Electrical properties of attapulgite

S. LOKANATHA, S. BHATTACHERJEE
Department of Physics, Indian Institute of Technology, Kharagpur 721 302, India

Attapulgite is a poorly crystalline fibrous clay mineral possessing several useful physical properties which result from its peculiarity of shape and structure. Because of its useful properties, the mineral has found wide application in industry. One of its potential commercial uses may be as insulating material like asbestos. It is well known that the dielectric constant and electrical conductivity are the two most significant parameters in determining the electrical behaviour of a mineral [1]. It appears from available literature that no serious attempt has so far been made to conduct an in depth study of the electrical properties of this potentially useful mineral. In view of this fact, an attempt has been made to study the temperature and frequency variations of the electrical properties of an attapulgite sample.

A specimen of attapulgite from Florida supplied by the Clay Mineral Society, source clay (USA) was used in the present work. The results of chemical analysis and preliminary structural work have already been communicated [2]. Thin circular pellets of diameter 1 cm and thickness 0.2 cm were prepared from a fine powder sample sieved through a 325 mesh screen, and hot pressed under a pressure of about 3.9 N m⁻² to maximum compaction in order to avoid moisture and air gaps [3, 4].

The dielectric measurements were carried out on a precision capacitance bridge (GR 716) in the frequency range 10² to 10⁶ Hz, and on a Marconi circuit magnification meter (TF 329 G) in the range 10⁵ to 10⁷ Hz by applying the resonance curve method [5]. Temperature variations of d.c.

![Figure 1 Variation of dielectric constant (K) and loss (tan δ) with frequency.](image)
conductivities were measured under dynamic condition by adopting a method similar to that of Bhuniya [6]. As the sample is highly hygroscopic due precautions were taken to avoid the moisture effect [4].

Results of the investigations are illustrated in Figs. 1 to 3. It is seen that both dielectric constant \( K \) and loss \( \tan \delta \) decrease in general, with frequency having relatively large values at lower frequencies (Fig. 1). The values of \( K \) and \( \tan \delta \) at \( 10^6 \) Hz are found to be 6.8 and 0.24 respectively, which are quite comparable with those of amphiboles [1, 3]. However, both \( K \) and \( \tan \delta \) decrease with temperature up to \( 150^\circ \) C; thereafter remain constant up to around \( 300^\circ \) C, beyond which both increase again with rise in temperature (Figs. 2a and b). Temperature variations of a.c. and d.c. conductivities above \( 150^\circ \) C are shown in Fig. 3. Both the conductivities follow the same pattern of temperature variation. However, the values of \( \sigma_{a.c.} \) at all temperatures are more than the corresponding \( \sigma_{d.c.} \) values as expected due to the contributions of various types of polarization [7]. Like \( \sigma_{a.c.} \), \( \sigma_{d.c.} \) also increases above \( 300^\circ \) C when the coordinated or bound water escapes from the sample as revealed by differential thermal analysis (DTA) [2]. The value of the activation energy in the intrinsic range is found to be \( \sim 2.5 \) eV.

We know that when a solid is placed in an electric field, the movement of charged defects and their accumulation at the interfaces of the sample and the electrodes, in addition to the various types of polarization, will play a dominant role. In fact the frequency variation of \( K \) in different ranges will be indicative of the type of polarization present. It is also well established that attapulgite is characterized by several types of water which escape at different temperature as revealed by DTA. These waters also play a dominant role and therefore the high values of \( K \) and