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TUNABILITY PROPERTIES OF MICA POWDERS INLAID NR/SBR MATERIAL

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ABSTRACT

NR (natural rubber) and SBR (synthetic rubber) elastomers are have in a wide range of applications due to their interesting properties. These are primarily in the automotive, aerospace, machinery manufacturing, construction and shoe industry [1,2]. NR/SBR based materials have increasingly attention with some different additions. In this study, dielectric tunability properties of the mica powder inlaid NR/SBR elastomer have been by using dielectric spectroscopy. The dielectric constant of the sample has been measured by using a LCR meter in the interval of 0-2500 V/m electric field. The measurements have been carried out at some fixed frequencies starting from 100 Hz. The dielectric constant depends on frequency and applied electric field. It decreases with the increase of frequency and applied field. The decreasing proportion of the dielectric constant with applied field decreases with increasing frequency. Finally, it is constant with applied field at high frequencies. The properties of the sample have been explained with tunability properties of the sample.

Keywords: NR (natural rubber), SBR (synthetic rubber), Tunability

1. INTRODUCTION

Natural rubber / styrene Bradykinin rubber (NR / SBR) type elastomers are obtained by mixing the natural or synthetic rubber in appropriate proportions. Recently, they have been gained importance because of their unique properties especially in industrial studies. Automotive, structure, shoe and tire based materials can be example to these elastomers [1].

To improve the physical properties of elastomers, they are generally mixed in specific proportions with different materials. Especially, cost reductive and physical property enhancer additives added in significant amounts to industrial elastomers. Today, lots of inorganic materials have used as an additive but researchers are currently working on new additive materials [2].

In NR/SBR type elastomer materials, their mechanical and physical properties affected positive when mica powder used as an inlaid material [3]. Mica is the name given to a very easy slicing leafy silicate group. The most common minerals are white mica and black mica. Mica crystals found in most of the rock and it constitutes one of the three main minerals in granite. The most important feature is that it is insulator [4]. Jolene et. al. have been expressed that mica powders as an inlaid is a good alternative from other inlaid materials [5].

Impedance Spectroscopy (Impedance Spectroscopy ISA), also known as dielectric spectroscopy. It is an easy method that often preferred. It is also used for explain classically electrical properties of materials. According to measurement capability of the measuring device used, it is a suitable method for AC and DC field measurements in a wide temperature range [6].

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In this study, NR and SBR elastomer-based materials instead of conventional fillers, mica powder filler is inlaided. With Dielectric Spectroscopy, conductivity and dielectric properties of mica powders inlaid NR/SBR type elastomers were investigated.

2. EXPERIMENTAL

NR/RSS3 natural rubber and SBR 1502 styrene butadiene rubber, laurel rubber, carbon black and mica powder were purchased from Petkim and Kaultun mineral companies. Other inlaid materials of polymer were purchased from Bayer chemical company. The inlaid material of polymers', known as SMW 375, density is 2,7 g/cm^3 and grain size is 50 µm. All inlaid and additive compozite materials weighed one by one and then mixture had been prepared. Mica powder as an inlaid material contributed to rubber % 17,2 (1000 g.).

Prepared rubber mixture was mixed into the dough with banbury for 12 min according to TS 2946 and TS EN ISO 20344. Banbury internal temperature is taken as 80 ° C. For each sample it was careful to same banbury internal temperature.

The rough that output from banbury, has passed through roll and brought into the plate. Plate rubber rough calcined for 5 min in vulcanization press under about 160 atmospheric pressure at 160-165°C ±2°C controlled temperature. Then they vulcanized and plates were ready for measurements.

From the resultant plate thin thickness, large surface pieces were cut. Then the surfaces of these parts has become very smooth with fine sandpapers. After that silver paste has been dured to the surface electrodes. For measure dependance of frequency of dielectric constant and impedance, 50 point determined that have been chosen logarithmic and equally spaced. For these frequencies, conductance, capacitance, impedance and phase angle values were measured with Lcr 8110G, between 20 Hz-10 MHz frequency range and slow mode. The 200 different points are preferred for the measurements under voltage. Measurements are controlled from a computer via a special software and data were collected on the computer. All measurements were conducted under conditions at room temperature.

