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Improvement of Electrical Insulation in Silicone Rubber by Adding Al_2O_3

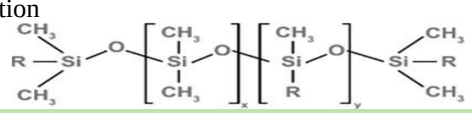
Khaja Zaffer, Pulla Sammaiah

Abstract: ***Polymer Nano composite in recent time has shown high improvement in mechanical, chemical and electrical properties. Granting all these, the use of polymer nano-composites has only recently begun starting explorer. In recent times, polymer materials has shown remarkable improvement in electrical insulation because of their numerous advantages in out-door insulation systems because of their negligible weight, better pollution performance, low cost, good dielectric properties with easy processing. In polymer materials, silicone rubber is one of the lead polymer currently used and has high ending properties like high voltage insulator, thermal stability, excellent UV resistance and hydrophobicity. Therefore, Silicone rubber with fillers can overcome few drawbacks such as low strength and insulating properties.Oxides with different properties can help silicone rubber to enhance its properties. Oxides such as alumina, zirconia are being widely used in silicone rubber. Alumina which has strong thermal conductive and compressive strength with good electrical is used in silicone rubber. Here Silicone rubber nano composites are prepared by incorporating*** Al_2O_3 ***nano partic les. Electrical, Chemical properties like NaCl, HCl, and corrosion tests were conducted to know the performance of silicone rubber insulation at pollutant conditions. Dielectric tests were also done to know whether*** Al_2O_3 ***has made any effect with silicone rubber. Tensile strength and Hardness test were carried out to determine mechanical strength of the rubber.***

Index Terms**: silicone rubbers, aluminium oxide, electrical insulation, mechanical properties.**

I. INTRODUCTION

The word silicone rubber ion was first proposed by Dumas in 1840. During 19th century, Ladenburg experimentally produced silicone rubber by reacting diethoxydiethysilane with water and trace amounts of acids[1-2]. Dow chemical company first commercially produced it in 1941. Silicone rubber is a synthetic elastomer[3]. It is a cross-linked silicon based polymer also bonded with carbon, hydrogen and oxygen. Silicone can be distinguished from rubbers by atomic structure. It consists of a backbone of silicone atoms with alternating oxygen atoms. He recounted few additional compounds of the generic formula R2SiO2. These were swiftly identified as being and actually corresponding to polyialkylsiloxanes, with the formulation



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Where 'R' represents Methyl or Phenyl or Vinyl or Trifluoropropyl [4].Here "organic" groups are combined with "inorganic" as a backbone which makes properties of Silicone rubber unique. Because of Si-O bond attached to the polymer backbone, the polymer molecular weight and the polymer conformation are largely affected and these are remarkably greater and efficient than C-C bond. These Si-O bonds in silicone have greater stability and resistance to thermal and thermo oxidative resistance, greater hydrophobicity, flame retardant [5-7]. Radioactive particles and electromagnetic were very rarely attacked in "inorganic" silicones. This allows there use in different sectors like electrical insulation, aerospace, electronic and medical devices. With the use of different oxides and Nano Particles silicone can be used in different industries. Aluminium oxide has various properties such as wear-resistance, good thermal conductivity, excellent dielectric properties, high strength and stiffness. In this paper, silicone rubber is used with and without alumina as a filler, various insulation, chemical and mechanical tests were carried out[8-9]. In the upcoming days there would be huge demand for power and for transmitting high voltage power, transmitting lines should have good insulating properties, higher strength, excellent hydrophobicity and high tensile strength. Porcelin insulators are limited and can not be used at costal areas and withstand high temperature. Here, we demonstrated on how silicone rubber improved insulating, chemical and mechanical Properties

II. EXPERIEMENTAL PROCEDURE

Our Main aim was to create an identical sample which can be used at high voltage transmit line by using Liquid Silicone Rubber (LSR). The following are the properties of Liquid Silicone rubber.

