DYE REMOVAL FROM TEXTILE WASTEWATER BY COAGULATION USING ALUM AND PAC

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ABSTRACT

Removal of solar brown and direct black dyes by coagulation with two aluminum based coagulants was conducted. The main objective is to examine the efficiency of these coagulants in the treatment of dye polluted water discharged from Al-Kadhymia Textile Company (Baghdad-Iraq). The performance of these coagulants was investigated through jar test by comparing dye percent removal at different wastewater pH, coagulant dose, and initial dye concentration. Results show that alum works better than PAC under acidic media (5-6) and PAC works better under basic media (7-8) in the removal of both solar brown and direct black dyes. Higher doses of PAC were required to achieve the maximum removal efficiency under optimum pH conditions for both dyes. It was observed that under optimum conditions of pH and dose values, PAC was significantly higher dye removal efficiency than alum for all dyes initial concentrations.

KEYWORDS

Dye removal, dye pollution, direct black, solar brown, coagulation.

ازالـة الالوان من الماء المطروح في الصناعـات النسيجيـة بالتخثيـر بواسطـة الشـب ومتعدد كلوريد الالمنيـوم

الخلاصـة

تم دراسة ازالة صبغة السوداء المباشرة والبني الشمسي بالتخثير باستخدام مخثر الشب ومتعدد كلوريد الالمنيوم لغرض معالجة الماء المطروح الحاوي على الصبغتين من معمل نسيج الكاظمية (بغداد-العراق). اداء كل من المخثرين تمت دراسته باستخدام اختبار الجرة وذلك بمقارنة نسبة الازالة اللونية من الماء المعامل تحت ظروف مختلفة من الدالة الحامضية وكمية المخثر والتركيز الابتدائي للصبغة. بينت النتائج بان الشب اثبت اداءً افضل من متعدد كلوريد الالمنيوم في الوسط الحامضي (5-6) بينما اثبت متعدد كلوريد الالمنيوم اداءً افضل من الشب في الوسط القاعدي (7-8). عند العمل في الظروف المثلى للدالة الحامضية تبين ان اقصى نسبة ازالة يمكن تحقيقها باستخدام متعدد كلوريد الالمنيوم عند جرعات اعلى من تلك اللازمة في حالة الشب. وتبين ان تطبيق الظروف المثلى من دالة الحامضية وجرعة المخثر بان متعدد كلوريد الالمنيوم افضل عمليا من الشب في حال تغير تركيز الصبغة في الماء الملوث المطروح ولكلا الصبغتين.

INTRODUCTION

Water pollution control is presently takes major area of scientific research. Automation and industrialization has resulted in rapid deterioration of water quality. Some of these industries such as textile, printing, leather, paint and so on are most of polluted resources (Joonghwan *et al*, 2005).

These processes use large amount of water and discharge colored wastewaters that are heavily polluted with dyes, hazard chemicals, and other toxic compounds. Presence of color has always been undesirable in water for either industrial or domestic needs. Even very small amounts of dyes in water (less than 1ppm for some dyes) are highly visible (Crini, 2006). These colored compounds causes reduction of sunlight penetration and depletion of dissolved oxygen. Additionally the majority of synthetic dyes are highly water-soluble which are toxic to some organisms and may pose serious health threat to human beings (Baoyou Shi *et al*, 2006). Thus dyes in wastewater have to be removed completely before discharging into receiving waters.

Since dye compounds are specifically designed to be recalcitrant with poor biodegradability, they are very stable and difficult to remove by conventional biological treatment, thus physicochemical techniques such as coagulation/flocculation, adsorption, membrane filtration and ozonation are usually used for the treatment (Ozer *et al*, 2006; Shi *et al*, 2007).

Each treatment method has its advantages and disadvantages. Generally adsorption process is the most common technique because of its effectiveness but it is an expensive process (Gutpvk *et al*, 2000). Membrane separation process is one of the popular methods used in textile treatment but this process has a problem of membrane fouling by the pollutants (Vrijenhoek *et al*, 2001). Ozonation improved the biodegradability of toxic substances but it may form toxic byproducts in the effluent after treatment (Pradeep *et al*, 2007).

Coagulation and flocculation processes have been widely used as pretreatments to remove suspended particles and coloring materials prior to biological treatment. It is one of most effective methods for dye removal from industrial wastewaters (Duk *et al*, 2005).

