

Spectrophotometric Estimation of Colour in Textile Dyeing Wastewater

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Summary: The coagulation / flocculation process was used for the treatment of colour removal from textile wastewaters with ferric chloride hexahydrate and ferrous chloride monohydrate. The process was very effective with 58 to 82 % colour removal. The ferrous chloride monohydrate showed 58 to 64 % colour removal and ferric chloride hexahydrate showed 79 to 82 % colour removal. Reactive Indian dyes were used as model dyes in the textile dyeing wastewater. In order to determine the optimum pH and coagulant concentration, a series of jar tests was done. Some experiments were performed using round flocculation tank and the magnetic stirrer with high and slow speed mixing (100 to 800 rpm) to evaluate influence of mixing. The mixing has an important role in the overall coagulation process efficiency.

Introduction

Dyes are intensely coloured chemical compounds which when applied to a substrate impart to this substrate. Retention of colour as well as stability is required for functional properties and is accomplished by chemical and physical forces. Today the protection of the environment has become a challenge for the chemical industry world wide, and the water pollution caused by synthetic dyes, in particular the control of effluent, continues to be a problem. All over the world environmental regulations are becoming stricter and are forcing the shift of technology towards less pollution or practically non-polluting areas of technological development [1,2].

But the problem does not simply encompass the manufacturing process alone. The reality of environmental protection demands reflecting upon the entire lifestyle of a product from conception to design, production, use and finally, its recycling or disposal. The natural water resources of the world are becoming increasingly polluted and are unable to meet increasing domestic and industrial demands. The major environmental problem that arises from the use of colorants is the removal of dyes from effluent. Untreated effluent from dyestuff production and dyeing mills are very highly colored and thus particularly objectionable if discharged into open waters. Wastewater dye concentration may be well below 10^{-3} kg/m³ i.e. lower than many other chemicals found in wastewaters, but the dye will be visible even at such low concentrations [3]. The presence of dark colour in water might not appear to have a negative effect other than aesthetic, but this is

not actually the case. The colour can absorb and reflect sunlight entering the water. Consequently, bacteria cannot grow sufficiently in the water and this, therefore, can have a disastrous effect on the food chain [4] due to the varying nature of the textile wastes. Textile dyeing effluents are generally hot alkaline, strong smelling and colored, resulting in lowering the dissolved oxygen of receiving waters, threatening aquatic life and damaging both the aesthetic value and water quality downstream. Contaminated water is a serious threat to surface and ground water resources in areas where textile units are situated, such as Faisalabad, Lahore and Karachi [3, 9]. The ultimate disposal of wastewater can only be onto the land or into the water body. But whenever the watercourses are used for the ultimate disposal, the wastewater is given a treatment to prevent any injury to the aquatic life in the receiving water. Textile mills generate millions of liters of dye wastewater every day [3] as a result of using some of the 3000 different dyes available in the market. These dyes mostly consist of substituted aromatic and heterocyclic substances [4]. Reactive dyes are characterized by the reactive groups in the dye molecule, with some of the dyes comprised azo anthraquinone or phthalocyanine or metal complex compounds, which are all soluble in water. The reactive groups in such compounds commonly di- or mono chlorotriazine or vinyl sulphone. Today, reactive dyes are used worldwide, with much research being carried out into developing new synthetic procedures to improve their application characteristics. However, due to their high solubility, reactive dyes can cause great effluent