S.No	Description	Parameter
1	Apperance	White
2	Hardness (A)	15
3	Viscocity (CPS 25Oc)	9500
4	Elongation break %	>450

Table 1: specifications of Liquid Silicone Rubber

2.1 Procedure of making Silicone Rubber Spicemen from Liquid Silicone rubber Without Adding any Fillers.

1. Take G.I sheet of required dimension (100X1000X4thickness) mm.
2. Fold the sheet in the form of a tray (as per required thickness).
3. Take the silicone gel in a separate bowl of required quantity.
4. Add the hardener to silicone gel in required proportion.
5. Stir the mixture properly.
6. Pour the solution into the tray

7. Allow it to solidify (generally it takes 24 hours).
8. After solidification remove the specimen from the tray.

2.2 The following tests were conducted to analyze the properties of materials:

Megger Test or Resistivity Test:

1. Megger test is done on the specimen to find its resistivity.
2. Two electrodes are placed on the specimen with varying distances and rotate the handle of machine to generate the emf.
3. Resistivity values are noted in the table.

Distance between two electrodes

Note: Megger test is done for voltages up to 1000V.

Table 2: Megger Test of Silicone Rubber without Filler.

Thickness of silicone rubber	1mm	2mm	3mm	4mm	5mm
2mm	Infinity	Infinity	Infinity	Infinity	Infinity
3mm	Infinity	Infinity	Infinity	Infinity	Infinity
4mm	Infinity	Infinity	Infinity	Infinity	Infinity

Dielectric Strength Test:

This test is done with high electric voltage to know the limit of insulation for LSR-1 and LSR-2. The specimen is placed in-between the 2 electrodes to find insulation. The results are as follows[11-15,23]:

1. Specimen is placed in between the two electrodes.
2. Switch on the mains.
3. Regulate the voltage slowly until the spark is generated.
4. Spark generation indicates that the specimen has reached its breakdown point.
5. Note the breakdown value.

Liquid Silicone Rubber	KV
LSR (4mm)	15

Table 3: Dielectric Test of Silicone Rubber without filler

Silicone Rubber has insulated the two electrodes from 0KV to 15KV, Spark was formed at 15KV which states that conductance of electricity from 15 KV.

Figure 1 Dielectric Test Equipment at Electrical Sub Station

Chemical Test:

(a) Salt test:

1. Sodium Chloride (NaCl) solution is prepared with concentrations of 0.1N, 1N and 2N[16].
2. Note the weight of specimen before testing.
3. This Specimen is kept in the solution under testing for the duration of 6 hours, 18 hours and 24 hours.
4. Note the weight of the specimen for each interval.

Table 4: Salt Test of Silicone Rubber without filler

NaCl Solution	Distilled water (ml)	Weight of Silicone Rubber Before Test (gms)	Weight of Silicone Rubber After Test (gms)
0.1N	100	1.2	1.2
0.2N	100	1.2	1.2
0.3N	100	1.2	1.2

(b) Acid test:

1. Note the weights of specimen before testing[17-18].
2. Specimen is placed in dilute HCl and H2So4 for duration of 6 hours, 18 hours and 24 hours.
3. Weights of the specimens are noted after testing.

Concentration	Actual Weight (gms)	Weight after 24 hours (gms)
H2So4	1.40	1.40
HCl	1.40	1.40

Table 5: Acid Test of Silicone Rubber without filler

(c) Corrosion test:

1. Prepare the acidic environment in the presence of inhibitor[19-22].
2. Weigh the sample by means of an electronic balance and record the weights of the sample.
3. Immerse samples in the acidic environment in the presence of inhibitor (immersion period=30 min).
4. After 30 min of immersion period take out the samples, one by one wash the samples in running water under the tap to remove the loosely held rust or other corrosion.
5. Rinse the surfaces in acetone.
6. Take them to oven and dry for 5 min.
7. Remove the plates from oven, cool them and weigh them again.
8. Record these weights.

