ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume XI (XXI), 2012, NR1

ELEMENTS REGARDING THE ANALYSIS OF SILICONE RUBBER CHARACTERISTICS OBTAINED FROM USED TILE OF ELECTRICAL COMPOSITE INSULATORS

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Keywords: silicone rubber, recovery, microscopy, SEM, AFM.

Abstract: The paper presents techniques and methods for analyzing the surface topography and microstructure examination of silicone rubber recovered from composite electrical insulators. There are presented AFM and SEM microphotograps with structural maps of material surfaces, different representative microstructure sections taken at different penetration depths and optical zoom levels. There are also presented the characteristics of the recovered silicone rubber.

1. INTRODUCTION

Silicone rubber is a polymer from the group of elastomers, having a series of special physical properties, among which:

- Resistance to dry temperature exposure up to 2000 C
- Flexible in the temperature range -600 .. 900 C
- Elastic at both high and low temperatures
- Wear resistant
- Neutral from olfactory and gustatory point of view
- Resistant to external chemical agents
- Good recycling capacity
- Good thermal insulator

Silicone coated composite insulators (figure 1) are designed for mounting in 20kV aerial electrical lines. They offer several advantages, among which are:

- longer life span
- robustness and reduced specific weight
- low maintenance costs
- hydrophobic
- resistance to chemical and atmospheric wear

This led to the necessity of recovering the silicone rubber envelope after a certain usage time, in order to be used in different technological applications.

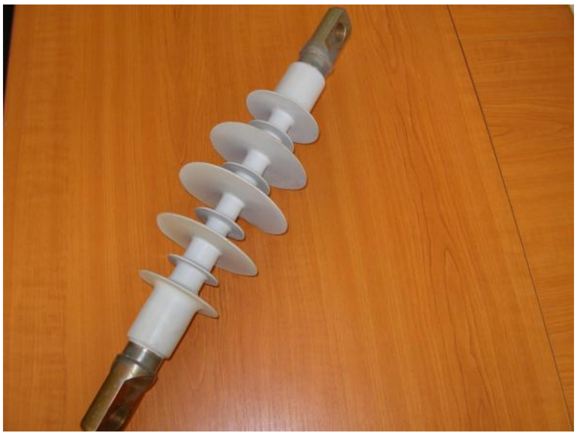

Figure 1. Composite electrical insulator

Silicone rubber is a composite material whose physical and chemical characteristics allow recovery only through mechanical operations, in order to maintain its original characteristics. As result of mechanical, physical and chemical operations, the following technological product was obtained in which the solid component of the used insulator coating (40%) was combined with a liquid additive (60%).

2. STRUCTURAL ANALYSIS OF RECOVERED SILICONE RUBBER

Among known modern structural analysis methods such as optical microscopy, electron microscopy, scanning probe microscopy, the most appropriate in the given case is the scanning electron microscopy (SEM) due to its penetration accuracy.

Another important advantage of SEM is the enhanced field depth at the same zoom level due to the narrowness of the electron beam. For this reason, the distance between the scanning tip and the probe must be taken into account: larger distance means narrow beam and higher field depth, while shorter distance gives wider beam and lower field depth.

For the characteristic analysis there were used teo technological products (figure 2,3) whose base structure is comprised of 40% solid component and 60% liquid component.

Figure 2, 3. Technological products obtained from recovered silicone rubber

For illustration there are presented some SEM microphotographs obtained for representative sections and investigation depths. The SEM material characterization was performed using a SEM – TESCAN VEGA 5136 LM device with EBL RAITH-ELPHY PLUS 3 nm resolution system.

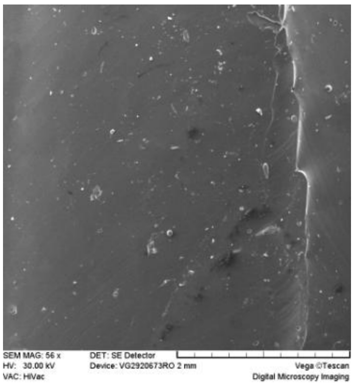

Figure 4. Electronic microphotograph, hinves=2mm, zoom 52x, product 1

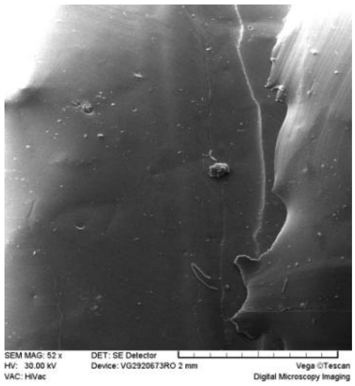

Figure 5. Electronic microphotograph, hinves=2mm, zoom 56x, product 2

By increasing the penetration depth there can be observed some defects in the material structure. The SEM analysis reveals the non-uniform character of the silicone rubber, increasing as the penetration depth gets higher.

