A Novel Carboxymethyl Cellulose-based Polymer

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Abstract - *In the past few years, the utilization of non-biodegradable petroleum-based surfactants has increased. Because of its non biodegradability it causes harm to the environment. To overcome this problem, a novel polymer based on carboxymethyl cellulose (CMC) has been synthesised. This novel polymer is synthesised with small quantities of oxalic acid, borax and sodium hydroxide. The synthesized polymer has been studied for its physiochemical properties like surface tension, viscosity, pH, and density. The study of biodegradation of polymer was carried out and it was found to be biodegradable based on the BOD/COD ratio of 0.6944. The synthesized polymer has been used in liquid laundry detergent to the extent of 18% to 20%. The liquid laundry detergent was analysed for its properties and was found to be on par with commercial liquid laundry detergents tested simultaneously.*

Key Words: Carboxymethyl Cellulose (CMC), biodegradable, liquid laundry detergent, polymer**.**

1.INTRODUCTION

The increasing demand of non-biodegradable surfactants are causing major concerns in water pollution. The raw materials used for the generation of the commercial liquid, powder and cake detergent are based on the active matters such as linear alkyl benzene sulfonate (LABS), alpha olefin sulfonate (AOS), primary alcohol sulphate (PAS), alcohol ethoxy sulphate (AES), etc come from petroleum derived products [1]. Because of the decreasing reserves of crude material and increasing demand, these raw materials may soon face the problem of shortage. To overcome such problem, there is a need to synthesize surfactants from renewable sources. In this context, we decided to design a novel polymeric surfactants composition based on carboxymethyl cellulose (CMC) derived from a natural renewable plant-based source i.e., cellulose. The carboxymethyl cellulose (CMC) or cellulose gum is a cellulose derivative with carboxymethyl groups (-CH2-COOH) bound to some of the hydroxyl groups of glucopyranose monomers that make up the cellulose backbone. The synthesized polymer is mainly based on carboxymethyl cellulose along with sodium hydroxide, oxalic acid, borax, and distilled water. This composition of polymer was prepared and then it was analysed for its properties like surface tension, viscosity, HLB ratio, and density. The polymer was then tested for its various other physiochemical properties like % solids, density, pH, biodegradability. Its HLB ratio indicates that the polymer is well suited for detergency, hence a liquid laundry detergent [2,3] was formulated using the polymer. The prepared liquid laundry detergent was tested for its basic characteristics and stain removing properties. The result has been compared with standard commercial laundry detergent to know the practical viability of formulation.

2. MATERIALS AND METHODOLOGY

2.1 Synthesis of polymer

In the experimental work, novel polymer has been synthesized. A two-liter glass reactor fitted with stirrer, thermometer and condenser has been used. Distilled water was added to the reactor. Heating was started. Water was boiled for few minutes and temperature of upto 90° C was maintained. Borax, sodium hydroxide and oxalic acid was added after boiling of water. The heating and agitation were continued for 1 hour. Then CMC was added slowly and steadily in small amounts in 5-minute intervals over half an hour. The prepared polymer was then allowed to cool down and the batch was withdrawn and stored in tightly closed bottles. The polymer sample was then analysed for its physiochemical characteristics by standard laboratory methods [4,5,6,7,8].

Table -1: Composition of polymer

Sr. no.	Polymer ingredients	Composition (%)
1	Carboxymethyl Cellulose	03
2	Oxalic acid	02
3	Borox	05
4	Sodium hydroxide	02
5	Distilled water	88

2.2 Preparation of liquid laundry detergent

HLB of the polymer is 14.9, which makes it more suitable for detergency. Hence a liquid laundry detergent was prepared using it. Liquid laundry detergent was prepared in batch process. An assembly of Heating mantle, mechanical stirrer and one litre glass reactor with four necks were utilised. One neck was fitted with a thermometer, central neck was reserved for stirrer and another neck for addition of ingredients. Water was added into glass reactor and heating was started along with constant stirring. The rest of the weighed components were consecutively added. Temperature is slowly raised to 70 C and process was continued until the entire mass became homogeneous. Fragrance and colour are added at room temperature. Then the prepared liquid detergent is filled in bottles.

Table -2: Composition of polymer

Sr. no.	Component	Composition (%)
1	Acid slurry	10
2	Polymer	20
3	SLES	10
4	NaOH	15
5	Borox	1.5
6	PED400	0.2
7	Fragrance	0.5
8	Colour	0.5
9	Water	q.s.

3. CHARACTERIZATION

3.1 Analysis of polymer

The prepared novel polymer sample was analyzed for its physiochemical characteristics by standard laboratory methods [4,5,6,7].

Table -3: Physiochemical analysis of polymer

Sr. no.	Polymer characteristic	Observation
1	Foam height (1% solution) (cc)	00
2	pH (1% solution)	09
3	Viscosity (sec) using ford cup no. $	118
4	% Solids	41.4
5	Density (gm/cm^3)	1.024
6	Surface tension (dyne/cm^2)(by stalagmometer)	49.5
7	HLB ratio	14.9

3.2 Biodegradability of polymer

Biodegradation is the process by which organic matter get decomposed by the action of micro-organisms present in aerobic or anaerobic environment [9,10]. There is a world-wide research effort to develop biodegradable polymers to reduce pollution in the environment [11]. Biodegradability is determined by the chemical structure of a polymer, on the other hand physical properties of the polymer are responsible for affecting the rate of biodegradation. Large natural molecules like starch, cellulose and proteins are decomposed by hydrolysis followed by oxidation [12]. Only a few high molecular weight carbon chain polymers are biodegradable [13], hence it is necessary to check the biodegradability of polymers. In this context the biodegradability of polymer was experimentally analysed using wastewater treatment method [14]. For this, ratio of biochemical oxygen demand [15,16] (BOD) and chemical oxygen demand [17] (COD) was analysed.

