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Modified Lacs as Compounding Ingredients of Styrene-Butadiene Rubber: Part II — Epoxidized Lac in Filled Stock

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The relative performance of epoxidized lac and straight shellac as compounding ingredients in styrene-butadiene rubber stock containing different fillers (HAF black, EPC black and clay) has been investigated. With HAF black as the filler, epoxidized lac raises the scorch time, tensile strength and tear resistance of the stock; straight shellac has an adverse effect on these properties. With EPC black, epoxidized lac imparts greater hardness to the stock than straight shellac; the improvements in the value of modulus and the swelling behaviour are of the same magnitude with both epoxidized lac and shellac. With clay as the filler, epoxidized lac brings about greater improvement in the tear resistance of the stock than straight shellac; the modulus, degree of hardness and resilience are improved to the same extent by both epoxidized lac and shellac.

IT was reported in an earlier communication[1] that epoxidized lac brings about greater improvement in the mechanical properties of styrene-butadiene rubber gumstock than straight (unmodified) shellac. The relative performance of epoxidized lac and straight shellac in the presence of different fillers has now been investigated and the results are presented in this paper.

Experimental procedure

The compositions of the various mixes are given in Tables 1-3. The fillers used were HAF black (Philblack 0) (*Phillips Carbon Black*, Calcutta), EPC black (M/s *Firestone*, Bombay) and clay (air blown) (M/s *National Rubber Manufacturers*, Calcutta). All the other chemicals used were the same as in the earlier study[1]. The methods employed for mixing, vulcanization and physical testing were the same as reported earlier[1].

Results and discussion

Effect of adding HAF black as filler — The physical properties of the mixes containing HAF black (*p*H 8-9) are given in Table 1. The base composition was similar to that of a tread type compound. It is seen that the time for optimum cure is not altered by the addition of shellac, but is enhanced by epoxidized lac.

The addition of both shellac and epoxidized lac results in slight lowering of Mooney viscosity; the magnitude of the lowering is the same for both of them, indicating that they help in the dispersion of the compounding ingredients to the same extent. While the scorch time falls on adding shellac, it is slightly increased on adding epoxidized lac.

The reduction in scorch time with shellac can be ascribed to the activity of the hydroxyl groups present in it; a similar observation has been made with the gum-stock also[1]. The slight increase in the value of scorch time on incorporating epoxidized lac is a welcome feature, as furnace blacks are otherwise scorchy and tend to hinder the processing of the stock.

The superiority of epoxidized lac over straight shellac is also brought about by the trend in the variation of other characteristics of the stock. While the increase in hardness as a result of the incorporation of shellac and epoxidized lac is of the same order, the addition of epoxidized lac (up to 5 parts per 100 parts rubber) increases the tensile

Table 1 — Effect of shellac and epoxidized lac on the characteristics of styrene-butadiene rubber using HAF black filler

(*Base mix composition*: *Styrene-butadiene rubber*, 100; *HAF black*, 40; *mineral oil*, 5; *zinc oxide*, 4; *sulphur*, 2; *stearic acid*, 1; *santocure*, 1; *and PBN*, 1 *parts*)

Shellac or epoxidized lac added parts/100 parts rubber	Optimum cure time (at 140°C.) *min.*	Mooney viscosity (ML 4 at 120°C.)	Scorch time *min.*	Modulus (at 200% elongation) *kg./cm.²*	Ultimate elongation %	Tensile strength *kg./cm.²*	Tear resistance *kg./cm.*	Durometer hardness	Impact resilience %	Abrasion loss ml./1000 revolutions	Immersion behaviour (wt increase, %)*: Benzene	Immersion behaviour (wt increase, %)*: Pet. ether
Resin, shellac												
0	45	46	37	56·5	400	161·5	68·7	61	50·4	0·62	170	44
2·5	45	45	36	56·0	425	148·1	70·4	64	50·4	0·73	186	48
5·0	45	44	35	50·5	440	140·7	65·0	65	48·8	0·79	195	49
10·0	45	43	33	46·9	450	132·0	54·2	66	45·8	0·84	208	50
Resin, epoxidized lac												
2·5	60	45	39	47·0	450	170·2	73·4	64	50·4	0·71	182	47
5·0	60	45	39	40·4	500	165·4	70·2	65	47·3	0·74	190	48
10·0	60	44	40	39·9	520	159·0	68·1	66	45·8	0·80	204	49

*The stock was immersed in the solvent for 96 hr at 25 ± 1°C.

