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EFFECT OF STORAGE ON PROPERTIES OF NATURAL RUBBER SHEETS IN TRIPURA

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Packed ribbed smoked sheets (RSS) as (50 kg bales) were stored at different locations of Tripura under normal conditions for a period of 18 months and changes in the quality parameters were compared with bales stored under controlled conditions. Sheets kept under normal conditions were affected with mould after five months of storage. No mould growth was observed in bales stored under controlled conditions even after one year of storage. However, slight mould growth was observed on the surface of the bales after one year. Mooney viscosity, initial plasticity, strength and gel content of the sheets increased with storage whereas the plasticity retention index decreased on storage. Acetone extractables were decreased slightly due to storage.

Keywords: Controlled conditions, Natural rubber, North-East India, Storage, Sheet bales

INTRODUCTION

Rubber tree (*Hevea brasiliensis)* is the most important source of natural rubber, which has commercial importance in the production of more than 45,000 items. *H. brasiliensis*, a native of the Amazon river basin, is traditionally cultivated in Kerala and Kanyakumari district of Tamil Nadu in India. The agroclimatic conditions of north-east region are unique and are suitable for rubber cultivation. Among north-eastern states, Tripura has 50070 ha plantation with an average production of 23280 t (Rubber Grower's Companion 2011) and is first in respect of area as well as production of natural rubber.

In India, natural rubber is available as ribbed smoked sheets, technically specified rubber, crepe rubber, centrifuged latex, creamed latex and preserved field latex. Among these, the major marketable form is ribbed smoked sheets (about 71%) as it can be produced by the simplest method of processing. Rubber sheets are sometimes stored for long periods by growers, dealers and also by government agencies anticipating better price while manufactures store rubber for ensuring sufficient stock for production (Mohankumar, 1999).

The storage of raw natural rubber affects its properties, the most important being an increase in Mooney viscosity, commonly referred to as storage hardening (Wood,

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1953; Sekhar, 1960; Bristow, 1974). Physical appearance of sheet rubber will be adversely affected by mould growth. Even though standard specifications are available for storage of vulcanized rubber and rubber products (ISO, 2002; BS, 1989: DIN, 1995), no such specifications are available for the storage of raw rubber.

The major factors that affect the properties of raw natural rubber on storage are the duration and the climatic conditions in which the rubber is stored (Sekhar, 1960; Leelamma *et al*., 2005). An understanding of impact of these factors on storage of sheet rubber will be helpful in evolving guidelines for storage raw rubber. However, no information is available regarding the effect of storage on properties of sheets under the climatic conditions of North East. Hence it is worth to study the effect of storage on rubber under the climatic conditions of this region.

MATERIALS AND METHODS

Rubber sheets prepared from the same bulk of field latex collected from the Regional Research Farm, Taranagar of Rubber Research Institute of India were used for this study. Rubber sheet bales were stored in different locations of Tripura under normal conditions and a set of bales were stored under controlled conditions of temperature and humidity. The sheets were stored as 50 kg bales at three different locations *viz*. Manimalayar godown at Agartala, Taranagar godown at Mohanpur and Rudijjala RPS godown at Melagar up to 18 months. One set of bales was also stored at controlled conditions of temperature and humidity (humidity 63% and temperature 25 ^{0}C). At the onset of the experiment, a composite sample was drawn from each bale as a control. Composite samples were also drawn periodically after every three months for laboratory analysis. The results obtained were compared with the control. Visual examination was done every month for mould growth, deformation stickiness, *etc.*

Mooney viscosity, initial plasticity (P_0), plasticity retention index (PRI), gel content,

Table 1. **Agroclimatic data of Agartala for the year 2008**

Month	Temperature			Humidity		
	Maximum	Minimum	Average	Maximum	Minimum	Average
January	24	12	18	93	60	77
February	26	12	19	89	48	69
March	31	20	26	91	57	74
April	34	23	29	88	52	70
May	34	24	29	85	64	75
June	32	25	29	84	76	80
July	31	25	28	92	77	85
August	32	25	29	93	79	86
September	33	25	29	91	73	82
October	31	22	27	91	74	83
November	30	16	23	89	53	71
December	27	15	21	90	60	75

volatile matter, acetone extract and strength of the sheets were determined periodically as per the standard test methods. Strength of raw rubber sheets as breaking load was determined in a Zwick Universal Testing Machine (Model 1474) at a cross head speed of 50 mm/min.

