

ON A PROBABLE QUANTUM MECHANICAL EFFECT ON MAGNETIC ANISOTROPY OF THE MAGNETO-ELECTRET STATE OF CARNAUBA WAX AS A FUNCTION OF THE FORMING FIELD

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The existence of preferred alignment of molecules in the magneto-electret state can be obtained from a study of magnetic anisotropy. In the present paper, variation of magnetic anisotropy of a magnetically polarized sample of carnauba wax as a function of the forming field is reported. The pulsating nature of the experimental curve suggests the existence of a quantum mechanical effect inherent in the phenomenon.

1. Introduction

In general, if a substance containing permanent electric dipoles or magnetically anisotropic molecules is placed under the influence of an electric or magnetic field an orientation effect is expected. Such orientation may, under suitable circumstances, produce induced magnetic anisotropy. In an earlier paper the dependence of magnetic anisotropy of carnauba wax thermo-electret on forming electric fields has been reported. In this paper, new evidence of the variation of magnetic anisotropy of carnauba wax magneto-electret prepared under different field strengths is given. This finding evidently confirms the reality of an ordered array of molecules in the magneto-electret state.

2. Preparation of magneto-electrets and the method of measurement of magnetic anisotropy

The magneto-electrets were prepared under various forming field strengths by the simultaneous application of heat and a magnetic field. The magnetic field was applied at a temperature slightly above the melting point of wax. The field was varied from 3.6 to 16.6 Kilo-Oersteds. For the measurement of magnetic anisotropy, small cubes (with sides of 4 to 5 mm) were carved out of the polarized specimens in such a manner that two opposite surfaces of the cube were perpendicular to the superimposed polarizing field.

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The cubical specimen was specially used to avoid any shape anisotropy. The measurement of the diamagnetic anisotropy of the specimen was then carried out by a modified Krishnan [1] method with the axis of suspension perpendicular to the direction of the forming field.

3. Results of measurements and discussion of the results

Fig. 1 illustrates the relationship between the induced magnetic anisotropy and the polarizing magnetic field. It is found that during the initial stage the magnetic anisotropy increases with the rise of the forming field but subsequently indicates an oscillatory nature

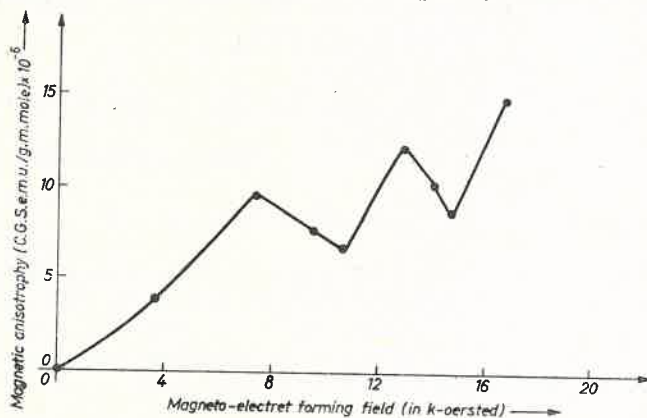


Fig. 1. Dependence of magnetic anisotropy of a magneto-electret of carnauba wax on electret forming magnetic field

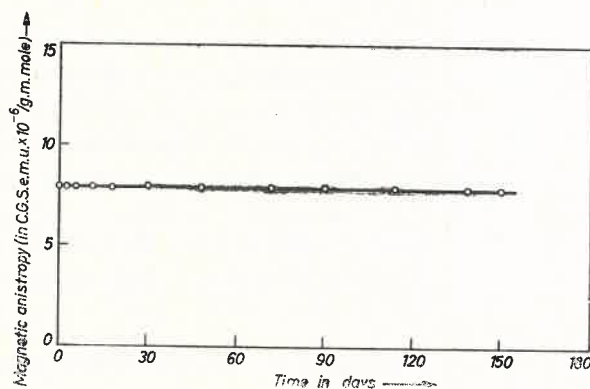


Fig. 2. Magnetic anisotropy versus time plot of a magneto-electret of carnauba wax

somewhat resembling the fluctuating magnetic susceptibility of bismuth at low temperatures in the De Haas Van Alphen effect [2]. In order to ascertain whether such magnetic anisotropy exhibits any variation with time, the measurements were carried out intermittently over a period of five months for a piece of magneto-electret polarized at a pre-determined field (~ 9 Kilo-Oersted). Fig. 2 clearly demonstrates that magnetic anisotropy remains unaltered in a magneto-electret.

It is well known that the diamagnetic anisotropy of any molecular crystal is due to the cumulative anisotropy of the individual molecules and to their orientation in the crystal. McMahon [3] detected an anisotropic increase in the dielectric constant of nitro-wax solidified under a magnetic field. He attributed it to the diamagnetic anisotropy of molecules. Dealing with chemical compounds Gallico and Mayr [4] found that if anisotropic compounds are allowed to crystallize in a magnetic field they tend to assume a preferred orientation with the direction of the largest algebraic susceptibility aligning itself parallel to the applied field. Neél [5] found the development of preferred direction of magnetization and induced anisotropy in the cases of cold working magnetic annealing and magnetic quenching. Following Selwood [6] one may reasonably assume that carnauba wax being essentially an open chain structure is likely to possess diamagnetic anisotropy and as such would be affected by an external magnetic field. In the molten state of the dielectric, as the magnetic field is applied, the molecules are oriented maintaining the direction of maximum susceptibility along the field. Since the degrees of freedom of thermal agitation are minimised in the solid state at room temperature at which the magneto-electrets are stored, the regular array of molecules get more or less fixed. This gives rise to fixed values of magnetic anisotropy. Fig. 2 emphasises the fact that the alignment of molecules is more or less rigid and unaffected by environmental causes. To interpret the pulsating nature of magnetic anisotropy as depicted in Fig. 1 the role of "free" electrons whose existence has been envisaged by Chatterjee et. al [7] may perhaps be taken into consideration. It is known that the effect of a magnetic field upon randomly moving electrons is to cause them to move in spiral paths. In the quantum theory the projections of the spiral paths upon a plane perpendicular to the lines of force represent circular periodic motions which must satisfy quantum conditions. These result in the electron suddenly changing its orbit when the field is excited. The different peaks observed in Fig. 1 may perhaps be attributed to the transitions of the electrons from lower energy states to higher energy states in a succession of jumps as postulated in Bohr's theory of atomic spectra. Unfortunately, our explanation of pulsating magnetic anisotropy does not appear to be convincing. Any other cogent explanation of the phenomenon would be most welcome. Meanwhile the experiment is being repeated with pure organic materials whose chemical structures are more well defined.

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