CONDUCTIVITY IN WHITE FILLED SILICONE RUBBER

Treena Topdar[1], Rupande Desai[2], C.G Bhagchandani[3]

[1]*Rubber Technology, L.D College of Engineering*
[2]*Rubber Technlogy, L.D College of Engineering*
[3]*Chemical Engineering, L.D College of Engineering*

Abstract — *The main objective of this review is to describe some of the important topics related to the use of silicone rubber for electrical conductivity purpose. The review aims at providing a thorough picture of state-of-the-art in improving electrical conductivity property in silicone rubbers. The properties of di-electric constant and volume resistivity of the polymer as well as the fillers play an important role in deciding the electrical conductivity properties. The purpose of using these inorganic fillers to get a coloured object other than that of black colour which can be used as an electrically conductive device.*

Also certain disadvantages of carbon black are discussed in the review which is not desirable in many applications and it proves to be carcinogenic to human health. So inorganic/white fillers are taken as an alternative to make silicone rubbers conductive equally as carbon black. The values of volume resistivities of various inorganic fillers are discussed and compared among each other. If the filler gives lower volume resistivity it gives higher electrical conductivity as volume resistivity is inversely proportional to electrical conductivity.

Keywords: *Silicone Rubber, Electrical Conductivity, Volume resistivity, Conductive fillers, Barium titanate,*

I. INTRODUCTION

Electrical conductivity is the measure of a material's ability to accommodate the transport of an electric charge. Polymer composites (particles dispersed in a polymer matrix) are of great interest because addition of fillers to a polymer matrix can enhance mechanical, thermal, barrier, and other properties.

These composites have drawn great interest for its versatile applications in the field of electronic materials such as integrated decoupling capacitors, acoustic emission sensors, electronic packaging materials and angular acceleration accelerometers. Many studies have been done on BaTiO3 due to their remarkable optical and electronic properties. The volume resistivity is the reciprocal of the electrical conductivity.

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II. PAPER

MATERIAL AND METHOD:
- Silicone rubber (Hardness: 40 Shore A, Density: 1.12 g/cc)
- Barium Titanate (BaTiO$_3$) as a conductive filler of different mesh sizes: 200, 400 and 600, M.P = 1630°C, Density: 6.03 g/cc and having a tetragonal structure.
- Dicumyl Peroxide-98 as a curing agent (Perkadox BC-FF), white crystalline sample, density= 1.11 g/cc, M.P= 39.5°C

PREPARATION OF POLYMER COMPOSITES:
Steps to be followed to prepare our polymer composite samples for testing:
- Mixing of BaTiO3 and other ingredients into Silicone rubber polymer matrix were done in a two roll mill for 15 minutes and a sheet is taken out of each batch.
- Samples are prepared by taking the concentration of the curing agent same and only varying the mesh size of the filler. (200, 400 and 600) in the polymer matrix.
- Filler concentration is kept same in all the batches.
- Monsanto rheometer R 100 will be used to determine the optimum cure time.
- Moulding to be done in an electrically heated press at a specified time (obtained through Monsanto rheometer) at 180°C.

TESTING:

- Sheets of 2-3 mm thickness are taken of uncured and cured samples for testing.
- A multimeter is used to measure the resistance of the samples.
- The electrodes of the multimeter are kept at various places of the samples and resistance values are noted; up to 10 readings are taken.
- The distance between the electrodes must be equal at all the time. Standard distance between the electrodes is kept as 2.5 cm.
- An average value of resistance is calculated.
- The value of resistivity is then calculated by the given formula:

$$\rho = \frac{R.A}{l}$$

where ρ = resistivity of the material

       R = resistance obtained by the multimeter

       A = cross sectional area of the sample

       l = distance between the two electrodes = 2.5 cm

- Obtain the conductivity value for the same by doing the reciprocal of resistivity value.

$$C = \frac{1}{\rho}$$

RESULT:

Comparison between resistance, resistivity and conductivity values according to particle size for uncured sample.

Values	200 mesh	400 mesh	600 mesh
Resistance	16.995×10^{-3} Ω	8.34×10^{-3} Ω	3.959×10^{-3} Ω
Resistivity	0.000153 Ω.m	0.00007089 Ω.m	0.00003959 Ω.m
Conductivity	6.535×10^{3} $\Omega^{-1}m^{-1}$	1.410×10^{4} $\Omega^{-1}m^{-1}$	2.526×10^{4} $\Omega^{-1}m^{-1}$

Comparison between resistance, resistivity and conductivity values according to particle size for cured sample.

Values	200 mesh	400 mesh	600 mesh
Resistance	15.276×10^{-3}Ω	4.706×10^{-3} Ω	2.275×10^{-3} Ω
Resistivity	7.332×10^{-5} Ω.m	2.258×10^{-5} Ω.m	1.092×10^{-5} Ω.m
Conductivity	1.364×10^{4} $\Omega^{-1}m^{-1}$	4.445×10^{4} $\Omega^{-1}m^{-1}$	9.157×10^{4} $\Omega^{-1}m^{-1}$

III.   FOOTNOTES

IV.   CONCLUSION

As per both the comparison tables, we can see that the values of resistance and resistivity decreases as the mesh size of the particles increases, in case of either cured or uncured state, that is the smaller the particle size, the lower will be the resistance and resistivity values.

The conductivity value of silicone is the lowest with 200 mesh size filler and the highest with 600 mesh size filler. Therefore, we can conclude that the conductivity increases as the mesh size increases or the particle size decreases.

Also if we study about the conductivity of the super conductor materials such as metals, this filler does not give as much conductivity value as per the metals. It gives conductivity value just above that of the semiconductors. This can be improved if filler of even lower particles are to be used.

POTENTIAL FOR COMMERCIALIZATION:

It can be used in many electrical applications where white product is desirable such as photovoltaics, encapsulation in solar cells, photodiodes etc. Metallic fillers like silver and platinum also give god electrical conductivity but taking their cost into consideration, barium titanate offers as a good conductive filler to the silicone rubber.

V.   REFERENCES

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