Application of Electrochemical Techniques in Decolorization of Dye Effluents in Textile Industry

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Renu Bala
Associate Professor
Dept of Chemistry
Seth R.L. Saharia Government P.G.College, Kaladera, Jaipur India

Abstract

The aim of this paper is to review electrochemical techniques applied to decolorizationof effluent in textile industries. Although for the past several years, electrochemical techniques are used in manufacturing fibers and in dyeing processes. These are electrochemical reduction reactions used in sulfur and vat dyeing. Another interesting use of electrochemical technique is bleaching of cotton fibres and denim[3] fabrics. The problem of water pollution is the biggest burning issue for us at this time. Waste water originating from textile industry polluting ground water. Electrochemistry can prove to be a boon for us to solve this problem. Electrochemical techniques are an efficient method to remove color of textile effluents, not only that, the reuse of this discolored effluent is possible, by which the wastage of water can be prevented.

Keywords: Effluent ,Oxidation ,Reduction ,Dyeing Process.

Introduction

From ancient times, electro chemical methods have been used for synthesis of compounds or for metal recovery methods. In general, electrochemical techniques are based, on the measurement of response of an electrochemical cell containing an ion-conducting phase, the electrolyte, on the application of an electric input through election conducting electrodes immersed into the electrolytes. The inefficacy of conventional water treatments for the elimination of refractory contaminants has placed electrochemistry in the spot light. Electrochemistry allows a very precise way of controlling a chemical reaction and more environmental friendly.

The textile industry produces large volumes of waste water in its dyeing and finishing processes. Global policies concerning water and energy consumption conduce to recycling and reuse treatments. In this sense electrochemical techniques demonstrate possibility of reusing these discolored effluents.

The growing popularity of electro-analytical method can be traced to developments and new application areas, which has put these techniques at par with other techniques. Few of them may be mentioned as follows :

1. Sensitivity for most of dyes.
2. Low capital investment and operating cost.
3. The ability to 'tailor' the electrode or electrochemical system for a wide range of species, cations and anions.
4. Some unique applications such as environmental pollution, biomedical and drugs.

Electrochemical Techniques

Most of electrochemical oxidation processes involve indirect reactions which imply the generation of hypochloride or hydrozyl radial in situ. These species can degrade dyes in waste water and make effluent colourless, generally electrochemical methods are cleaner than other techniques as they use election as reagent which is unique and do not produce solid residues.

Most of electrochemical decolourisation research are focused on reactive dyes. They represent approximately 20-30% of total dyes[12]. When triazine is reactive group nucleophilic displacement reaction occurs[4].

$$\text{dye-Cl + HO - cellulose} \rightarrow \text{dye-o-cellulose + HCl} \quad ...(1)$$

$$\text{dye-Cl + } H_2O \rightarrow \text{dye-OH + HCl} \quad ...(2)$$

Numerous methods are used for removal of organic dyes from waste water, only biological treatment is insufficient to remove colour, so specific treatments are required. Direct black textile dye was studied by Baseem H. Fadhill et al[2] in presence of NaCl graphite electrode used as anode and cathode. Results showed that decolorisation increases with increasing salt concentration and applied voltage. Best decolourisation of 86% can be achieved after 17 minutes at 7 volts and 5 g/h salt. No significant decrease in pH was observed.

Textile dye C.I. reactive REd 2 (RR2) that contains dichlorotriazine ring was studied by Sakthisharmila Paleamismy et al[5]. Dye was subjected to electrocoagulation process using aluminium (Al) electrodes. A maximum of 97% of colour and 72% (COD) chemical oxygen demand removal efficiencies were achieved and 9.5 kWh/Kg dye electrical energy and 0.8 Kg Al/Kg dye electrode consumption were observed. The mechanism was studied by analysing results of UV spectrum of RR2.

The electrochemical decolorisation of structurally different dye (bromophenol, blue inido) by means of application of DC electric current was assessed by MA Sannoman et al[7]. They concluded that electrochemical process allowed a colour removal of all dyes studied, but decolorisation rate mainly depends on chemical structure of dyes. The results proved that addition of a redox mediator ($Co^{2+/2+}$) clearly enhanced degradation rate of all tested dyes. Similar research was carried out by Victorhope-Grimau et al[8]. The study is focused on optimisation of electrochemical decolorisation of effluent containing reactive dye with aim of making feasible technically and economically this method at industrial scale. Dyeing effluent with 0.5 to 20 gL^{-1} of NaCl reached a high decolorisation yield, also depending on current density. Other than this, after electrochemical treatment effluent were stored in a tank and exposed under different lighting conditions, UV light, solar light, gave better results. Dye mineralisation study was also carried out with high current density. This treatment required a high electrical consumption comparably in another research, electrochemical decolorisation of Methylene blue (MB) was studied by M.A. Hasnat et al at Pt electrode in presence of KNO_3 & KCl as supporting electrolyte under acidic condition. According to results KNO_3 displayed MB decolorisation effect, where MB molecules exhibited 2 redox on peaks at -0.48 V and -0.34 V respectively in cyclic voltammogram (CV). The research proved high efficiency toward decolorisation of MB dye. This report indicates the possibility for improving the quality of waste water discharged from textile and other industries.

Meanwhile, another study was done by Bahadir K. Korbahti et al[10]. In this case electrochemical textile dye decolorised, other than this, metal ions were removed simultaneously. [Textile dye] [metal ion] binary mixture of [AB29/CuII], [RR2/Cu(II)], [AR97/Ni(ii)] and [RB4/Ni(ii)] were investigated using iron anode and Na_2SO_4 electrolyte in a batch electrochemical reactor. The experimental data optimized using response surface methodology (RSM). The mean energy consumption values were evaluated between 29.2-38.1 kWh/Kg dye decolorisation and 14.2-22.5 kWh/Kg metal ion removal at RSM optimized operating conditions.

Objective of the Study

Many attempts have been made to developed combined methodology to treat textile waste water . Conventional waste water treatment methods such as chemical , coagulation , electrochemical oxidation filtration & biological treatment are used for several years Result showed that electrochemical methods & use of selected microorganisms is a good method to enhance the performance in treatment of waste water..

Conclusion

This paper is a review of Electrochemical methods used in decolorisation of dye effluents from textile industries. Advantages of electrochemical methods are simplicity, how cost and speed. The results revealed the suitability of process to effectively decolorised waste water from dyeing process. But unfortunately, there are only few applications at industrial scale as most of electrochemical treatments are still being studied at laboratory scale. Now is the time, to encourage the research on new applications of these techniques, because they provide important benefits. Electrochemical method has a good effect in decolorisation of dyeing waste water and has a certain potential in its reuse process.

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