STUDIES ON THE EFFECT OF STABILIZER SYSTEMS ON QUALITY OF CONDOMS

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ABSTRACT

Effect of different stabilizer systems in latex compounding on quality of condoms was studied. It was observed that casein pottassium laurate system significantly reduces rejection due to pin holes without adversely affecting the quality of condoms. A slight increase in mechanical strength was observed from the measurement of the air pressure necessary to burst the condom and volumes at burst. Retention of tensile properties after ageing was also found to be better for casein pottassium laurate combination.

INTRODUCTION

The relative effectiveness of condoms as a contraceptive has been established, but its dependability in actual use as a barrier to virus transmission is being questioned. Recent laboratory tests on porosity of condoms have shown that they can be a barrier to HIV cytomegalovirus or hepatitis B virions[2-3] if the condom is properly used and does not break. For this it should be properly designed to have adequate strength and elasticity and free from holes.

Proper compounding of latex can ensure the quality of condoms to a certain extent. Latex being a stable dispersion of polyisoprene in an aqueous medium, stabilizers or surface active substances are important among the compounding ingredients. There are a number of latex stabilizers used for various purposes. Based on their function they are known as

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wetting agents, dispersing agents, dispersion stabilizers, emulsifiers, foam promotors, foam stabilizers etc. Being surface active materials, these materials can cause frothing in latex which may lead to formation of pin holes in dipped goods. The extent of frothing depends on the type of stabilizer and its dosage. The present study was conducted using commercially available stabilizers such as potassium oleate, potassium laurate, casein, polyvinyl alcohol, Emulvin-T, Vulcastab VL etc. Varying concentrations and combinations of these stabilizers were tried to assess their effect on the rejection due to pin hole formation and on the physical and ageing properties.

EXPERITMENTAL

MATERIALS

Natural rubber latex containing 60% rubber prepared by centrifuging was used. Compounding ingredients such as casein, potassium oleate, potassium laurate, polyvinyl alcohol, emulvin-T (Stabilizer based on polyethelene oxide condensate, manufactured by Bayer (India) Limited), Vulcastab VL (Stabilizer based on polyethelene oxide condensate, manufactured by ICI (India) Limited), ammonia, Nocceler TP (sodium di-n-butyl-dithiocarbomate, manufactured by Ouchi Shinko Chemical Industrial Co. Limited, Japan), setsit-5 (activated dithioarbomate, manufactured by Vanderbilt Co., USA), zinc oxide, Noccrac NS-5(2,2 methylene 4-ethyl-6 tert-butyl phenol, manufactured by Ouchi Shinko Chemical Industrial Co. Ltd., Japan), Sulphur, Darvan No.1 (sodium salt of polymerised alkyl naphthalene sulphonic acid manufactured by Vaderbilt Co., USA), Darvan No.2 (sodium salt of polymerised substituted benzoid alkyl sulphonic acid, manufactured by Vaderbilt Co., USA) etc. were of commercial grade.

METHODS

Latex parameters were determined to ensure the quality of raw latex used (Table-I). Dispersions of solid ingredients were prepared by ball milling. Setsit-5 and Nocceler TP were added to latex directly as these are soluble in water. Compounding of latex was done by adding the ingredients in the order given in Table-II. Prevulanisation of the latex compound was done by heating it in a water bath for 8 h. at 55 deg.C. Continuous stirring was maintained during prevulcanisation. The latex compound was then diluted using 1% ammonia solution to adjust the total solids content to 47. Condom samples were dip moulded using glass formers. Straight dipping technique was adopted for the process. Double dipped samples were prepared for the study. Vulcanisation was done in an air oven at 80 deg.C for 30 minutes. The formers cooled to room temperature and then the products stripped from them using French Chalk power.

