

Effect of ATH Content on Electrical and Aging Properties of EVA and Silicone Rubber Blends for High Voltage Insulator Compound

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ABSTRACT: The effect of trihydrated alumina ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$) (ATH) filler in ethylene-vinyl acetate copolymer (EVA) and silicone rubber blends was investigated by performing a series of laboratory experiments to simulate different natural aging conditions. Samples with varying ATH content in a 50-50 blend of EVA and polydimethylsiloxane (PDMS) (silicone rubber, MQ) were tested to investigate the tracking resistance, resistance to UV radiation, corona, heat, and water immersion. Changes in surface resistivity, volume resistivity, and hydrophobic characteristics were evaluated for different compounds having ATH content. These exercises were mainly carried out to optimize the filler level. In immersed condition the water absorption increases with

ATH content. The recovery of hydrophobicity, after aging by heat, is appreciable at higher ATH levels, than at lower ATH levels. The tracking and erosion resistance decrease as ATH content increases. When compounds containing different ATH content were subjected to corona treatment, the samples with higher ATH levels exhibited better results. All samples changed their color to a darker shade and there was an increase in the hydrophobicity, when subjected to UV radiation. © 2007 Wiley Periodicals, Inc. *J Appl Polym Sci* 104: 3505–3516, 2007

Key words: trihydrated alumina (ATH); EVA-silicone rubber blend; HV insulators; tracking; erosion resistance

INTRODUCTION

Electrical insulator is a very important component in the electrical power system such as substations, distribution, and transmission lines. In-depth study and practical knowledge on this subject is necessary for the professionals in the electric power field. Insulators are recognized as the most important constructional element in any transmission system. Any weakness of insulation will result in the failure of the system.

With the ever-increasing complexity in power systems the requirements for insulation are becoming extremely stringent. Composite design of nonceramic insulators generally employs a fiberglass rod or hollow core for mechanical strength, with an outer housing made from either silicone rubber, EPDM, or EPR. The advantages of polymeric insulators have led to the continued development of polymer housings for insulator and arrester designs. In particular, silicone rubber seems to be emerging as a material of choice among insulator manufacturers.¹ Composite insulators designed with silicone rubber have been found to reduce the need for maintenance in areas of moderate to high contamination. The surface of a silicone elas-

tomer has a unique ability to interact with the contaminant and control leakage currents, interrupting the normal process that leads to contamination-induced flashover.²⁻⁵ It is reported that silicone rubber insulators sometime are pecked by birds, as the polymer is soft and as a polymer silicone rubber is also relatively costly.⁶ Silicone rubber in general has excellent ability to reduce leakage current compared to polyolefins like EPDM and ethylene-vinyl acetate copolymer (EVA). However, it is poor in mechanical strength and more care is required during compounding and processing. EVA (28%VA) on the other hand has much better mechanical properties and cheaper in price, compared to polydimethylsiloxane (PDMS) silicone rubber. The judicious blending of these two polymers may lead to materials with better properties and economics. In fact, blending of these two polymers will improve each other's shortcomings which may prove to be valuable. Therefore, efforts are on by various agencies to blend cheaper polymers with silicones and achieve the same level of performances leading to cost effective alternatives.⁶ However, the performance of these insulator and housing do not depend only on base polymer/polymer blends but also very much depends on the incorporation of appropriate filler in requisite amount.

In the present work, efforts are being made to study the performances of housing compounds based on EVA and silicone rubber (PDMS) 50/50 blend con-

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taining different trihydrated alumina (ATH) levels so as to develop an insulator compound replacing a silicone rubber partially. The performance of PDMS/EVA blend under several types of stress is evaluated. Alumina tri hydrate is used as a filler material to improve the tracking and erosion property of rubber based insulator/housing. The filler material is effective because it reacts either physically or chemically with the polymer to remove the degradation by products formed by dry band arcing, from the surface of the material and, hence prevent total degradation. The material eventually tracks or erodes completely when the energy input from the arc exceeds the rate of removal of the degradation products by the filler.⁷⁻⁹

During dry band arcing, the temperature at the surface is about 260–400°C, during this, the endothermic decomposition of ATH takes place. The water of hydration is released as vapor which then cools the surface thus limiting the thermal degradation. In polymers like EPDM and EVA, in which free carbon is formed, the release of water vapor at the surface prevents the formation of a continuous track. When temperature of 607°C or higher are reached the water vapor dissociates into hydrogen and oxygen. The free carbon produced during the breakdown of the bonds combine with oxygen and is released as CO and/or CO₂.^{10,11}

EXPERIMENTAL

Materials

Silicone rubber (MQ/PDMS) was obtained from Dow Corning, USA. (specific gravity = 0.9 g/cc, ML₁₊₄ at

TABLE I
Identifications of Samples and Their Composition

Samples designation	Samples composition		
	EVA content (phr)	PDMS content (phr)	ATH (phr) ^a
ES 50.60	50	50	60
ES 50.80	50	50	80
ES 50.100	50	50	10
ES 50.120	50	50	120
ES 50.140	50	50	140

^a phr, parts per hundred parts of rubber.

100°C = 45). Twenty eight percent VA content EVA (Piline EVA 2806), PILINE 2806, was obtained from NOCIL, India. (specific gravity = 0.95 g/cc, MFI at 90°C = 6 g/10 min).

Sample preparation and identification

The blending of 50/50 EVA and silicone rubber was accomplished in Brabender plasticorder PEE 330 at the temperature 120°C at the rotor speed of 60 rpm. Initially, EVA was added in the mixer and allowed to melt for 2 min then silicone rubber was mixed and the blending was carried out for half a minute, the addition of filler, plasticizer, and anti-oxidant was accomplished within next 4 min and the whole mass was taken out from the mixer and curing agent DCP (2 phr) was added in open mixing mill.

