



POWDER AND LIQUID DETERGENTS COMPOSED ON SORBITOL – STARCH BASED POLYMERIC SURFACTANT

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Abstract: Sorbitol-starch based polymer can be used as surfactant. In current research work we successfully used this polymer for making of powder and liquid detergents. Several compositions constructed by considering ingredients like SLS, SLES, acid slurry and Polymeric surfactant. The performance characteristics like bulk density, foam height, surface tension, viscosity pH and stain removing capacity have been evaluated. We find that our powder and liquid detergent show similar and comparable result when it compare with commercial powder and liquid detergents. We avoid most common ingredient like alpha olefin sulphonate and phosphate to prevent water pollution. In some formulations we minimized the quantity of acid slurry to make detergent more ecofriendly. In some cases we completely replace acid slurry by our sorbitol starch based polymeric surfactant.

Key Words: - Sorbitol, Starch, Polymeric surfactant, Powder and Liquid Detergents

I. INTRODUCTION

Detergent is the substance that helps in the removal of dirt. Powder and liquid detergents are the most consumable household products. The laundry detergents [1] preparations may contain substances called builders, which enhance cleansing but use of phosphates in detergents is very serious source of water pollution. The other aspect is biodegradability of surfactants [2]. LABS is biodegradable but at a rate slower than soap. Other surfactants like alcohol sulphate and AOS look like a better alternatives but they are costly, so unable to use it on large scale. To solve the above mention problems there is a need to develop detergent free from phosphate and petroleum based raw materials. Polymeric surfactant [3] is one of the best alternatives to replace these materials. Carbohydrate [4] based polymers has a high potential to use as surfactant. We developed a sorbitol-starch based polymeric surfactant [5]. In current work, we made some formulation of powder and liquid detergents and analyzed their properties against commercially available products.

II. EXPERIMENTAL

The polymeric surfactant used for making of powder and liquid detergents is A₄₄. It is mainly based on sorbitol and maize starch. It is successfully synthesized in laboratory. The percent composition by weight of polymeric surfactant is as given in table-1

Table 1: Percent Composition by weight of polymeric surfactant A₄₄

Ingredients	Percent by weight
Sorbitol (70%)	47.5
Starch (70%)	28.6
Maleic Anhydride	9.5
Pthaleic Anhydride	6.6
Citric Acid	2.8
Sodium metabisulphite	5.0

Preparation of powder detergents:

The mention ingredients in the powdered form are weighted and mixed uniformly in a tray. Then add liquid ingredients like acid slurry, sodium lauryl sulphate (S.L.S.), sodium lauryl ether sulphate (SLES) and polymer A₄₄. Whole mass is then transfer to homogenizer pot. After mixing, this homogeneous mass has been put in a tray for drying. Then is store in a plastic bag. Some formulation of powder detergents are given in a table 2.

Table 2: Powder Detergents Based On Polymers A₄₄

Ingredients	PD-21	PD-22	PD-23	PD-24	PD-25
Acid Slurry	05	08	06	03	00
SLS (100%)	01	01	01	01	2
SLES (40%)	-	02	02	03	7
Sodium carbonate	30	35	33	30	35
Dolomite	29	-	22	27	20
Polymer A ₄₄	05	05	06	06	06
Salt	30	30	30	30	30
Sodioum sulphate	-	19	-	-	-

Note: 1) Sodium lauryl sulphate (S.L.S.)

2) Sodium Lauryl ether sulphate (S.L.E.S.)

Preparation of liquid detergents:

All the ingredients present in formulation are weighted and taken in a large beaker. It is mixed thoroughly and slurry is formed. Then measured quantity of fragrance and distilled water added in slurry. After mixing, solution is kept steady for overnight. We get a clear liquid. It is kept in a plastic bottle.

Table: 3 Liquid detergents based on polymer A44

Ingredients	LD-21	LD-22	LD-23	LD-24	LD-25
Acid Slurry	7.0	5.0	5.0	2.5	00
SLES (40%)	18.0	15	11	20	20
SLS (30%)	2.0	5.0	1.0	2.0	3
Sodium Carbonate	2.5	2.5	2.0	2.0	2.0
Sodium Sulphate	1.0	1.0	1.0	1.0	1.0
Polymer A44	8.0	8.0	10	10	10
Fragrance	0.25	0.25	0.25	0.25	0.25
Distilled Water	61.25	63.25	69.75	62.25	63.75

Foaming characteristics: Foam characteristics are measured in terms of volume. Bubble Cylinder Method is used to measure foam characteristics [6].