Table 6: Corrosion Test of Silicone Rubber without filler

Concentration	Actual Weight Before Test (gms)	Actual Weight After Test (gms)
0.1N	1.4	1.4
1N	1.4	1.4
2N	**1.4**	**1.4**
H2so4	1.4	1.4
HCl	1.4	1.4

2.3 With addition of Al_2O_3 Nano particles:

Procedure for preparation ofAl_2O_3 Nano filler with silicone rubber for electrical insulation:

1. First, we have calculated the density of silicone rubber and according to that we have added 5%, 10%, 15% of Al2O3 and required amount of hardness liquid is added to it.
2. Then we have also added the mixer in cavity for required shape.
3. The mixer is then heated for 30 min in furnace at 80C so that Al2O3 can react with silicone rubber and form a stable state.
4. After that the mixture is left for ample time so that it could solidify at room temperature.

The following are the calculation taken to produce 4mm of silicone rubber with Al2O3 as fillers.
Calculation of Al2O3 for LSR-2:
Density of Al_2O_3 => 0.00389 gm/mm3
Density of LSR= 1.09 gm / cm3 = 0.00109 gm/mm3
Mass= density x volume
For 100x100x4 dimension, mass = 0.00109 x 10000 =10.9 gm
Available weight of Al_2O_3 is 2.260gm
For 2.260gms of Al_2O_3
5% is (2.260 x 5 / 100) = 0.113gms
Similarly, for 10% = 0.226gms

	For 95% (LSR2+hardener) +5% Al_2O_3) (gms	For 95%
LSR weight	9.837	9.319
Hardner	0.517	0.490
Al2O3	0.113	0.226

Table 7: Calculation of fillers in LSR

Table 8: Megger Test of Silicone Rubber with Filler.

Thickness of silicone rubber	1mm	2mm	3mm	4mm	5mm
2mm	Infinity	Infinity	Infinity	Infinity	Infinity
3mm	Infinity	Infinity	Infinity	Infinity	Infinity
4mm	Infinity	Infinity	Infinity	Infinity	Infinity

Dielectric Strength Test:

Liquid Silicone Rubber	KV
LSR (4mm) 5%	17
LSR (4mm) 10%	20

Table 9: Dielectric Test of Silicone Rubber with filler

Silicone Rubber has insulated the two electrodes from 0KV to 15KV, Spark was formed at 15KV which states that conductance of electricity from 15 KV.

Figure 2: Dielectric Test Equipment at Electrical Sub Station

Chemical Test:

(a) Salt test:

Concentration	Actual Weight (gms)	Weight after 24 hours (gms)
H2So4	1.60	1.60
HCl	1.60	1.60

Table 9 Salt Test of Silicone Rubber with filler

(b) Acid test:

Concentration	Actual Weight Before Test (gms)	Actual Weight After Test (gms)
0.1N	1.6	1.6
1N	1.6	1.6
2N	1.6	1.6
H2so4	1.6	1.6
HCl	1.6	1.6

Table 10: Acid Test of Silicone Rubber with filler

(c) Corrosion test:

NaCl Solution	Distilled water (ml)	Weight of Silicone Rubber Before Test (gms)	Weight of Silicone Rubber After Test (gms)
0.1N	100	1.6	1.6
0.2N	100	1.6	1.6
0.3N	100	1.6	1.6

Table 11: Corrosion Test of Silicone Rubber with filler

III. RESULT

Dielectric Test:

Dielectric test of Liquid silicone rubber with and without fillers are carried out.

Liquid Silicone Rubber	KV
LSR (4mm) without filler	15
LSR (4mm) 5% of filler	17
LSR (4mm) 10% of filler	20

Table 12: The above table replicates liquid silicone rubber with and without filler and their insulation in KV.