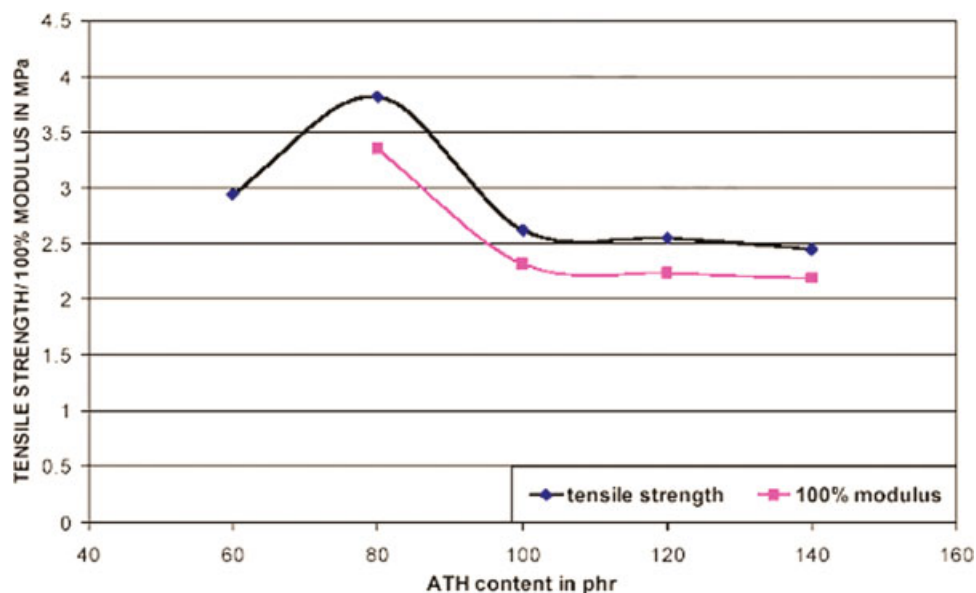


Figure 1 Variation of tensile strength and modulus at 100% elongation, with ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

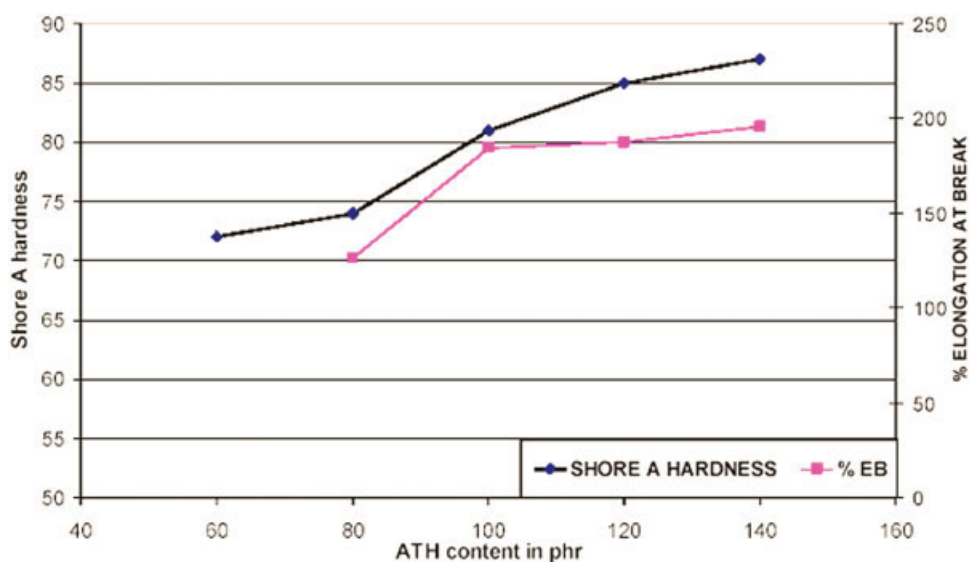


Figure 2 Variation of shoreA, hardness, and elongation at break with ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Sample identification

A series of test samples were prepared to evaluate the effect of ATH on different properties. ATH was also mixed at a level of 160 phr (per hundred parts of rubber), but the mixing and processing were very difficult and the mass of the polymer mix was found to crumble under minor loads. Hence, the investigations were restricted to the maximum level of filler ATH 140 phr. The cured samples of different compositions were subjected to UV, corona, dry band arcing, heat,

and water immersion stresses by artificial age acceleration methods. The samples used for evaluation and their identification are shown in Table. I. The physical properties, electrical properties, and hydrophobic stabilities were evaluated for each sample. The effect of electrical and environmental stress on material aging and hydrophobic reduction, and recovery were also studied. At least three specimens per sample were tested for each property unless otherwise mentioned and the mean of these values were taken and reported.

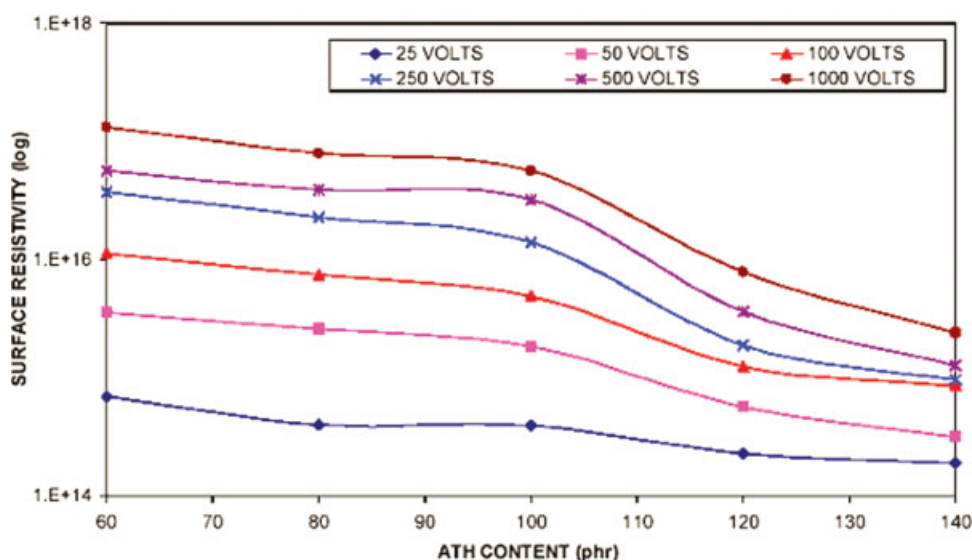


Figure 3 Variation of surface resistivity at different applied voltage with ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

