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ADSORPTION OF REMAZOL BRILLIANT BLUE R DYE FROM WATER BY POLYALUMINUM CHLORIDE

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ABSTRACT
The efficiency of polyaluminium chloride as inorganic coagulant for the adsorption of Remazol Brilliant Blue R from dye containing water has been investigated. Polyaluminium chloride was synthesize and characterized by powder X-ray diffraction pattern and ^{27}Al nuclear magnetic resonance spectra. Concentration of dye was determined by UV/VIS spectroscopy. Excellent efficiency of polyaluminium chloride for the adsorption of Remazol Brilliant Blue R dye has been observed. The adsorption efficiency of PAC is dependent on the turbidity of water.
Keywords*:* **Polyaluminium chloride; Inorganic coagulant; Remazol Brilliant Blue R dye; Adsorption; UV/VIS Spectroscopy.**

INTRODUCTION

The dyestuff industry is one of the largest industries in the world [1]. There are a number of dye substances which could be highly polluting if released into the environment. Over 50 000 tonnes of dye, containing hazardous substances which can damage aquatic and vegetal life, are discharged via effluent into the environment annually [2]. During the last decade, among different classes of dyes, the use of reactive ones continually increased, mainly because of the increased utilization of cellulose fibers in the textile industry [3]. Generally, reactive dyes contain functional groups like azo, phthalocyanine, anthraquinone, formazane, and oxazine as chromophore. During the dyeing process, under the influence of heat in alkaline conditions, a dye's reactive sites react with the functional groups of the fiber. However a large fraction of the applied reactive dye is wasted because in the process of dyeing reactive dye is hydrolyzed to some extent and some of the reactive dyestuff is inactivated by this competing hydrolysis reaction. Compared with other dyes, reactive dyes represent severe pollutants [4]. Hence, removal of dyes from textile dyeing wastewaters is a major environmental problem and complete dye removal is necessary because dyes will be visible even at very low concentrations [5, 6]. Various methods have been investigated for treating dye bearing effluents, based on physical and chemical processes, and their combinations, such as coagulation electroflotation, electrokinetic coagulation, precipitation, oxidation, ozonation, adsorption and biosorption [1, 6-24]. The coagulation/flocculation process is extensive use for pre-, main, and post-treatment. However, for all these processes pre-treatment is needed for removal of dye and organic materials, consisting of coagulation and sedimentation. Polymeric coagulants based on Al are increasingly used at treatment plants for wastewater, water pool water, potable water etc. [25], among which polyaluminium chloride (PAC), a polymerized form of alum, is most often used. PAC has proved itself as an efficient coagulant especially for removal of organic materials present in the water, independent from their origin and complex composition [26]. The purpose of this study was to investigate the applicability of PAC as a coagulant/flocculant for the removal of textile dyes from dyeing wastewater, and to determine the optimal coagulation conditions for wastewater pre-treatment. Present work describes the PAC as inorganic coagulant for the adsorption of Remazol Brilliant Blue R dye (C. I. 61200). Structure of the dye is given in Fig 1. The efficiency of PAC for the adsorption of Remazol Brilliant Blue R dye was dependent on the turbidity of water.

EXPERIMENTAL

Materials

Remazol Brilliant Blue R dye (C. I. 61200) was obtained from M/s. Atul Industries, India. Purity of dye was 50%. $AlCl_3 \cdot 6H_2O$ and $NaHCO_3$ were purchased from S. D. Fine Chemicals Mumbai, India, and used as such. All the chemicals received were used without further purification. The bentonite clay was collected from Barmer district of Rajasthan state of India.

Synthesis of the polyaluminum chloride

The polyaluminum chloride was prepared from $AlCl_3 \cdot 6H_2O$ and $NaHCO_3$ using published procedure [27]. Resulted powder PAC was accumulated in vacuum desiccators. Powder X-ray diffraction pattern of the PAC was recorded on a Phillips X"pert MPD diffract meter in 2θ range (10-80) at scan speed of 0.4 °/s. ^{27}Al-NMR spectra of PAC were recorded on 200 MHz spectrometer (Bruker advance DPX 200 MHz FT-NMR).