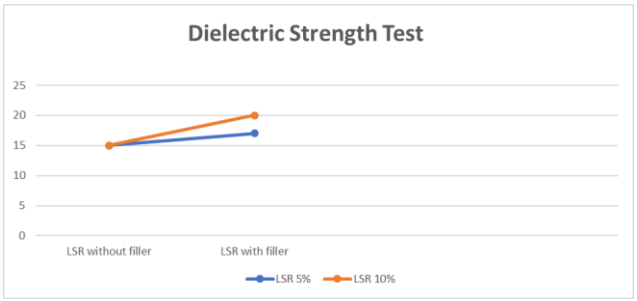

Figure 3: Dielectric test of LSR with and without filler

The above line graph represents improvement of electrical insulation when LSR is added with 5% and 10% of Al_2O_3.

2.4 Hardness and Tensile Strength Test

Because LSR with 10% have shown better electrical insulation, when compared to LSR with 5%. Hardness and Tensile Strength Test were carried out for LSR with 10%.

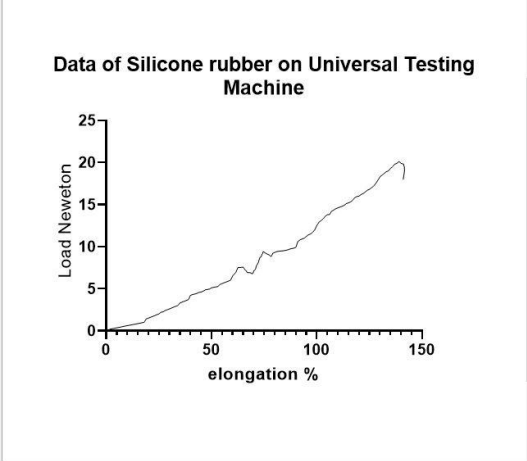

Figure 4: Hardness and Tensile Strength of LSR without filler

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The above graph illustrates that Liquid silicone rubber with Al2O3 as filler had a peak load of 20.0116 newton, where as elongation break was at 143.5870%

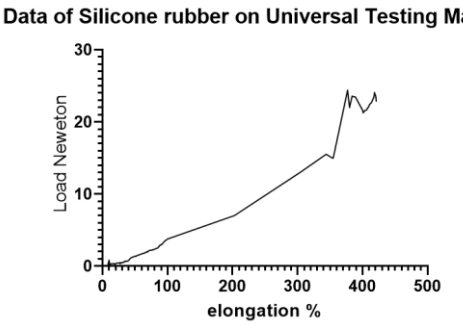

Figure 5: Hardness and Tensile Strength of LSR with Filler

The above graph illustrates that Liquid silicone rubber with Al2O3 as filler had a peak load of 24.3726 newton, where as elongation break was at 421.3292%

Hence, from the above tests, filler played a pivotal role in not only improving of electrical insulation but also hardness and Strength of LSR.

IV. CONCLUSION

The above research is about the development of Silicone Nano composites for not only outdoor high voltage insulators but also can be used near by costal areas. Silicone rubber Nano composites have been prepared by incorporating Al_2O_3 Nano particles. Electrical and chemical properties of the Nano composites were investigated. Chemical properties such as NaCl, Corrosion and Acid tests were conducted to know the performance of silicone insulation at pollutant conditions. Dielectric tests were conducted on both LSR with and without filler. With addition of fillers in silicone rubber particularly in LSR with 10% 5 KV of electrical insulation was increased.With addition of Al_2O_3 as filler insulation has increased to total of 20KV from 15 KV. Mechanical tests such as hardness and tensile strength were conducted on Liquid Silicone rubber without and 10% Al_2O_3 filler and out of which 10 % Al_2O_3 filler in silicone rubber showed huge strength when compared to without filler. Silicone rubber without filler showed elongation % of 150 at 20.0 N whereas silicone rubber with filler had elongation % of 421.3 at peak load of 24.3 N on Universal Testing Machine.

The results obtained for various tests indicate that the compatibles of Silicone rubber withAl_2O_3 have improved mechanical, thermal and dielectric properties. Silicone Rubber with Al_2O_3as a filler would be a better way for high voltage electrical insulation due to its improved dielectric. Chemical and mechanical characteristics.

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