Dielectric Dispersion of Copper Sulphate Pentahydrate Crystals

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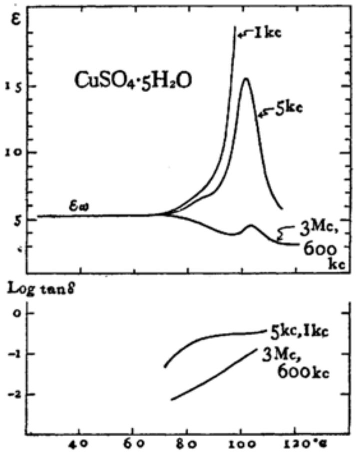
Temperature dependences of the dielectric constants and losses of copper sulphate pentahydrate single crystals perpendicular to their ω $(1\bar{1}\bar{1})$ planes have been measured from −180° to 120°C and at frequencies between 300 c and 3 Mc.

In order to approach to equilibrium conditions under the water vapour pressures for given temperatures, we put a considerable amount of the crystal grains in the bottom of the glass cell, thus we were able to obtain reproducible values up to 96°C which coincides with the dehydration temperature.

At temperatures higher than about 70°C, there is a distinct dispersion of the dielectric constants. Up to 96°C they decrease gradually at higher frequencies (600 kc and 3 Mc). The



Dielectric Dispersion of Copper Sulphate Pentahydrate Crystals values are 5.36 at 20° and 4.0 at 95°C. In this frequency region, we have obtained the same values for several specimens, therefore, this fall must be of an essential nature of this crystal. At lower frequencies (500 c to 5 kc), on the contrary, the higher the temperature, the larger is the dielectric constant. In this frequency region, however there has been found no saturation phenomenon and also no loss maximum.

The dielectric constants increase rapidly when dehydration occurs. Such a phenomenon is common in many dehydration processes of hydrated crystals, and this is originated mainly from the proton-conduction in the absorbed layer of dehydrated water molecules on the crystal surfaces.

The reason of the dispersion phenomenon below the debydration temperature may be attributed to the orientation polarization of the fifth water molecule of this pentahydrate. This water molecule is linked with other water molecules by hydrogen bonds as shown by the determination of crystal structure, and resembles to the molecules in ice. Other four water molecules coordinated directly to the copper ion do not contribute presumably to the orientation polarization.

Next, the reason of the gradual fall of the dielectric constants at higher frequencies must be the diminution of protonic polarization caused by the expansion of the crystal lattice as the temperature rises. Such a protonic polarization may have a larger value when a proton is forming a hydrogen bond between two oxygen atoms than simply in a hydroxyl radical. When the strength of a hydrogen bond is weakened by the lattice loosening at higher temperatures, such an ionic nature of this hydrogen atom will decrease and a covalent nature of it will increase. Then, as the result of such protonic polarization, the dielectric constant at higher frequencies where no orientation polarization takes place falls down gradually with temperature.

Datails will be published in this Bulletin.

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