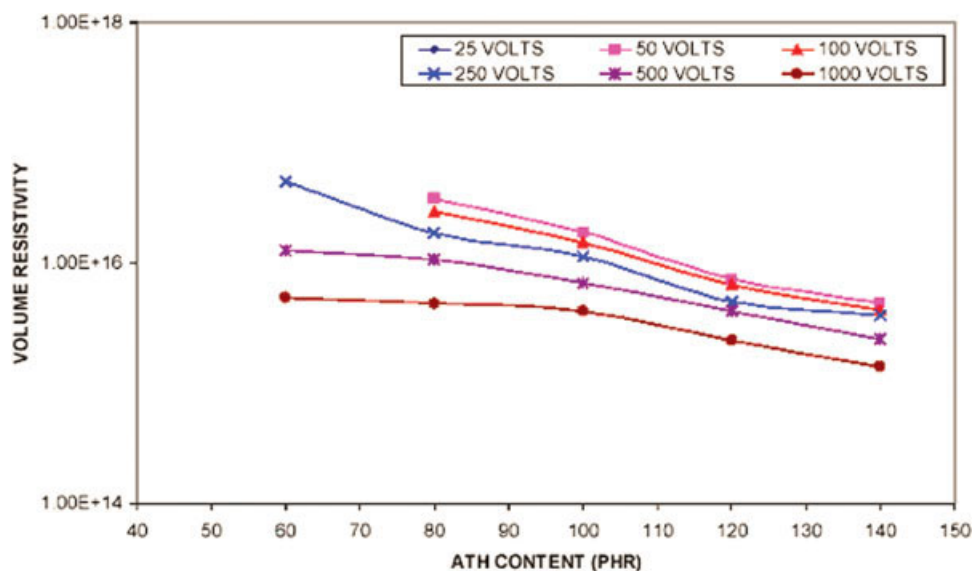


Figure 4 Variation of volume resistivity at different applied voltage with ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Mechanical properties

Shore A type durometer was used to measure the hardness of the vulcanizates. The method adopted was as per ASTM D 2240-81. Modulus, tensile strength, and elongation at break were determined according to ASTM D 412-80 test method using dumb-bell shaped test pieces. The tests were carried out in Zwick universal testing machine of model 1445. All the tests were carried at the crosshead speed of 500 mm/min and at room temperature.

Electrical properties

The surface resistivity and volume resistivity of the samples were measured using Hewlett-Packard High Resistance meter (Model 4329A) coupled with Hewlett-Packard Resistivity Cell (M16008A). Dielectric constant was measured using an LCR meter, in accordance with ASTM D150. The equipment used was 7600 Precision LCR meter Model B of M/s. Quadtech Instruments, USA.

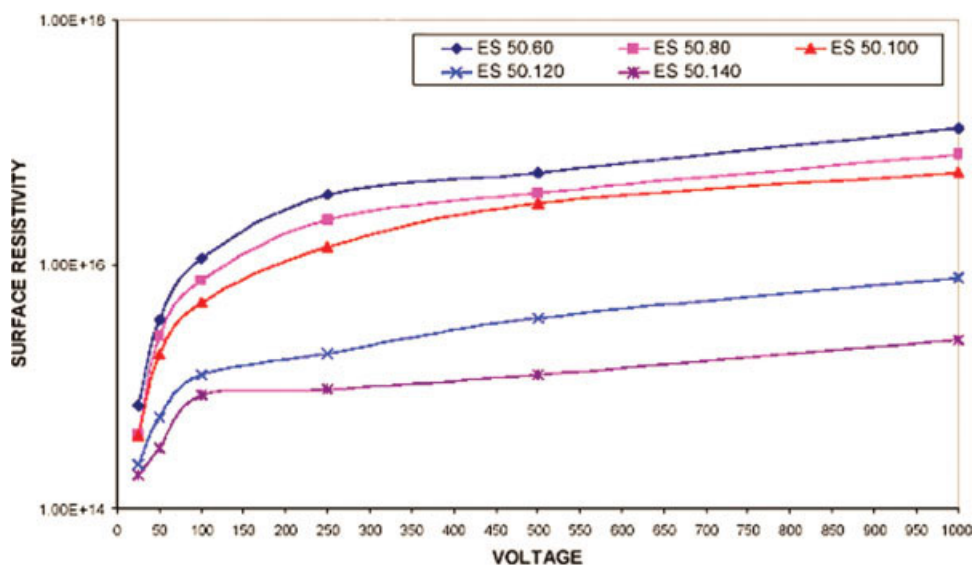


Figure 5 Variation of surface resistivity with voltage. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

