DCP concentration effect on the surface resistivity value in silicone rubber material

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ABSTRACT – Insulation materials such as Silicone Rubber (SiR) require excellent electrical and mechanical properties. This could either be achieves through filler addition or vulcanization process. This study focus on analysing the impact of using different vulcanizer concentration of Dicumyl Peroxide (DCP) and their impact towards the performances of SiR in terms of its surface resistivity value. Three different concentration of DCP (0.5pphr. 1.0pphr and 1.5pphr) were added to the SiR material. It can be seen through the results that too much of DCP (1.5pphr) is non-favourable in SiR as the value of surface resistivity may drop substantially which might also indicates the poor performances of SiR.

1. INTRODUCTION

Vulcanization is a process of curing polymer through the process of crosslinking that were done with the aid of curing agent. Curing process allows polymeric material to undergo desirable changes from a material with lower strength to material with higher strength and resilience. A material that already undergoes cross-linking will usually have a higher resistance against temperature changes which also means a longer lifespan under extreme weather conditions [1].

SiR is usually vulcanized using peroxides within a specific range of temperature and as for DCP the range of temperature required is in between 154 – 177◦C [2]. The decomposition of peroxides at the provided temperature range allows free radicals to be generates. The heating process of peroxides initiates the breaking down of oxygen bonds (O-O) which then generate free radicals. The free radicals will then initiate the formation of crosslinking within the polymer. The cross-linking help to improvise the function ability of SiR mechanically and also electrically [1].

However, DCP is bound to release byproduct during crosslinking which have also been reported to cause increase in conductance of the material studied [3]. Therefore, in this study, the levels of DCP used for curing were varied in three levels of 0.5pphr, 1.0pphr and 1.5pphr. The values were adjusted from the recommended values given by the industries.

On the other hand, surface resistivity is the ability of a material to resist current flow when subjected to direct voltage injected from two electrodes placed on its surface. Higher resistivity value indicates a better insulating material with a smaller leakage current [4].

Moreover, higher surface resistivity also indicates that the SiR have a larger contact angle and hence a better hydrophobicity traits [5]. It should be noted that hydrophobicity characteristic of SiR helps in protecting the SiR itself against humidity and pollutions which also contributes in restricting the formation of conducting path that will then limits the leakage current on SiR. Basically, an insulation with high surface resistance and low leakage current were preferable as it was proven that high leakage current enhances tracking and erosions performances for an outdoor high voltage insulation [6].

2. METHODOLOGY

The materials of SiR with three different level of DCP (0.5pphr, 0.1pphr and 1.5pphr) were prepared and cured via hot-press process. The process was done for about 10 minutes under 175◦C. Then, the materials were post-cured for 12 hours under 130◦C.

The testing for surface resistivity for all samples of SiR were done accordingly as the ASTM D257 standard [7]. The readings were taken under room temperature condition of 23 ± 2◦C with relative humidity ranges of 65 ± 5. Furthermore, it was also advisable to clean up the samples before testing using ethanol as to ensure that the surface was free from any dust or other contaminations. Each sample were tested 3 times and the average reading was recorded. The surface resistivity set up is shown in Figure 1.

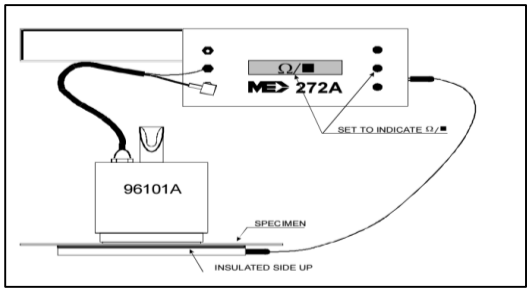

Figure 1 Portable resistivity meter set up

3. RESULTS AND DISCUSSION

The average results obtained for the surface resistivity of all three samples were shown in Table 1.

Table 1 Surface Resistivity of SiR.

DCP concentration (pphr)	Surface Resistivity (Ω/sq)
0.5	5.1×10^{12}
1.0	5.9×10^{12}
1.5	4.1×10^{10}

Through the results obtained, it could be seen that there is a slight increase in the surface resistivity of SiR when the concentration of DCP increased from 0.5 to 1.0 pphr. The increment in the value of slight resistivity of 15.6% was probably due to a better yield of crosslinking in the sample of 1.0pphr.

On the contrary, the highest DCP of 1.5pphr had resulted in substantial decrease in the surface resistivity value of the SiR. The decrease was suspected due to the presence of byproduct of the crosslinking process of SiR. It should be noted that during the curing process, DCP gives out by-products such as cumyl-alcohol and radical as shown in Figure 2 [1]. It was also reported in previous study of DCP with Low-density polyethylene (LDPE) had results in two by-products of acetophenone and a-methyl styrene.

Apparently, the value of resistivity is lower in samples with higher DCP content due to the effect of the by-product generated during vulcanization process. In the reference [3], the by-products of curing were found to cause an increase in the conductance of the material and inhibits permittivity value. Supposedly, these by-products were removed during post-curing but too much of DCP content might actually cause massive leftover of by-product in the sample even after the completion of post-curing process. Hence, it can be said that excessive curing agent does not necessarily contributes towards increase of resistivity strength of SIR even if there are is findings that shows that curing agent have the strongest effect on samples of epoxy compared to filler and their dispersion method [8]..

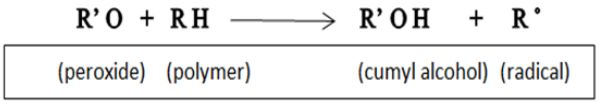

Figure 2 Reaction during vulcanization process of SiR

4. CONCLUSION

The surface resistivity tests were conducted on SiR materials with three different levels of DCP (0.5pphr, 1.0pphr and 1.5pphr). The results shows that increase in DCP content from 0.5 to 1.0 had caused an increase of 15.6% in the surface resistivity result of SiR. However, 1.5pphr seems to be excessive and non-preferable for SiR but it had caused the surface resistivity of SiR to decrease drastically.

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