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천연고무의 전기전도기구에 관한 기술 동향

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A Technical Trend on Natural Rubber Electrical Conduction Mechanism

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Abstract - The efficiency of such work highly depend on the worker's safety, who is protected by tools such as gloves, sleeves, blankets and flexible coverings among other manufactured natural-rubber goods. Use, storage and maintenance of these tools guarantee the quality and durability of the material. However, it might be observed that good tools made of such material are disapproved of when received from manufacturers or when they are removed from the warehouse for replacement. This work shows the experimental results obtained from ageing at a temperature of 100 °C for 48, 70 and 312 h, although the application of AC electrical tension in samples and the measuring of current leakage are presented. The measurements in samples were carried out with samples prepared from the deformulated commercial materials and respectively reformulated into thin films. The obtained results showed the mechanisms of conduction of samples in low and high electric fields. It was also identified an electric tension transition showing that in low fields it prevails the Ohm's law conduction, and in high electric fields it prevails the conduction of space charge limited current (SCLC). These results can support the natural rubber formulation process having as their main objective the reducing of the mechanisms that occur under high conduction current in high electric fields, which leads the material to a dielectric breakdown. It is necessary to research this raw material from different internationally standard clones to characterize dielectric and electric properties for industrial applications. Moreover, this natural material has a low commercial price when compared to the synthetic ones.

1. Introduction

The service in live lines becomes more important because it avoids interruptions in the electric power supply to consumers and it reduces the loss for electric companies. Good execution for such a service depends highly on the worker of these live lines, and this only will be safe if the worker is protected by good quality tools. Gloves, sleeves and insulating blankets made out of natural rubber are part of this set of tools. It could be said that many tools made of natural rubber have a reduced lifespan.

In this paper, the authors introduce a technical trend in a natural rubber electrical characteristic. The films were made by using the thermal-pressing method and led to a temperature of 150 ℃ [1], with a thickness of 600 μm. The samples were aged at a temperature of 100 ℃ for 312 h, as well as aged in AC electric field of 6MV/m of intensity for 6, 24 and 168 h. Other times and aging temperatures were used, although only the most significant results were shown.

2. Experimental

The equipment used in the experiment consists of a high tension AC source, Mark Haffley Multi Test Set 272 model and Mark Tektronix Digital multi-meters TX3 model. The sample is placed between two metallic electrodes with a constant pressure applied upon it. During the experiment the sample remains immersed in insulating silicone oil, as it can be seen in figure 1, having as the main goal to avoid flashover or superficial discharges.

In low fields the ohmic conduction prevails with species of charge carriers that can be of electronic or ionic nature [2-4]. The materials that present this kind of behavior in low fields follow Ohm's law, as far as the tension or the electric field transition where the material starts to suffer the action of the high electric field, where the conduction mechanisms prevail and depend on the kind of carrier injected by the contacts.

3. Results and Discussion

As it can be seen in the graph of the Figure 1, there is an increase in the current density for the same electric field in function of aging time, which indicates an alteration in the conduction mechanisms of the samples. The observation results shows a tendency of an ohmic conductivity increase along aging time. This fact can be explained by the dissociation of chains and the natural rubber bonds, which increase the numbers of electric carriers in the ionic conduction. This can also be justified because of the larger interaction between the molecular chains, which increases the electronic conduction. The coefficient A shows a tendency in the increase along aging time, one possible indicating that there is an increase in the number or mobility of carrier in the SCLC process, also indicating that a larger number of traps appear in the material in function of its aging time. According to these results, it is more probable that a breakage of the chain is occurring as well as its dissociation and so increasing the ohmic conduction. It also can be realized that the voltage transition has a poor tendency to increase along aging time, which elevates the region of low electric field (low field).

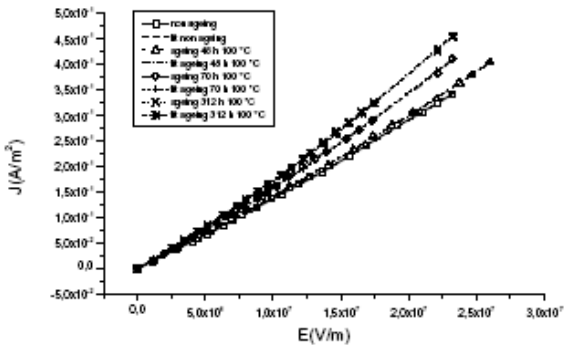

Fig. 1. J versus E plot of samples of non-aging and aging natural rubber at a temperature of 100 °C for 48, 70 and 312 h.

4. Conclusion

The obtained results clearly show that the natural rubber shows two mechanisms of predominant conduction in AC: the ohmic conduction in low field and the SCLC process in high field. It also shows that the breakdown of the natural rubber used in tools of live lines occurs through the SCLC processes. This result becomes important because by using it, the formulation of natural rubber can be changed having as the objective the reducing of the number of traps for spatial charges.

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