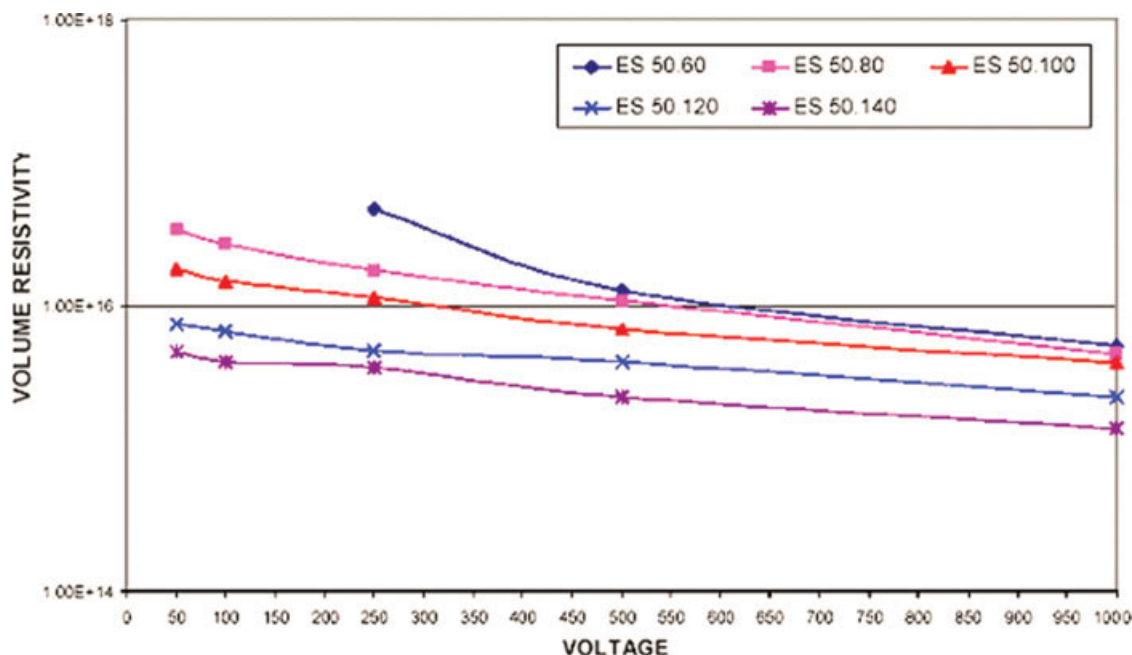


Figure 6 Variation of volume resistivity at different applied voltage. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Surface properties

Hydrophobicity classification was done according to STRI Guide.¹² The advancing and receding contact angles were measured using a dynamic contact angle meter Data Physics DCAT 11. The measurements were undertaken at 25°C.

Aging

The main purpose of the artificial aging is to determine the expected performance of the material under natural aging so extreme UV, acid, and humidity conditions can give accelerated aging though conditions may not be adequately simulated during the natural aging. The arti-

ficial aging was performed under laboratory conditions. To simulate the condition of aging under rain and fog, the samples were immersed in distilled water for 7 days at room temperature.¹³ The effect of thermal stress on hydrophobicity was also studied. The samples were heated in a hot air oven at 100°C for 7 days. The measurements were done at room temperature after the samples were allowed to cool. UV stress was applied using a Ultra-Vitalux UV lamp. The intensity was maintained at 1.5 kW/m². The corona stress was applied using a pointed electrode. The samples were mechanically stressed so as to induce the ozone effect. A voltage of 12 kV was applied to induce corona for a period of 100 h.^{14–16} The continuous dry band arcing, which occurs during the loss of hydrophobicity, is capable of

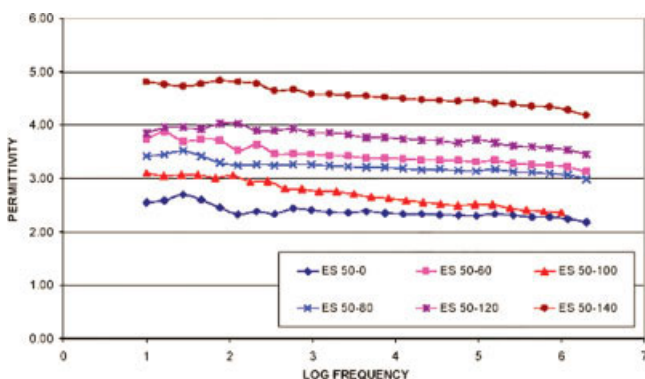


Figure 7 Variation of permittivity against applied field frequency. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

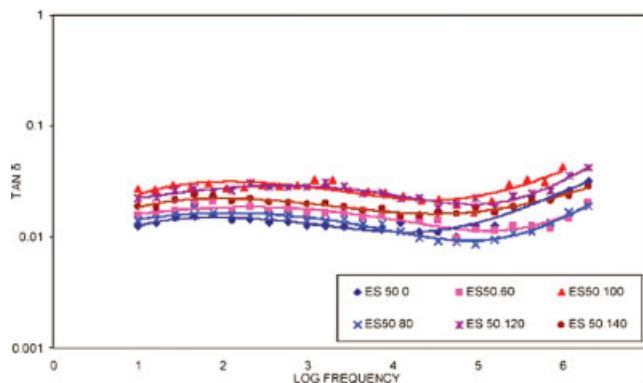


Figure 8 Variation of $\tan \delta$ against applied field frequency. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

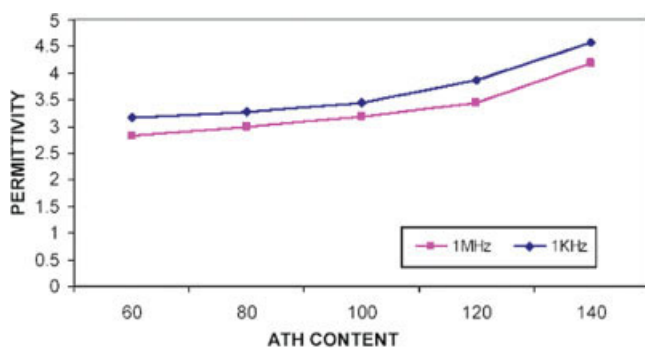


Figure 9 Variation of permittivity with ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

decomposing the polymeric materials, which results in tracking and erosion. Dry band arcing is evaluated by inclined plane tracking and erosion test according to IEC 587.¹⁷

RESULTS AND DISCUSSION

Physical properties

Different physical properties of blend containing 50/50 Silicone (PDMS): EVA with varying ATH content was evaluated. The tensile strength, modulus at 100% elongation, elongation break, and Shore A hardness are plotted against ATH content and shown in Figures 1 and 2.

It can be observed from the Figure 1 that the tensile strength increases up to 80 phr of ATH content and then decreases up to 100 phr and there after attains a more or less steady value. This marginal increase followed by marginal decrease is because of the dilution effect caused by increased ATH content, where the polymer does not properly wet filler particles. Moreover, ATH is not reinforcing filler; so increased addition is expected to reduce the matrix strength. As the

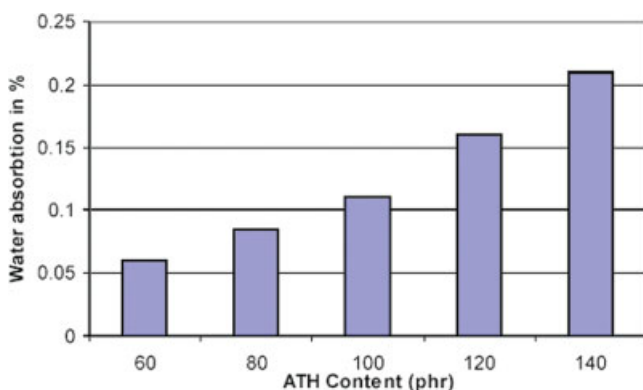


Figure 10 Effect of ATH content on water absorption. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

