Cationic Chitosan in Wastewater Treatment

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ABSTRACT

Treatment of chemical industry wastewater is a challenge for the world to save the environment. There are many processes developed for the treatment of industrial wastewater. Very simple to highly complex methods are invented by different researchers. These methods can be compared on various aspects such as their performance on wastewater, ease of operation, cost, etc. Coagulation and flocculation is one of the most widely used technique for the treatment of wastewater. A wide variety of chemicals are used as coagulants and flocculants and used in different combinations. Very few natural chemicals are used for this role. Natural chemicals are biodegradable, environment-friendly and not harmful to the environment compared to synthetic chemicals/ polymers. Chitosan is one such natural polymer, reported its usefulness in treatment as flocculent. In this paper, The COD is studied, and reported the performance of modified chitosan as a flocculent along with different conventional coagulants. Chitosan has been modified, to improve its performance. A variety of combinations of coagulants and flocculants is used for the treatment of wastewater.

Keywords: Biodegradable wastewater treatment, Modified chitosan, Natural flocculent

1 Introduction

The wastewater treatment process aims to produce chemically and biologically safe water in terms of turbidity, COD, appearance, etc. [1]. A wide variety of processes are developed and used for wastewater treatment, such as membrane separation, coagulation and flocculation, phase separation, etc. The selection process also becomes complex. Coagulation and flocculation is one of the simplest and cheapest processes that give good results for the primary treatment of wastewater [2]. All the techniques aim to make water reusable or recyclable. Usually, in wastewater treatment, coagulation is followed by flocculants. A large variety of coagulants are used for this application, like lime, alum, ferric chloride, ferrous sulfate, etc. Similarly list of flocculants is also long. The majority of the chemicals used as flocculent are synthetic polymers. Chitosan is a natural polymer obtained from chitin [3]. Chitosan-based natural flocculants [4] reduce the production of a large quantity of sludge. It does not cause any secondary pollution [5], [6]. Due to the high density of chitosan, it increases the floc size, which decreases the sedimentation time [4], [7].
The combination of coagulants and flocculants depends on a variety of factors [8]. A large number of combinations are used in plants for wastewater treatment. In this research work, calcium carbonate (Lime), alum, ferric chloride, and ferrous sulphate were tried as coagulants along with modified chitosan [9], [10]. Chitosan was modified to improve its flocculation performance for wastewater treatment. Wastewater samples were taken from the common effluent treatment plant.

2 Materials and Methods

Chemicals:

Chitosan- AR was supplied by SRL, Mumbai. Acetic acid, NaOH, was occupied from CDH, New Delhi. Reagent ((3-chloro-2-hydroxypropyl) tri methyl ammonium chloride) was supplied by SRL. Water was taken from TCI and used without any further treatment.

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Flocculant preparation

2.1 Cationic chitosan (CATC)

Chitosan solution was prepared in acetic acid solution. 6 ml of ((3-chloro-2-hydroxypropyl) tri methyl ammonium chloride) is added gradually with 1 hr of stirring [11]. The reaction was trapped with NaOH solution. The neutralized slurry was washed with methanol to remove the water molecules. The final product was dried until the weight was found constant [12].

In the modification process, two steps, neutralization, and methanol wash, were eliminated. It was observed that the pH of the slurry was nearly 6, and it was performing the same to the water treatment process, so the neutralization step was eliminated. Eliminating the methanol wash step will sufficiently reduce manufacturing costs and time. During the direct use of the slurry, 50 gm of slurry (equivalent to 1 gm powder flocculent) was required. Different grades of CATCs were prepared and used to compare performance in wastewater treatment.

2.2 Reagent preparation

100 ml isopropyl alcohol was added in 60 grams of 1 mol 29% aqueous NH_4OH. Then 3 moles of epichlorohydrin were added and let it stir for an hour. Then concentrated, the solution into a vacuum oven at room temperature for 7 h to concentrate the solution up to 80%. [13]

Wastewater treatment procedure

A 10% solution of coagulant was prepared in distilled water. 1% flocculent solution was prepared in 2% acetic acid.