Air leakage test was conducted by inflating the condom with air to a diameter of 150 mm and by examining them for the presence of pin holes The examination of the inflated condom was completed within a minute. Water leakage test was conducted by filling the condom with 300 ml of water at room temperature. It was then suspended for 1 minute to detect any visible leakage through the condom wall. The condom was then rolled over an absorbant paper after closing its open end by twisting it near the rim. The paper was inspected for signs of leakage.

Burst volume and burst pressure tests were conducted as per ISO 4074/6-1984(E). In this test a constant length of the condom was inflated with air at a rate of 0.4 to 0.5 dm^3 /s.

Its bursting volume and bursting pressure were noted from the equipment attached to the testing apparatus. For electrical resistance measurement condoms were filled with a conducting solution and placed inside the conducting medium through which electricity is passed. Electrical resistance offered by the condom wall was measured using the Japanese industrial standard machine.

Tensile properties such as tensile strength, elongation at break, modulus at 500% elongation etc. were also measured before and after ageing as per ASTM D 412 - 87. Ageing was done in an air oven at 70 deg. C for 168 h.

The promising stabilizer systems were selected for further study.

RESULTS AND DISCUSSION

Studies were conducted to assess the effect of stabilizers on quality of condoms. Control system was 0.02 phr each of casein and potassium oleate.

Effect of Stabilizer system on rejection due to pin holes

When the quality of condoms were assessed in terms of pin hole rejection rate, it was found that casein potassium laurate system is much better compared to all other systems. The control compound with 0.02 phr each of casein and potassium oleate gave 8.75% rejection due to pin holes while the same concentration of casein-potassium laurate system gave only 2.5% rejection.

A stabilizing system was found essential as otherwise the rejection rate was very high (25%) as indicated by Sl.No.27

in Table-III. Potassium oleate alone was also highly undesirable as the pin hole rating was substantially high (18.75%) as indicated by Sl.No.1 in Table IV.

Latex being a dispersion of polyisoprene in an essentially aqueous medium, stabilizers play a vital role in keeping the system stable. Chances for microcoagulation will be higher without a surface active agent. Any stabilizer can contribute to reduce the microcoagulation tendency. This may be the reason for the reduction in pin hole rejection rate from 25% to 18.75% observed at 0.02 phr potassium oleate alone in the system (Table IV). When casein was also added at 0.02 phr level, rejection rate was further reduced to 8.75% as indicated by the control system (Sl.No.4, Table-III). When the concentrations of casein and potassium oleate in the control compound was changed to study their individual effet it was noted that even in the absence of potassium oleate rejection rate was less compared to compounds containing potassium oleate. Also it was observed that as the concentration of potassium oleate increased the rejection rate also increased. Casein was used as primary stabiliser and its concentration was kept constant at 0.02 phr, when these observations were made.

Normally when a surface active agent is added chances for frothing will be higher. Bubbles present in the dipping compound an lead to pin holes in the moulded latex film or it can lead to a weak spot. Increased frothing effect of potassium oleate may be contributing to the increased pin hole rejection values at higher concentration of oleate. It has already been reported that as chain length of fatty acid component of a soap inreases, its foaming efficiency increases[4]. As lauric acid is having lower chain length, it causes less frothing. At the same time lauric acid is more efficient in improving the stability of latex[5].

The effect of stabilizers on pin hole rejection rate with casein as primary stabilizer was also studied. Potassium laurate and Vulcastab VL were found to reduce pin hole rejection rate compared to the control compound. Thus they can replace potassium oleate to reduce rejection rate due to pin holes. Polyvinyl alcohol and Emyulvin T were having more or less the same effect as that of potassium oleate. But compounds containing polyvinyl alcohol gave inreased viscosity values. While the viscosity of the control compound was 18.5 cps, the viscosity of the compound containing polyvinyl alohol was 21.5 cps.