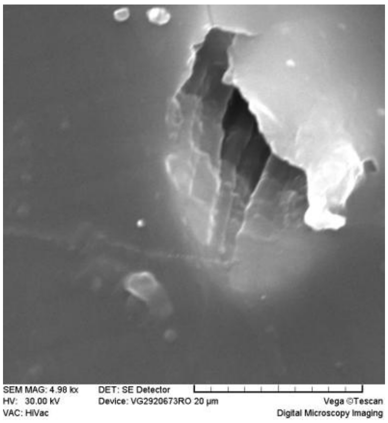

Figure 6. Electronic microphotograph, hinves=20μm, zoom 4980x, product 1

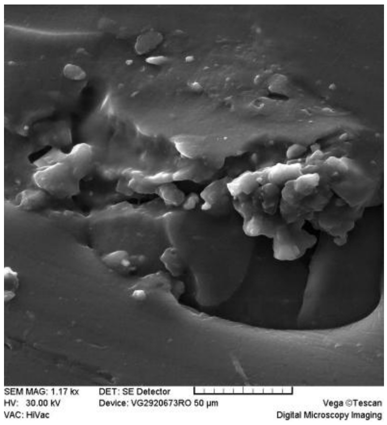

Figure 7. Electronic microphotograph, hinves=50μm, zoom 1170x, product 2

3. TOPOGRAPHY ANALYSIS OF RECOVERED SILICONE RUBBER SURFACE

The investigation was performed using Atomic Force Microscope (AFM), in which the sample surface is scanned by the cantilever-attached tip. The system is capable of detecting and measuring nN-level forces using optically assisted detection. The contact mode technique used based on the interaction between the individual atoms of the cantilever tip and the probe surface provides the morphological characterisation of the probe surface.

Figures 8,9 represent sample microphotograps of the surface microstructure for the two technological products.

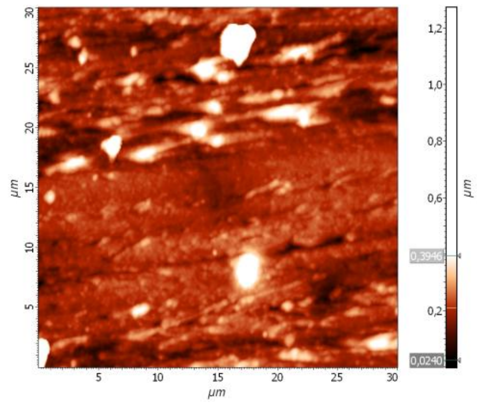

Figure 8. 2D microphotograph, penetration 30µm, sample 1

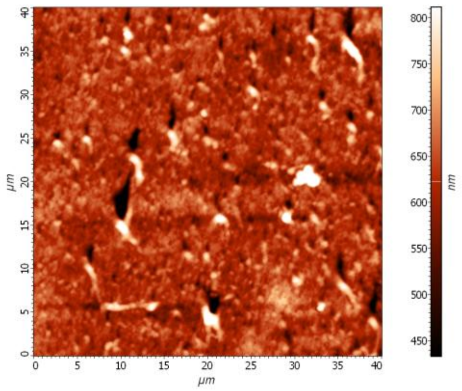

Figure 9. 2D microphotograph, penetration 40µm, sample 2

Contact mode AFM imagery provides information about placement and size of defects or surface anomalies present in the analyzed sample. Examples are presented in figure 10.

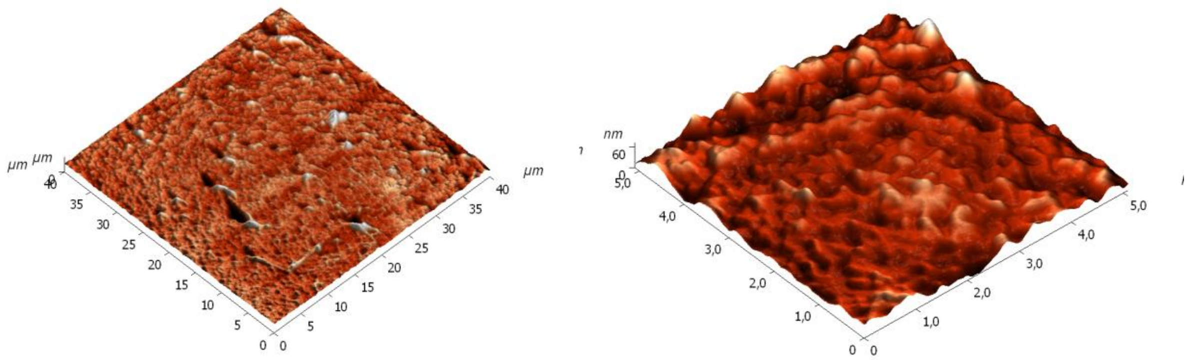

Figure 10. 3D microphotograph, penetration 5/40µm

The AFM analysis was performed under the following conditions: atmospheric, liquid, gas, controlled low vacuum (10-20 torr), work surface 100 x 100 x 10 µm, noise level XY: 0.3 nm, Z: 0.6 nm, closed-loop X-Y non-linearity ≤ 0.15%.

4. CONCLUSIONS

Taking into account the complexity and the structural particularities of silicone rubber, as well as the practical usage domain and the prospects of obtaining a significant quantity of recovered silicone rubber, the technological product was obtained in the first phase by mechanical stripping using specially designed devices, powdered into 1-3 mm granules and compacted using polyol polyether (Petol), methylene disocyanate (MDI) and dibutylamine (DBA).

In a second phase, the technological products were obtained based on a solid silicone rubber component recovered from composite electrical insulator coating (40%) and a liquid component (60%).

It can easily be observed the non-uniform characteristic of the silicone rubber structure as well as some defects in the structure of the analyzed material.

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