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USE OF RUBBER SEED OIL SOAP IN LATEX FOAM FROM NATURAL RUBBER AND NATURAL RUBBER / STYRENE BUTADIENE RUBBER BLEND

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Latex foam was prepared from natural rubber and a blend of natural rubber and styrene butadiene rubber using rubber seed oil soap as well as potassium oleate. Evaluation of the properties indicated that the quality of foam obtained using rubber seed oil soap was comparable to that of the foam prepared using potassium oleate and conformed to Bureau of Indian Standards (BIS) specification for latex foam. Rubber seed oil soap was also found to be comparable to potassium oleate as foaming agent in blends of NR and SBR latices for foam production.

Key words: Latex foam, Natural rubber, NR/SBR latex blend, Potassium oleate, Rubber seed oil.

INTRODUCTION

Rubber tree (*Hevea brasiliensis*) is widely used as the source of natural rubber (NR) and its seed has been found to be rich in oil (Potty, 1980; Haridasan, 1992; Thomas *et al.*, 1996). The dried kernel of the seed contains about 42% oil and it is extracted usually by the expulsion process. Rubber seed oil (RSO) is a light yellow coloured semidrying oil.

RSO contains about 18-22% saturated and 78-82% unsaturated higher fatty acids. The composition of fatty acids in RSO is given in Table 1. There are several industrial applications for RSO. It has strong potential to substitute linseed oil in alkyd production (Aigbodion, 1991, 1995; Aigbodion and Okieimen, 1995; Aigbodion *et al.*, 2000, 2003; Aigbodion and Pillai, 2000, 2001; Coomarasamy, 1977). It can also be used in the manufacture of paint, linoleum, soap, factice (Donnelly, 1963; Flint *et al.*, 1969; Vijayagopalan, 1971; Fernando, 1971), varnish (Williams, 1950; Haridasan, 1977), leather industry (Vijayalakshmi *et al.*, 1988) and preparation of grease (Njoku and Ononogbu, 1995). According to Nandanan *et al.* (1999) RSO can be used as a multipurpose ingredient in NR and SBR compounds. It was also evaluated as an alternative to diesel oil as fuel (Perera and Dunn, 1990). Epoxidised rubber seed oil (ERSO) (Vijayagopalan and Gopalakrishnan, 1971) is used in the formulation of anticorrosive coating, adhesive and alkyd resin coating (Aigbodion, 1994). Use of RSO, ERSO and its lead and barium salts as heat stabilizers for PVC has been reported (Okieimen and Ebhoaye, 1992, 1993a; 1993b). There are reports on the use of RSO and ERSO in natural rubber compounds for improving the processability characteristics and physico mechanical properties (Aigbodion *et al.* 2000).

Potassium oleate is commonly used as the foaming agent in latex foam production.

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Table 1. **Composition of fatty acids in rubber seed oil**

Fatty acid	Content (%)
Palmitic acid	10.8
Stearic acid	10.0
Oleic acid	23.5
Lenoleic acid	38.5
Linolenic acid	16.2
Undectatable portion	1.0

Table 3. **Properties of rubber seed oil**

Parameter	Value
Acid value	36
Saponification value	191
Iodine value	132
Hydroxyl value	31
Unsaponifiables (%)	0.80
Refractive index (40°C)	1.47
Specific gravity (30 °C)	0.92
Titre (°C)	28

Mixture of carboxylate soaps promotes foaming more efficiently than do the components separately (Blackley, 1998a). Rubber seed oil and castor oil contain saturated and unsaturated higher fatty acids such as stearic acid, recinoleic acid, oleic acid and linoleic acid. Hence in this study, use of RSO soap as partial or full substitution for potassium oleate in latex foam production was attempted. As the price of rubber seed oil is less than that of oleic acid use of rubber seed oil for rubber latex foam will be advantageous.

MATERIALS AND MTHODS

Concentrated NR latex conforming to BIS: 5430-1981 (Table 2) was obtained from the Pilot Latex Processing Centre (PLPC) of the Rubber Board. Rubber seed oil was obtained from Virudhunagar, South India. The properties of the oil are given in Table 3. All other chemicals such as zinc oxide, sulphur, accelerators, antioxidant, filler etc. were of commercial grade.