Surface Tension: We have used stalagmometer method to measure the surface tension [7] of liquid.

Viscosity: Viscosity [8] was determined by ford cup method, ford cup no. 4 at 30°C. This consists of a cylindrical metal cup with parallel side and a conical base. The time required for the cup to get empty through the orifice was noted and result was expressed in seconds at a given temperature.

Measurement of Stain Removing Capacity:

The samples, which are washed, dried and ironed, are used to find out percent detergency [9]. The % detergency is found out using lamberts and sanders formula.

$$\% \text{ Detergency} = \frac{R_w - R_s}{R_o - R_s}$$

Where,

- R_w = Reflectance measured on washed cloth
- R_s = Reflectance measured on stained cloth
- R_o = Reflectance measured on original cleaned cloth

The reflectance of the cloth samples are measured by using "Reflectance Meter" manufactured by Universal Engineering Corporation, Ambala Road, Saharanpur (U.P). This is a digital instrument. This is first standardized by using the magnesium oxide or tile, which is provided along with the instrument. This tile having brightness of 81.3% that is adjusted by using the knob provided on instrument. Once this is adjusted then samples are kept on the instrument and note down the digital readings and calculate the Percent detergency by using above formula.

Table 4: Basic Analysis of Powder detergents based on Polymer A44

Parameter	PD-21	PD-22	PD-23	PD-24	PD-25	CD-1	CD-2
Bulk density	0.91	0.84	0.87	0.97	1.02	0.88	0.94
pH(digital pH meter)	8.9	8.4	8.6	9.0	9.8	9.3	9.6
Colour	White	White	White	White	White	White	White

Note: CD-1: Commercial powder detergent-1

CD-2: Commercial powder detergent-2

Table 5: Analysis of powder detergents based on polymer A44 and commercial detergents

Concentration	Samples	Foam Volume in cm ³ (By glass cylinder method)				Surface tension Dyne/cm (Stalagmometer)
		0 min.	5 min.	10 min.	15 min.	
0.25%	PD-21	700	620	540	460	32.85
	PD-22	760	670	590	510	28.83
	PD-23	720	640	560	480	29.27
	PD-24	600	530	460	380	36.96
	PD-25	500	430	350	290	39.64
	CD-1	750	730	710	680	27.92
	CD-2	800	770	750	720	30.43
0.5%	PD-21	820	740	650	580	31.53
	PD-22	900	820	770	680	27.99
	PD-23	840	770	690	600	29.46
	PD-24	700	600	510	440	34.85
	PD-25	600	520	430	360	37.74
	CD-1	900	870	850	820	25.27

	CD-2	1000	950	910	880	28.02
1%	PD-21	960	880	800	610	26.88
	PD-22	1000	890	800	630	25.90
	PD-23	1000	880	790	600	27.36
	PD-24	800	720	660	580	32.48
	PD-25	710	600	510	440	35.84
	CD-1	1000	940	890	850	24.31
	CD-2	1000	940	880	830	26.56

Table 6: Removal of Soil Stain from cotton cloths at different concentration by powder detergent samples based on polymer A44

Ro = Reflectance measured on clean cloth = 100

Rs = Reflectance measured on stained cloth = 39

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	PD-21	82	70.4
2		PD-22	83	72.1
3		PD-23	83	72.1
4		PD-24	80	67.2
5		PD-25	78	68.9
6		CD-1	84	73.7
7		CD-2	85	75.4
8	0.5%	PD-21	88	80.3
9		PD-22	89	82.0
10		PD-23	88	80.3
11		PD-24	86	77.0
12		PD-25	85	75.4
13		CD-1	90	83.6
14		CD-2	91	85.2
15	1.0%	PD-21	93	88.5
16		PD-22	95	91.8

