THE INFLUENCE OF WATER PERMEABILITY AND WATER ABSORPTION ON RTV SILICONE RUBBER

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ABSTRACT

Silicone rubber has better gas and water permeability than other organic elastomers owning to its microporosity structure, which makes it permeable and leads to unstable internal dielectric property. Silicone rubber is a mixture of polyorganosiloxane and inorganic fillers such as silica and aluminium hydroxide. These fillers are hydrophilic and easy to absorb water, thus leading to the destruction of interface between polyorganosiloxane and filler and performance degradation. Under non-energized conditions, permeability of silicone rubber is only related to superficial area, time, air pressure as well as the free volume and filler composition. In this paper, the influences of water on silicone rubber is analysed and results show that the water permeation process and water absorption have obvious influences on the operation performance of RTV silicone rubber. It is also concluded that a precise criteria and test procedures should be specified for RTV coatings to be used in high humidity areas.

Index Terms — silicone rubber, water absorption, permeability,

1. INTRODUCTION

Silicone rubber has now been widely used in electrical industry to manufacture insulation components, such as composite insulators, RTV coating and so on [1]. Thanks to its good hydrophobicity property and unique hydrophobicity transference property, silicone rubber has gained better anti-pollution performance than most other organic materials. As a result, composite insulators and RTV coatings, which are all made of silicone rubber, are widely used in China, especially in some heavy polluted areas [2]. In North China, field experience has demonstrated that composite insulators and RTV coatings could have a lifespan of 10 years or even longer [3-5]. In South China where the climate is subtropical, however, degradation phenomena such as colour fading, cracking, chalking and peeling off have been observed. It is believed by some field electrical engineers that high humidity strong sunlight are main causes leading to the degradation phenomena [6]. In this paper, experiments were conducted to study the permeability and water absorption property of RTV silicone rubber. Four types of RTV coating were selected as test specimens. It is concluded that high humidity has great impact on the long-term performance of silicone rubber, especially RTV silicone rubber. Some liquid silicone rubber and high temperature vulcanized silicone rubber specimens were also tested in this paper as control groups. Experimental results showed that liquid silicone rubber and HTV silicone rubber have better resistance to humidity than RTV silicon rubber.

2. EXPERIMENTAL ARRANGEMENT

2.1 PREPARATION OF SAMPLES

Four types of RTV coatings were tested in this paper. All these four RTV coatings, which have been used on glass or porcelain insulators in many parts of China, were collected from their manufacturers. The samples are shown in Figure 1.

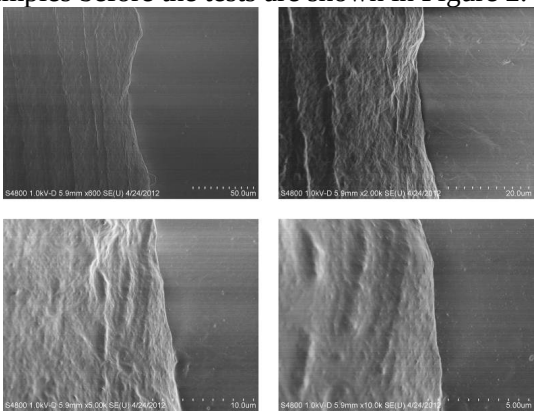
(a) RTV 1#

(b) RTV 2#

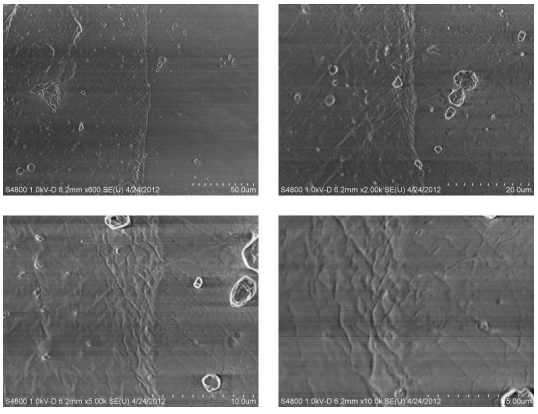
(c) RTV 3# (d) RTV 4#

Fig. 1 Four RTV samples

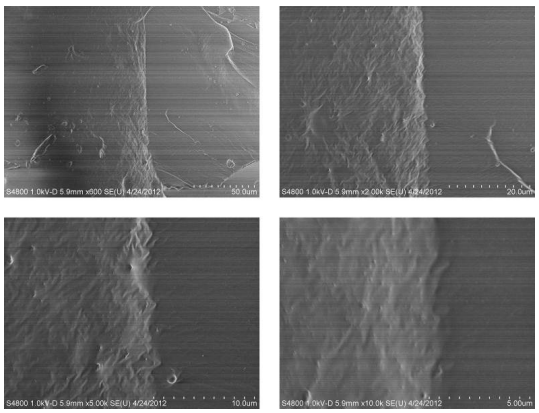
All RTV samples were vulcanized on a piece of liquid silicone rubber specimen to form a rectangle-shaped solid specimen so that microstructure comparison figures between RTV samples and LSR samples could be acquired, as to be discussed in Section 3. The microstructure of RTV samples after the tests and the interface between RTV and LSR could indicate the permeability and water absorption property of RTV samples. Scanning electronic microscope (SEM) was utilized to study the change of microstructure and interface of these samples. The microstructure appearances of these four samples before the tests are shown in Figure 2.