This work was mainly focused on the determination of the optimum conditions for the treatment of cotton textile dyeing wastewaters such as pH, coagulant dose, and initial dye concentration to study their effect on the dye removal efficiency using coagulation/flocculation process.

MATERIALS AND METHODS

Materials

Two direct dyes were used to simulate dye-polluted waters, direct black and solar brown. These dyes were procured from Al-khadimya Cotton Textile Company (Baghdad, Iraq). Two chemical coagulants: aluminum sulfate (alum, $Al_2 (SO_4)_3$) and poly aluminum chloride (PAC) were selected in this study for the coagulation-sedimentation process since they represent the most widely used coagulants. 1M Solutions of H_2SO_4 and NaOH were used to adjust pH.

Coagulation and Flocculation Experiments

A standard jar-test floc tester apparatus was used for the coagulation flocculation processes. Six beakers of 1 liter capacity were filled with synthetic wastewater and transferred to the jars. The pH of prepared synthetic wastewater was adjusted with H_2SO_4 and NaOH solutions using Thermo Fisher Scientific portable pH meter (model Orion 3 star, USA). The samples in the jars were rapidly mixed at a paddle speed of 200 rpm and inorganic coagulant (alum or PAC) was added during mixing. Rapid mixing at 200 rpm was continued for 2 min, followed by slow mixing for 10 min at 35 rpm, followed by settling for 45 min. After settling, samples were withdrawn for analysis using a pipette from 2-3 cm below the surface treated wastewater in each jar. All experiments were conducted between 27-30°C.

Preparation of Synthetic Wastewater

Stock solutions of concentration 5000 mg/l for each dye were prepared and then diluted using deionized water to obtain the desired concentrations of 5, 10, 15, 20, and 25 mg/l for each dye. It is important to notice here that the natural effluent wastewater discharged from the company contains about 10 mg/l under normal conditions (Rasha, 2010).

Measurement of Dye Concentration after Coagulation

The wavelength of maximum absorbency (λmax) of the two dyes in the background of deionized water were measured to be 419 nm for solar brown and 566 nm for direct black according to scanning patterns performed on a UV spectrophotometer (model Shimatatzu 160A, Japan). The absorbency of the two dyes was measured using Labomed Inc. spectrophotometer (model Spectro SC, USA) for different dye concentrations at the determined wavelengths. Linear relationships were obtained between dye concentrations and absorbency for each dye as shown in **Fig**.1 and **Fig**. 2. Measured absorbency for each dye was converted into units of concentration and further into removal percentage.

