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Improvement of paint effluents coagulation using natural and synthetic coagulant aids

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Abstract

The coagulant iron chloride and the flocculants Polysep 3000 (PO), Superfloc A-1820 (SU) and Praestol 2515 TR (PR) have been used in this study to show the efficiency of coagulation flocculation process in the chemical precipitation method for the removal of organic and colouring matters from the paint industry wastewater. This study also includes the amount of produced sludge.

The results indicate that $FeCl_3$ is efficient at pH range 8–9 and at optimal dose of 650 mg l^{-1}. Iron chloride allows the removal of 82% of chemical oxygen demand (COD) and 94% of colour. However, sequential addition of coagulant and polymeric additives enhance clearly pollutant removal and produces less decanted sludge compared to the results obtained when the coagulant is used alone. The removal efficiency of COD reaches 91% and that of colour 99%. Coagulation–biflocculation process is more effective than the coagulation–monoflocculation one. The sequential addition of iron chloride, Polysep 3000 (cationic flocculant) and Praestol 2515 TR (anionic flocculant) seems to be the most suitable combination for the treatment of the paint industry wastewaters.

Keywords: Iron chloride; Coagulation–flocculation; Paint wastewater; Polyelectrolytes; Colour

1. Introduction

Latex paints generally consist of organic and inorganic pigments and dyestuffs, extenders, cellulosic and noncellulosic thickeners, latexes, emulsifying agents, anti-foaming agents, preservatives, solvents and coalescing agents. In manufacturing paint and allied products, all the constituents entering mixers or reactors come out as products and, as such, there is no major stream of wastewater associated with the production. Wastewater is mainly generated by the cleaning operations of mixers, reactors, blenders, packing machines and floors. Because of the varying degree of chemicals used, the wastewater contains considerable concentrations of biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, toxic compounds and colour [1]. The discharge of such coloured wastewater into the environment is not only aesthetically displeasing, but impedes light penetration, damages the quality of the receiving streams and may be toxic to treatment processes, to food chain organisms and to aquatic life [2]. For these reasons, the effluent treatment is necessary before their discharge into the environment.

Physical and chemical decolourization treatment operations include adsorption [3–5], oxidation [6,7] and chemical precipitation [8,9]. Each of them has its own merits and limitations in application. In recent years, with the technological advancements in polymer chemistry and the increasing interest in nutrient control in addition to the rising construction and energy costs, substantial interest has developed in chemically enhanced wastewater treatment methods [10]. Coagulation–flocculation has always attracted considerable attention for yielding high removal efficiency in wastewater treatment; this process can be directly applied to wastewaters to remove organics together with suspended solids, without being affected by the toxicity in the wastewater. In addition, the main advantage of the conventional processes, like coagulation and flocculation, is the decolourization of the waste stream due to the removal of dye molecules from the effluents, and not due to a partial decomposition of dyes, which can lead to an even more potentially harmful and toxic

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aromatic compound [11]. However, the coagulation process is not always perfect as it may result in small flocs when coagulation takes place at a very low temperature or fragile flocs which break up when subjected to physical forces [12]. It is not only necessary to overcome these problems but also to improve the coagulation and flocculation processes to obtain a good quality effluent and rapid sedimentation of the flocs formed. For this, several products, denominated coagulant aids, can be used to bring together and agglutinate the flocs formed by the coagulant in order to increase floc density and, hence, to improve sedimentation [13,14]. Polymeric additives can act either by polymer bridging or charge neutralisation [15].

The purpose of this study is to improve the coagulation–flocculation process applied to a paint wastewater by adding coagulant aids. The flocculants used are Polysep 3000 (PO) (natural cationic flocculant), Superfloc A-1820 (SU) (synthetic anionic polymer) and Praestol 2515 TR (PR) (synthetic anionic polyelectrolyte). The polymers are used in combination with ferric chloride. As terminology for the use of one polymer in addition to coagulant we suggest "coagulation–monoflocculation", and for the use of sequential addition of coagulant and two polymers there is "coagulation–biflocculation". These data provide new information about the role of polymeric flocculants in the industrial wastewater treatment operations, especially coloured effluents.

2. Materials and methods

Wastewater samples are collected from the discharges of a paint factory. The wastewater is mainly characterized by its colour variation and high load of COD, generated effluent is discharged into municipal sewer. The characteristics of the raw wastewater (RW) are as shown in Table 1.

2.1. Coagulant and flocculants used

2.1.1. Iron chloride

Two principal inorganic coagulants used in water treatment are salts of aluminium and ferric ions. However, ferric ions are often the coagulants chosen to destabilize the colloidal and suspended solids [16]. In this study, iron chloride ($FeCl_3$) for reagent grade is used as coagulant.

2.1.2. Coagulant aids

The coagulant aids used in this study are for commercial grade.

- *Polysep 3000*: P3000 is a natural organic polymer supplied by AQUAREX-ARCIE, Italy. It is a stable product prepared with acidified vegetable tannic substances. The flocculant is a brown liquid cationic flocculant of a viscosity between 10 and 50 cps and a pH value close to 1.5 and density about 1.1 g cm^{-3} at 20 °C [9].
- *Superfloc A-1820*: Superfloc A-1820 is an anionic polyacrylamide. The flocculant of high molecular weight is supplied by Cytec Industries. It is an opaque liquid of a viscosity of 600 cps (at 0.5%), specific gravity from 0.99–1.03 (at 25 °C) and the freezing point is −18 °C.
- *Praestol 2515 TR*: Praestol 2515 TR is a modified polyacrylamide, poly(acrylamide-*co*-sodium acrylate). Anionic polyelectrolyte with very high molecular weight, provided as powder by Stockhausen, Krefeld, Germany.

2.2. Procedure in the jar tests

Jar test experiments are conducted under controlled laboratory conditions using a standard jar test apparatus. Four equal-volume polyethylene beakers are used to examine the four different dosages of coagulant/flocculant in each run. The sample bottles are thoroughly shaken for resuspension of possibly settling solids and then the appropriate volume of sample is transferred to the corresponding jar test beakers. The optimum coagulant and flocculants doses are determined on the basis of COD and colour removal and the amount of sludge produced. For each test, 1000 ml of paint wastewaters was taken in a 1000 ml worked volume beaker and, after addition of coagulant, mixed for 5 min at 150 rpm to insure complete dispersion. In coagulation–monoflocculation tests, after coagulant addition, a known amount of polymer solution is added while rapid stirring continues for another 1 min more. In coagulation–biflocculation tests, after coagulant addition, a desired amount of polymer solution is added first into the beaker. After the mixing time of 30 s, the second flocculant is added and stirred for 30 s at 150 rpm. Sequential addition of flocculants is a better mode than co-addition. In this mode, a maximum amount of the second

Table 1
Characteristics of paint wastewaters

Parameters	Concentrations			Moroccan guide level (rejection into sewer)
	Minimum	Maximum	Average	
pH	6.70	7.80	7.35	6.5–8.5
Conductivity (ms cm^{-1})	2.05	2.68	2.33	2.7
Turbidity (NTU)	1.09	56.00	26.83	–
SM (mg l^{-1})	4735.29	13,350.00	9532.43	600
COD (mg l^{-1})	4438.19	25105.69	16342.32	1000
BOD (mg l^{-1})	960.00	1968.00	1465.20	500
TKN (mg l^{-1})	50.03	490.30	199.73	–
Total phosphorus (mg l^{-1})	1.42	16.08	7.46	10
Chloride (mg l^{-1})	177.65	355.00	266.33	–
Sulphate (mg l^{-1})	55.35	5768.87	2389.01	400

Number of samples = 6.