Experiments on coagulation and flocculation were performed using a jar test apparatus followed by a standard process. [1] 10 ml coagulant solution was added to the 100 ml wastewater. After sufficient mixing for 60-70 seconds, 1 ml flocculent solution was added for 30-40 rpm agitation speed and allowed for the settling of the flocs. The supernatant is collected by filtration.

3 Theory and Calculation

COD Analysis

COD was measured following the standard APHA (American Public Health Association) method. [14]

COD= (A-B) * M * 8000 * D.F. / ml sample

Where:

A= ml FAS used for blank, B= ml FAS used for sample, M= molarity of FAS

D.F. = Dilution factor

All measured parameters are shown in Table 1. Parameters measured for treated wastewater samples are also compared visually in Figure 1.

4 Results and Discussion

Table 1: *Parameters measured for treated wastewater samples*

Sample Description		Wastewater	Coagulant					
			Lime				Alum	
			Flocculent					
			Pure Chitosan	Cationic Chitosan*	Cationic Chitosan**	Cationic Chitosan***	Cationic Chitosan***	Cationic Chitosan**
Parameters / Batches		B0	B1	B2	B3	B4	B5	B6
pH		8.66	7.57	7.42	7.44	7.42	3.6	3.6
COD	(ppm)	1345	990	960	984	990	962	916
COD	% Reduction	-	26.39	28.62	26.84	26.39	28.47	31.89
TDS	(ppm)	3760	3410	3370	3400	3380	4750	4810
TDS	% Reduction	-	9.30%	10.37%	9.57%	10.11%	-26.33%	-27.93%
TSS	(ppm)	141	255	225	231	256	517	373
TSS	% Reduction	-	-80.85%	-59.57%	-63.83%	-81.56%	-266.67%	-164.54%
Color	(pt-Co)	506	325	330	351	356	402	513
Color	% Reduction	-	35.77%	34.78%	30.63%	29.64%	20.55%	-1.38%

*Cationic chitosan prepared with readymade reagent

**Cationic chitosan prepared with labmade reagent

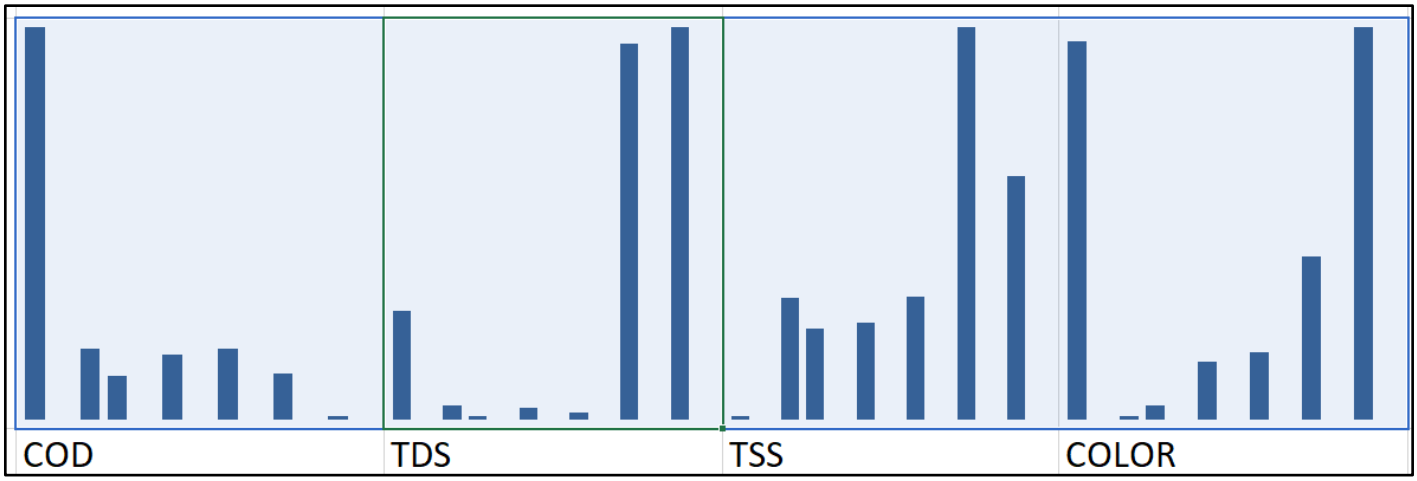

Figure 1: *Comparison of performance of batches*

Here, we can analyse that the addition of alum with flocculent CATC (B6) gives a maximum of 31.89% reduction of COD.