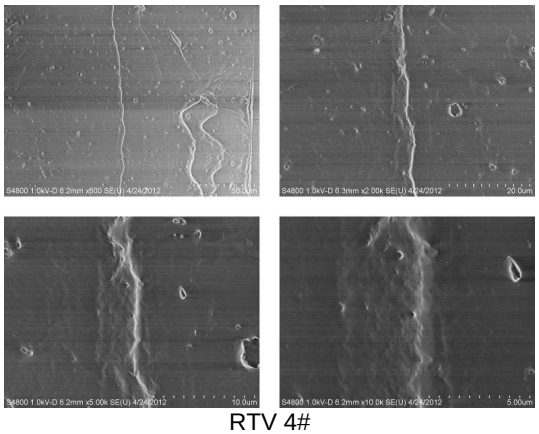
RTV 1#



RTV 2#



RTV 3#



RTV 4#

Fig. 2 Microstructure of samples before tests

In Figure 2, clear interfaces could be observed in all RTV samples. RTV samples were on the left side and LSR samples were on the right side.

2.2 EXPERIMENT ARRANGEMENT

Two series of tests were carried out respectively to study the permeability and water absorption property of silicone rubber [7] .

A constant temperature and humidity test was conducted to study the permeability property of silicone rubber. Biochemical incubators were utilized in order to generate a constant temperature environment. According to Raoult's law, saturated salt solutions were applied to acquire constant humidity. In this paper, temperature was set as 40℃ and NaCl and K_2SO_4 saturated salt solution were applied so that the relative humidity inside the incubators were kept at around 74.7±0.2% and 96.4±0.4% respectively.

In the water absorption tests, the temperature was also kept at 40℃. All samples were soaking in distilled water.

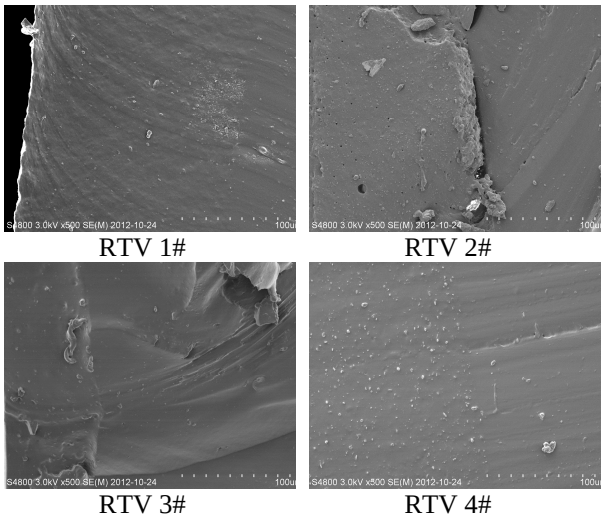
Fig. 3 Constant humidity and temperature test

3. RESULTS AND DISCUSSION

3.1 PERMEABILITY PROPERTY

In this test, all samples were kept in an environment with constant temperature and humidity for 4000 hours. After the test, microstructure figures of all samples were collected utilizing a SEM device [8]. The micro appearances of samples are shown in Figure 4 and Figure 5.

In Figure 4, four samples were kept in a container in which the relative humidity was 75%. This could be regarded as a regular relative humidity in South China. After this test, the interfaces in RTV 2# and RTV 3# have become sharper and clearer whereas the interfaces in RTV 1# and RTV 4# have been significantly blurred. Unlike the interfaces, the microstructural appearances of all samples remain smooth and tight without being destroyed, demonstrating that RTV silicone rubber could function quite well in a 75% relative humidity environment. Blurred interfaces indicate that water has permeated RTV samples

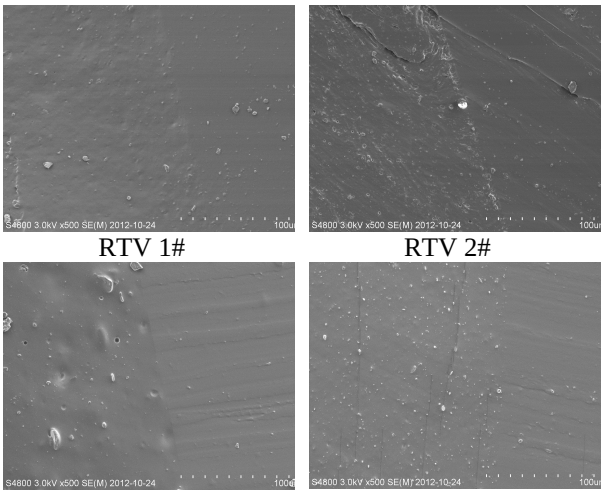


RTV 1# RTV 2#

RTV 3# RTV 4#

Fig. 4 Microstructure of samples after 40℃，RH 75%, 4000 h test

It could be seen in Figure 5 that all interfaces in the four RTV samples have been blurred, demonstrating that water has permeated more seriously than those in Figure 4. It could also be noticed that microstructures of the samples still remained smooth.