Table 2. **Properties of natural rubber latex**

Parameter	Value
Dry rubber content (%)	60.1
Total solid content (%)	61.6
Ammonia (%)	0.22
Volatile fatty acid number	0.03
Potassium hydroxide number	0.60
Mechanical stability time (sec.)	1227
Sludge content	Trace
Coagulum content	0.004
Copper (ppm)	Trace
Manganese (ppm)	Trace
Zinc oxide stability time (sec.)	166

Preparation of soap

A 20% solution of soap was prepared as follows (NR Technical Bulletin, 1973).

Mixture A (parts by weight)

Oil	100
Water	400

Mixture B (parts by weight)

KOH	25
Water	50

Mixture A was warmed to 75°C and Mixture B was added to it in small quantities under constant stirring, which was continued till a clear solution was obtained. Formulations given in Table 4 were used for preparing the foam by the Dunlop process.

Preparation of foam

NR latex concentrate was initially compounded with the soap (0.2 phr), dispersions of sulphur, ZDC, ZMBT and antioxidant SP (emulsion) and were kept for maturation for about 16 h. The matured latex compound, mixed with an additional quantity (1 phr) of soap, was taken in a planetary mixer and run at high speed (150 rpm) to expand the latex by the frothing action of

Table 4. **Formulation of latex foam**

Ingredients	Compound no. (Dry weight)									
	POE	RSOS	POCO	PORO	CORO	POEF	RSOSF	PORO1	POROF	RSOS1
NR latex (60%)	100	100	100	100	100	100	100	100	100	100
Potassium oleate (20%)	0.2	-	0.2	0.2	-	0.2	-	0.2	0.2	-
Castor oil soap (30%)	-	-	-	-	0.2	-	-	-	-	-
Rubber seed oil soap (10%)	-	0.2	-	-	-	-	0.2	-	-	0.2
Sulpur dispersion (50%)	2	2	2	2	2	2	2	2	2	2
ZDC dispersion (50%)	1	1	1	1	1	1	1	1	1	2
ZMBT dispersion (50%)	1	1	1	1	1	1	1	1	1	1
SP emulsion (50%)	1	1	1	1	1	1	1	1	1	1
	Maturation (16 hrs.)									
Potassium oleate (20%)	1	-	0.4	0.4	-	1	-	-	-	-
Caster oil soap (30%)	-	-	0.6	-	0.4	-	-	-	-	-
Rubber seed oil soap (10%)	-	1	-	0.6	0.6	-	1	1	1	0.8
China clay (as powder)	-	-	-	-	-	20	20	-	20	-
Cetyl trimethyl ammonium bromide	1	1	1	1	1	1	1	1	1	1
Zinc oxide dispersion (50%)	5	5	5	5	5	5	5	5	5	5
Sodium silicofluoride dispersion (20%)	2	2	2	2	2	2	2	2	2	2

POE : 1.2 phr potassium oleate soap
POCO : 0.6 phr potassium oleate + 0.6 caster oil soap
POEF : 1.2 phr potassium oleate + 20 clay (filler)
POROF : 0.2 oleate + 1 rubber seed oil + 20 clay
RSOS 1 : 1 phr rubber seed oil soap
RSOS : 1.2 phr rubber seed oil soap
PORO : 0.6 phr oleate + 0.6 phr rubber seed oil
RSOSF : 1.2 phr rubber seed oil soap + 20 clay
PORO1 : 0.2 phr oleate + 1 rubber seed oil soap
CORO : 0.6 phr castor oil soap + 0.6 phr rubber seed oil

soap to the required level. The level of expansion was kept the same (1:7) in all the cases. Time taken for 7 times expansion of the compounded latex is given in Table 5. At this stage, the foam was refined under slow speed stirring so as to break down the large air bubbles into smaller ones, which make the foam more uniform. At this point, the foam stabilizer (cetyl trimethyl ammonium bromide) was added. After one minute, zinc oxide (50% dispersion) and the delayed action gelling agent, sodium silico fluoride (20% dispersion) were added. The pH of sodium silico fluoride was adjusted to between 6-7 prior to its addition into the foam. After one minute, it was transferred to the mould, which had already been treated with a mould-release agent and warmed to 40°C. The filled moulds were allowed to stand for 10 min for gelation. The foam in the mould was steam vulcanized at 110-115°C for 45 min. The foam was washed and dried at 70°C for 4 h. Both filled and unfilled compounds were used for the study. The properties of the vulcanized latex foam were determined as per BIS: 1741-1999.

