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Developing Electrical Insulating Materials from Renewable Biological Sources: The Case for Havea Brasiliensis Latex

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Abstract: The search for renewable and sustainable sources of high grade insulating materials has been on for many years. Biological sources of insulating materials have the dual advantage of being renewable and sustainable. Plant sources have the additional advantage of being easily grown, multiplied, modified, processed and controlled. The study presents, an experimental investigation to determine the insulation classification of Havea Brasiliensis (Natural Rubber) latex and its suitability for use as machine insulating material for high temperature operations. Samples of the processed latex were subjected to heat-run in a sealed industrial oven. The insulation resistances of the samples were measured at regular temperature intervals until the given sample burns out. The measured values of weight, insulation resistance and temperature are shown in tables. The variation of insulation resistance with temperature is plotted in a curve. From the experimental results, at the class A limiting temperature of 105°C, the insulation resistance was 3 MΩ, which is unacceptable for that class of insulation. At the class Y limiting temperature of 90°C, the latex had a robust insulation resistance of 10 MΩ. Thus, it should be classified as a class Y insulating material. It could thus serve as a viable, cheap, renewable and sustainable source of insulating materials for lower temperature electrical machine operations.

Key words: Insulation class, heat-run, sustainable, renewable, temperature, latex

INTRODUCTION

Latex is a natural polymer derived from the sap of trees mainly in the Asclepiadaceae family. Havea Brasiliensis is the largest latex producing plant in the world. Natural latex circulates in the branches, trunks and other tissues of the tree, acting as an excretory system. The primary product from latex is rubber. Water is its base solvent. Latex is easily damaged by many different oils, Ozone and UV light. Liquid latex is a combination of water, latex sap and ammonia. The base of liquid latex is natural latex. Records of natural latex use dates back to the early Mayan and Haitian civilizations. Europeans were first introduced to latex when Columbus came to the Americas in 1492 and discovered the residents of Haiti playing with a rubber ball. The most important discovery concerning latex occurred when, Charles Goodyear mixed sulphur dust and latex, discovering vulcanization. Liquid latex has many uses. It is used for theater props including masks and gloves, toys, puppet heads, imitation pottery, clothing, hoses, coatings for rain gear and driving gear and hot water bottles. Natural latex is a polymer of the monomer isoprene with the chemical formula $\{CH_2: C (CH_3) CH: CH_2\}$.

The researchers believe that in addition to the above uses of natural latex, it is important to investigate the possibility of using natural latex as machine insulating material for high temperature operations. For example, the breakdown and dielectric characteristics of silicone rubber and its blends with epoxy resins was studied by Danikas (1994), Cherney (2005), Takahashi *et al.* (2005), Raja Prabu *et al.* (2007), Ali and Hackam (2008), Anderson *et al.* (2008), Fuji *et al.* (2009), Ishikawa *et al.* (2009), Ramirez *et al.* (2009) and Singha and Thomas (2009).

In their own research, Blahut *et al.* (2001), Du (2001, 2005), Notingher *et al.* (2001), Nearaj Kumar and Nath (2005), Taylor and Fernandez (2005), Perrier *et al.* (2006) and Hosier *et al.* (2007) investigated the insulating properties of organic and polymer insulating materials such as polyolefins, cyanobiphenyl, polyvinyl fluoride, polypropylene, dodecyl benzene and synthetic esters while, Bauer (2006), Nelson and Shaw (2006), Lamarre and David (2008), Takala *et al.* (2008) and Hong *et al.* (2009, b) examined the use of cellulose materials, electrets and epoxy composites as insulating materials for transformers and other electrical equipments. By subjecting the samples of natural rubber latex to heat run until, they burn out, their insulation classification can be determined. In addition, their suitability for use in high temperature machine operations can be evaluated.