17		PD-23	94	90.2
18		PD-24	91	85.2
19		PD-25	89	82.0
20		CD-1	95	91.8
21		CD-2	96	93.4

Table 7: Removal of Tea Stain from cotton cloths at different concentration by powder detergent samples based on polymer A44

R_o = Reflectance measured on clean cloth = 100

R_s = Reflectance measured on stained cloth = 41

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	PD-21	83	71.1
2		PD-22	84	72.9
3		PD-23	83	71.1
4		PD-24	81	67.8
5		PD-25	80	66.1
6		CD-1	85	74.6
7		CD-2	86	76.3
8	0.5%	PD-21	88	79.7
9		PD-22	90	83.0
10		PD-23	89	81.3
11		PD-24	86	76.3
12		PD-25	85	74.6
13		CD-1	90	83.0
14	CD-2	91	84.7	
15	1.0%	PD-21	92	86.4
16		PD-22	94	89.8
17		PD-23	92	86.4
18		PD-24	91	84.7
19		PD-25	89	81.3

20		CD-1	94	89.8
21		CD-2	96	93.2

Table 8: Removal of Coffee Stain from cotton cloths at different concentration by powder detergent samples based on polymer A44

Ro = Reflectance measured on clean cloth = 100

Rs = Reflectance measured on stained cloth = 42

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	PD-21	82	69.0
2		PD-22	84	72.4
3		PD-23	82	69.0
4		PD-24	80	65.5
5		PD-25	79	62.1
6		CD-1	84	72.4
7		CD-2	86	75.9
8	0.5%	PD-21	89	63.8
9		PD-22	90	82.7
10		PD-23	89	81.0
11		PD-24	87	77.6
12		PD-25	85	74.1
13		CD-1	91	84.5
14		CD-2	92	86.2
15	1.0%	PD-21	93	88.0
16		PD-22	95	94
17		PD-23	93	88.0
18		PD-24	91	84.5
19		PD-25	89	81.0
20		CD-1	95	91.4
21		CD-2	96	93.1

Table 9: Removal of Spinach Stain from cotton cloths at different concentration by powder detergent samples based on polymer A₃₈

R_o = Reflectance measured on clean cloth = 100

R_s = Reflectance measured on stained cloth = 48

Sr. No.	Concentration	Sample	R _w (by reflectance meter)	% detergency
1	0.25%	PD-21	83	67.3
2		PD-22	85	71.1
3		PD-23	84	69.2
4		PD-24	82	65.4
5		PD-25	81	63.5
6		CD-1	86	73.1
7		CD-2	87	75.0
8	0.5%	PD-21	90	80.8
9		PD-22	91	82.7
10		PD-23	90	80.8
11		PD-24	88	76.9
12		PD-25	85	71.1
13		CD-1	92	84.6
14		CD-2	93	86.5
15	1.0%	PD-21	93	86.5
16		PD-22	95	90.4
17		PD-23	93	86.5
18		PD-24	94	88.5
19		PD-25	92	84.6
20		CD-1	96	92.3
21		CD-2	97	94.1

Table 10: Basic analysis of Liquid detergents based on polymer A44

Parameter	Parameter	LD-21	LD-22	LD-23	LD-24	LD-25	CLD-1
Viscosity(30 ⁰ C) S	Viscosity (30 ⁰ C) S	206	180	150	72	40	More than 300
pH (Digital pH meter)	pH(digital pH meter)	8.4	8.4	8.9	9.3	9.7	11
Colour	Colour	Pale Yellow	Pale Yellow	Pale Yellow	Pale Yellow	Pale Yellow	Pale Yellow

Note: CLD-1: Commercial Liquid detergent-1

CLD-2: Commercial Liquid detergent-2

Table 11: Analysis of Liquid detergents based on polymer A44 & Commercial liquid detergents

