THE DIELECTRIC CONSTANT OF MICA.

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SYNOPSIS.

Dielectric Constant of Mica.—The constant was determined for 18 samples of mica, varying in thickness from 0.005 to 0.073 inch and including 12 different grades. Each sheet was placed between two mercury electrodes and the capacity of the condenser thus formed was determined with a shielded capacity and conductance bridge using alternating current at 1,000 cycles per second. It was found that while thick sheets with plainly visible air films had low dielectric constants, those without such films gave fairly consistent results, running from 6.4 to 9.3 with an average of 8.1. When a thick sheet was split, the thinner sheets had higher constants except in the case of a sample of Canadian amber.

Power Loss in Mica Condensers was too small to determine accurately with the apparatus used, but was higher for stained than for clear micas.

IN looking for an average value of the dielectric constant of mica in the handbooks of the Physical Constants of materials such as, the Smithsonian Tables, Kays and Laby, Chemiker Kalender, and Landolt-Börnstein, the writer was impressed with the wide variations found by different investigators. The values given in these reference books varied from 2.5 to 10. It seemed likely that at least a part of this large variation might be due to air pockets or films between the various laminæ, especially since most of these low values were found on rather thick sheets. The high values, on the other hand, might be due to conducting films between the laminæ increasing the effective area of the electrodes. Therefore, it was decided to measure the dielectric constant of different grades of mica, and especially those grades used by other investigators, with a view of making an accurate determination of the dielectric constant and of finding, if possible, the causes of these wide variations.

Accordingly 18 samples of mica of varying thicknesses were obtained, including 12 different grades. Unfortunately it was impossible to obtain all of the grades for which other investigators had given low values. These grades apparently do not reach the New York market (India micas). It was possible, however, to get mica of the same thicknesses as were used in these other investigations. The samples were numbered from 1 to 18. The subscripts A, B and C denote thin sheets split from the original sheet after the first measurement was made.

METHOD.

Most of the sheets did not require cutting, but where necessary the sheet was clamped between brass plates and carefully cut to $3\frac{1}{4} \times 2\frac{1}{2}$ inches with a sharp knife. The sheet of mica was floated upon a copper plate amalgamated with mercury which served as the bottom electrode. This plate was grounded. The top electrode consisted of a hollow brass rectangle $1\frac{7}{8} \times 2\frac{5}{8} \times \frac{1}{4}$ inches high. This rectangle was placed in the center of the sample and filled with mercury.

The capacity of the condenser thus formed was measured with alternating current at 1,000 cycles per second by a shielded [1] capacity and conductance bridge which had been checked against condensers calibrated by the Bureau of Standards. The thickness of the sheet between the electrodes was measured with an accurate micrometer, measuring to 0.0001 inch. Wherever the original sheet was thick enough, it was split into thinner sheets along its natural lines of cleavage and each of these measured as above. Considerable difficulty was experienced in preventing air pockets from forming between the mercury and the sheet on the under side. Every effort was made to reduce to a minimum the errors introduced by these air pockets and in each case the highest obtainable capacity reading was taken as the correct one. The individual capacities varied from 100 to 1,200 mmf. Over this range of capacity the bridge error was less than 1 per cent.

The results of these measurements are given in Table I. There is a probable error not greater than minus 5 per cent. due to air films between the electrodes and the sheet. Check readings given for samples of Madras green 5–*A* and 5–*B* show how closely it was possible to duplicate readings. The sample 5 having a dielectric constant of 2.9, was very badly split and the various laminæ were quite noticeably separated. However, thin sheets split from this sample had dielectric constants of 6.6 to 8.4. It was this effect, namely a thick sheet having a low dielectric constant (due to air films) while thin sheets split from it had a high dielectric constant, which undoubtedly caused the low values given by others. Sample 17 further illustrates the above point. It had a dielectric constant of 4.8 while thin sheets split from it had dielectric constants of 8.4 and 8.6.

While some sheets having plainly visible stains did have a dielectric constant somewhat higher than the average, there was no such pronounced effect as that shown by air films. None of the sheets, however, was badly stained. Sheets 7, 8 and 9 were the only ones having stains

[1] G. A. Campbell, Elect. World and Eng., Vol. XLIII, pp. 647, 1904.

which looked at all like continuous films. These sheets had dielectric constants a little higher than the average value of 8.1.

TABLE I.

Sample.	Thickness Inches.	Dielectric Constant.	Material.
1.............	.0273	7.9	Madras brown
1-*A*...........	.0134	7.9	" "
1-*B*...........	.0143	8.4	" "
2.............	.0165	8.7	" "
3.............	.0218	8.7	Madras ruby
4.............	.0534	8.1	Canadian amber
4-*A*...........	.0270	8.0	" "
4-*B*...........	.0142	7.3	" "
4-*C*...........	.0071	6.4	" "
5.............	.0274	2.9	Madras green
5-*A*...........	.0045	7.0(6.6)	" "
5-*B*...........	.0048	8.0(7.9)	" "
5-*C*...........	.0064	8.4	" "
6.............	.0232	8.0	" "
7.............	.0122	9.3	Indian brown stained
8.............	.0052	8.4	" " "
9.............	.0065	8.9	" " "
10............	.0060	8.6	Ruby—source unknown
11............	.0031	7.2	Clear—source unknown
12............	.0286	8.1	Argentine clear
12-*A*..........	.0076	8.0	" "
13............	.0294	7.4	Brazilian stained
13-*A*..........	.0104	8.1	" "
13-*B*..........	.0190	8.2	" "
14............	.0158	8.6	Brazilian clear
15............	.0643	6.6	Argentine stained
15-*A*..........	.0113	8.0	" "
15-*B*..........	.0117	5.9	" "
15-*C*..........	.0068	7.7	" "
16............	.0674	5.6	Indian brown clear
17............	.0736	4.8	" " "
17-*A*..........	.0122	8.6	" " "
17-*B*..........	.0097	8.4	" " "
18............	.0233	8.4	Argentine clear
18-*A*..........	.0088	8.8	" "

Samples 5, 15-B, 16 and 17 had visible air films.
Samples without visible air films—Average 8.1
Maximum 9.3
Minimum 6.4

The phase angle also was measured, but the bridge readings were too small to make an accurate determination possible. The phase angle readings showed that stained sheets had higher losses than clear sheets.

CONCLUSIONS.

1. When air films in the interior of the sample of mica were eliminated by splitting it along its natural lines of cleavage into thin sheets, in no case was the dielectric constant less than 6.4.

2. Where air films were plainly visible, the dielectric constant was low (2.9 to 4.8).

3. It seems likely that the low values given by some investigators undoubtedly were due to air films between the laminæ. These air films were in most cases very hard to see without carefully examining the edges of the sheets.

4. Stained sheets did not show a dielectric constant enough higher than the average value of 8.1 to determine the effect of stains in mica upon the dielectric constant.

5. No difference in the dielectric constant is readily discernible between the different grades or kinds of mica which were tested.

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