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Decolourization of Textile Dye (4-(2-Hydroxy-5-Methylphenylazo)Acetanilide) by Electrochemical Method

A. Sahaya Raja[1,*], J. Sathiyabama[1], V. Prathipa[2]

[1]PG & Research Department of Chemistry, G.T.N. Arts College, Dindigul – 624 005, TN, India.
[2]Department of Chemistry, PSNA College Engineering and Technology, Dindigul – 624 622, TN, India.

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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 textile dye 4-(2-hydroxy-5-methylphenylazo)acetanilide from an aqueous medium by the electrocoagulation 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 as platinised titanium > SS > Al > mild steel > Cu.

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 4-(2-hydroxy-5-methylphenylazo)acetanilide (Fig. 1) dye by electrochemical methods using platinised titanium, mild steel, aluminium, copper and stainless steel as anodes and graphite as cathode.

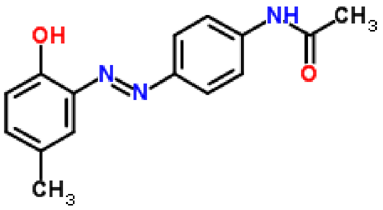

Fig. 1 Structure of 4-(2-hydroxy-5-methylphenylazo)acetanilide

2. Experimental Methods

Dye solution: 50 ppm of 4-(2-hydroxy-5-methylphenylazo)acetanilide dye 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. 2). UV-Visible spectra were recorded in a Landa 35 model.

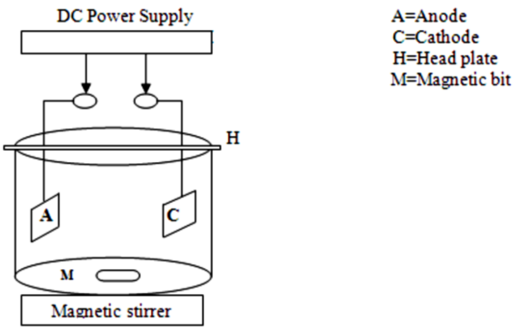

Fig. 2 Schematic diagram of experimental setup

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*Corresponding Author
Email Address: spsahayamdgl@gmail.com (A. Sahaya Raja)

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Cathode : Graphite
Current Density : 0.005 A/cm^2
Volt : 4 Volts
Duration of Electrolysis : 5 m
Initial OD : 0.10
Electrolyte : 3.75 g of NaCl dissoluted in 100 mL of dye solution
pH of Dye solution Before electrolysis : 3.8

3. Results and Discussion

Decolourisation process was carried out in an undivided glass cell, provided with a stirring bar. About100 mL of the dye solution was taken (50 ppm of 4-(2-hydroxy-5- methylphenylazo)acetanilide). Graphite was used as cathode. One of the metal specimens (platinised titanium / mild steel /aluminium /copper/ SS) was used as anode. A 3.75 g 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

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 90%; SS 80%; Al 70%; Mild steel offers 60 % and Cu 40 %.

Table 1 Decolourization efficiency of 4-(2-hydroxy-5-methylphenylazo)acetanilide dye solution

S. No.	Anode	pH after electrolysis	NaCl 3.75 g 4 volt	
			OD After electrolysis	DE
1	Pt/Ti	3.7	0.01	90%
2	Cu	3.5	0.06	40%
3	Mild Steel	3.2	0.04	60%
4	Stainless Steel	3.5	0.02	80%
5	Al	3.3	0.03	70%

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 4-(2-hydroxy-5-methylphenylazo)acetanilide dye (before decolourization) the three peaks were appeared at 269 nm,295 nm, 422 nm (Fig. 3). After decolourization, only one peak was appeared at 205 nm (Fig. 4). 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 90%. 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%.

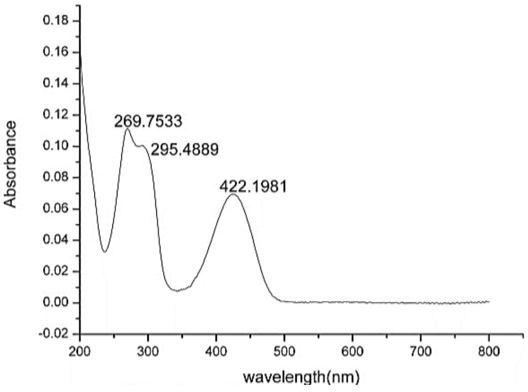

Fig. 3 UV-Visible spectrum of 4-(2-hydroxy-5-methylphenylazo)acetanilide Dye (before decolorization)

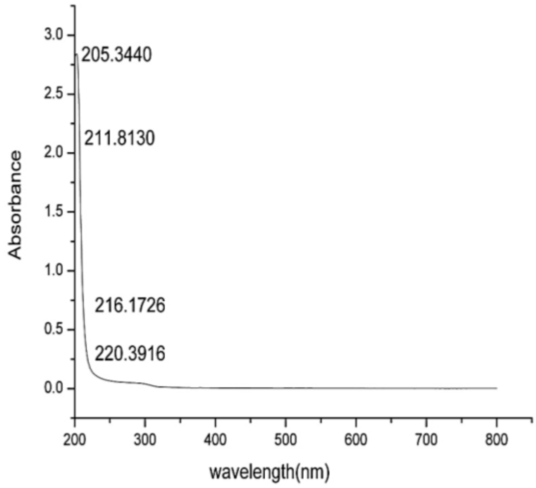

Fig. 4 UV-visible spectrum of 4-(2-hydroxy-5-methylphenylazo)acetanilide dye (after decolourization) [Pt/Ti Electrode; 3.75g NaCl ; 4 volt ; DE=90%]

3.2 Mechanism of Decolourisation

When sodium chloride solution is electrolysed, positive chloride ion (Cl^+) is produced (Fig. 5). It is highly reactive. It decolorizes the coloured material into colourless product. Now negative chloride (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].

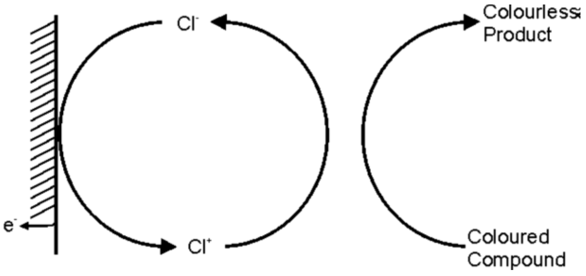

Fig. 5 Electrochemically regenerated Cl^+

4. Conclusion

The removal of the reactive textile dye 4-(2-hydroxy-5-methylphenylazo)acetanilide from an aqueous medium by the electrocoagulation 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 90%; SS 80%; Al 70%; mild steel 60 % and Cu 40 %. The decolourisation efficiency is in the decreasing order. Platinised titanium > SS > Al > mild steel>Cu. In the case of platinised titanium, the DE is very high 90%. 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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