1998 IEEE International Conference on Conduction and Breakdown in Solid Dielectrics, June 22-25, 1998, Västerås, Sweden

AN INVESTIGATION on ELECTRICAL PROPERTIES of MEERSCHAUM

Hasbi Ismailoglu, Ozcan Kalenderli
Istanbul Technical University
Electrical & Electronics Faculty
80626 Maslak/Istanbul, Türkiye

Hülya Kuş
Royal Institute of Technology
Centre for Built Environment
S-801 02 Gavle, Sweden

ABSTRACT

Meerschaum is a mineral, hydrous silicate of magnesium, of organic origin. Composed of the fossilized shells of tiny sea creatures that fell to the ocean floor millions of years ago, meerschaum is found in red clay deposits. In this study, relative permittivity ε_r and dielectric loss factor tan δ of the meerschaum were measured as a function of sample temperature at alternating voltage, using Schering Bridge. The results, obtained on specimens of meerschaum, are reported and compared with those of well-known solid insulator materials.

INTRODUCTION

Solid dielectric materials are used in all kinds of electrical circuits and devices as insulators. A good dielectric should have low dielectric loss, high mechanical strength, should be free from gaseous inclusions, and moisture, and be resistant to thermal and chemical deterioration [1].

Solid dielectrics have higher breakdown strength compared to liquids and gases; but studies of the breakdown of solid dielectrics are of extreme importance in insulation studies. When breakdown occurs, solids get permanently damaged while gases fully and liquids partly recover their dielectric strength after the applied electric field is removed.

Insulation arrangements usually contain gaseous, liquid or solid insulating materials, e.g. for high voltages, whose breakdown strength is many times that of atmospheric air. For the practical application of these materials not only their physical properties but also their technological and constructional features must be taken into account [2].

The understanding of insulating materials and of insulating systems has been advancing on many fronts [3]. The latest trend is to develop different and new types of materials, and to determine properties of materials, used for various purposes. With this in view, the aim of our study is to determine some electrical properties of a natural material such as meerschaum, unknown as an electrical and thermal insulator.

Meerschaum is a German word meaning, sea-foam, and is widely used as gems material. Meerschaum deposits of the highest quality are found only in one place in the world - in Eskisehir in central Türkiye. And here the deposits are confined to a small area.

Mined with hand tools, and by men trained in this singular family tradition, meerschaum is excavated at depths ranging from 70 to 90 m. The miners wash the raw meerschaum lumps and sort them into six categories according to quality. Each of these six categories is further divided into sub-categories according to size, color, porosity and homogeneity of the mineral [4].

In this study, some electrical properties of meerschaum, such as dielectric loss factor and relative permittivity are measured, experimentally and reported.

EXPERIMENTAL

Experiments were carried out on pure specimens of meerschaum. Because of it was easy to work with the softened material, the split block-meerschaum was soaked in water for 15-30 minutes until the material achieves a cheese-like consistency. Then, test specimens were prepared from the split block-meerschaum, as uniform discs having diameters of 100 mm and thickness of 4 mm, approximately. And then, these specimens were dried in an oven at high temperature (~120°C), for about two hours, before the tests, to diminish the humidity of the samples.

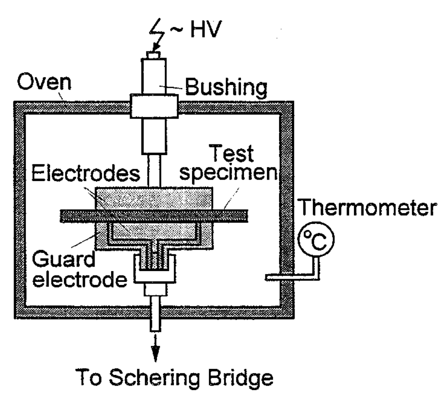

Fig. 1 Test arrangement.

In the experiments plane-plane electrode system was used (Fig. 1). The upper plane electrode had a diameter of 75 mm and a height of 15 mm with a well-rounded edge. And the lower one, surrounded by a ring guard electrode to eliminate electrode edge effect, was a 50 mm in diameter. The electrodes were made of brass. The specimens were sandwiched between the electrodes. This system was placed in a thermostatic oven, with dimensions of 500x400x400 mm, occupied with a thermostat, which can be used at the temperatures up to 250° C.

The upper plane electrode was connected to an ac 50 Hz voltage source. The lower plane electrode was connected to Schering bridge, and the guard electrode was earthed.

Specimen temperature was varied within the range of room temperature to 120°C, by an increment of ~20°C. At each temperature step, specimen was left for about one hour before measurements, to equilibrate the system respect to temperature. The temperature was measured with a thermometer with an accuracy of ~2°C.

At each temperature, dielectric loss factor and relative permittivity of meerschaum specimens were measured, to get the relations between these properties and temperature.

Measurements of dielectric loss factor and relative permittivity of meerschaum were made at 500 V_{rms} alternating voltage. The lowest measurement limit and accuracy for dielectric loss factor of the bridge, used in this study, were 10^{-6} and ±1%, respectively.

RESULTS and DISCUSSION

The relative permittivity ε_r and dielectric loss factor tan δ were measured as a function of sample temperature at constant alternating voltage, using Schering bridge.

The temperature dependence of ε_r and tanδ at 500 V_{rms} (50 Hz) of two different specimens of meerschaum are illustrated in Fig. 2 and 3. In these figures, curves (a) and (b) show results of preconditioned meerschaum samples at two different time periods, in order to stabilize the material properties. Curve (a) and (b) indicate results of the specimens held at ~120°C for 2 and 4 hours, respectively, before the tests.