The same stabilizers when used in combination with potassium oleate as primary stabilizer it was found that the compound containing potassium laurate behaved almost the same way as the control. Potassium oleate-polyvinyl alcohol combinations were not found better than the control. Viscosity of the compound was found to be increasing with increasing concentrations of polyvinyl alcohol. Potassium oleate-Emulvin T system and potassium oleate-Vulcastab VL system were found to be inferior to the oantrol system with respect to pin hole formation.

Effect of casein-potassium laurate system on physical properties

Based on the results obtained from the pin hole rate studies the stabilizer system most suitable was the combination of casein and potassium laurate. Therefore this system was considered for further studies.

Physical properties such as tensile strength, elongation at break, modulus, burst volume and burst pressure, electrical resistance etc. were determined. Ageing resistance also was measured for the different concentrations of the selected stabilizer system and the control. Maximum percentage retention of tensile strength was found for potassium laurate-casein system compared to the other systems as is seen from Table-V. Elongation at break values were more or less the same for all the systems. Modulus at 500% elongation also was comparable for all concentrations of the system. Burst volume and burst pressure values (Table-VI) showed that dependable values were observed for casein-potassium laurate system. Electrical resistance was found comparable for all the systems.

CONCLUSION

From the results it can be concluded that potassium laurate is a better replacement for potassium oleate at the same concentration of 0.02 phr as a secondary stabilizer along with 0.02 phr of casein in latex compound for condoms.

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TABLE - I

Specifications of raw latex

Appearance	Clear milky white colour without grey or yellow
D.R.C, % by mass min	60
T.S. - D.R.C, % by mass max	1.2
Total Alkalinity, %	1.72 - 2.3
Viscosity at 25 deg. C, max	150
MST, Cps, Second, min	1000
VFA No., max.	0.04
Coagulum content, % by mass, max.	0.1
KOH No., max.	0.5
pH at 25 deg.C	10.5 - 11
ZOV (5 minutes after adding 1 phr ZnO as 40% dispersion) max.	20% thickening at 25 deg. C
ZOV (60 minutes after adding 1 phr ZnO as 40% dispersion) max.	22% thickening at 25 deg. C
ZST Seconds (60 minutes after adding 1 phr ZnO as 40% dispersion)	120(min.) 210 (max.) or 12% retention of original MST
ZHST (60 mts. after adding ZnO)	250 - 350 at 90 $\pm$ 2 deg.C

TABLE - II

FORMULATION

		(phr)
Natural rubber latex	:	100
Ammonia	:	0.28
Stabilizer - I	:	x
Stabilizer - II	:	Y
Noceeller T.P	:	0.2
Setsit - 5	:	0.5
ZnO	:	0.9
Nocrac NS-5	:	0.5
Sulphur	:	1.5

Note : X and Y can vary depending upon the system tried.

T A B L E - III*

Effect of stabilizer system on pin hole formation

(Casein as primary stabilizer)

Sl. No.	Concentration of secondary stabilizer (phr)		Percentage rejection due to		
			Air leakage	Water leakage	Pin hole
1.	Potassium oleate	Nil	7.5	7.5	7.5
2.		0.01	7.5	7.5	7.5
3.		0.015	7.5	7.5	7.5
4.		0.02	10.0	7.5	8.75
5.		0.025	20.0	10.0	16.00
6.		0.03	22.5	10.0	16.25
7.	Potassium laurate	0.01	10	5.0	7.5
8.		0.015	7.5	0.0	3.75
9.		0.02	5.0	0.0	2.5
10.		0.025	2.5	0.0	1.25
11.		0.03	7.5	0.0	3.75
12.	Polyvinyl alcohol	0.01	10.0	7.5	8.75
13.		0.015	10.0	7.5	8.75
14.		0.02	10.0	7.5	8.75
15.		0.025	12.5	10.0	11.25
16.		0.03	12.5	10.0	11.25
17.	Emulvin T	0.01	10.0	10.0	10.0
18.		0.015	7.5	7.5	7.5
19.		0.02	10.0	7.5	8.75
20.		0.025	10.0	5.0	7.5
21.		0.03	10.0	5.0	7.5
22.	Vulcastab VL	0.01	12.5	7.5	10.0
23.		0.015	7.5	5.0	6.25
24.		0.02	7.5	5.0	6.25
25.		0.025	5.0	5.0	5.0
26.		0.03	7.5	5.0	6.25
27.		Nil	40.0	10.0	25.0

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* Casein at 0.02 phr was used as primary stabilizer in all the cases except in Sl.No.27 where no stabilizer was used.

