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Modified Lacs as Compounding Ingredients of Styrene-Butadiene Rubber: Part III—Ethylene Glycol Modified Lac in Gum Stock

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The incorporation of ethylene glycol modified lac in styrene-butadiene rubber (1502) affects favourably the Mooney viscosity, modulus, tensile strength, tear resistance, hardness and swelling in petroleum ether and benzene of the rubber. The detrimental effect on impact resilience and abrasion resistance resulting due to the incorporation of straight shellac in styrene-butadiene rubber is also overcome to a large extent. Out of three accelerator systems tried, viz. (1) mercaptobenzthizole, (2) cyclohexyl benzthiazyl sulphenamide and (3) a combination of mercaptobenzthiazyl disulphide and tetramethyl thiuram disulphide, the last one gives maximum improvement in most of the properties.

IT was reported in the earlier parts of this series[1], that epoxidized lac improves most of the mechanical properties of styrene-butadiene rubber to a greater extent than straight shellac. However, the resilience and abrasion resistance of the resulting compositions were found to have been adversely effected. As the detrimental effect on these properties is possibly due to the inherent brittleness of shellac, further work was carried out employing flexible compositions prepared from shellac. One such composition was obtained by treating shellac with ethylene glycol[2]. The present paper presents the characteristics of the product obtained by compounding this product with styrene-butadiene rubber (1502) gum stock. The effect of incorporating different accelerator systems has also been studied.

Experimental procedure

The reaction between lac and ethylene glycol was carried out at $180 \pm 5°C$ using concentrated sulphuric acid as the catalyst. A Dean and Stark separator was used for driving out the water of reaction; other details were the same as reported by Gidvani[2]. A typical sample prepared had acid value 32·0 and hydroxyl number 200·2.

The methods employed for mixing, vulcanization and physical testing were the same as reported earlier[1]. The compositions of the various mixes are given in Table 1. Ethylene glycol-modified lac was incorporated only up to a concentration of 10 parts/100 parts rubber, as its incorporation at concentration levels higher than this presented difficulties due to its sticky nature.

Results and discussion

Time for optimum cure — The time for optimum cure is not affected by the presence of ethylene glycol-modified lac (hereafter referred to as modified lac), when either mercaptobenzthizole (MBT) or cyclohexyl benzthiazyl sulphenamide (CBS) is the accelerator. However, when a combination of mercaptobenzthiazyl disulphide (MBTD) and tetramethyl thiuram disulphide (TMTD) is used, the cure is slightly retarded by its presence at a concentration level higher than 7·5 parts/100 parts rubber. As there was a simultaneous reduction

Table 1 — Effect of incorporation of ethylene glycol modified lac on the properties of SBR

[*Base mix*: *SBR* (1502), 100; *zinc oxide*, 4; *sulphur*, 2; *stearic acid*, 1; *PBN*, 1 *part*]

Modified lac added parts/ 100 parts rubber	Optimum cure time (at 140°C) min	Mooney No. (ML 1+ +4 at 120°C)	Scorch time min-sec	Ultimate elongation %	Tear resistance kg/cm	Durometer hardness	Abrasion loss ml/1000 rev	Impact resilience %
			ACCELERATOR, MBT 1·5					
0·0	45	29·0	70·0	350	14·0	48	3·1	65·3
2·5	40	29·0	36-30	300	14·4	50	3·5	68·9
5·0	40	28·2	35-3	330	15·0	50	3·6	65·3
7·5	40	27·0	34-7	360	15·2	51	3·68	65·3
10·0	40	25·0	32-5	400	15·4	52	3·65	64·6
			ACCELERATOR, CBS 1·5					
0·0	40	28·8	81-0	250	15·4	50	3·2	72·5
2·5	40	28·8	63-38	240	15·5	50	3·58	68·9
5·0	40	27·0	50-2	320	15·6	51	3·6	68·9
7·5	40	26·2	43-30	330	17·0	52	3·63	67·0
10·0	40	24·0	36-2	350	19·7	53	3·68	65·3
			ACCELERATOR, MBTS 1·25+TMTD 0·25					
0·0	30	28·5	45-11	200	10·7	46	3·7	67·0
2·5	30	27·8	43-2	230	10·8	49	3·85	67·0
5·0	30	27·0	40-30	250	10·8	52	3·9	67·0
7·5	35	26·4	38-0	245	11·0	54	4·2	68·9
10·0	40	25·5	36-17·5	250	11·0	55	4·5	70·0

nearly to the same extent in the acid and hydroxyl values of shellac during the course of preparation of modified lac, its incorporation has an effect similar to that of shellac on the rate of cure of the mix[1].