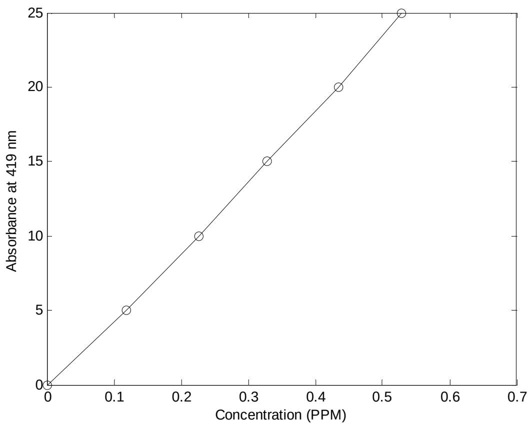

Fig. 1 Absorbency vs. concentration for solar brown dye

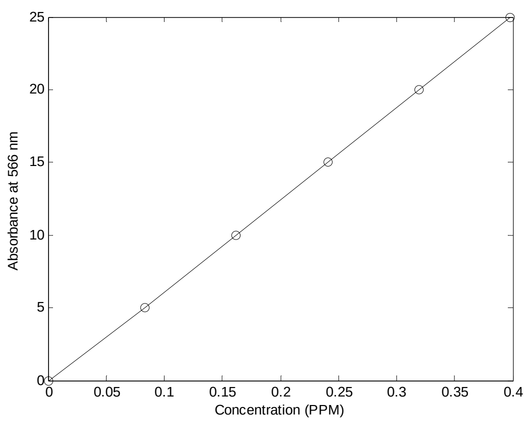

Fig. 2 Absorbency vs. concentration for direct black dye

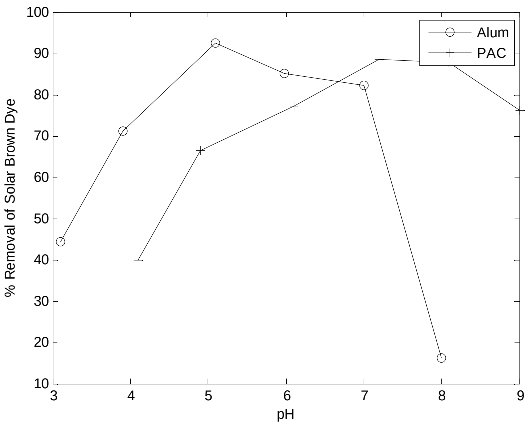

Fig. 3 Removal efficiency for solar brown dye at different pH values

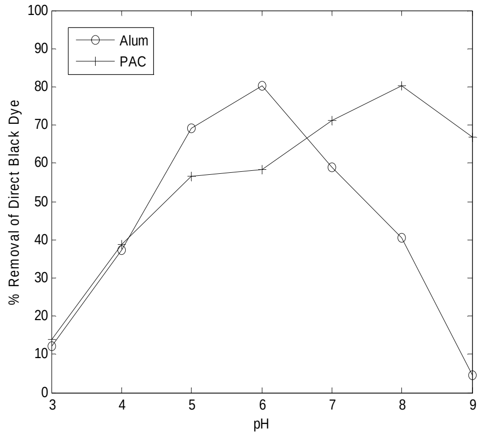

Fig. 4 Removal efficiency for direct black dye at different pH

RESULTS AND DISCUSSION

Effect of pH on Dye Removal

The effect of pH of the synthetic dye wastewater on the percentage of dye removal was studied since the pH plays an important role in determining coagulation efficiency. An optimum pH range in which metal hydroxide precipitates occur, should be determined to establish optimum conditions for coagulation (Duk *et al*, 2007; Maryam *et al*, 2008).

To study the effect of pH on dye removal, the dosages of alum and PAC were kept constant at 30 mg/l, while varying the pH of samples from 2 up to 9. Dye concentration was kept constant at 10 mg/l for all solutions during the experiments at this time. **Figs**. 3 and 4 show the removal efficiency of both solar brown and direct black dyes respectively at different values of PH using alum and PAC.

It was observed that alum is active in the acidic medium whereas PAC is more active in alkaline medium for the removal of both dyes. The reduction of dissolved organics (dyes) during coagulation with coagulants at different pH values follow two different mechanisms. At low pH the effluent containing anionic organic molecules coordinate with metal cation and form insoluble metal complexes at higher pH (alkaline range). The organics are adsorbed on or form flocs of metal hydroxide and then precipitated. The combined effect of two mechanisms show that the reductions of dissolved organics with different coagulants can occur at different pH. The maximum dye removal may thus occur where the combined effect of both the mechanisms is high (Pradeep *et al*, 2008). **Table** 1 shows the optimum pH obtained in which maximum dye removal occurred.

Table 1 Optimum pH and coagulant dose in which maximum dye removal can be obtained

	pH		Coagulant dose (mg/l)	
Coagulant type	Solar brown	Direct black	Solar brow n	Direct black
Alum	5	6	30	40
PAC	7	8	45	50

Effect of Coagulant Dose

The effect of coagulant dosage on dye removal efficiency was examined. Variable amounts of inorganic coagulant (alum and PAC) were dosed into the dye containing solutions. Dye concentration was kept constant at 10 mg/l and pH was adjusted to optimum values as indicated in **Table** 1. The results are shown in **Figs**. 5 and 6 as percent of dye reduction. It was observed that the reduction in color for both dyes was increased initially as the dose of both alum and PAC increased. For alum the removal efficiencies increased for the doses from 10 up to 30 mg/l for solar brown and from 10 up to 40 mg/l for direct black. For PAC the removal efficiencies increased form 10 up to 45 mg/l for solar brown and from 10 up to 50 mg/l for direct black. With further increase in coagulant dose the dye percent reduction decrease. However, it was observed that PAC is more effective relative to alum but with higher doses for the removal of both dyes. **Table** 1 show the optimum coagulant dose obtained in which maximum dye removal was occurred.

