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LOW FREQUENCY DIELECTRIC PROPERTIES OF MARBLE

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Dielectric properties of some varieties of marble have been measured in the frequency range 0.5 – 100 kHz. The coloured varieties are found to have higher values of dielectric constant and dissipation factor as compared to white marble. The results are consistent with previously published data.

INTRODUCTION

Marble is found in different varieties in nature. Data on electrical properties of marble is meagre, and almost no data is available on electrical properties of marble found in Pakistan. Moreover, the published data on the dielectric properties of marble vary widely. The present work was undertaken to get information about the dielectric properties of marble.

MATERIALS AND METHODS

Marble slabs of different colours are obtained from the market. The disc-shaped specimens were cut from the slabs. The surfaces were made smooth and parallel to fill the sample holder. The final thickness of white, green and brown sample is 180.6, 184, and 148.6 mils* respectively. All the specimens were 5.08 cm in diameter. All the samples were placed in an oven at 80^{0} for two days to make them dry. They were then cooled and silver painted for good electrical contact and for avoiding any moisture absorption during measurements.

The sample holder [1] is formed of two circular electrodes. The surfaces of these electrodes are optically ground to be plane within a few wavelengths (as claimed by the manufacturer). A precision-ground micrometer screw drives the movable grounded electrodes with respect to the fixed insulated electrode. The screw adjustment is a convenient size instrument-type knob, in contrast to the small thimble employed in the usual machinist's micrometer commonly employed for this purpose. The spacing of the electrodes is indicated by the large legible calibration on the drum. The smallest division is one-half mil, with 1/10th mil easily readable. The micrometer screw is electrically shunted by a flexible copper bellows to assure low and constant resistance and inductance in the current path to the movable electrode. The lower electrode is supported in position by VYCOR insulator, which are well away from the field between the electrodes.

A unique feature of the design is the method of driving the movable electrode. A spring-loaded drive is used so arranged that, when movable electrode comes into full contact with the specimen (or the bottom electrode) the drive disengages. Two important results are achieved by this design feature; (i) the movable electrode assumes the plane of the top surface of the specimen, thus assuring best possible contact even if the faces of the specimen are not rigorously parallel, and (ii) straining of the micrometer screw is avoided since the drive disengages at a predetermined pressure.

The electrode assembly is mounted in a rugged aluminum casting, which shields the assembly on four sides. The shielding is completed by two aluminum wide panels which can be swung out of the way to insert and remove the specimen.

A GR capacitance measuring assembly type 1610-A with 716-C capacitance bridge of General Radio and 1690-A dielectric sample holder was used to measure the capacitance and dissipation factor of the sample by using substitution method [2]. The bridge has an accuracy of ±0.2% or ±2PF, whichever is larger, for capacitance and ±0.00005 or ±2% of the change in dissipation factor, when the change is less than 0.06.

RESULTS AND DISCUSSIONS

The values of dielectric constant and dissipation factor versus frequency are shown in Figs. 1 – 3. The salient features of the graphs are:

1. The dielectric constant and dissipation factor of all the three varieties decreases with increasing freqency.
2. The coloured marbles have higher values of dielectric constant and dissipation factor than that of white marble.
3. Brown marble is more sensitive to frequency as compared to other two varieties of the marble.

*1mil = 2.54×10^{-3} cm.

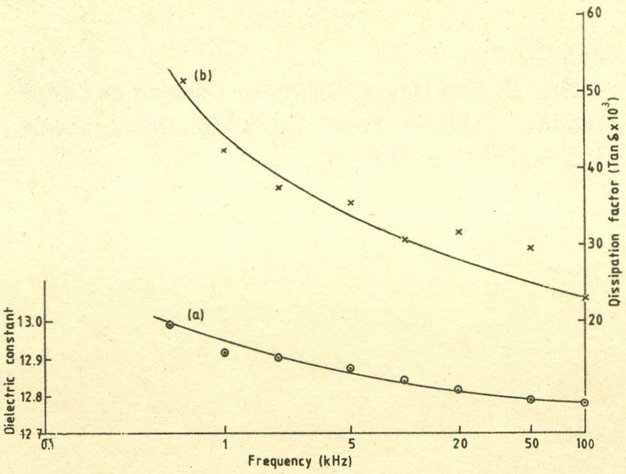

Fig. 1. Frequency dependence of (a) dielectric constant (b) dissipation factor for white marble.

