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A NEW COAGULANT FOR NATURAL RUBBER LATEX

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ABSTRACT

Coagulant AC can be very safely used as coagulant for NR latex. The optimum dosage required for coagulation is 8 g per dry kg. rubber and coherent coagulum is obtained in about 2½ hrs. The rubber obtained with this coagulant has mooney viscosity about 4-6 units lower than conventional formic acid coagulanted rubber. The technological properties of the rubber processed with this coagulant is comparable to those obtained for conventionally processed rubbers.

INTRODUCTION

Coagulation of *Hevea* latex is the primary process in the conversion of latex to marketable forms of natural rubber viz., sheet, crepe or crumb. Field latex after dilution is conventionally coagulated with organic acids, usually formic or acetic acid. Formic acid is now the best available coagulant for NR latex. During the past years several other materials were tried and evaluated as coagulants for NR latex. Wiltshire (1932) suggested the use of sulfuric acid as a coagulant for latex. Later on further work on the use of sulfuric acid for coagulation was carried out by Martin and Davey (1934). They have reported that correct dosage of sulfuric acid for coagulation will not in any way affect the raw rubber properties or vulcanizate properties while excess quantity of sulfuric acid will deteriorate the properties of rubber. The findings of Martin and Davey was later confirmed by Van der Bie (1946) and Best and Morrel (1955). Other methods of coagulation have also been investigated. John (1966 a,b) reported the auto-coagulation of latex in about 48 hours by bacteria and yeasts. The time of coagulation can be further reduced to about 16 hrs by adding carbohydrates (John and New Sam, 1969). John and Pillai (1971) suggested the use of anionic surfactants for even speedy coagulation. In a later work John (1971) has reported the continuous coagulation of latex by the use of the surfactant dioctyl sodium sulfosuccinate and the salt calcium chloride at about neutral pH.

In the present paper attempts have been made to evaluate the suitability of coagulant AC, which is a derivative of sulphamic acid, supplied by M/s. Dharamsi Morarji Chemical Co., Ltd., Bombay. This chemical is a white free flowing solid, non-delequecant and highly soluble in water. The solid or the solution is non corossive and is less acidic than sulfuric acid.

Materials and Methods

The first part of the study was to find out the optimum dosage of this chemical for same-day coagulation and next-day coagulation. Field latex collected from the RRII experiment station was used for this study. Known weight of latex samples diluted to approximately 12.5 drc were coagulated by adding different quantities of coagulant AC ranging from 2-12 g/kg drc as one per cent solution with control samples coagulated with acetic acid and formic acid. Complete coagulation was observed within a period of 2-3 hours only in samples to which coagulant AC at the rate of 8 g/kg drc and above were added. Lower dosages of coagulant AC ranging from 5-7 g/kg drc were tried for next-day coagulation. Though coagulation was observed to be complete, air bubbles were observed on the lower surface of the wet coagulam. This coagulam on sheeting and drying had an unsatisfactory appearance. After fixing the optimum dosage of this chemical for the same-day coagulation of field latex, the percent recovery of rubber was evaluated. Known weight of latex samples were coagulated by adding coagulant AC, formic acid and acetic acid in the usual dosages for the same-day coagulation, the coagula were machined, washed, and dried at 70°C in an oven, determined the weight of dry sheets and calculated the percent of dry rubber content recovered. (Table 1).

NR latex was collected from 6 different sources. Each batch of latex was divided into two parts. One part from each batch was coagulated with formic acid as reference (4 ml per kg dry rubber). The other part was coagulated with coagulant AC (8 g per kg dry rubber). The pH of coagulation with formic acid and coagulant AC were 4.8 and 4.95 respectively. The latices for which formic acid was used as coagulant formed coherant coagulam in 3 hrs, while coagulant AC treated one took only 2½ hrs. Of the six batches, 4 were processed into ribbed smoked sheet rubber and two

Table 1. Percent Recovery of Rubber

Coagulant AC	Formic Acid	Acetic Acid
8 gm/Kg. drc	4 cc/Kg. drc	8 cc/Kg. drc
36.67	36.65	36.68
36.64	36.67	36.69
41.03	41.08	41.04
41.04	41.00	40.91
40.42	40.30	40.43
40.38	40.36	40.48
40.37	40.37	40.35
40.33	40.35	40.35
40.27	40.25	40.25
40.25	40.24	40.29

into solid block rubber. These sheet rubber samples were subjected to visual examination, evaluation of raw rubber properties, acid retention in the raw rubber, cure properties and technological properties while the block rubber samples were subjected to evaluation of raw rubber and cure properties. Raw rubber properties were evaluated as per IS 3660 and technological properties as per IS 3400. The raw rubber properties studied were ash content, nitrogen content, initial plasticity (PO), plasticity retention index (PRI), accelerated storage hardening, Mooney Viscosity and acetone extractable materials. For evaluation of cure properties, with each sample a gum rubber compound as per ACS-I formulation and a tread compound were prepared. The formulations are given in Tables 2 and 3 respectively.

Table 2. ACS-1 Formulation

Natural Rubber	..	100
Stearic Acid	..	0.5
Zinc Oxide	..	6.0
MBT	..	0.5
Sulphur	..	3.5

Table 3. Tread Formulation

Natural Rubber	..	100
Stearic Acid	..	2.5
Zinc Oxide	..	3.5
HAF Black	..	50
Aromatic Oil	..	5
HSL Beads	..	1
CBS	..	0.6
Sulphur	..	2.5

Results and Discussion

Visual examination of the sheet rubber samples revealed that formic acid coagulated and those coagulated with coagulant AC belonged to the same grades. But the block rubber samples prepared by using coagulant AC possessed lighter colour over the control.