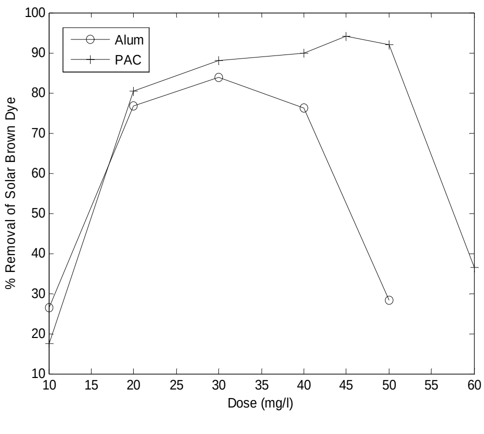

Fig. 5 Removal efficiency of solar brown dye at different

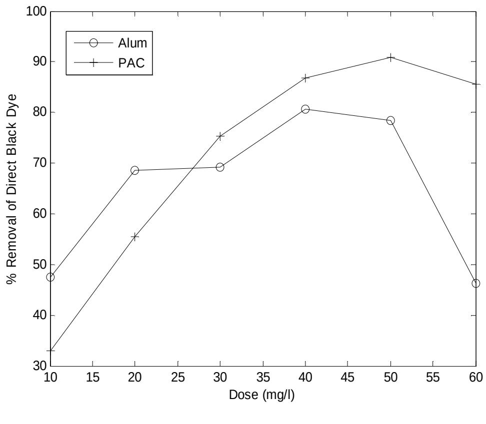

Fig. 6 Removal efficiency of direct black dye at different

Effect of Initial Dye Concentration

The influence of initial dye concentration on the dye removal efficiency was investigated. Optimum coagulant dosage (30 mg/l for alum and 45 mg/l for PAC) for solar brown and (40 mg/l for alum and 50 mg/l for PAC) direct black were used in which maximum dye removal occurs.

For alum, when the concentration of two dyes was increased from 5 mg/l to 10 mg/l, the removal efficiency increased to 84% for solar brown and to 87% for direct black. For dyes concentrations more than 10 mg/l the efficiency decreased and reached to 73% and 67% for solar brown and direct black respectively. Similar behavior was observed in the case of PAC. However the values of the removal efficiencies were superior for PAC for two dyes. Figs. 7 and 8 show the removal efficiency for both solar brown and direct black dyes under different initial dye concentrations.

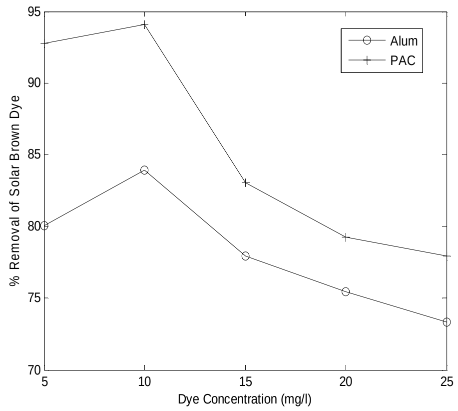

Fig. 7 Removal efficiency of solar brown dve at different dve

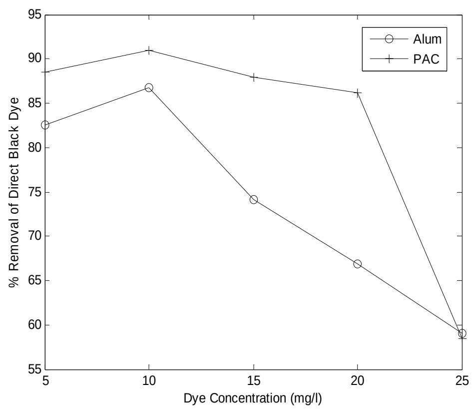

Fig. 8 Removal efficiency of direct black dve at different dve

CONCLUSIONS

1. Dye removal of direct black and solar brown dyes from textile wastewater can be achieved by coagulation using traditional coagulants of alum and PAC. Removal process was affected highly by pH. Changing coagulant dose should be accomplished at optimum pH to maximize the removal efficiency.
2. Maximum removal efficiency occurred when the pH was about 5 and 6 for solar brown and direct black respectively using alum coagulant.
3. Maximum removal efficiency occurred when the pH was about 7 and 8 for solar brown and direct black respectively using PAC coagulant.
4. Optimum coagulant dose was found to be 30 and 40 mg/l for solar brown and direct black respectively using alum coagulant.
5. Optimum coagulant dose was found to be 45 and 50 mg/l for solar brown and direct black respectively using PAC coagulant.

6. Generally, PAC gives more removal efficiency than alum at all dye concentrations from 5 up to 25 mg/l.

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