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Table 1: Initial parameters of samples of natural rubber latex

Sample	Average weight of samples (g)	Insulation resistance (MΩ)
Natural rubber latex	53.382	100

Table 2: Heat run and insulation resistance measurement of samples of latex lump

Temperature (°C)	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
Insulation resistance (MΩ)	100	94	88	82	75	67	59	50	42	30	27	19	10	8	6	3	1

MATERIALS AND METHODS

The natural latex of Havea Brasiliensis was obtained, filtered and made into lumps. Three samples were made from the lump for the experimentation. The average values of the weights of the samples as well as the initial insulation resistance (at room temperature) are shown in Table 1.

Heat-run: Each of the three samples of the natural latex lump was subjected to heat-run in a well-lagged industrial oven. The insulation resistances of the samples were measured at regular temperature intervals of 5°C until, the given samples burns out. Table 2 shows, the average values of the insulation resistance measurement of the latex lump samples during the heat-run.

RESULTS AND DISCUSSION

Figure 1 shows the variation of insulation resistance with temperature for the latex lump of Havea Brasiliensis.

At lower temperatures, the gradient of the curve is;

$$m_1 = \frac{\Delta y_1}{\Delta x_1} = \frac{AB}{BC} = \frac{75-30}{50-75} = -1.8 \tag{1}$$

$$/m_1/ = 1.8 \tag{2}$$

At higher temperatures, the gradient is;

$$m_2 = \frac{\Delta y_2}{\Delta x_2} = \frac{DE}{EF} = \frac{8-1}{95-110} = -0.47 \tag{3}$$

$$/m_2/ = 0.47 \tag{4}$$

Equation 1 and 3 shows that the gradient is negative throughout the curve which implies that the insulation resistance is higher for lower temperatures and lower for higher temperatures. From the absolute values of the gradients Eq. 2 and 4, we can deduce that the gradient is higher for lower temperatures and significantly lower for higher temperature. In fact, the curve has an elbow at 90°C. The patent implication of this is that the insulation resistance falls rapidly as the temperature increases, in the lower temperature region while, the fall of insulation resistance becomes markedly slower in the higher temperature region. From Table 2, Havea Brasiliensis latex has insulation resistance of 6 MΩ at 100°C. At the higher temperature of 110°C, the insulation resistance had collapsed to 1 MΩ. Thus, the latex is suitable for machine insulation up to the limiting temperature of 100°C. To locate the insulation class of the latex, two classes of insulation, Y and A become relevant. At the class A limiting temperature of 105°C, the insulation resistance was 3 MΩ, which is unacceptable for that class of insulation. At the class Y limiting temperature of 90°C, the latex lump had a robust insulation resistance of 10 MΩ. It should thus be classified as a class Y insulating material.

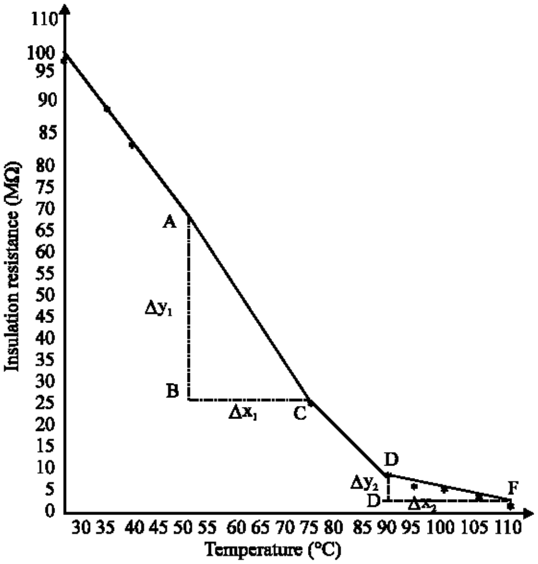

Fig. 1: Variation of insulation resistance with temperature

CONCLUSION

Havea Brasiliensis is the largest latex producing plant in the world. It is both a renewable and sustainable source of natural latex. The experiments proved that the latex could be used for machine insulation up to the limiting temperature of 100°C. Havea Brasiliensis could thus serve as a viable, cheap, renewable and sustainable source of insulating materials for lower temperature electrical machine operations.

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