Table 2 — Effect of shellac and epoxidized lac on the characteristics of styrene-butadiene rubber using EPC black filler

(*Base mix composition*: *Styrene-butadiene rubber*, 100; *EPC black*, 70; *mineral oil*, 2; *zinc oxide*, 4; *sulphur*, 2; *stearic acid*, 1; *MBT*, 1·5; *and PBN*, 1 *parts*)

Shellac or epoxidized lac added parts/100 parts rubber	Optimum cure time (at 140°C.) *min.*	Mooney viscosity (ML 4 at 120°C.)	Scorch time *min.*	Modulus (at 200% elongation) *kg./cm.²*	Ultimate elongation %	Tensile strength *kg./cm.²*	Tear resistance *kg./cm.*	Durometer hardness	Impact resilience %	Abrasion loss ml./1000 revolutions	Immersion behaviour (wt increase, %)* Benzene	Pet. ether
						Resin, shellac						
0	60	40·5	53	22·6	450	80·1	52·1	58	56·8	1·7	290	57
5	60	39·5	47	25·6	480	64·0	50·8	62	55·1	2·3	218	48
10	60	37·0	48	27·2	500	58·4	49·4	65	50·4	2·7	207	44
15	60	35·0	48	29·0	510	51·1	46·1	69	48·8	3·1	240	47
20	60	33·0	49	31·1	500	44·4	41·6	75	45·8	3·3	258	49
						Resin, epoxidized lac						
5	60	38	47	27·7	450	57·2	42·0	65	53·5	2·3	196	45
10	60	35	42	27·2	500	53·0	40·0	69	48·8	2·8	200	42
15	60	32	37	27·1	450	49·2	40·5	72	45·8	3·1	250	48
20	60	30	33	27·0	620	44·1	40·9	77	44·3	3·3	315	54

*The stock was immersed in the solvent for 96 hr at 25±1°C.

Table 3 — Effect of shellac and epoxidized lac on the characteristics of styrene-butadiene rubber using china clay as filler

(*Base mix composition*: *Styrene-butadiene rubber*, 100; *china clay*, 100; *mineral oil*, 3; *zinc oxide*, 4; *sulphur*, 2; *stearic acid*, 1; *MBT*, 1·5; *and PBN*, 1 *parts*)

Shellac or epoxidized lac added parts/100 parts rubber	Optimum cure time (at 140°C.) *min.*	Mooney viscosity (ML 4 at 120°C.)	Scorch time *min.*	Modulus (at 200% elongation) *kg./cm.²*	Ultimate elongation %	Tensile strength *kg./cm.²*	Tear resistance *kg./cm.*	Durometer hardness	Impact resilience %	Abrasion loss ml./1000 revolutions	Immersion behaviour (wt increase, %)* Benzene	Pet. ether
						Resin, shellac						
0	50	49	63	18·1	800	50·0	26·3	64	43·7	2·7	224	44
5	50	46	60	20·3	1100	51·1	30·3	67	44·3	3·0	235	45
10	50	44	58	21·9	850	41·4	28·7	72	45·2	3·2	247	46
15	50	42	57	22·0	870	38·7	27·5	74	44·3	3·7	300	57
20	60	40	57	22·1	890	36·5	26·0	77	42·9	4·3	352	58
						Resin, epoxidized lac						
5	60	45	53	20·9	1000	55·4	32·5	68	44·3	2·95	275	48
10	60	41	50	21·0	1100	41·0	30·5	72	43·7	3·20	327	55
15	60	38	47	21·2	1020	39·5	30·0	74	42·9	3·80	328	54
20	60	36	43	21·5	900	38·0	30·5	76	42·3	4·40	330	54

*The stock was immersed in the solvent for 96 hr at 25±1°C.

strength and tear resistance, though shellac has an adverse effect on these properties.

There is no effect of incorporating up to 2·5 parts of shellac or epoxidized lac per 100 parts rubber on the resilience of the stock. The abrasion resistance falls slightly; the fall is more with straight shellac than with epoxidized lac.

Effect of adding EPC black — When EPC black (*p*H 3·8-5·0) is used as the filler, the time for optimum cure is not affected by the addition of either shellac or epoxidized lac (Table 2). Incorporation of shellac or epoxidized lac again helps in giving enhanced plasticization (lower Mooney No.), the effect being more with epoxidized lac. Both shellac and epoxidized lac tend to be scorchy.

An appreciable enhancement in hardness is brought about by the incorporation of both shellac and epoxidized lac, the latter having a more noticeable effect. Other beneficial effects are increase in modulus and resistance towards benzene and petroleum ether, which are nearly of the same order with both types of lac.

Effect of adding china clay as filler — Rubber compositions incorporating china clay as a filler are specially used for flooring and for the preparation of extruded goods, such as hoses and tubes. It is seen from Table 3 that using china clay (*p*H of slurry, 5·0) as a filler, the time for optimum cure of the compositions is not affected when shellac is present, but is somewhat enhanced in the presence of epoxidized lac.

The plasticization brought about by shellac or epoxidized lac is shown by the lowering of Mooney viscosity, the effect of epoxidized lac being more prominent than that of shellac. The scorch time is reduced by both shellac and epoxidized lac.

The incorporation of shellac or epoxidized lac has a beneficial effect on modulus, hardness and resilience nearly to the same extent, while tear resistance is enhanced somewhat more with epoxidized lac. Tensile strength is improved by the incorporation of both shellac and epoxidized lac up to the level of 5 parts/100 parts rubber; the improvement is more with epoxidized lac than with shellac.

The abrasion resistance is slightly impaired by the addition of both shellac or epoxidized lac. However, the detrimental effect is much less than that when black fillers are used.

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