Preparation of artificial turbid water

1.5 g bentonite clay was added in 1 L of distilled water and was stirred for 30 min on the jar test apparatus followed by sedimentation for overnight. After sedimentation, supernatant water was used for turbidity measurements. Turbidity of the water samples were measure using TN-100EUTECH turbidity meter.

Preparation of dye solutions

Remazol Brilliant Blue R (RBBR) dye solution was prepared in 2L beaker using artificial turbid water under rapidly mixed for 1 min at 140 rpm and was allowed to settle down for overnight. Concentration of the dye in water was analyzed by UV-Visible spectrophotometer (Shimadzu 3101PC).

Coagulation and flocculation experiments

Experiments were conducted in a 2L beaker contain 1 L of dye solution. All Coagulation and flocculation experiments were conducted using a conventional Jar Test apparatus equipped with stirring paddles and provision for controlled mixing. The flock size and its settle ability were observed with the illuminating device at the base of the apparatus obtained from Pooja Scientific Instruments, India. PAC solution was freshly prepared by dissolving 10 g of the PAC in 1L of distilled water. For making 1% solution of PAC, the dilution of the coagulant was done with distilled water on daily basis. After the addition of coagulant in each beaker simultaneously, rapid mix was maintained at 140 rpm for 1 min followed by slow mix at 40 rpm for 30 second. At the end of the stirring period, the beakers were removed slowly from the Jar tester platform and the contents of the beakers were allowed to settle for 20 min. After sedimentation, supernatant samples were taken from a point of 5 mL, 10 mL, 25 mL and 100 mL the surface of the test water samples for RBBR dye analysis. After 5 min of genital stirring the samples were analyzed by UV-Visible spectrophotometer.

RESULTS AND DISCUSSION

Characterizations of PAC

Powder X-ray diffraction pattern of the PAC is given in Fig. 2. The high intensity and sharp signal of Al_{13} appeared in the range of 2θ from 5 to 25°. No peak was observed in the range of 2θ from 5 to 25° in $AlCl_3 \cdot 6H_2O$. In addition, the sample shows diffraction pattern of sodium chloride in the range of 2θ >25°. Sodium chloride was the by-product formed during hydroxylation and polymerization of Al^{3+} and was difficult to remove. PAC was further characterized by ^{27}Al-NMR specroscopy.^{27}Al-NMR spectrum of PAC is given in Fig 3. It gave one broad signal near 62.5 ppm and another peak at 0 ppm. No peak was observed at 80 ppm indicated that Al $(OH)_4$ species was absent. The peak as 62.5 ppm was due to polymeric Al_{13} species [28].

Preparation of artificial turbid water and coagulation studies by PAC

The chemical composition of the clay was as 54.9% SiO_2, 21.1% Al_2O_3, 7.3% Fe_2O_3, 2.6% MgO, 6% CaO and 1.2% Na_2O with loss on ignition 6.8% [29]. The amount of bentonite clay *vs* turbidity produced in water has been presented in Fig. 4. The pH of the artificial turbid water was found in the range of 7.2 to 7.5. 0.250 g bentonite clay in distilled water was used for the preparation of turbid water of 132 NTU. Turbidity and pH of the treated and untreated water sample was measured and found that the 0.040 g dose of powder PAC is the optimum dose for to bring down the turbidity of water below 5 NTU.