The relative permittivity ε_r values of meershaum, given in Fig. 2, are obtained using the following relation.

$$\varepsilon_r = C_x/C_o \tag{1}$$

where C_x is specimen capacitance measured by Schering bridge and C_o is the capacitance of capacitor of the electrodes separated by vacuum, calculated from Eq. (2).

$$C_o = \varepsilon_o A/t \tag{2}$$

In Eq. (2) $\varepsilon_o = 8.854 \times 10^{-12}$ F/m, A is effective area of the electrodes with diameter of D,

$$A = \pi D^2/4 \tag{3}$$

and t is the specimen thickness.

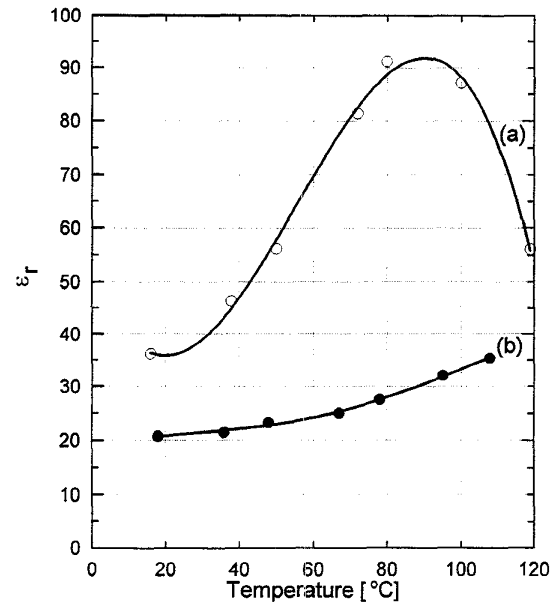

Fig. 2 Temperature dependence of ε_r of meerschaum.
(a) heat treatment at ~120°C for 2 hours,
(b) heat treatment at ~120°C for 4 hours.

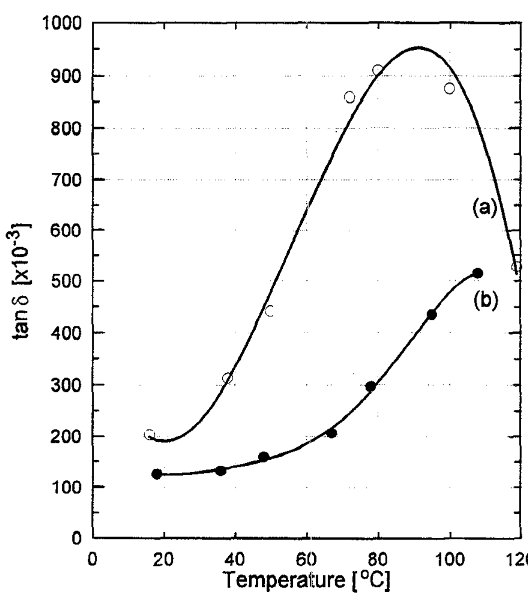

Fig. 3 Temperature dependence of tanδ of meerschaum.
(a) heat treatment at ~120°C for 2 hours,
(b) heat treatment at ~120°C for 4 hours.

Both of the relative permittivity and the dielectric loss factor increase rapidly with increasing temperature up to ~90°C and then decrease dramatically above this temperature, for specimen (a). On the other hand, these values, for the specimen (b), increase moderately with increasing temperature, in the range of the studied temperatures, without a maximum.

Dependence of permittivity of meerschaum on temperature can be attributed on ionic polarization mechanism. Due to this mechanism, relative permittivity ε_r increases with increasing temperature. In the low temperature region, the molecules of material cannot orient themselves. When temperature rises the orientation of dipoles is facilitated and this increases the permittivity. As the temperature grows the chaotic thermal oscilations, molecules are intensified and the degree of orderliness of their orientation is diminished. This causes the curve of ε_r to pass through the maximum and then drop. It was reached to this maximum at temperature about of 90° C, for specimen (a) (curve (a) in Fig. 2). On the other hand, for specimen (b), this maximum looks like to be at higher temperatures than the temperature range examined in this study.

Dielectric loss factor tanδ appreciably increases when temperature rises, due to the same mechanism as in ε_r explained above. The variation of loss factor with temperature is dependent on the sum of the dielectric losses and the losses due to electrical conduction.

CONCLUSION

Both of the relative permittivity and the dielectric loss factor of meerschaum increase rapidly with increasing temperature up to ~90°C and then decrease dramatically above this temperature, for the specimen dried at temperature of 120°C, at about 2 hours. On the other hand, these values, for the specimen dried twice at thistemperature, increase moderately with increasing temperature, in the range of the studied temperatures, without a maximum. These variations of permittivity and dielecric loss factor of meerschaum with temperature can be attributed on ionic polarization mechanism.

The dielecric loss factor of meerschaum is higher then those of well-known solid materials, especially at higher temperatures, its relative permittivity is also high. The volume resistivity of meerschaum used in our tests was about 5.10^7 Ω.m. Furthermore, it is resistant to thermal deterioration, beside it has high permittivity. Owing to high permittivity and thermal resistance may lead to put meerschaum into practical use, as a solid material.

It may be interesting to investigate physical, chemical, mechanical and other electrical properties of meerschaum.

LIST OF REFERENCES

[1] M.S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw-Hill Publishing C. Ltd., New Delhi, 1989.

[2] D. Kind, "High-Voltage Experimental Technique-Textbook for Electrical Engineers", Friedr. Vieweg & Sohn Braunschweig/Wiesbaden, 1978.

[3] H.J. Wintle, "Basic Physics of Insulators", IEEE Transactions On Electrical Insulation Vol.25, No.1, pp.27-44, February 1990.

[4] Turkish Standard, TS 9561,"Meerschaum-For Use as Gems Material", November 1991.