Table 5. **Time required for expansion of latex compound (1:7)**

Compound	Time (min)
POE	8
RSOS	6
RSOS1	7
POCO	5
PORO	7
PORO1	7
CORO	5
POEF	8
RSOSF	6
POROF	7

Trials were also conducted with blends of NR and SBR latices. The formulation used for this study is given in Table 6. A 50:50 blend of NR and SBR was used to achieve the desired properties and to reduce cost.

RESULTS AND DISCUSSION

The time required to get the desired expansion (Table 5) was lower for the compounds, containing rubber seed oil soap compared with potassium oleate. This indicated the better foaming efficiency of the soap from rubber seed oil.

The properties of the latex foam prepared using different types of soaps/combinations of soaps are given in Table 7. Hardness of foam basically depends on expansion of the latex compound and in this study the expansion was kept constant (7 times the original volume) in all the trials. When potassium oleate was completely replaced with an equal quantity of soap prepared from rubber seed oil or where 1 phr of the soap was used in place of 1.2 phr of potassium oleate, almost the same hardness was obtained for the foam. Results indicated that the use of 50:50 mixture of oleic acid and rubber seed oil soaps yielded foam having higher hardness (39.5) compared with a 50:50 mixture of oleic acid and castor oil soaps (31.5). Mixtures of soaps of castor oil and rubber seed oil or that of oleic acid and castor oil resulted in foams of much lower hardness compared with soaps of oleic acid, rubber seed oil or an equivalent mixture of these two indicating the low load bearing capacity of the foam from castor oil soap. The hardness

Table 6. **Formulation for latex foam from NR/SBR latex blend**

Ingredient	Parts (Dry weight)
NR latex (60%)	50.0
SBR latex (40%)	50.0
Soap (20%)	0.2
Sulphur (50%)	2.0
Zinc salt of 2-Mercapto benzothiazole	1.0
Zinc diethyl dithiocarbamate (50%)	1.0
Styrenated phenol (50%)	1.0
Mix A&B and kept for maturation (16 hrs.)	
Soap (20%)	1.0
Cetyl trimethyl ammonium bromide (30%)	1.0
Zinc oxide (50%)	5.0
Sodium silicofluoride (20%)	5.0
China clay as powder (phr)	20.0

Table 7. **Physical properties of latex foam (tested as per BIS 1741-1999)**

Compound	Initial hardness (kg)	Compression set (%)	Flexing		Whole sample compression	Ageing	Mould shrinkage (after 15 days)
			Increase in hardness (%)	Reduction in thickness (%)	Change in thickness (%)	Increase in hardness (%)	Reduction in diameter (%)
POE	38.0	6.0	5.0	3.8	4.7	9.5	11.0
RSOS	38.0	5.0	15.0	3.8	4.8	14.3	11.4
POCO	31.5	5.6	4.5	2.5	3.5	8.0	8.2
PORO	39.5	5.0	1.0	2.4	1.2	11.1	11.0
CORO	33.0	4.0	3.2	2.4	4.1	6.6	8.7
POEF	35.0	6.0	5.7	2.4	2.3	11.8	9.9
RSOSF	35.0	5.0	14.2	3.8	3.6	15.9	11.6
RSOS1	38.5	5.0	15.0	1.2	4.7	13.5	11.0
PORO1	34.0	5.0	5.9	4.8	3.6	14.6	10.6
POROF	35.0	5.5	1.7.0	3.8	5.0	13.3	11.2
Max. values	20.0	20.0	20.0	5.0	5.0	20.0	NA

of the foams containing 20 phr of china clay was independent of the type of soap used. However, the hardness was lower than that of the unfilled compounds. The reduction in hardness values of the clay filled foam from compounds POEF, RSOSF, POROF and those containing mixtures of soaps CORO, PORO1 and POCO is expected to be due to the difference in the structure of the foams obtained.

Latex foam made using rubber seed oil soap showed lower set values compared with those made using oleate soap, both in the unfilled and china clay filled samples. In the case of foams prepared using mixtures of soaps also the same trend was noticed (CORO better than POCO). The change in thickness under compression was almost the same for POE, RSOS and RSOS1. In the case of china clay filled sample, a higher change in thickness was noticed for the sample RSOSF compared with POEF. However, when mixed soaps were used, the change in thickness was the least for PORO.