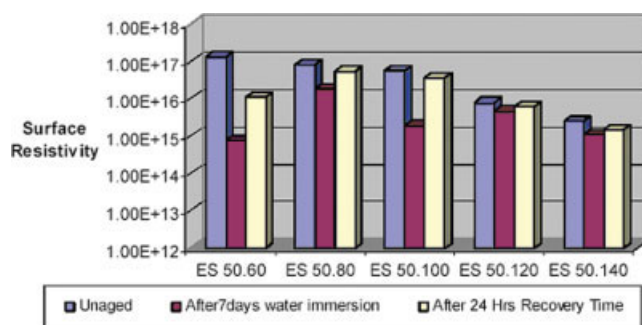


Figure 11 Effect of water immersion and recovery time on surface resistivity at different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

elongation at break for these systems are not very high the modulus at 100% elongation is mainly used as reference. However, 100% modulus is high strain modulus and it indicates the extent of polymer matrix reinforcement by the filler. The 100% modulus decreases with ATH content and then assumes a steady value. It is note worthy that Shore A hardness which may be taken as low strain modulus is continuously increasing with filler loading, where as modulus at 100% elongation which is high strain modulus decreases with filler loading. This is in well agreement with the effect of nonreinforcing filler loading in nonself reinforcing rubber vulcanizates. The elongation at break increases initially up to 100 phr followed by marginal change at loadings more than 100 phr.

Electrical properties

The surface and volume resistivity of the samples with varying ATH content were measured. The surface and volume resistivity at fixed voltages are plotted against ATH content and shown in Figures 3 and 4. The surface and volume resistivity at fixed ATH levels are plotted against voltage and shown in Figures 5 and 6. The base matrix of different systems under investigation is derived from the 50/50 blend of silicone

TABLE II
Effect of Water Aging on Hydrophobicity for Different ATH Content

Samples	A		B		C	
	ACA	RCA	ACA	RCA	ACA	RCA
ES 50.60	98.09	69.62	95.3	45.3	97.45	63.6
ES 50.80	98.55	69.51	94.81	49.85	95.22	61.4
ES 50.100	98.02	69.36	94.19	49.9	97.8	68.4
ES 50.120	97.17	68.06	94.81	53.5	96.37	68.0
ES 50.140	97.19	65.12	95.21	60.51	96.77	61.2

Values of ascending contact angle (ACA) and receding contact angles (RCA) of A (virgin samples), B (after immersion for 7 days), and C (after 24 h recovery time).

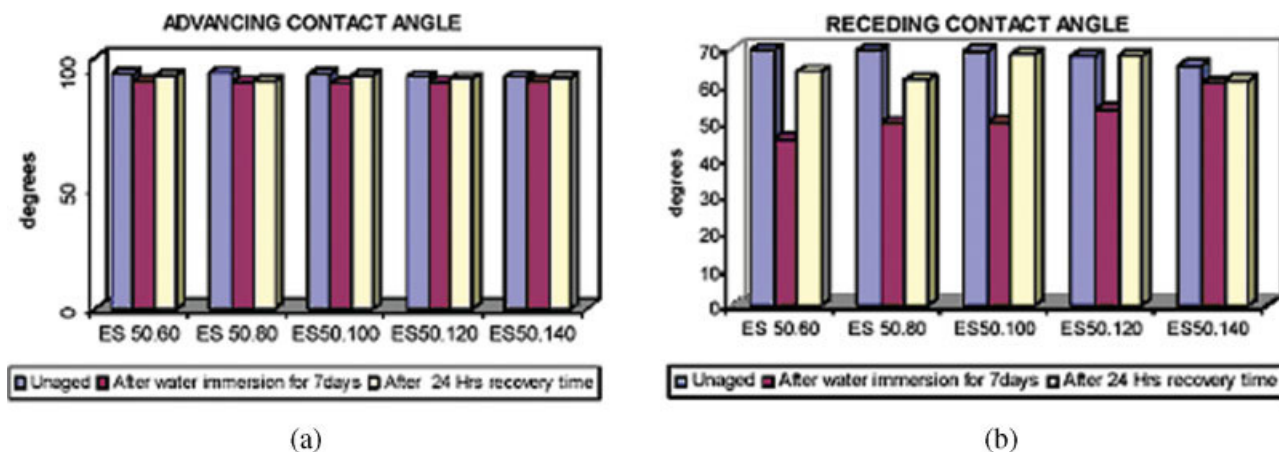


Figure 12 Effect of water immersion and recovery time on hydrophobicity at different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

and polar EVA. These compounds contain low molecular weight polymer chains mainly from silicone matrix and also contain some plasticizer. In these polymer systems, there is a tendency of low molecular weight material blooming to the surface. The low molecular weight chains encapsulate the contaminants and filler particle on the surface of the material. With the increase in filler content, there is depletion in the low molecular weight polymer chains on the surface and subsequent wetting, the hygroscopic contaminants and filler particles absorb water and form a thicker water film. This results in a lower surface resistance with the increased ATH content. The volume resistivity remains more or less constant. The effect of voltage on surface and volume resistivity is only marginal. The dielectric constant and dissipation factor $\tan\delta$ are plotted against frequency, for various ATH content, and are shown in Figures 7 and 8. The dielectric constants at 1 MHz and 1 kHz are plotted against ATH content and are shown in Figure 9. As expected, dielectric constant (permittivity) decreases with increase in frequency. The loss tangent however shows marginal variation over the measurement range

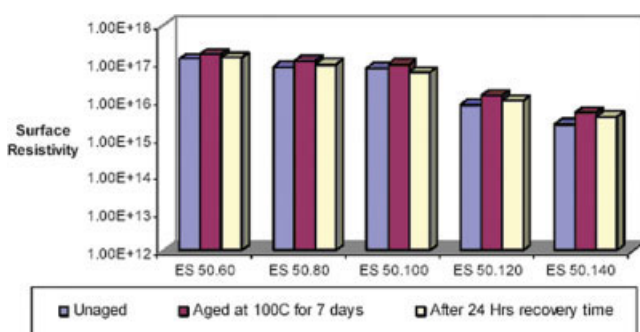


Figure 13 Change in surface resistivity because of the heat aging for different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

of frequency except some drop in the tangent is observed for all samples at frequency 10^5 Hz. The dielectric constant increases with the increase in ATH content, because of the higher dielectric constant of ATH (114) over the base polymer (2.5–3.5). The blends with higher ATH content are found to be dielectrically lossier as with the increase in ATH content the loss tangent increases at all frequencies (not shown in figure).