RESULTS AND DISCUSSION

Climatic effect

The important climatic parameters which influence the quality of sheets are the temperature and humidity. In addition, due to oxidation and the associated molecular breakdown, the rubber develops soft patches and stickiness and becomes deformed. The higher humidity, the more the bales become prone to the attack of mould. The climatic data of the year 2008 (January to December) are shown in Table 1. The monthly average temperatures varied from 18 to 29%. The average humidity was in the range 69 to 86%.

Volatile matter

Volatile matter in the sheets is contributed mainly by the moisture present in the sheets. Sheets not dried properly generally show higher volatile matter. This parameter was found to be varying with storage as shown in Table 2. It was found that the volatile matter increased in the initial periods of storage and decreased towards the end. This may be due to absorption of moisture by well dried sheets and the final decrease of volatile matter may be attributed to the drying of sheets on prolonged storage. The change in volatile matter under controlled and normal conditions showed more or less same pattern. This may be due to the fact that the rubber was almost completely dry (initial volatile matter of 0.29% against the permitted limit of 0.8 %). The effect of storage on volatile matter from different locations was not significant.

Mooney viscosity

Mooney viscosity is an important parameter on the industrial point of view. It is an indication of molecular weight, degree of branching, entanglement and crosslinking. It also suggests the quantum of mechanical work required on raw rubber to give mixes with consistent rheological properties after mastication, compounding and mixing. Rubber with high Mooney viscosity may require longer pre-mastication time or needs morepeptizers to obtain a product of workable and consistent viscosity. The effect of storage on Mooney viscosity is presented in Table 3. It was found that as the storage period increases the Mooney viscosity also

Table 2. **Effect of storage on volatile matter**

Storage period (months)	Controlled condition	Volatile matter (%)		
		Manimalayar	Rudhijala	Taranagar
0	0.29	0.29	0.29	0.29
3	0.34	0.43	0.34	0.45
6	0.47	0.49	0.44	0.46
9	0.46	0.45	0.48	0.44
12	0.23	0.33	0.38	0.25
18	0.27	0.28	0.38	0.29

Table 3. **Effect of storage on Mooney viscosity**

Storage period (months)	Controlled condition	Mooney viscosity		
		Manimalayar	Rudhijala	Taranagar
0	88	88	88	88
3	91	91	93	91
6	94	95	96	94
9	95	96	96	96
12	96	97	97	98
18	96	98	99	101

increased significantly in all locations and the increase was more or less uniform. This may be due to hardening on account of crosslinking among the rubber molecules involving the aldehyde or keto groups (Subramaniam, 1975) and certain aldehyde condensing groups in the non-rubber phase including some polypeptides (Gregory and Tan, 1976). The effect on Mooney viscosity from location to location was not significant.

Initial plasticity

The initial plasticity P_0 is measured by Wallace plastimeter and is also an important parameter indicating bulk viscosity. Hard rubbers always exhibit high P_0 values. Rubber sheets exhibit a positive correlation between Mooney viscosity and P_0 (Dick *et al*., 1999; Mariamma *et al*., 2004). The effect of storage on P_0 is given in Table 4. Similar to Mooney viscosity, P_0 was also found to be increasing significantly with duration of storage. The values ranged from 51 to 63 and were not significant

Gel content

The main chain molecule of natural rubber contains certain functional groups which may undergo crosslinking reactions with some non-rubber constituents which in turn result in the formation of branching in natural rubber (Gan, 1996; Tanaka *et al*., 2003). This branching will result storage hardening and gel formation. Incorporation of functional groups such as peroxides, hydroperoxides, alcohols, ketones, aldehydes, epoxides, ethers, esters and carboxylic acids takes place on storage thereby increasing the extent of crosslinking

Table 4. **Effect of storage on initial plasticity**

Storage period (months)	Controlled condition	Initial Plasticity (P_0)		
		Manimalayar	Rudhijala	Taranagar
0	51	51	51	51
3	52	52	55	53
6	52	53	57	53
9	57	57	58	62
12	59	58	59	62
18	60	60	61	63

Table 5. **Effect of Storage on gel content**

Storage period (months)	Controlled condition	Gel content		
		Manimalayar	Rudhijala	Taranagar
0	88	88	88	88
3	91	91	93	91
6	94	95	96	94
9	95	96	96	96
12	96	97	97	98
18	96	98	99	101

(Burfield, 1986). The changes in gel content during storage are shown in Table 5. The increase in gel content was significant for sheets stored in all locations. Location to location effect was not significant.