RTV 1# RTV 2#

RTV 3# RTV 4#

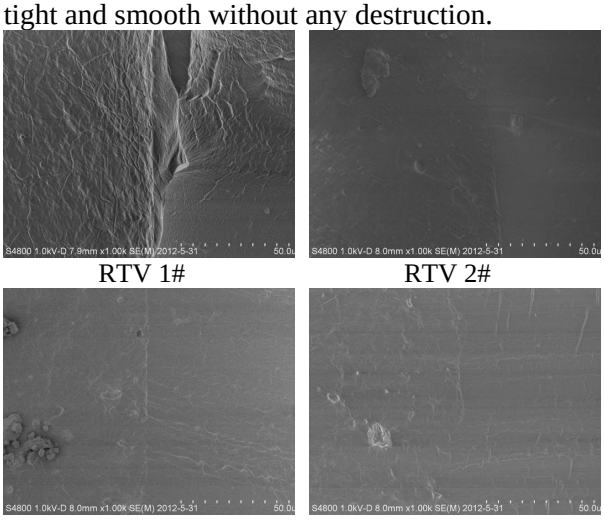
Fig. 5 Microstructure of samples after 40℃，RH 96%, 4000 h test

Results of constant temperature and humidity tests show that the microstructural appearances of RTV samples have kept tight and smooth whereas the microporosity of interfaces of RTV samples have changed after 4000-hour test, indicating that the permeability of water has influences on the interfaces of RTV silicone rubber. As a result, RTV coatings is presumably peeling off after long-term service in South China with high humid and high temperature environment.

3.2 WATER ABSORPTION

The water absorption process has great impact on the operation performance of RTV coatings, as shown in Figure 6 and 7.

Figure 6 shows the microstructure of RTV samples after 300 h test. It could be seen in the figure that the appearances of all samples were tight and smooth without any destruction.



RTV 1# RTV 2#

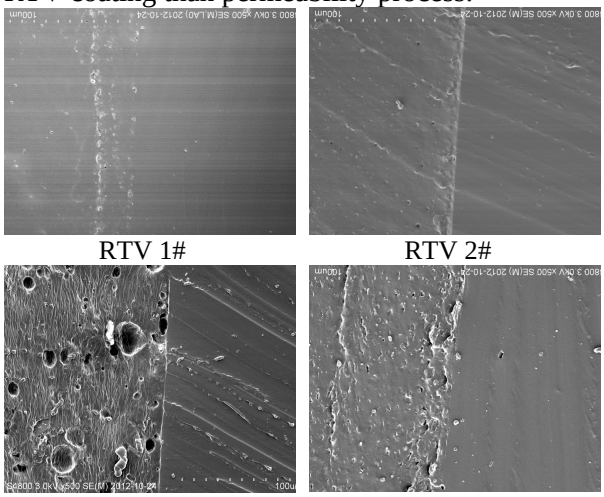
RTV 3# RTV 4#

Fig. 6 Microstructure of samples after 300 h test

In Figure 7, however, the appearances of RTV 3# was severely damaged and RTV 4# was

damaged slightly as well. On the other hand, the appearances of RTV 1# and RTV 2# were still smooth after 4000-hour water absorption test.

Test results show that water absorption process has greater impact on the performance of RTV coating than permeability process.



RTV 1# RTV 2#

RTV 3# RTV 4#

Fig. 7 Microstructure of samples after 4000 h test

It could be seen in microstructures of RTV 1# and RTV 2# that these two RTV samples performed relatively well during the tests whereas RTV 3# and RTV 4# were damaged, which demonstrates that not all RTV coatings could survive the high humidity environment, especially long-term soaking by rain.

4. CONCLUSIONS

Permeability of water has influences on the interfaces of RTV silicone rubber and RTV coatings is presumably peeling off after long-term service in South China with high humid and high temperature environment.

Water absorption process has greater impact on the performance of RTV coating than permeability process, which demonstrates that not all RTV coatings could survive the high humidity environment, especially long-term soaking by rain.

It is recommended that a series of test procedures should be specified for RTV coatings to be used in high humidity areas to test its resistance to water absorption and permeability.

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