3. RESULTS AND DISCUSSION

Dielectric constant and loss factor are important electrical properties for a sample. These parameters are a measure of samples deposited energy of applied electro magnetic wave and loss parts. These parameters derived from capacitance and conductance that are measured simultaneously. These parameters calculated from the following equations:

$$\varepsilon' = \frac{Cd}{\varepsilon_0 A} \tag{1}$$

$$\varepsilon'' = \varepsilon' \tan\delta \tag{2}$$

$$\varepsilon'' = \sigma/2\pi f \varepsilon_o \tag{3}$$

Here C is capacitance, A is surface of electrode and σ is conductance. $tan\delta$ is loss factor. The examined polymer materials' dielectric constant vs frequency plot shown in Figure 1. Measurements have been realised in room temperature. Dielectric constant of examined sample decreases with increasing frequency. Rapid decrease at lower frequencies gives way to slow decrease at high frequencies. Decrease of dielectric constant is attributed to effects of polarizability component with frequency. Thus, dielectric constant decreases. At lower frequencies decreasing is fast because the number of polarizability components are redundant. Contarary to this at higher frequencies polarizability components are less. Because of this decreasing is slow. Dielectric constant at lower frequencies named static dielectric constant (ε_o) and at higher frequencies named dinamic dielectric constant (ε_∞). Decrement at high and low frequencies is a measure of number of dipole. These decrease is about 20 and it is really less value.

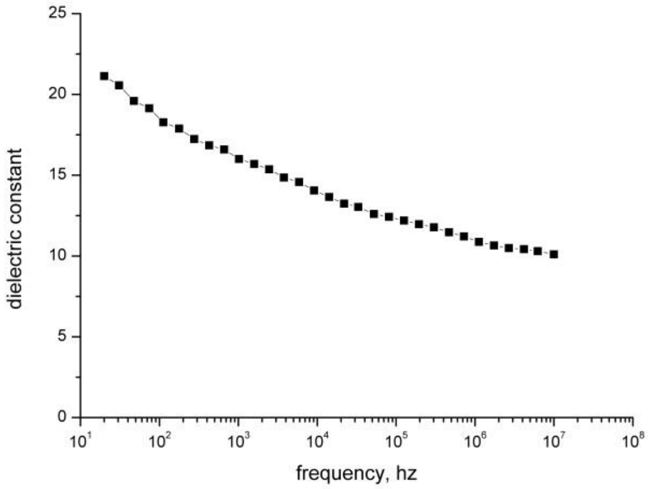

Figure 1. The dielectric constant of the frequency change

In Figure 2. shows dielectric loss factor vs frequency of examined polymer sample. Loss factor is ratio of real part to imaginary part of the dielectric constant.

$$tan\ \delta = \frac{\varepsilon''}{\varepsilon'} \qquad (4)$$

Loss factor is shaped in accordance with energy needs of the active grain boundary at low-frequencies and active grains at high frequencies. As can be seen clearly from figure loss factor shows a sharp increase after decreasing slowly to 10^5 Hz. Here we can also examine the change of tan δ at three regions. The first region is the region under 10^3 Hz that reduces with increasing frequency. The second region is the less dependent in frequency and nearly constant region the range of 10^3-3.10^4 Hz. The last region is the high frequency region that tanδ increases rapidly with increasing frequency. Although there is not a resonance peak in the investigated frequency range, predicting that sharp increase is the beginning of a peak. The formation of the resonance peak can be explained as follows: when it is equal to the natural frequency of ions with the externally applied Ac field frequency, they transfers the highest electrical energy to release ions and a sharp increase occurs at loss factor. As a result, resonance occurs.

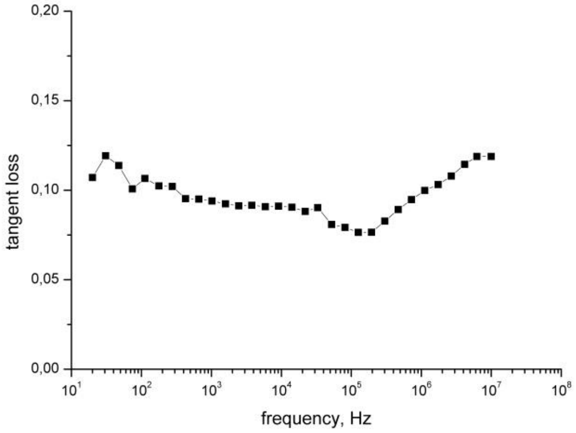

Figure 2. frequency variation of dielectric loss factor

It can not be distinguished any dielectric relaxation mechanism for the examined frequency range. However, relaxation may not be seen where the relaxation spread to a very wide frequency range or dc conductivity contribution that is active in the low-frequency shadows relaxation occurrence with increasing frequency. Therefore, instead of the dielectric constant real and imaginary components of impedance is appropriate to examine. Figure 3. shows the imaginary impedance changing with the real impedance of the examined sample. This curve resembles a semicircle part. This semi-circle is a result of relaxation process. It is clear that the center remains below the real axis. Therefore, it can be formulating by Cole-Cole model that represents the interacting dipoles. The accompanying frequency of the relaxation time in the pole of the full circle can be said that the huge order of 10^{-2} sec. While it is clear that large relaxation time as a result of surface charge.

