MAGNETIC ANISOTROPY OF NATURALLY OCCURRING SUBSTANCES.

I. Mother of Pearl.

BY P. NILAKANTAN, M.Sc.
(From the Department of Physics, Indian Institute of Science, Bangalore.)

Received November 11, 1935.
(Communicated by Sir C. V. Raman, Kt., F.R.S., N.I.)

7. Introduction.

The recent investigations of K. S. Krishnan and his collaborators have shown that in magne-crystallic action we have a powerful method of determining molecular orientations in crystals. When magnetically anisotropic molecules or ions are arranged regularly as they are in a crystal, the crystal also will show anisotropy, the magnitude of which will depend upon the orientation of the molecules in the crystal lattice. A correlation of the anisotropy of the crystal with that of the individual molecules enables the orientations of the latter to be calculated. The approximate molecular orientations in the naphthalene crystal were first determined by S. Bhagavantam by this method. Recently, accurate determinations of anisotropy for a large number of para- and dia-magnetic crystals, both organic and inorganic, have been made by Krishnan and his collaborators, and in some favourable cases such as biphenyl and dibenzyl, the orientations of the molecules have been determined with precision.

Just as a crystal is an aggregate of ions or molecules regularly arranged, there are naturally occurring substances which are known to be aggregates of minute crystals in a more or less regular arrangement. If the individual crystals are anisotropic, we should expect the substance also to show anisotropy, and we can employ Krishnan's method for determining the crystal orientations. One such substance is the nacre of iridescent shells. The magnetic properties of nacre have not been investigated quantitatively, although Nacken and others have observed its anisotropy in connection with the study of the differences between real and "culture" pearls. The latter contain a small spherical inner core of mother-of-pearl and as a consequence take up a definite orientation in a magnetic field unlike real pearls, which do not show any preferred orientation. The object of the present investigation is chiefly to determine the anisotropy of nacre quantitatively with a view to
gain some knowledge of its structure and thereby supplement what is already known from X-ray and optical studies.

2. Structure of Nacre.

It is well known that mother-of-pearl consists of minute crystals of aragonite arranged in thin layers and honey-combed in between an organic cementing medium called conchylolin. Aragonite is diamagnetic, and its magnetic properties are known both as regards its absolute susceptibilities along the three axes (Voigt and Kinoshita) and magnetic anisotropy (Krishnan). By examination under the polarising microscope, W. J. Schmidt has shown that the aragonite crystals are orientated in nacre with the c-axes normal to the elementary laminae. Recently, from a study of the diffusion haloes of nacre, Sir C. V. Raman has drawn attention to the structural differences in the shells of the three main classes of molluscs. These differences have been verified by Dr. S. Ramaswamy by X-ray analysis. He has found that while the c-axes of the crystals are orientated normal to the laminae in all the shells, the orientations of the a and b axes are different in the various shells, viz., a random orientation in Turbo and Trochus and a preferred orientation in Margaritifera vulgaris and Mytilus viridis. Evidence of twinning has been found in Nautilus pompilius, the twins being arranged symmetrically with respect to the lines of growth. In a more recent paper a preferred orientation has been found by the same author in the case of Haliotis also with however a very large error in orientation.

3. Determination of the Anisotropy of Nacre.

This was done by means of the method of oscillations developed by Krishnan. If $\chi_1$ and $\chi_2$ are algebraically the maximum and minimum values of the susceptibility along two perpendicular directions in the plane of oscillation of a body suspended by means of a quartz fibre in a uniform magnetic field, it will orientate itself with the $\chi_1$ axis in the field direction. If the torsion head is turned so that the torsion of the fibre is zero at this position, and if $T_1$ and $T$ are the periods of oscillation in and outside the field respectively, we have,

$$\chi_1 - \chi_2 = \frac{1}{m} \frac{c}{H^2} \cdot \frac{T^2 - T_1^2}{T_1^2}$$

$\chi_1 - \chi_2$ = Specific anisotropy in the plane of oscillation.

$c$ = Modulus of torsion of the fibre.

$m$ = Mass of the body.

$H$ = Field strength in Gauss.