Plasticity retention index (PRI)

PRI is a measure of resistance of raw rubber to oxidative degradation at deviated temperature. The basic thermal degradation process is usually described as a chemical bond scission consisting of primary and secondary decomposition (Cunneen, 1978). The effect of storage on PRI is shown in Table 6. The study showed that there is a reduction in PRI with storage in all locations. This is due to degradation of natural rubber assisted by copper and

Table 6. **Effect of storage on plasticity retention index**

Storage period (months)	Controlled condition	Plasticity retention index		
		Manimalayar	Rudhijala	Taranagar
0	80	80	80	80
3	79	78	74	76
6	79	78	72	75
9	76	74	71	73
12	74	73	70	69
18	70	70	69	65

Table 7. **Effect of storage on acetone extract**

Storage period (months)	Controlled condition	Acetone extract (%)		
		Manimalayar	Rudhijala	Taranagar
0	1.9	1.9	1.9	1.9
3	2.1	2.1	1.8	2.1
6	1.9	1.9	1.1	1.9
9	1.7	1.8	1.1	1.2
12	1.7	1.8	1.3	1.2
18	1.7	1.7	1.3	1.2

Table 8. **Effect of storage on Strength of sheets**

Storage period (months)	Controlled condition	Strength of sheets (kg/cm)		
		Manimalayar	Rudhijala	Taranagar
0	31	31	31	31
3	31	34	30	34
6	32	34	35	32
9	32	34	35	32
12	35	35	35	33
18	35	36	35	34

manganese which are pro-oxidants present in the natural rubber. The increase in P_0 also contributes towards the decrease of PRI. In the case of PRI also location to location effect was not significant.

Acetone extract

The acetone extractable constituents of natural rubber are non-rubber materials like lipids, sterols, esters and fatty acids. These constituents have a direct effect on processability, curing and end product performance. In processing, the rubber may be stiff and it may be difficult to mix. With high acetone extractables, the rubber becomes scorchy and the tensile strength becomes low. This is estimated by extraction using a soxhlet extraction unit. The effect of storage on acetone extract is shown in Table 7. It was found that there is a slight reduction in acetone extractable portions as a result of storage. This could be attributed to the condensation and crosslinking of certain lipids which makes them acetone insoluble.

Strength

The strength of raw sheets was measured in terms of breaking load. The change in strength is given in Table 8. It was found that on storage, the strength of raw sheets increased slightly in all locations. This change is attributed to the hardening acquired by the natural rubber due to crosslinking.

Visual observation

Even though specific test methods are applied for quality measurements of technically specified rubber (TSR), quality of sheet rubber is assessed by visual grading as per the specifications in the Green Book. In this study it was observed that the sheets stored in all locations except those stored under controlled conditions of humidity, were affected by mould growth after five months. However, the sheets stored under controlled conditions of humidity and temperature did not develop any mould growth even after one year. After one year slight mould growth was observed on the surface of the bales and no penetration of mould was found inside.

CONCLUSION

The study revealed that the raw rubber properties were affected by storage and the effect of storage was almost same in all locations. Mooney viscosity, initial plasticity, strength and gel content of the sheets increased on storage whereas the plasticity retention index decreased. Acetone

extractables of the sheets were also decreased slightly due to storage. Sheets stored under normal conditions were affected with mould after five months whereas in low humidity area, sheets were not affected up to one year. The study clearly reveals that natural rubber sheets can be stored under normal climatic conditions of Tripura, without mould growth only up to five months. If rubber has to be stored for longer periods it should be stored under controlled conditions of humidity. However, the raw rubber properties are affected upon storage for several months.

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