Table -4: Biodegradability analysis of polymer

Sr. no.	Day	BOD (mg/L)	COD (mg/L)	BOD/COD
1	2nd Day	85	273	0.3113
2	4th Day	130		0.4761
3	6th Day	160		0.5860
4	8th Day	180		0.6593
5	10th Day	190		0.6959

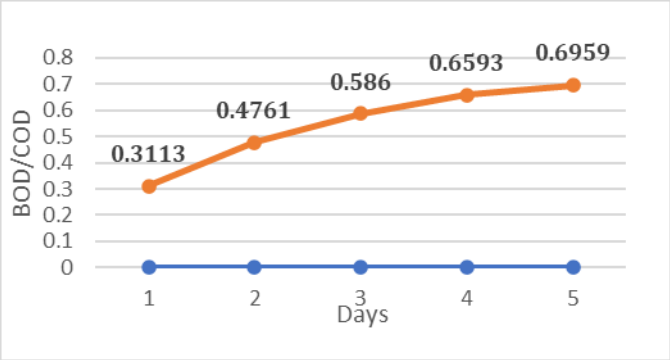

Chart -1: Rate of Biodegradability analysis of polymer

3.3 Analysis of liquid detergent

After preparing the liquid detergent, it was stored in tightly closed bottle, cooled and left overnight. After a day it was filtered, and a transparent solution was obtained. It was then analyzed for its various physiochemical properties and characteristics. Different stain samples of soil, tea and coffee were prepared to analyze the detergency [17,18]. Similarly, a commercially available liquid laundry detergent was also analyzed to compare it with the prepared laundry detergent.

Table -5: Physiochemical properties of liquid laundry detergent

Sr. No.	Characteristic	Observation for LS	Observation for CS
1	pH (1% solution)	9	6
2	Viscosity (sec) using ford cup no. 4	618	293
3	Appearance	Transparent	Transparent

Note: CS - Commercially available liquid laundry detergent sample
LS - Prepared liquid laundry detergent sample

Table -6: Physiochemical analysis of liquid laundry detergent

Concentration	Sample	Foam Volume (cm^3)		Surface Tension (dyne/cm^2)
		0 min	20 min	
1%	LS	950	200	21.71
	CS	700	200	26.15
0.5%	LS	400	350	22.85
	CS	550	100	27.66
0.25%	LS	370	330	11.8
	CS	300	100	27.89

Table -7: Cleaning analysis for 1% solution

Sample	Staining medium			Total Points
	Soil	Tea	Coffee	
LS	4	4	3	11
CS	3	4	3	10

Cleaning Points: - 0- no cleaning, 1- 25% Cleaning, 2- 50 % Cleaning, 3- 75 % Cleaning, 4 -100% Cleaning

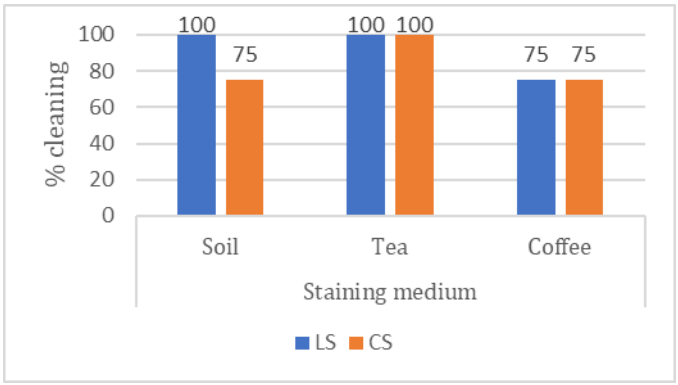

Chart -2: Cleaning analysis of 1% solution

4. RESULTS

1) Table-1 gives the composition of novel polymer. Carboxymethyl cellulose, borax, oxalic acid, NaOH, and water were mixed for about 1 hour to form the polymer
2) The physiochemical analysis of polymer is given in table 3. The polymer has an excellent viscosity of 118 seconds, HLB ratio of 14.9, surface tension of 43.4 dyne/cm2, 57.2% solids are present in the polymer. It has a foam height of 170 cc, its density is 1.392 gm/cc and has a pH of 8.
3) Chemical oxygen demand of diluted polymer was found to be 288 mg/L
4) Biochemical oxygen demands and ratio of BOD/COD are given in Table-4. The rate of biodegradability analysis of polymer is given in chart 1.
5) BOD/COD ratio for 10th day is found to be 0.6944.
6) Laundry detergent based on the composition of polymer, acid slurry, SLES has been prepared. Its composition is given in table 2.
7) Laundry detergent has an alkaline pH and gives excellent result of foaming, surface tension and stain removing properties for stains of soil, tea and coffee as given in Tables 5, 6, and 7 and chart 2.

5. CONCLUSIONS

1) The polymer after selection of proper mole ratio, heating period give final product which can be used as partial replacement of acid slurry in laundry detergent compositions.

2) It exhibits many advantages of being non- toxic, being low excitant to humans, and demonstrating exceptional performance of environmental compatibility.
3) The measure of biodegradability is the ratio of BOD:COD. If Ratio is 0.6 and above the polymer is considered to be biodegradable. The biodegradation study indicates that Polymer has ratio 0.6944. Therefore, the polymer can be considered as biodegradable.
4) Liquid detergent based on the polymer can be prepared. Only using 10-15% of the polymer can give results on par with commercially available laundry detergents.

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