Discoloration and optimum condition for the adsorption of dye

Adsorption of RBBR dye by coagulation was first carried out using tap water having turbidity of ~5 NTU and pH of 7.80. 0.100 g dye was dissolved in the 1 L of tap water and optimum doses (0.025 g to 0.050 g) of PAC had been given for the adsorption of dye during jar test. Due to higher solubility of the dye and low turbidity of the tap water, color of the dye remains as such. Experiments were also repeated in distilled water and similar results were observed. The probability of chemical flocculation was lower for reactive dyes because of its high solubility and high charged [30]. UV-Visible spectrum of the PAC treated and un-treated water sample prepared in the artificial turbid water was recorded, given in Fig. 5A. As the dose of the PAC increases from 0.025 g to 0.150 g, there was a decline in the absorbance at λ_{max} = 663 nm which was due to the decrease in dye concentration in treated water. Concentration of dye was calculated from the absorption data at λ_{max} of dye = 663 nm. Fig. 5 (B) gives the plot of added PAC *vs* dye concentration. The results were further summarized as a plot of concentration of dye removal vs. equilibrium dye concentration (Fig 6). It was cleared evidence from Fig. 5(A),(B) and 6 that more than 95% of the dye could be removed from the waste water (from the initial dye concentration of 0.100 g/L). A minimum 0.150 g/L dose of PAC was required for the discoloration of water having 0.100 g/L of dye. Further increases in the PAC doses have marginal effect on the dye removal efficiency.

CONCLUSION

It has been possible to prepare powder polyaluminum chloride using $AlCl_3$ and $NaHCO_3$ having Al_{13} polymeric species. Turbid water could be made using bentonite clay in distilled water. Adsorption of Remazol Brilliant Blue R dye (C. I. 61200) efficiency by PAC depends on the turbidity of water.

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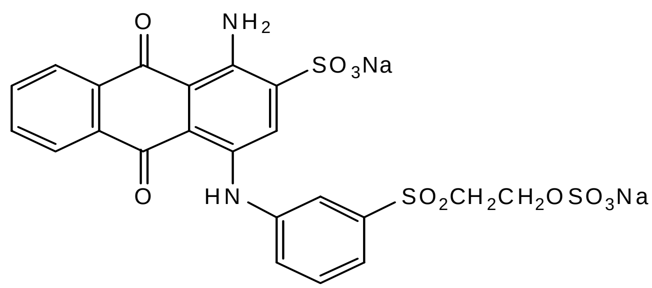