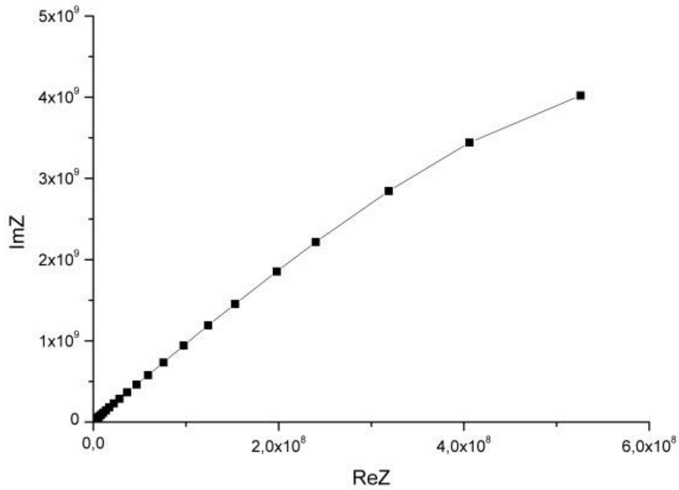

Figure 3. Imaginary impedance changes according to real impedance

The dielectric constant of the examined sample corresponding to applied voltage change is given in Figure 4. As seen from the figure, the dielectric constant of the sample decreases nearly a linear manner with the applied potential increases. This reduction is because the direction of the dipole in the sample with the applied potential and electromagnetic waves can be said that resistance to change. In such case dipoles easily loses its ability to rotate together with field and the dielectric constant is reduced. This amount of the reduction is from 8.8 up to 16 values. With using following equation:

$$n = \frac{\varepsilon_0 - \varepsilon_{app}}{\varepsilon_0} \times 100\% \quad (5)$$

n known as tunability. Here ε_o is dielectric constant in zero field and ε_{app} is tunability value for applied voltage. This value is significantly high. Tunability value is abaut 45% for all applied voltage range. This measurement completed at room temperature and 1 kHz frequency. Figure of merit (FOM) value is described as following:

$$FOM = n/tan\delta \quad (6)$$

This value represents tunability properties of examined sample. The higher value means that tunabilite well. Considering the average value of the loss factor is 0.1 for the entire frequency range, it is understood that FOM value of the examined sample is abaut 450. If this value is generally considered to be greater than 50 for samples with tunability property, it understood that this value is quite good. But the problem is dielectric constant of the sample is small. Because of this reason dielectric constant of exemined samples should be developed to increase with different additives. Dielectric constant fits following equation with applied dc field:

$$\frac{\varepsilon_{app}}{\varepsilon_0} = \frac{1}{\left[1+(\varepsilon_0')^3 \alpha E^2\right]^{1/3}} \quad (7)$$

In here $m = \alpha(\varepsilon_0)^3$ is nonlinear parameter. α is a parameter representing non-harmonic interaction between the ions. If $x = E^2$ and $y = \left(\frac{\varepsilon_0'}{\varepsilon_{app}}\right)^3$, α could be easily found 150 from the slope of linear graph of x-y.

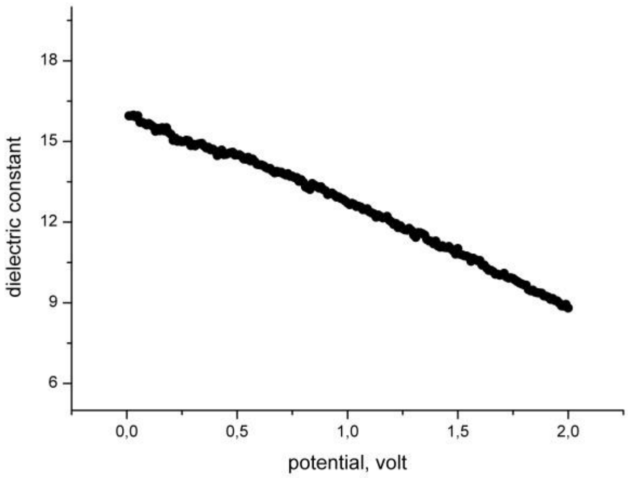

Figure 4. Difference of dielectric constant with dc potential

4. CONCLUSION

Mica powders inlaid NR/SBR material was performed with dielectric spectroscopy analysis in the range of 20 Hz - 10 MHz. With the resultant data dielectric constant, loss factor and tunability studies depending on frequency have done. When dielectric constant has been observed that dependent of frequency and decrease with increasing frequency, loss factor could be examined three region. And it has ovserved from the graphs that loss factor acts both dependent and independent from frequency. Calculated tunability value compared with other studies have tunability feature can be accentuated as a pretty good value.

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