Raw Rubber Properties: From Table 4 and 5 it can be seen that the ash content, nitrogen content and acetone-extractable materials of the rubber obtained by using coagulant AC are comparable with those of the respective formic acid coagulated reference samples. Slightly softer rubber is obtained by coagulation with coagulant AC as evidenced by lower Po values and Mooney Viscosity. The response of the two types of rubber to accelerated storage hardening test is almost comparable. Tables 4 and 5 show slightly higher PRI values for the test samples over the control.

Evaluation of Cure Properties: Tables 6 and 7 give the data on cure characteristics. The gum rubber compounds prepared according to ACS-I formulation show an increase of 3-4 minutes at 150°C in cure time and about 15 minutes in scorch time at 120°C over the control compounds. But this difference is not observed in the case of the carbon black loaded tread rubber compound. Best and Morrel (1955) have reported that the tendency to scorch and the rate of vulcanization of rubber do not appear to be appreciably affected by the method of coagulation. This is found to be true only with the tread compound. The scorch safety of the compound suggests that the rubber coagulated using this material may be more advantageous in the production of products like tread rubber.

Table 4. Raw Rubber Properties of Sheet Rubber

Parameters	A1	B1	A2	B2	A3	B3	A4	B4
Ash Content %	0.339	0.328	0.271	0.287	0.261	0.311	0.226	0.297
Nitrogen Content %	0.413	0.429	0.382	0.405	0.411	0.425	0.418	0.446
Initial Plasticity (Po)	57	50	52	50	48	46	54	51
Plasticity Retention Index (PRI)	80.7	92.0	86.0	84.0	91.7	93.5	80.7	88.0
Accelerated Storage Hardening (No. of units hardened △Po)	22	24	21	20	36	32	34	32
Mooney Viscosity (ML (1+4)100°C)	91	85	87	81	83	78	87	83
Acetone Extractable Materials %	2.57	2.47	3.64	3.33	2.42	2.20	2.47	2.48

A—Rubber Coagulated with Formic Acid

B—Rubber Coagulated with Coagulant AC

Table 5. Raw Rubber Properties of Block Rubber Samples

Parameters	A5	B5	A6	B6
Ash Content %	0.184	0.166	0.229	0.215
Nitrogen Content %	0.390	0.450	0.351	0.372
Initial Plasticity (Po)	53	51	51	48
Plasticity Retention Index (PRI)	77.0	80.0	79.0	82.0
Accelerated Storage Hardening (No. of units hardened, △Po)	19	20	20	18
Mooney Viscosity ML (1+4) 100°C	80	74	83	78
Accelerated Extractable Materials %	3.42	3.30	2.70	2.52

A—Rubber Coagulated with Formic Acid
B—Rubber Coagulated with Coagulant AC

Table 6. Cure Properties of Rubber Compound from Sheet Rubber

Sample	Gum Compound		Tread Compound	
	Cure time at 150°C)	Scorch time at 120°C	Cure time at 150°C	Scorch time at 120°C
A1	16′	18′30″	10′	28′
B1	20′45″	35′	10′	26′
A2	17′5″	22′30″	10′	27′
B2	20′	37′30″	10′	28′
A3	16′30″	21′	9′30″	26′
B3	20′	33′	9′30″	25′
A4	15′	20′	9′	24′
B4	18′30″	31′	9′30″	26′

A—Rubber Coagulated with Formic Acid
B—Rubber Coagulated with Coagulant AC

Table 7. Cure Properties of Rubber Compounds from Block Rubber

Sample	Gum Compound		Tread Compound	
	Cure time at 150°C	Scorch time at 120°C	Cure time at 150°C	Scorch time at 120°C
A5	16′30″	21′	10′	27′30″
B5	20′30″	36′30″	10′	27′
A6	16′	22′30″	10′	27′30″
B6	20′30″	35′	9′30″	28′30″

A—Rubber Coagulated with Formic Acid
B—Rubber Coagulated with Coagulant AC

Table 8. Evaluation of Technological Properties

Properties		A1	B1	A2	B2	A3	B3	A4	B4
Modulus 300% kg/cm²		85	82	77	77	87	85	95	90
Elongation at break %	Before	630	610	660	625	610	600	605	595
Tensile Strength kg/cm²	ageing	238	246	237	224	235	245	243	220
Modulus 300% kg/cm²		117	115	113	112	121	120	120	120
Elongation at break %	After	542	530	580	537	523	520	548	533
Tensile Strength kg/cm²	ageing	242	240	263	232	240	240	248	219
Hardness Shore A		57	55	55	55	56	58	59	55
Heat Build up $\Delta T^{c}F$		39	38	38	39	38	40	38	39
Compression Set %		31.16	31.75	39.13	41.80	35.57	33.55	33.89	36.39
Abrasion loss in Volume CC/hr.		1.664	1.545	..	..	..	..	1.521	1.406
Flex Cracking (Initiation Kilocycles)		32.23	32.23	32.23	32.23	32.23	32.23	32.23	32.23
Failure (Kilocycles)									
Tear Strength kg/cm		72.59	86.49	81.13	86.41	85.51	77.12	84.24	82.33
Ozone Resistance									
(% Retention of Property)		25	25	25	25	20	25	25	30

A—Rubber Coagulated with Formic Acid

B—Rubber Coagulated with Coagulaant AC

Evaluation of Technological Properties: The technological properties evaluated are modulus, elongation at break and tensile strength before and after ageing at 70°C for 96 hrs., hardness, heat build up, compression set, resilience, abrassion loss, flex cracking, tear strength and ozone resistance. The values obtained for all these parameters prepared from rubber obtained by coagulation with coagulant AC is comparable with those of the reference rubber compound.

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