Concentration	Samples	Foam Volume in cm ³ (By glass cylinder method)				Surface tension Dyne/cm (Stalagmometer)
		0 min.	5 min.	10 min.	15 min.	
0.25%	LD-21	450	380	320	250	29.13
	LD-22	450	390	320	250	29.52
	LD-23	430	360	290	220	29.30
	LD-24	400	330	270	210	31.28
	LD-25	320	280	240	200	33.87
	CLD-1	300	240	200	180	30.93
	CLD-2	230	210	200	190	29.38
0.5%	LD-21	600	530	450	380	27.51
	LD-22	600	520	450	380	27.09
	LD-23	580	520	460	390	28.64
	LD-24	550	480	410	340	29.11
	LD-25	520	450	380	320	30.84
	CLD-1	490	400	320	250	29.43

	CLD-2	260	230	200	190	28.53
1%	LD-21	1000	920	870	790	25.58
	LD-22	1000	930	880	800	25.88
	LD-23	700	630	550	480	26.67
	LD-24	650	580	510	440	27.26
	LD-25	600	530	470	400	28.46
	CLD-1	700	600	510	420	27.75
	CLD-2	300	270	250	230	26.38

Table 12: Removal of Soil Stain from cotton cloths at different concentration by liquid detergent samples based on polymer A44

Ro = Reflectance measured on clean cloth = 100

Rs = Reflectance measured on stained cloth = 39

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	LD-21	86	77.0
2		LD-22	86	77.0
3		LD-23	86	77.0
4		LD-24	84	73.7
5		LD-25	81	68.8
6		CLD-1	86	77.0
7		CLD-2	88	80.3
8	0.5%	LD-21	91	85.2
9		LD-22	91	85.2
10		LD-23	91	85.2
11		LD-24	89	82.0
12		LD-25	86	77.0

13	1.0%	CD-1	90	83.6
14		CD-2	92	86.9
15		LD-21	96	93.4
16		LD-22	96	93.4
17		LD-23	96	93.4
18		LD-24	94	90.2
19		LD-25	92	86.9
20		CLD-1	96	93.4
21		CLD-2	97	95.1

Table 13: Removal of Tea Stain from cotton cloths at different concentration by Liquid detergent samples based on polymer A44

R_o = Reflectance measured on clean cloth = 100

R_s = Reflectance measured on stained cloth = 41

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	LD-21	86	76.3
2		LD-22	87	78.0
3		LD-23	86	76.3
4		LD-24	84	72.9
5		LD-25	82	69.5
6		CLD-1	87	78.0
7		CLD-2	88	79.7
8	0.5%	LD-21	91	84.7
9		LD-22	91	84.7
10		LD-23	91	84.7
11		LD-24	89	81.3
12		LD-25	86	76.3
13		CLD-1	91	84.7

14		CLD-2	92	86.4
15	1.0%	LD-21	95	91.5
16		LD-22	95	91.5
17		LD-23	95	91.5
18		LD-24	93	88.1
19		LD-25	91	84.7
20		CLD-1	95	91.5
21		CLD-2	96	93.2

Table 14: Removal of Coffee Stain from cotton cloths at different concentration by liquid detergent samples based on polymer A44

Ro = Reflectance measured on clean cloth = 100

Rs = Reflectance measured on stained cloth = 42

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	LD-21	87	77.6
2		LD-22	87	77.6
3		LD-23	87	77.6
4		LD-24	85	74.1
5		LD-25	83	70.7
6		CLD-1	87	77.6
7		CLD-2	88	79.3
8		0.5%	LD-21	90
9	LD-22		90	82.7
10	LD-23		90	82.7
11	LD-24		88	79.3
12	LD-25		87	77.6
13	CLD-1		90	82.7
14	CLD-2		91	84.5
15	1.0%		LD-21	96
16		LD-22	96	93.1

17		LD-23	96	93.1
18		LD-24	94	89.6
19		LD-25	91	84.5
20		CLD-1	96	93.1
21		CLD-2	97	94.8

Table 15: Removal of Spinach Stain from cotton cloths at different concentration by powder detergent samples based on polymer A44

R_o = Reflectance measured on clean cloth = 100

R_s = Reflectance measured on stained cloth = 48

Sr. No.	Concentration	Sample	Rw (by reflectance meter)	% detergency
1	0.25%	LD-21	86	73.1
2		LD-22	86	73.1
3		LD-23	86	73.1
4		LD-24	84	69.2
5		LD-25	81	63.5
6		CLD-1	87	75.0
7		CLD-2	88	76.9
8	0.5%	LD-21	90	80.8
9		LD-22	90	80.8
10		LD-23	90	80.8
11		LD-24	88	76.9
12		LD-25	85	71.1
13		CLD-1	90	80.8
14		CLD-2	92	84.6
15	1.0%	LD-21	95	90.4
16		LD-22	95	90.4