Effect of water immersion

Change in electrical properties

Filled polymer can absorb water an order of magnitude higher than the pure polymer. This is mainly because organic bodies in polymer are hydrophobic in nature. However, mineral fillers has tendency to be hydrophilic. The water absorption of various compositions having different ATH content was measured and is shown in Figure 10. The increased water absorption by higher ATH content is because of the absorption of water by the filler particles. The surface resistivity of the samples subjected to water immersion and measurement after 24 h recovery time are compared with that of the virgin sample and are

TABLE III
Effect of Heat Aging on Hydrophobicity for Different ATH Content

Samples	A		B		C	
	ACA	RCA	ACA	RCA	ACA	RCA
ES 50.60	98.09	69.62	93.62	62.56	95.64	63.33
ES 50.80	98.55	69.51	93.58	66.52	95.19	68.25
ES 50.100	98.02	69.36	93.38	66.34	95.6	68.48
ES 50.120	97.17	68.06	92.41	66.58	95.91	68.21
ES 50.140	97.19	65.12	92.72	62.16	95.77	63.13

Values of ascending contact angle (ACA) and receding contact angles (RCA) of A (virgin samples), B (after heating at 100°C for 7 days), C (after recovery period of 24 h).

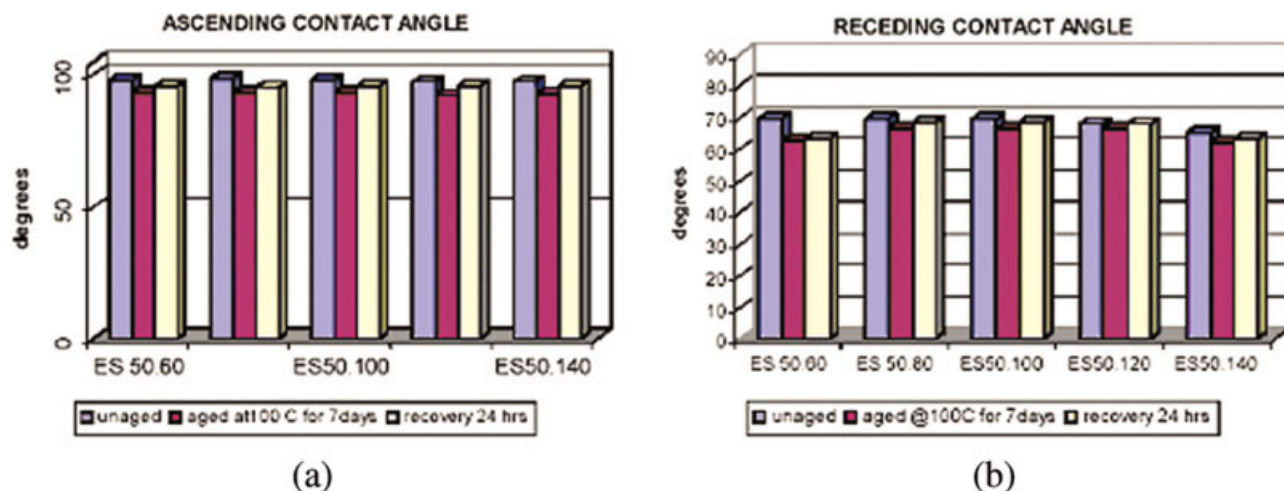


Figure 14 Effect of water immersion and recovery time on hydrophobicity for different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

shown in Figure 11. The resistivity measurement at 1000 V are shown and similar trend is observed for other voltages. The surface resistivity of different samples decreases when immersed in water. This reduction in surface resistivity is mainly because of absorption of water by the filler particles.¹⁸ The loss of surface resistivity is lower for higher ATH content, but the recovery of surface resistivity after definite time interval, decreases as ATH content increases.

Change in hydrophobicity

Hydrophobicity of different samples is assessed through measurement of dynamic contact angles. The values are shown in Table II, where ACA represents the ascending contact angle and RCA represents receding contact angle. The reduction in hydrophobicity because of immersion in water is also attributed to the absorption of water by ATH. The reduction in advancing contact angle is much less, when compared to the reduction in receding contact angle, as can be seen in Figure 12.

Effect of heat aging

Change in electrical properties

The samples were subjected to heat aging in an open air oven for 7 days at 100°C and then conditioned at room temperature before measurement. The surface resistivity of aged samples is compared with that of the virgin (unaged) samples and is shown in Figure 13. The result shown was taken at 1000 V; however, similar trend is observed for other voltages also. An increase in the surface resistivity as found was because of aging of samples at 100°C. When samples were subjected to prolonged heat at 100°C, it is expected that both the adsorbed moisture and the low molecular weight (LMW) fractions of polymer and plasticizer evaporate from the sample surface. When allowed to recover the LMW chains migrate back to the surface from bulk and subsequent absorption of moisture from the atmosphere by the filler particles will return the value of surface resistivity to nearly that of the virgin sample. There is reduction of the adsorbed moisture on the surface of the aged samples as compared to that of unaged ones.^{19–22}

TABLE IV
Results of Tracking and Erosion Tests

Sample	Appearance of scintillations	Residue	Time for tracking (min)	Original thickness	Depth of erosion	Remarks
ES 50.60	Yellow with some parts blue	Fluffy	53	4.26	3.64	Failed due to high leakage current
ES 50.80	Yellow with some parts blue	Fluffy	360	3.98	3.96	Failed due to excessive pitting
ES 50.100	Yellow with some parts blue	Fluffy	360	4.05	1.68	Passed
ES 50.120	Yellow with some parts blue	Fluffy	360	3.85	0.67	Passed
ES 50.140	Yellow with some parts blue	Fluffy	360	4.19	0.31	Passed