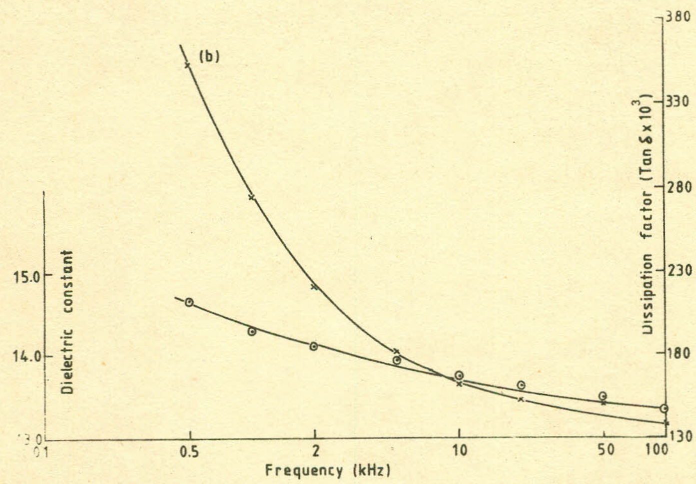

Fig. 2. Frequency dependence of (a) dielectric constant (b) dissipation factor for green marble.

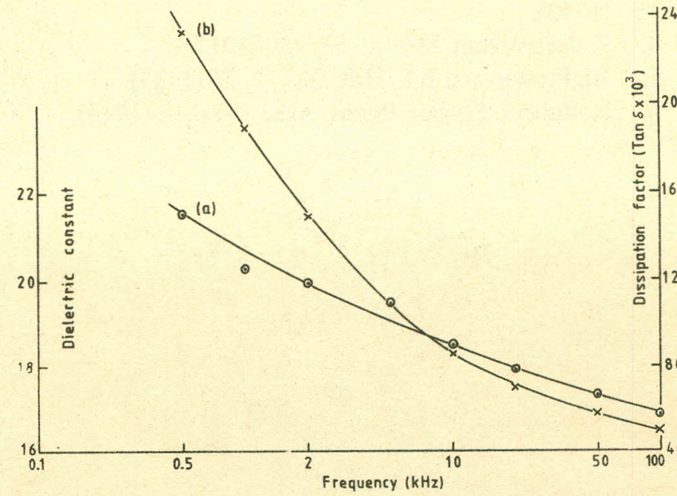

Fig. 3. Frequency dependence of (a) dielectric constant (b) dissipation factor for brown marble.

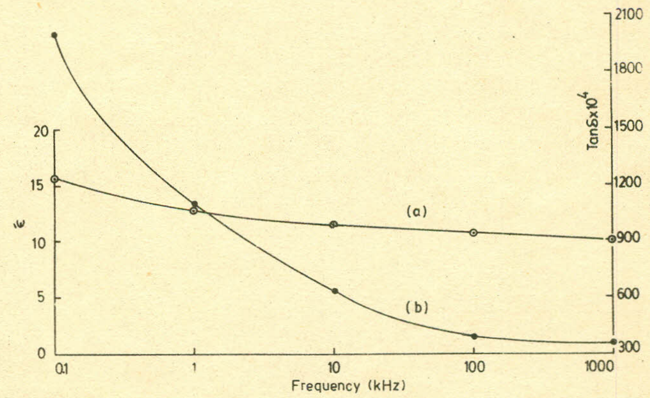

Fig. 4. Frequency dependence of (a) dielectric constant (b) dissipation factor for marbel, after Von Hippel.

Although all the three varieties of the marble considered here show the same response to frequency yet the change in dielectric constant and dissipation factor of white marble is very small as compared to the other two samples. The dielectric constant and dissipation factor of green marble lies in between the dielectric constant and dissipation factor of white and brown marbles whereas the brown variety has the highest values of dielectric constant and loss tangent, which may be attributed to the impurities developing the colours in marble. There is a marked effect of frequency on the behaviour of dielectric constant and dissipation factor of brown marble. The change in dielectric constant of brown marble, as we proceed from 0.5 – 100 kHz frequency is about twenty-there times more than that of white marble and about three-and-half time more than that of green marble.

According to Scott [3] coloured marbles have higher dielectric constants and power factors than the white marbles. However, he has not given any explanation for this behaviour. The samples studied here also show this behaviour thus confirming the earlier work. Scott has also reported that the results of Jaeger [4] and Preston and Hall [5] show that dielectric constant of marble does not change with frequency but the results of Rubens [6] indicate that the dielectric constant of marble increases with frequency. Scott [3], however, found that the dielectric constant of marble decreases with frequency. Von Hippel [7] has also given the values of dielectric constant showing a decrease with increasing frequency which is also verified with the present data. The results of Von Hippel [7] are also shown graphically in Fig. 4 for comparison.

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