problem for the dyeing industry. Increased public concern and ecological awareness, as well as stricter legislative control of effluent discharge in recent years, has led to increased interest in methods of de-colorization. Over the years, coagulation has been the only economically feasible method for colour removal [5]. Today, this method still has many disadvantages and is still used, both on its own as well as in combination with other methods. Lin and Liu [6] employed a continuous process of combined ozonation and chemical coagulation for treatment of textile dyeing wastewater from dyeing plants. This combined treatment was found to be very effective. It was shown that complete de-colorization of the wastewater was achieved by ozonation, whilst chemical coagulation was responsible for removing the dissolved organic compounds and solid suspensions resulting in a high percentage of (COD) chemical oxygen demand removal. It is very difficult to find a universal method, which can be applied to a wide range of dyes due to their very different chemical structures and molecular sizes. Various wastewater treatment methods for reactive dyes have been proposed using polymeric cationic flocculants [7-9] hydrogen peroxide-iron (III) Sulphate, a sodium hydro Sulphite reduction pretreatment followed by carbon adsorption and a new ion exchange resin prepared by cross linking and quartering sugarcane bagasse [10,11]. Coagulation - flocculation process for the treatment of other kinds of coloured effluents (pulp bleaching, tannery) is described in the literature [11-12]. Emphasized the importance of rapid mixing in the overall coagulation- flocculation process. The reason to choose this study is that ferric chloride hexahydrate has been studied but the ferrous chloride monohydrate has not been investigated and this can be locally manufactured and easily available in local market and saves the foreign exchange.

Result and Discussion

The purpose this experimental work was to achieve complete colour removal, which corresponds to transmission values for treat wastewater of over 80 %, equivalent to a residual dye concentration of approximately $8 \times 10^{-3} \text{ kg/m}^3$. Organic synthetic dyes may be present in true solutions, as single molecules or as reversible aggregates of them. Solutions of such molecules are called macromolecular or hydrophilic, because the weights of such macromolecules often fall within the range of particle weights, which have been arbitrarily chosen as belonging to the special

sphere of colloid science [13]. Randtke discussed the fundamental mechanisms by which coagulation removes organic contaminants from water [14]. It was shown that the characteristics of the molecules themselves have an influence on their removal by coagulation. Molecules possessing acidic functional groups, which are able to coordinate with iron to form relatively hydrophobic complexes, can be removed by coagulation. Therefore, the coagulation process was studied as a viable method for the treatment of the reactive dye wastewater.

In this study the results of textile dyeing effluents treated with ferric chloride hexahydrate and ferrous chloride monohydrate are presented in Fig. 1, 2 and 3 and residual colour concentration with variation in pH are presented in Fig.4. The red, green, and blue coloured unknown samples were collected from the textile-dyeing unit from the point of disposal. These bulk samples were divided into small portions of different colour concentrations and treated for colour removal using ferric chloride monohydrate and ferrous chloride hexahydrate. The graphs are Fig 1, 2, 3 and 4 drawn for the colour concentration against absorbance for the colour removal. The results of treated textile dyeing effluent shows 0.05 mg/100 ml is the most suitable concentration of ferric chloride hexahydrate for colour removal from textile dyeing effluent, it removes 82 % colour from the effluent of Indian reactive dyes and 79 % colour removal from the effluent of direct dyes. In case of ferrous chloride monohydrate it removes 65 % colour from Indian reactive dyes effluent and 59 % colour removal for direct dyes. Both of these coagulants ferric chloride hexahydrate and ferrous chloride monohydrate can be used for colour removal from textile dyeing wastewater of Indian reactive dyes and direct dyes. The efficiency of ferric chloride is better than that of the ferrous chloride. Ferrous chloride is more economical than the ferric chloride. Ferrous chloride can also be used for colour removal. It removes 59 - 65 % colour, which is also near to colourless and clear water.

Ferric chloride monohydrate and ferrous chloride hexahydrate coagulant is able to remove 82 % and 64 % dyes from the textile dyeing effluent. pH plays a very important role, Fig 4, in coagulation of dyes. In the pH range from pH 3 to 5, coagulant showed a higher colour removal percentage. The mechanism of coagulation is found to be charged adsorption neutralization. For reactive dyes the

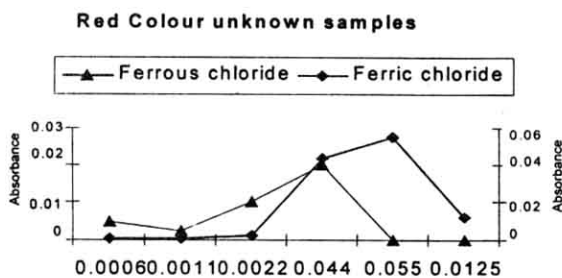


Fig. 1: Colour concentration mg/100ml.