Fig.-1: Structure of Remazol Brilliant Blue R dye

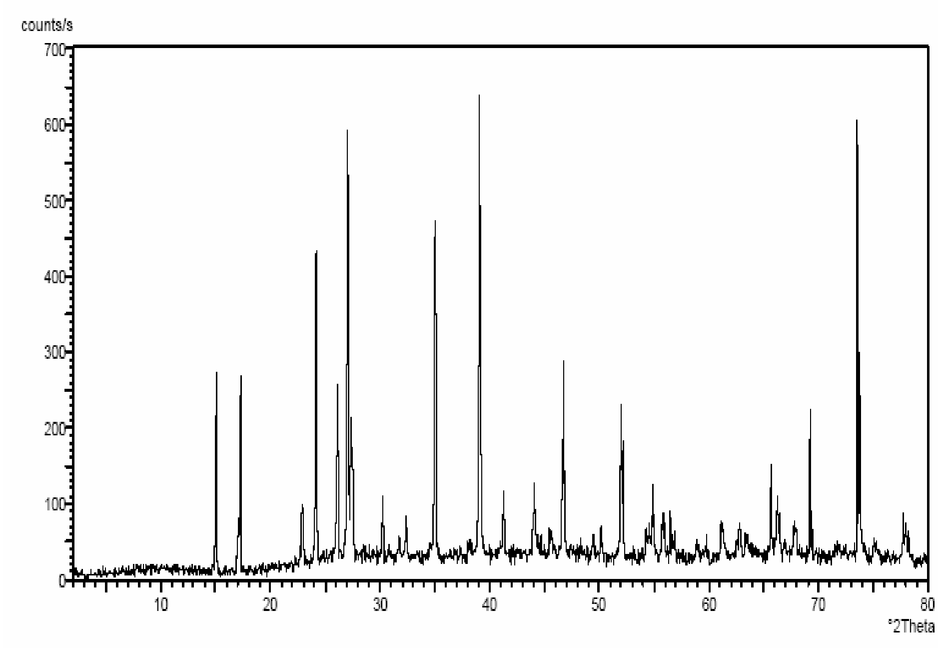

Fig.-2: Powder X-ray diffraction pattern of the PAC

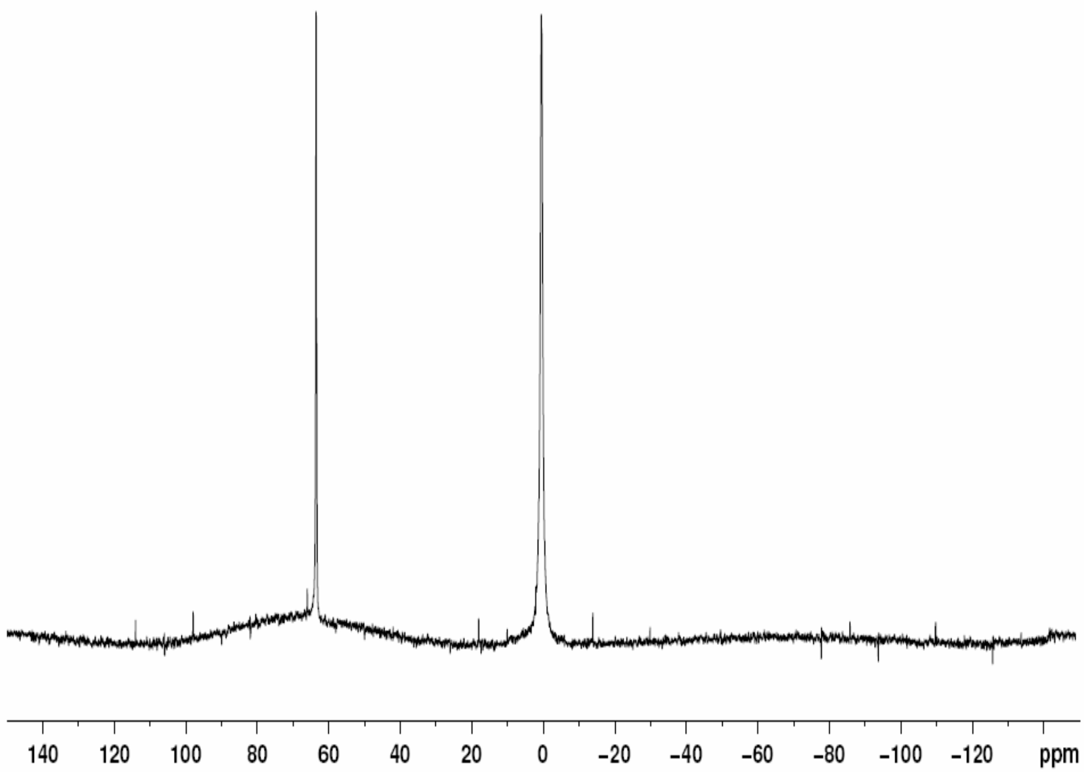

Fig.- 3: ^{27}Al-NMR spectrum of PAC

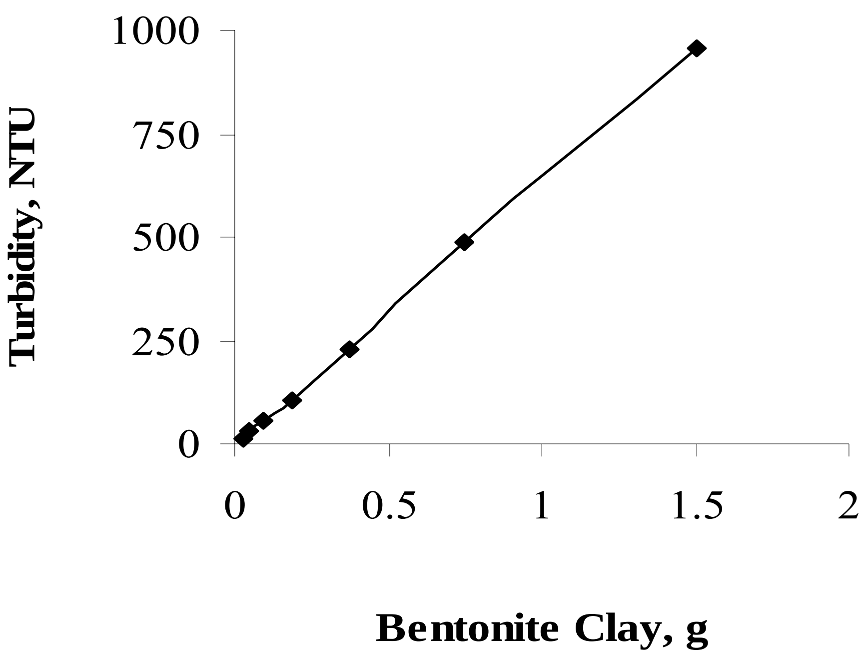