17		LD-23	95	90.4
18		LD-24	93	86.5
19		LD-25	91	82.7
20		CLD-1	96	92.3
21		CLD-2	96	92.3

III. RESULT AND DISCUSSION

The compositions of sorbitol starch based polymer is given in table 1. The total quantity of carbohydrates used in making of polymer is 76.1 %. The organic acids and anhydride used were 18.9 %.

Powder detergents:

Few formulation of powder detergents are given in table 2. We used 5-6% polymer A₄₄ in different composition. In PD-25, we totally removed acid slurry. All polymer A₄₄ based detergents contain 30 % of salt by weight. The amount of sodium carbonate is 30 to 35%. The bulk density and pH of polymer based composition are almost parallel to commercial detergents. Basic analysis of powder detergents as given in table 4. The foaming characteristics are excellent at 1% concentration refer table 5. Acid slurry free formulation has slightly low foaming than remaining samples. As its cleaning is good, it can be recommended for washing machine detergents. The reduction in surface tension is good and comparable to commercial products simultaneously tested. When we examine stain removal (soil table 6, tea table 7, coffee table 8 and spinach table 9) tendency on cotton cloth at 1 % concentration, we find out that our result of polymer based compositions are comparable with commercial detergents.

Liquid Detergents:

Several compositions of liquid laundry detergents have been prepared. They contain 8 to 10% by weight of polymer A₄₄, while remaining are routine commercial ingredients. We take effort to minimize the amount of acid slurry of petroleum origin. Liquid detergents based on A₄₄ polymer are recorded in table 3. Formulation LD-25 is free from acid slurry. SLES and SLS are common ingredients of detergent formulations for getting good foam. The basic analysis of liquid detergents is reported in table 10. The viscosity of commercial liquid detergent is greater than 300 s, while polymer based liquid detergents show the viscosity below 206 s. Commercial detergent is more basic than our detergents. The foaming characteristics are given in table 11. Excellent foaming and surface tension reduction is observed at 1% concentration which is on par or some times better than commercial samples. Soil and other stain removing properties are excellent as shown in table 12 to 15.

IV. CONCLUSION

1. Excellent cleaning, soil and stain removing and bright white appearance of cloth are special feature of starch based polymer.
2. Satisfactory powder detergent compositions containing 5-6% polymer have been prepared. They have excellent foaming, surface tension reduction and cleaning capacity. The soil and stain removing properties are excellent and comparable with commercial one. The best powder detergent composition is given in table 16.

Table 16. The Best powder composition

Ingredients	% by Weight
Acid slurry	08
Sodium lauryl sulphate (100%)	01
Sodium lauryl sulphate (40%)	02
Sodium carbonate	35
Polymer A ₁₀	05
Salt	30
Sodium sulphate	19

3. Liquid laundry detergents were prepared by using 8-10% of our polymer. The amount of acid slurry has been reduced from 7 to 0% in successive formulations. Here we can recommend high foaming liquid detergent for general purpose and low foaming liquid for washing machine application. Low foaming liquid detergent will reduce the consumption of water by two bucket per family. This saving of water is critically important in water scarcity and remote areas. The best liquid detergent is given in table 17.

Table 17. The Best liquid composition

Ingredients	% by Weight
Acid slurry	5.0
Sodium lauryl ether sulphate (40%)	15
Sodium lauryl sulphate (30%)	5.0
Sodium carbonate	2.5
Sodium Sulphate	1.0
Polymer A ₁₀	8.0
Fragrance	0.25
Distilled water	63.25

4. We are not using sodium tripolyphosphate (STPP) in any of our liquid or powder compositions. This will help in reducing water pollution.
5. Finally we can recommend our polymer based liquid composition for commercial used, as our compositions are techno-chemically viable prepositions. Our products will be a step towards eco-friendly green environment as we are using reduce amount of acid slurry.

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