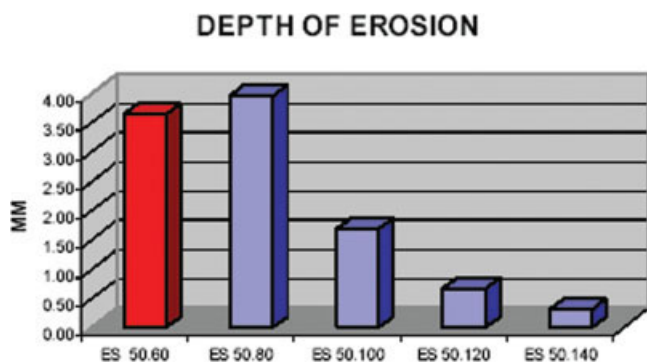


Figure 15 Depth of erosion during tracking test IEC 587 for different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Change in hydrophobicity

Hydrophobicity of sample surface can be estimated by the measurement of dynamic contact angle. The values are given in Table III. A decrease in the contact angles was found after subjecting the sample for heat aging at 100°C. This may also be because of the evaporation of LMW chains, present on the surface. The results are shown in bar diagram in Figure 14. When aging time is prolonged the change in property are found to be more pronounced. The loss of hydrophobicity, after aging at 100°C, for 7 days, increases with the increase in ATH content; however, the recovery of hydrophobicity is found to be more at higher ATH than that at lower ATH levels.

Tracking and erosion resistance

The events that lead to tracking or erosion may be explained as follows. The tracking is a surface phenomenon, which takes place under high potential gradient. Under high voltage a carbonized path is formed on the surface of the polymer matrix because of charring of the polymer chain, which has mainly

C—C(carbon-carbon) linkage. Where there is dearth of carbonized path formation the tracking resistance is expected to be higher as in the case of silicone rubber having Si—O—Si linkages. Moreover, the nature of the surface contaminants either aids or retards the process of tracking. If the surface contaminants are polar in nature like adsorbed moisture or other surface impurities the tracking process gets accelerated and takes place relatively at lower voltages, whereas, if the surface impurities are nonpolar like oil type plasticizer migrating to the surface it may decelerate the tracking process.^{7,13,14,20,23} The addition of ATH filler particles retards the onset of tracking. ATH (Trihydrated alumina), at high temperatures caused by the scintillations during the tracking phenomenon, will get converted into anhydrous alumina. Anhydrous Alumina is highly resistive in nature more than the anhydrous version. The inclusion of highly resistive alumina particles, in the carbonaceous track, will deter the formation of continuous conductive path, necessary for tracking and hence imparts higher erosion and tracking resistance. It is observed that substantial addition of ATH increases the tracking and erosion resistance. The samples were tested and the observations made during the tests are given in Table IV. During natural (oxidative) and thermal aging of the polymer, a permanent change may occur causing degradation that is de-polymerization of the surface. This means that filler particles on the aged surface are not as tightly bound to the polymer as they were on the virgin sample. The filler particles now act as individual entities and promote a thicker water film because of its hygroscopic nature. In addition, as the bonding of the polymer with filler on the surface is weakened, the interaction of filler with the polymer is reduced. This leads to a reduced tendency for tracking and erosion. The further reduction in the tracking and erosion resistance is possible, as it takes lesser energy from the arc to erode short chains than long chains. Thus a cumulative process of degradation occurs from de-polymerization of the surface layers. The incorporation of ATH filler mitigates against the severe degrada-



Figure 16 Test samples after tracking test IEC 587 for different ATH content. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

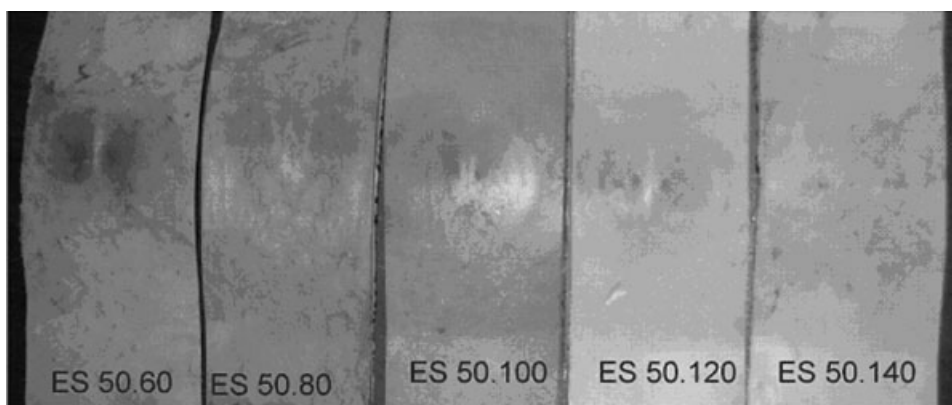


Figure 17 Test samples after corona discharge for 100 h for different ATH content.

tion of the surface of the material. Hence tracking and erosion resistances increases with the increase in ATH content. The depth of erosion for different samples is shown Figure 15. This illustrated by the photographs of the test samples as shown in Figure 16.

Effect of corona

Corona is another high voltage phenomenon, which generally occurs when high voltage gradient is applied over strained polymeric insulation. The polymer undergoes failure in strained condition because of ozone attack. The degradation is not only because of high temperature caused by the electrical discharge at high voltage, but also because of the formation of ozone from atmospheric oxygen because of this electrical discharge. Ozone at small quantity, even at parts per million (ppm) level is specially detrimental for polymers having unsaturation. Polymer undergoes ozonolysis reaction which gets accelerated, when the sample is under stress leading to micro-crack formation. These cracks increase in dimension during prolonged exposure to ozone.^{24,25} When samples were exposed to corona for a period of 100 h and

examined, deposition of carbonaceous material in a concentric pattern was observed on all samples. The photographs of the samples after aging and removal of carbonaceous material are given in Figure 17. The effect of hydrophobicity was also checked for these samples. The results are tabulated in Table V It is found that the effect of corona decreases with increase in ATH content. The deposition of carbonaceous material on the surface of the sample is because of the presence of LMW, PDMS chains on the surface. Thus as the ATH level increases, the LMW chain content decreases and the deposition of carbonaceous material reduces. Because of prolonged exposure all most all the LMW chains are drawn to the surface from the bulk and oxidized. Hence hardly any recovery of the hydrophobicity is observed.

