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VARIATION OF THE DIELECTRIC CONSTANT OF DIMETHYL SILICONE WITH TEMPERATURE

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Although the polysiloxanes constitute a relatively new family of synthetic compounds, research into the chemical and physical characteristics of these polymers has already produced a considerable body of published literature.

Liquid dimethyl polysiloxanes have received much of the attention directed toward the polysiloxane group. These materials are distinguished by tetravalent silicon atoms, each of which is linked to two methyl groups and two oxygen atoms, the oxygen-silicon linkages forming a chain molecule analogous to the carbon-carbon linkages of the hydrocarbon oils.

This investigation was undertaken as part of a joint research agreement between the Physics Department of Southern Illinois University, and the Sangamo Electric Company, Capacitor Division, at Ordill, Illinois. Its aim was to obtain information concerning the physical properties of dimethyl silicone oils which would be of use in determining the advisability of utilizing them as impregnating compounds for oil-impregnated capacitors. Three viscosities, 20 centistoke, 50 centistoke, and 350 centistoke, were selected as offering more promise than other viscosities for use as impregnating compounds.

Silicone oils manufactured by the Dow Corning Corporation of Midland, Michigan, were used. All measurements were made at 1000 cycles per second, because information released by the manufacturer indicated that there was no appreciable change in the dielectric constant with variations in frequency below frequencies of the order of 10^8 cycles per second, frequencies beyond the range of most "high frequency" laboratory equipment, and far outside the range of standard equipment. The temperature range investigated extended from—73°C. to 160°C.

The apparatus consisted of a General Radio Type 716-C capacitance bridge, with a General Radio Type 722-M precision condenser, a General Radio Type 1302-A oscillator as source, and a General Radio Type 1231-B amplifier and null-detector. Measurements above room temperature were taken with a Sargent 850-watt electric oven. Measurements below room temperature were taken with dry ice and a dry ice-acetone mixture as cooling agents. A capacitance test cell, constructed according to standards set up by the American Society for Testing Materials, was used for the capacitance measurements.

The "substitution method" was used with the bridge. The bridge is first balanced without the unknown capacitor. Then the unknown is connected in parallel with the balancing capacitor of the bridge, and the bridge again balanced. The capacity of the unknown is given by the difference between the first and second settings of the balancing capacitor of the bridge.

The maximum possible error of the bridge when the substitution method is used is 2 micro micro farads. However, with the use of a correction chart, this may be reduced to 0.5 micro micro farad, making a maximum error of 0.8 percent. If a conservative estimate of the maximum error introduced by a temperature measurement error is added to this, the total maximum possible error is one percent. In determining the dielectric constant of the oil, the capacitance of the test cell, filled with oil, is divided by the capacitance of the cell, with air as the dielectric. (The capacitance in air may be taken as the capacitance in vacuum, because the dielectric constant of air is 1.0006 under standard conditions of temperature and pressure.) If there were an error in the determination of the value of the capacitance of the test cell in air, this error would show up in the experimental curves as a constant vertical displacement.

The experimental values for room temperature agreed well with the published values, in fact, well within one percent. There was a small amount of data available over the temperature range 25°C. to 145°C. This material also checked well with the experimental results. The values for the dielectric constants over the range 145°C. to 160°C. and —73°C. to 25°C., however, represent, as far as available sources are concerned, new information.

Two sets of data were taken for each oil: one over the temperature range above room temperature, and one over the lower temperature range. A small overlapping of the two sets of data was obtained by preheating the test cell before it was placed in the cold chamber. The agreement between the two sets is good for 50 and 350 centistoke silicone. However, the disagreement between the two sets for 20 centistoke is only a difference of about one percent for the two points most widely separated—a difference well within the maximum possible difference of two percent.

The curves show a smooth variation over the entire temperature range studied. This is an interesting result, because mineral oils, which are widely used as impregnating compounds for oil-impregnated capacitors show a drop of about ten percent at their "freezing" point. The "freezing," or solidification point, of dimethyl silicone oil varies with the viscosity, but for the oils investigated it lies within the —40°C. to —60°C. temperature range.

In conclusion, from the point of variation of dielectric constant with temperature, the silicones seem promising as an impregnating compound for oil-impregnated capacitors that would be used in installations subjected to wide ranges in temperature.