Fig.-4: The amount of bentonite clay *vs* turbidity produced in water

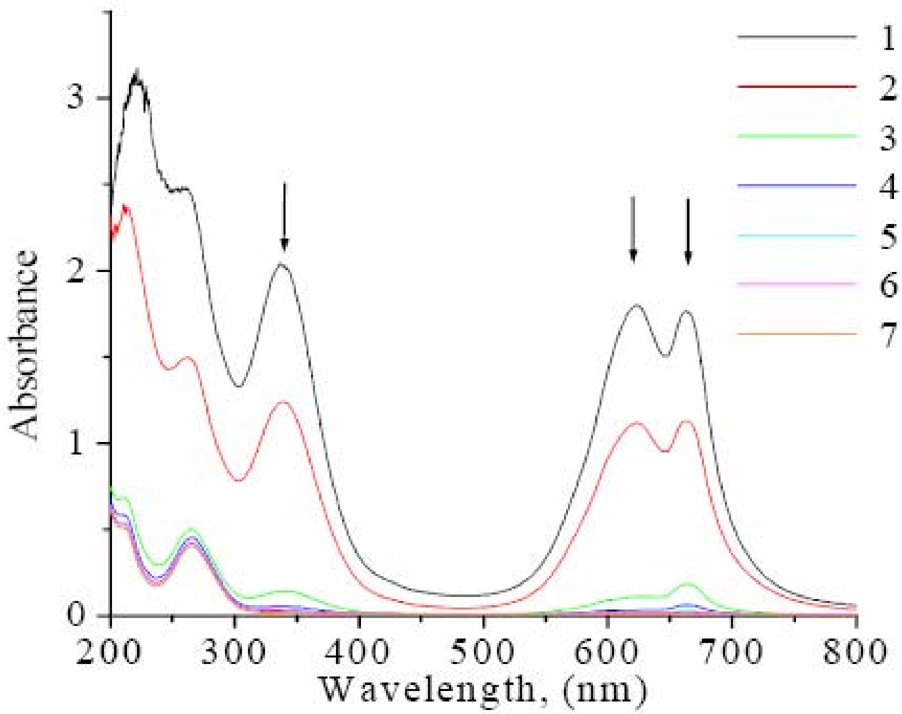

Fig.-5A: UV-Visible spectrum of the PAC (1) 0.0, (2) 0.025, (3) 0.050, (4) 0.075, (5) 0.100, (6) 0.125 and (7) 0.150 g/L treated water sample