TABLE - IV*

Effect of stabilizer system on pin hole formation

(Potassium oleate as primary stabilizer)

Sl. No.	Concentration of secondary stabilizer (phr)		Percentage rejection due to		
			Air leakage	Water leakage	Pin holes
1.	Casein	Nil	10.0	27.5	18.75
2.		0.01	27.5	10.0	18.75
3.		0.015	7.5	7.5	7.5
4.		0.02	10.0	7.5	8.75
5.		0.025	10.0	5.0	7.5
6.		0.03	10.0	5.0	7.5
7.	Potassium laurate	0.01	10.0	7.5	8.75
8.		0.015	5.0	7.5	6.25
9.		0.02	7.5	7.5	7.5
10.		0.025	10.0	10.0	10.0
11.		0.03	10.0	20.0	16.0
12.	Polyvinyl alcohol	0.01	12.5	10.0	11.25
13.		0.015	10.0	7.5	8.75
14.		0.02	10.0	7.5	8.75
15.		0.025	12.5	5.0	8.75
16.		0.03	10.0	7.5	8.75
17.	Emulvin T	0.01	12.5	10.0	11.25
18.		0.015	10.0	10.0	10.0
19.		0.02	10.0	7.5	8.75
20.		0.025	12.5	10.0	11.25
21.		0.03	10.0	7.5	8.75
22.	Vulcastab VL	0.01	17.5	10.0	13.75
23.		0.015	12.5	10.0	11.25
24.		0.02	12.5	7.5	10.0
25.		0.025	10.0	7.5	8.75
26.		0.03	12.5	7.5	10.0

* Potassium oleate at 0.02 phr was used as primary stabilizer in all the cases.

T A B L E - V

Effect of stabilizer system on tensile properties of condoms

Concentration		Tensile strength (MPa)			Elongation at break (%)			Modulus at 500% elongation (MPa)		
Primary stabilizer	Secondary stabilizer	B	A	% reten-tion	B	A	% retention	B	A	% reten-tion
Potassium oleate	Casein									
Nil	Nil	15.97	8.0	50.09	830	640	77.11	5.0	5.0	100
0.02	Nil	19.33	11.1	57.42	773	751	97.15	7.0	5.0	71.42
"	0.01	20.25	11.2	55.30	760	730	96.05	7.5	5.0	66.66
"	0.015	20.30	14.0	68.96	803	740	92.15	8.5	7.0	82.35
"	0.02	19.30	13.5	69.95	793	735	92.68	8.0	7.0	87.5
"	0.025	20.0	13.0	65.0	802	765	95.39	8.5	7.0	82.35
"	0.03	20.1	14.4	71.64	805	761	94.53	8.5	6.0	70.58
Potassium oleate	Potassium laurate									
0.02	0.01	20.61	13.18	63.95	800	790	98.75	7.0	6.0	85.71
"	0.015	19.18	12.86	67.05	761	777	102.1	7.5	6.0	80.0
"	0.02	21.1	12.5	59.29	805	786	96.64	8.0	7.5	93.75
"	0.025	20.36	12.9	63.36	788	763	96.83	7.5	7.5	100.0
"	0.03	20.58	13.01	63.2	710	707	99.58	8.0	8.0	100.0
Casein	Potassium oleate									
0.02	Nil	21.5	17.0	79.07	758	700	92.35	7.0	6.0	85.71
"	0.01	22.1	16.0	72.40	823	725	88.09	8.0	7.0	87.5
"	0.015	21.5	16.5	76.74	802	700	87.28	7.5	6.0	80.0
"	0.02	21.3	17.5	82.16	835	720	86.23	7.5	6.0	80.0
"	0.025	20.9	17.0	81.34	823	730	88.69	8.0	7.0	87.5
"	0.03	22.7	16.0	70.48	812	700	86.21	7.5	6.0	80.0
Casein	Potassium laurate									
0.02	0.01	20.09	17.1	85.12	762	720	94.49	8.0	6.0	85.71
"	0.015	21.32	18.0	84.43	782	711	90.92	7.0	6.0	85.71
"	0.02	22.06	18.0	81.59	766	700	91.38	7.5	6.5	88.0
"	0.025	20.63	18.0	87.25	792	710	89.65	8.0	7.0	87.5
"	0.03	20.59	18.0	87.42	805	700	86.96	8.5	7.0	82.35