4.1 Combination of Coagulants

A combination of various coagulants with the flocculent CATC is Analyzed. 10 ml of each coagulant is added to the 100 ml wastewater. After sufficient mixing for 60-70 seconds, 1 ml Flocculent is added for 30-40 rpm agitation speed and allowed for the settling of the flocs for 1 minute. The supernatant is collected by filtration [8], [9]. Table 2 shows the results of the treatment of wastewater. The results are compared and shown on the chart in Figure 2.

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Table 2: *Results for a combination of coagulants*

Batch No.	Description		COD (ppm)	% Reduction
C1	Wastewater		1920	-
	Coagulant	Flocculent		
C2	Lime + Alum	CATC**	320	83.3
C3	Lime + Ferric Chloride	CATC**	352	81.7
C4	Lime + Ferrous Sulphate	CATC**	1000	47.9

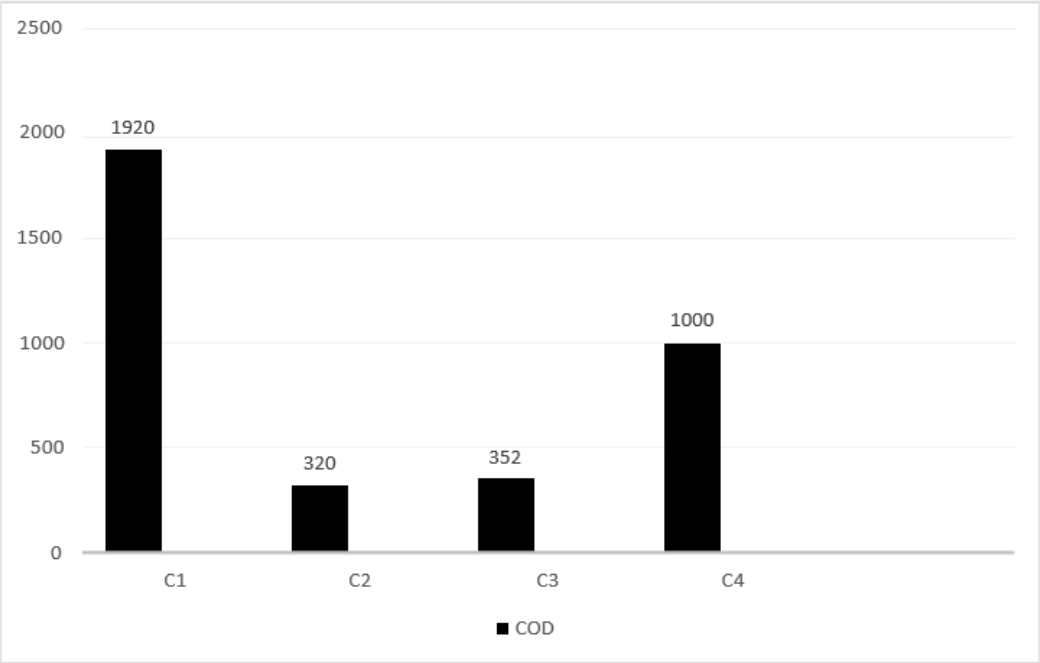

Figure 2: *Comparison of performance of batch*

5 Conclusions

In the presented work, cationic chitosan (CATC) is prepared by attaching the cationic group to chitosan by using reagent (3-chloro-2-hydroxypropyl)-trimethyl ammonium chloride. A combination of calcium carbonate ($CaCO_3$), ferric chloride, ferrous sulphate, and cationic chitosan (CATC) is used as a coagulant and flocculent, for the treatment of wastewater. It has been observed that a combination of lime/alum or lime/ferric chloride with flocculent CATC gives 83.3% and 81.7% reduction in COD.

6 Declarations

6.1 Competing Interests

There is no conflict of interest involved in the work.

6.2 Publisher's Note

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How to Cite

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