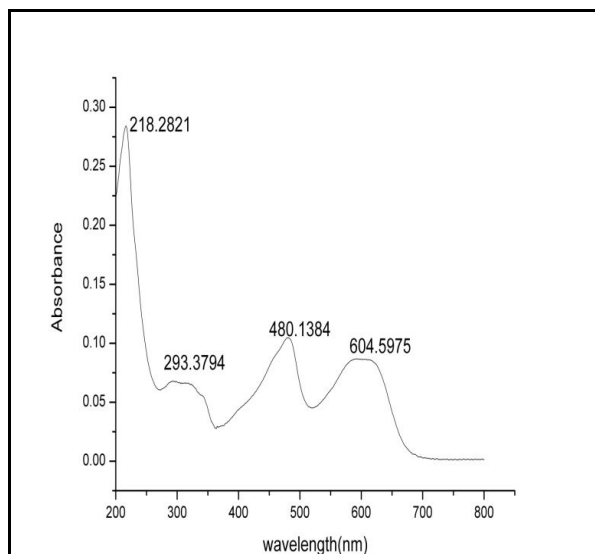
Fig.2. UV-Visible spectrum of Fast Sulphon Black F (before decolorization)
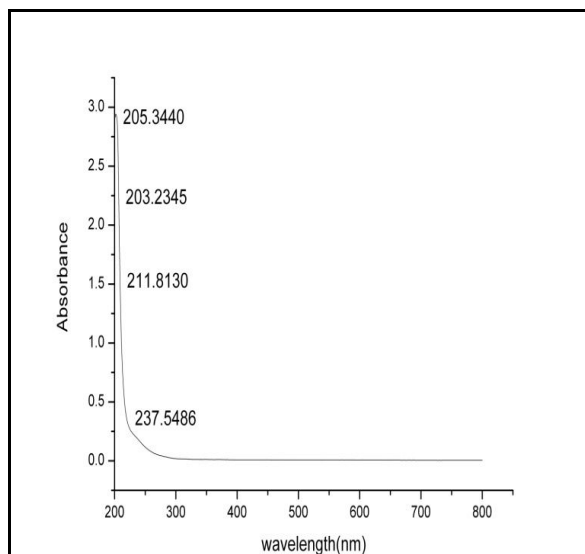
Fig.3. UV-Visible spectrum of Fast Sulphon Black F (After decolourization)
[Pt/Ti Electrode; 3.75g NaCl ; 4 volt ; DE=84%]

4. Mechanism of decolourisation

When sodium chloride solution is electrolysed, positive chloride ion (Cl^+) is produced (**Figure – 4**) .It is highly reactive. It decolorizes the coloured material into colourless product. Now negative chloride is (Cl^-) is produced. It transfers the electrons to the metal surface and hence Cl^+ is produced[14,15]. Various other species have also been proposed responsible for the declourisation of dyes. Some of the reactive species proposed are OCl^- [14], $OH^.$ Radicals and OCl^-[15]; OH^-, $O^.$ and $ClOH^.$[16] and Cl^-, Cl_2^-, $ClOH^-$[17].
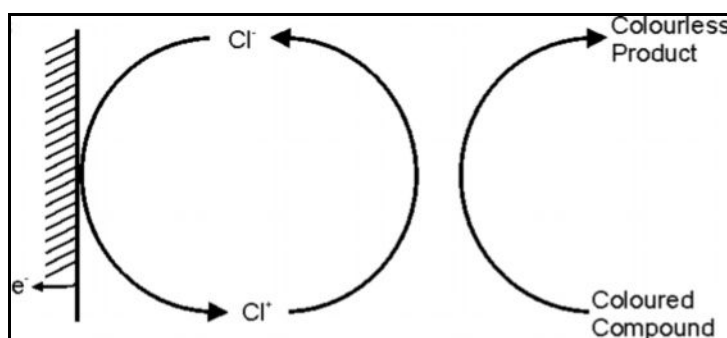
Figure:4 Electrochemically regenerated Cl^+

5. Conclusion

The removal of the reactive textile dye Fast Sulphon Black F acetanilide from an aqueous medium by the electrochemical method using platinised titanium, mild steel, aluminium, Copper and stainless steel electrodes have been investigated. It is observed that platinised titanium offers the maximum DE of 84%; Cu 66 %; SS 44%; Mild steel offers 36 % and Al 22%. The decolourisation efficiency is in the decreasing order. Pt/Ti>Cu>SS>Mild Steel>Al. In the case of platinised titanium, the DE is very high 84%. This is attributed to the fact, that this metal readily accepts the electron released by Cl^-. Hence Cl^+ is produced readily, easily and abundantly. This Cl^+ converts the coloured compounds in to colourless products. The decrease in DE of other metals is attributed to the fact that these metals accept the electron from Cl^- less readily and produced Cl^+ species less readily and slowly. Eletrochemical decolorization of dye solution takes less time than any other decolorization methods.

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