In flexing test, the foam is subjected to cyclic loading for 250 kilocycles at 240 cycles per minute. The reduction in thickness was almost the same for the foam samples prepared using potassium oleate and rubber seed oil soaps. However, the foam prepared using rubber seed oil soap showed higher change in hardness except when a mixture of potassium oleate and rubber seed oil soap was used. Potassium oleate and castor oil soap had no significant effect on the modulus of the foam rubber. Treatment of latex with alternative soaps such as potassium soap of saturated fatty acid can bring about enhancement of compression modulus and reduced foam shrinkage (Wong, 1978). In both the unfilled and clay filled foams some enhancement in the compression modulus was observed. The change in modulus after flexing or ageing did not show any deleterious effects of the soap. These values were well within acceptable levels and much less than the maximum permissible values (20%) as per the BIS specifications.

Change in hardness after ageing at 70°C for 168 h gives an indication about the long-term performance of the product. In this case also, samples prepared using rubber seed oil soap showed increase in hardness compared with that made using potassium oleate. This may be due to further crosslinking during ageing. However, the change in hardness was well within the permissible limits.

Mould shrinkage of the foam prepared using either potassium oleate or rubber seed oil soaps was about 11%. Information on mould shrinkage of the products helps to give proper allowance in the size of the mould so that product of exact dimensions can be prepared.

The properties of the foam prepared using a blend of NR and SBR latices also showed similar hardness values when potassium oleate (NSPOF) or rubber seed oil (NSROF) soaps were used (Table 8). Other properties showed marginal differences but were within the specified limits.

Figures 1 and 2 are the optical micrographs of foam from POE and RSOS. Both the foam samples had uniform distribution of the cells and cell size with the same hardness. Close examination indicated that the sample RSOS had more uniform cells and finer structure than sample POE. Thus it is concluded that rubber seed oil can be used in foam production without any adverse effect on the quality of foam.

Table 8. **Physical properties of latex foam from NR/SBR blends, as per BIS 1741-1999**

Sample	Initial hardness (kg)	Compression set (%)	Flexing		Whole sample compression	Ageing
			Increase in hardness (%)	Reduction in thickness (%)	Change in thickness (%)	Increase in hardness (%)
NSROF	25	8	12	2.43	4.90	13.6
NSPOF	26	6	7.7	1.28	4.59	6

NSROF : Foam with rubber seed oil soap
NSPOF : Foam with potassium pleate soap

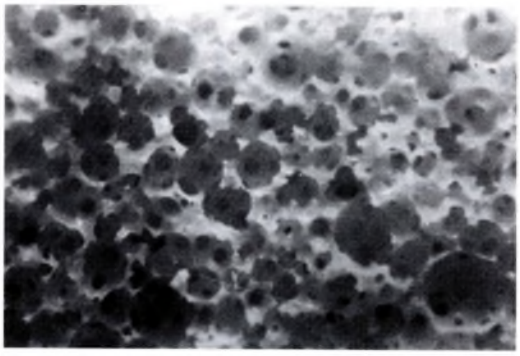

Fig. 1. Photomicrograph of foam sample POE

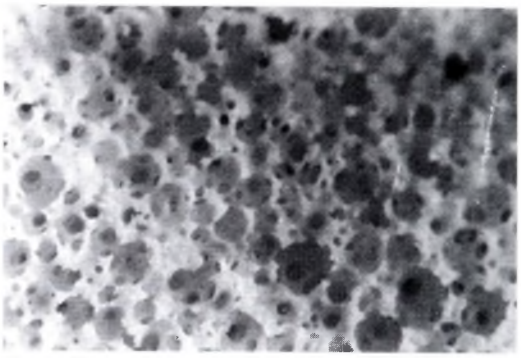

Fig. 2. Photomicrograph of foam sample RSOS

CONCLUSION

Rubber seed oil can be used for the production of foam from NR latex or a NR/SBR latex blend. The quality of foam was comparable to that prepared using oleic acid soap. The properties of the foam prepared using rubber seed oil soaps or mixtures of rubber seed oil and potassium oleate soaps were conforming to BIS specifications. There was no fungal growth on foam on storage. The properties of the foam prepared from a 50:50 NR/SBR latex blend also indicated that rubber seed oil soaps could be used in such cases as well.

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