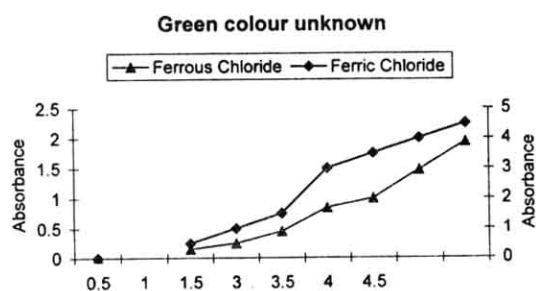


Fig. 2 colour concentration mg/100 ml.

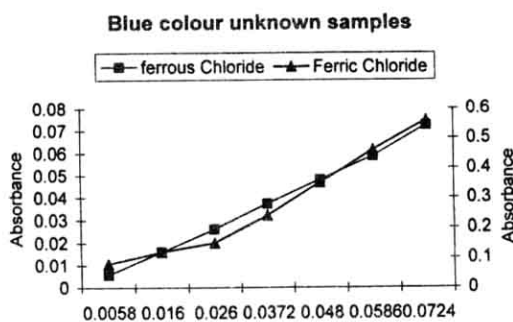


Fig. 3: Colour concentration mg/ 100 ml.

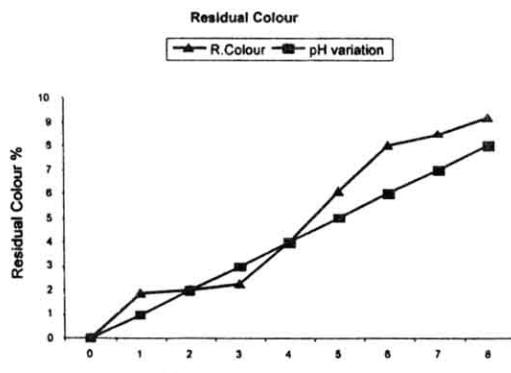


Fig. 4: Variation in pH.

colour removal efficiency using ferric chloride monohydrate coagulant is better than using alum. 82 % removal of colour could be achieved when pH is adjusted to 5. However the removal with alum and at their optimum pH is only 51 %, which is even poorer than the result obtained with ferric and ferrous coagulant with unadjusted pH.

Experimental

A bulk sample from a textile dyeing industry was collected from the disposal of the factory. This sample was used for characterization of colour using standard methods of examination of water and wastewater [15] and then used for treatment in different batches. The bulk sample was divided into different portions and these portions were used for treatment with ferric chloride hexahydrate and ferrous chloride monohydrate. Fifty percent samples were treated with the ferric chloride hexahydrate 0.01 mg/100ml to 0.05 mg/100ml and the remaining fifty percent samples were treated with the 0.01 to 0.05 mg/100ml ferrous chloride monohydrate. The 100 ml samples were taken in a round bottom batch reactor and 0.01, 0.02, 0.03, 0.04, 0.05 mg of ferric chloride hexa hydrate was added and mixed with the magnetic stirrer. The pH of the effluent was adjusted using NaOH solution. After 30 minutes mixing at constant speed the batch reactor was switched off to allow the suspended material to settle for two hours. The sludge was settled at the bottom of reactor. After two hours settling then supernatant colourless water sample was obtained. The absorbance of untreated and treated dye wastewater samples were measured on spectrophotometer (Bush & Lamb 21 USA) at 470 nm. The absorbance scale was adjusted at zero using double distilled water for each sample.

Conclusion

Therefore we can conclude that ferric coagulant is effective to improve the quality of textile wastewater only by reducing colour, turbidity and suspended solids. Ferrous chloride can also be used for colour removal treatment if it removes the colour from the effluent according to the wastewater limits of national environmental quality standards.

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