B - Before ageing. A - After ageing at 70 C for 168 hours.

T A B L E - VI

Effect of stabilizer system on quality of condoms

Concentration		Burst volume (litres)			Burst pressure (kilopascals)			Electrical resistance (kilo ohm)		
Primary stabilizer	Secondary stabilizer	B	A	% Retention	B	A	% Retention	B	A	% Reten-tion.
Potassium oleate	Casein									
Nil	Nil	8.6	6.9	80.23	0.7	0.4	57.14	7893	6851	86.79
0.02	Nil	13.1	7.8	59.54	0.6	0.3	50.0	8523	7761	91.05
"	0.01	12.3	9.8	79.67	0.4	0.3	75.0	8318	7814	93.94
"	0.015	24.7	20.7	83.80	1.1	1.1	100.0	8312	8318	100.07
"	0.02	26.9	25.1	93.31	1.2	1.4	116.6	10000	8321	83.21
"	0.025	29.8	21.1	70.81	1.1	1.4	127.2	9586	7518	78.43
"	0.03	22.7	21.1	92.95	1.2	1.3	108.3	10000	8319	83.19
Potassium oleate	Potassium laurate									
0.02	0.01	18.6	11.1	59.67	0.7	0.5	71.4	8211	7119	86.70
"	0.015	21.7	18.8	86.63	0.9	0.7	77.7	9880	9040	91.49
"	0.02	22.0	19.1	86.82	1.0	0.8	80.0	10000	10000	100.0
"	0.025	24.5	20.7	84.49	1.1	0.8	72.72	8331	8286	99.46
"	0.03	23.6	20.1	85.17	1.1	0.7	63.63	9208	10000	108.60
Casein	Potassium oleate									
0.02	Nil	23.4	19.0	81.19	1.18	0.9	76.27	6986	5582	79.90
"	0.01	29.6	19.1	64.52	1.36	0.8	58.82	7985	7621	95.44
"	0.015	29.2	18.2	62.32	1.46	0.8	54.79	8516	6113	71.78
"	0.02	41.6	17.8	42.79	1.72	0.7	40.69	10000	5218	52.18
"	0.025	38.7	17.8	45.99	1.50	0.9	60.0	9004	6111	67.87
"	0.03	40.2	18.9	47.01	1.62	0.8	49.38	7985	7313	91.58
Casein	Potassium laurate									
0.02	0.01	36.3	26.2	72.18	1.5	1.0	66.60	10000	9613	96.13
"	0.015	38.7	25.5	65.89	1.62	1.1	67.9	8516	9514	111.7
"	0.02	40.2	29.9	74.38	1.48	1.2	81.08	10000	8318	83.18
"	0.025	41.6	33.3	80.04	1.55	1.2	77.4	10000	10000	100.00
"	0.03	37.2	28.5	76.61	1.85	1.0	54.05	10000	10000	100.00

B- Before ageing: A - After ageing at 70 C for 168 hours.