Mooney viscosity and scorch time — The Mooney viscosity falls regularly with progressive increase in the concentration of the modified lac, indicating that it has a plasticizing effect similar to that of shellac.

The scorch time is reduced with the addition of modified lac along with all the three accelerator systems; this can be ascribed to the activity of the hydroxyl groups present in the modified lac.

Modulus and ultimate elongation — On the addition of modified lac, the value of modulus increases when MBT or a combination of MBTD and TMTD is used as the accelerator (Fig. 1), the latter system behaving more favourably. With CBS, a decrease in the value of modulus is noticed. This is contrary to the behaviour of shellac with

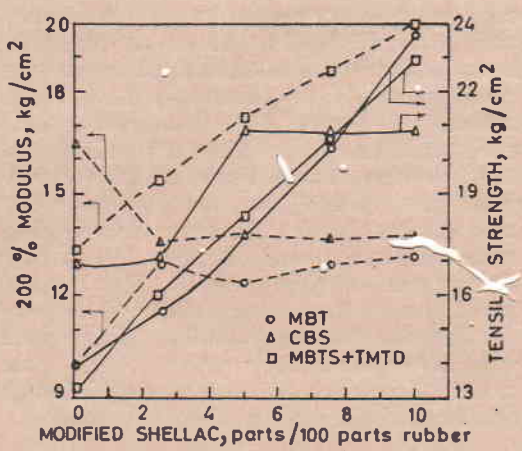

Fig. 1 — Effect of concentration of ethylene glycol modified lac on modulus and tensile strength of SBR

CBS, when the value of the modulus was found to increase[1]. The ultimate elongation increases on the addition of the modified lac which is due to its plasticizing effect.

The simultaneous increase in the value of modulus and elongation is similar to that observed in the case of shellac[1]; this indicates the possibility of binding between the molecules of the modified lac and rubber.

Tensile strength and tear resistance — The accelerator systems comprising MBT and a combination of MBTD and TMTD behave alike in increasing the tensile strength with progressive addition of the modified lac (Fig. 1), the increase being quite marked. With CBS, the tensile strength increases up to a concentration of 5 parts/100 parts rubber and then remains steady.

The tear resistance increases with all the three accelerator systems, CBS giving the maximum increase.

Hardness, abrasion resistance and impact resilience — The hardness increases almost linearly with the addition of the modified lac; best results are obtained with the combination of MBTD and TMTD.

The abrasion loss increases on the incorporation of the modified lac with all the three accelerator systems. However, the detrimental effect is comparatively much less than with shellac[1].

Out of the three accelerator systems tried, the combination of MBTD and TMTD is most favourable for improving the impact resilience.

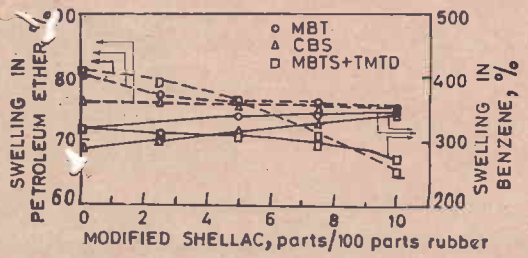

Fig. 2 — Effect of concentration of ethylene glycol modified lac on the extent of swelling of SBR in petroleum ether and benzene

Swelling — The incorporation of the modified lac lowers the extent of swelling of SBR in petroleum ether, the combination of MBTD and TMTD being the best accelerator for this purpose. This accelerator system reduces the extent of swelling in benzene as well (Fig. 2).

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