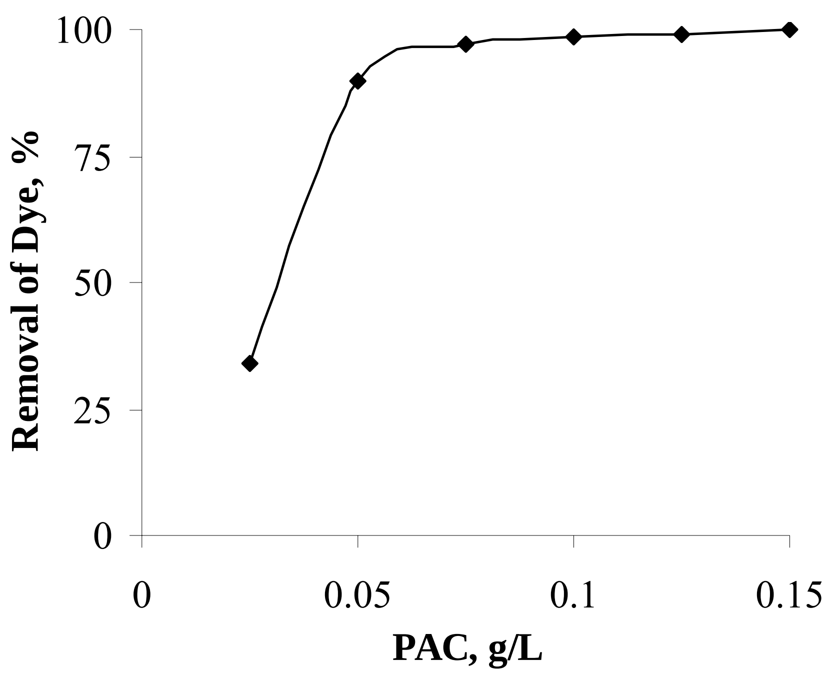

Fig.-5B: The plot of added PAC *vs* dye concentration

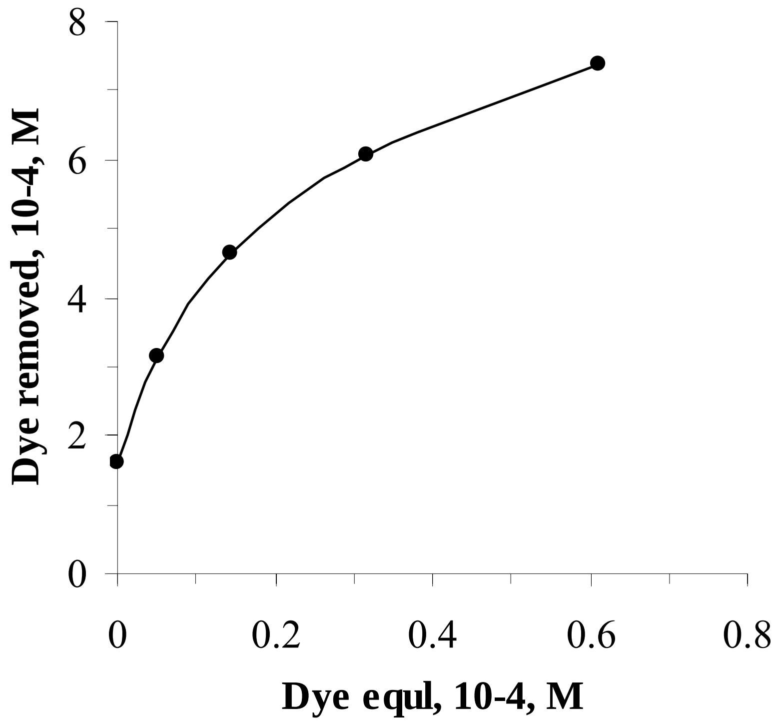

Fig.-6: Plot of concentration of dye removal vs. equilibrium dye concentration

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I hate facts. I always say the chief end of man is to form general propositions - adding that no general proposition is worth a damn.

-Oliver Wendell Holmes