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Oriented X-Ray Diffraction Patterns Produced by Hydrus Liquid Crystals

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April 20, 1948

IN the course of an investigation of the fine structure of hydrous fibrous liquid crystals, we have been able to obtain some x-ray photographs having a relatively high degree of symmetry. These patterns were obtained from samples of the "middle soap" phase of the system dodecyl sulfonic acid-water which had been oriented by a special thermal "annealing" process, essentially as follows:

A sample of the system is sealed in a thin-walled Pyrex glass capillary by a method previously described;¹ the capillary, in turn, is sealed in a glass tube which also contains a small amount of water (to prevent the capillary from bursting in the following step). The entire ensemble is then heated in an air thermostat to a temperature at which the system is an isotropic solution according to the phase diagram of M. J. Vold.² It is then allowed to cool slowly so that the fibrous liquid crystalline phase is

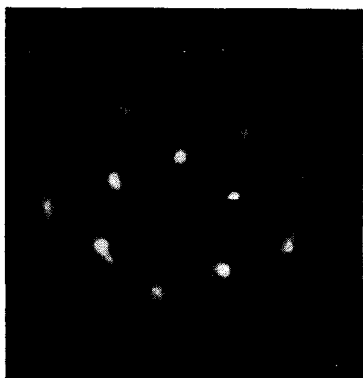


FIG. 1. 36.5 percent dodecyl sulfonic acid in water. "Middle soap" or hydrous fibrous liquid crystalline phase.

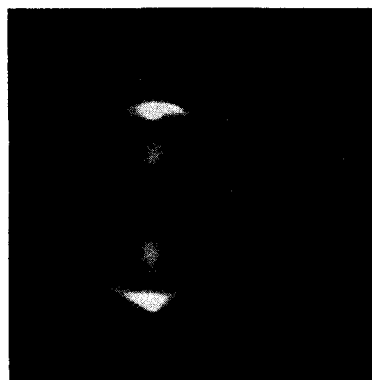


FIG. 2. 96.0 percent dodecyl sulfonic acid in water. "Superneat" or hydrous lamellar liquid crystalline phase.

reformed under conditions which allow relatively large, uniformly oriented masses to be established.

When the capillary was removed from the glass tube and viewed in the dark field of a polarizing microscope, most of the sample gave highly colored patterns, but small portions were observed to be light grey and uniform in texture. When these portions were photographed in an experimental set-up similar to that previously described,¹ they gave x-ray patterns similar to Fig. 1. The innermost set of six "spots" correspond to a Bragg spacing of 45.9Å, the next to 26.4Å, and the outer set to 23.0Å; these are in the ratio of $1:\sqrt{3}:\sqrt{4}$, which is the requisite condition for the two dimensional hexagonal arrangement of particles, previously found by Bernal and Fankuchen³ for certain aqueous systems of tobacco mosaic virus, and postulated by the authors for the middle soap phase of the system dodecyl sulfonic acid-water.⁴

A great similarity between the above photograph and the electron diffraction photographs of monomolecular films of soaps and fatty acids^{5,6} is evident, both with respect to the number of spots and their orientation relative to each other. In the monomolecular films the long molecules are arranged laterally in a two-dimensional hexagonal lattice; in the hydrous fibrous liquid crystal it is believed that long soap fibers are arranged hexagonally with respect to each other, with water or an "ionic atmosphere" in between these fibers.

It may be pointed out that oriented samples of the "superneat" or non-expanding lamellar phase of this same system give an entirely different sort of x-ray pattern, as illustrated in Fig. 2 (96.0 percent dodecyl sulfonic acid in water). The Bragg spacings are in the ratio of $1:\sqrt{4}$, and the "maxima of intensity" (rather than spots) are oriented perpendicular to the axis of the capillary, indicating that the lamellar colloidal particles are oriented parallel to the long axis of the capillary.

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