Effect of UV-radiation

Most polymers undergo UV degradation during prolonged exposure to UV radiation and this radiation is present in sunrays. Discoloration and cracks are observed on polymer samples exposed to UV radiation. It has been reported that PDMS can maintain

TABLE V
Hydrophobicity Classification of Test Samples after Corona Discharge for 100 h

Sample	Appearance of scintillations	Residue	Time for tracking (min)	Original thickness	Depth. of erosion	Remarks
ES 50.60	Yellow with some parts blue	Fluffy	53	4.26	3.64	Failed due to high leakage current
ES 50.80	Yellow with some parts blue	Fluffy	360	3.98	3.96	Failed due to excessive pitting
ES 50.100	Yellow with some parts blue	Fluffy	360	4.05	1.68	Passed
ES 50.120	Yellow with some parts blue	Fluffy	360	3.85	0.67	Passed
ES 50.140	Yellow with some parts blue	Fluffy	360	4.19	0.31	Passed

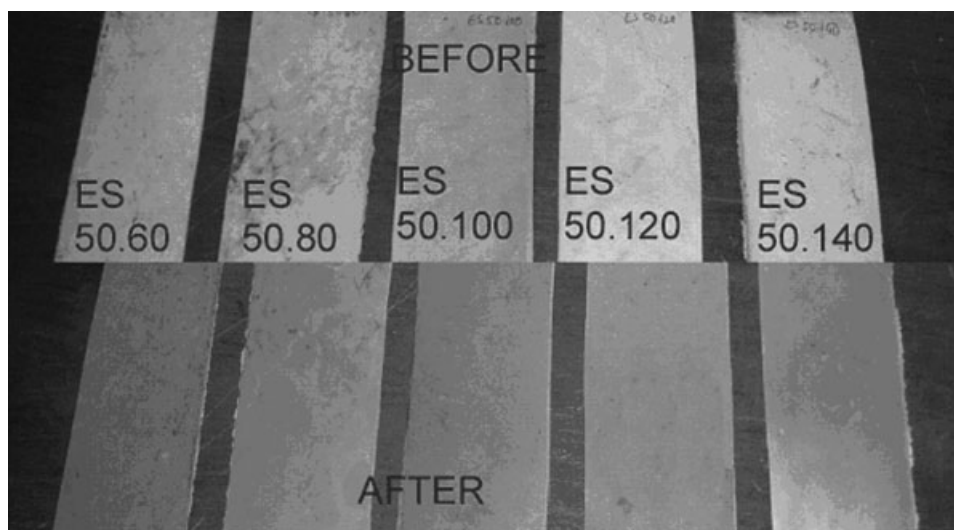


Figure 18 Test samples after UV radiation for 100 h for different ATH content.

hydrophobicity up to 6000 h of UV radiation.¹³ However, samples were subjected to UV radiations for only 100 h. On visual examination, it was observed that all samples have changed their color to a darker shade and there was an increase in the hydrophobicity. The photographs are given in Figure 18. The results are tabulated in Table VI. It is found that all samples have an increased Hydrophobicity. This is because of the migration of LMW chains to the surface under UV radiation. The recovery of hydrophobicity is not much affected by ATH content.

SUMMARY AND CONCLUSIONS

It was observed that tensile strength and hardness increases as ATH content increases. The elongation at break decreases with the increase in ATH content. With the increase in filler content, the surface resistance decreases. The volume resistivity remains more or less constant. The surface and volume resistivity do not change much with the applied voltage, thus they exhibit an ohmic behavior. The dielectric constant increases with the increase in ATH content, because of the higher dielectric constant of ATH compared to the base polymers. The blends with higher ATH content are electrically more lossy in nature. The increased water absorption by samples of higher ATH content is because of the absorption of water by

the filler particles. The surface resistivity of different filled samples decreases when immersed in water. The reduction in advancing contact angle is much less compared to the reduction in receding angle, after water immersion. The loss of hydrophobicity after heat aging is more at higher ATH content. The recovery of hydrophobicity is appreciable at higher ATH levels, than at lower ATH levels. Tracking and erosion resistances decrease as ATH content increases. When subjected to corona treatment, the samples show higher resistance at higher ATH levels. All samples exhibit change from off-white color to a darker shade accompanied with the increase in the hydrophobicity, when subjected to UV radiation. The concentration and dispersion of filler (volume effects) are thought to play an important role in the hydrophobicity and tracking and erosion resistance of materials. At high filler concentration, some inorganic molecules may be exposed at the surface, because of the heat of arcing. Also high concentration of filler improves the thermal conductivity of materials, which in turn improves the heat dissipation and helps preventions of development of hot spots. An additional consequence of the depletion of the low molecular weight chains and depolymerization on the surface is the clustering of the filler particles, i.e., the conglomerates of filler appears on the surface in place of small filler particles. They will again lead to reduction in the

TABLE VI
Hydrophobicity Classification of Test Samples after UV Radiation for 100 h

Samples	Virgin sample	UV radiation for 100 h	Surface wiped and checked	Recovery time 2 h	Recovery time 24 h
ES 50.60	HC2	HC1	HC6	HC6	HC6
ES 50.80	HC2	HC1	HC6	HC6	HC6
ES 50.100	HC2	HC1	HC6	HC4	HC4
ES 50.120	HC2	HC1	HC7	HC5	HC5
ES 50.140	HC1	HC1	HC7	HC5	HC5

tracking and erosion resistance as the interaction of the polymer with filler is reduced because of increased size of the filler particles. Higher loading of ATH is found to be more effective in restricting the leakage currents and improves tracking and erosion resistance. Hence it is concluded that ATH at the level of 140 phr may be good enough in HV insulators. Processing of the polymer was also not found to be difficult at this filler level.

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