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NONAQUEOUS LYOTROPIC LIQUID CRYSTALS FROM LECITHIN AND NONIONIC SURFACTANTS

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(Submitted for Publication: 30 September, 1981)

ABSTRACT

Lyotropic liquid crystals were prepared from mixtures of lecithin and nonionic surfactants with the general formula polyethylene glycol dodecyl ethers with no low molecular solvents being added.

The repeat distance in the structure was reduced with increased amount of the nonionic surfactant showing complete penetration of the surfactants between the lecithin molecules.

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INTRODUCTION

Lyotropic liquid crystals by definition consist of an amphiphilic compound and a solvent. The latter modifies the structure of amphiphile from solid or liquid to liquid crystalline by changing the environment around the polar part of the amphiphile (1, 2). Numerous examples of such systems with biological importance (3) have been reported in which water serves as the solvent. The most conspicuous biological tissue with a lecithin/water lamellar structure is the central bimolecular layer of the biomembrane (4-6).

Nonaqueous lyotropic liquid crystals have also been reported. The well-known systems of polymers and nonpolar solvents (7, 8) and especially those with polypeptides (9) deserve mentioning. Recently our group (10-13) has found the first nonaqueous counterpart to the common aqueous systems with surfactants (14). The water in the lecithin/water structure was replaced by an organic hydroxo compound.

Among the compounds found to give nonaqueous liquid crystals were different chain lengths alkanediols (12), low molecular weight polyethylene glycols (13), different cellosolves (13) and some amines (13).

This result led us to expect the existence of liquid crystals from a combination of two amphiphilic compounds

but with no low molecular weight solvent being present. This communication will present such a structure.

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EXPERIMENTAL

Lecithin, chromatographically pure (12) was combined with tetra and hepta-ethylene glycol dodecyl ether (Nikkol, 98% tested by gas chromatography) to give liquid crystals at 25 and 35°C. Low angle X-ray reflections gave a characteristic repeat distance.

RESULTS AND DISCUSSION

The interlayer repeat distance is given in Fig. 1 as function of the nonionic surfactant/lecithin molecular ratio. The distance was reduced with increased nonionic surfactant content for both the investigated compounds.

We interpret these results as indicating a structure with the hydrophobic part of the nonionic surfactant being located between the lecithin molecules. Presumably, the polar part of the nonionic surfactant would serve as the solvent with a location close to the polar part of the lecithin. The tetra and hepta compound gave similar interlayer spacings.

The microscopic pictures in polarized light showed

the presence of lecithin crystals in the two-phase range with small amounts of nonionic surfactant. Under these conditions, the low angle X-ray data gave "anomalously" high values (Fig. 1) for the interlayer spacing.

We interpret this information as the initially added nonionic surfactant being located entirely between the lecithin layers. Penetration between the lecithin molecules can only take place at a minimum concentration of nonionic surfactant, indicating a cooperative effect of the local perturbation caused by the penetration.

Accepting this model, the reduced interlayer distance with increased ratio of nonionic surfactant (Fig. 1) and with increased temperature became reasonable and expected results.

CONCLUSIONS

A liquid crystalline phase was formed by mixing lecithin with a nonionic surfactant but with no low molecular solvent being present. It appears probable that the polar part of the nonionic surfactant served as a solvent, causing the necessary disorder of the lecithin polar group arrangement.

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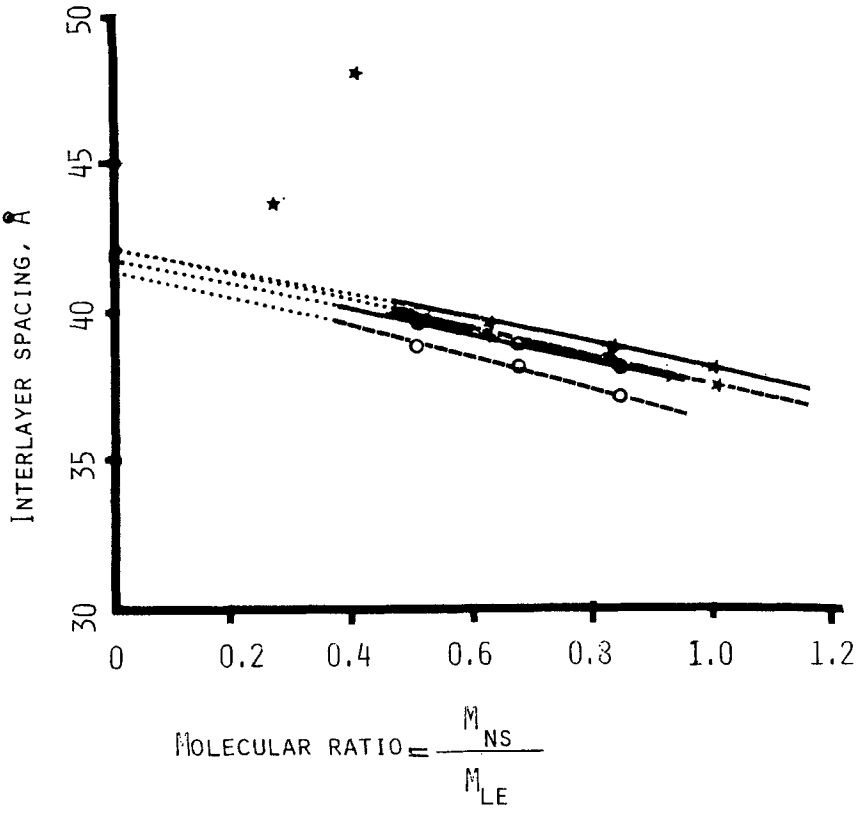

Fig. 1. The interlayer spacing versus nonionic surfactant/ lecithin molecular ratio

——— 25°C

- - - - - 35°C

* Tetra - ethyleneglycol - dodecyl ether

° Hepta - ethyleneglycol - dodecyl ether

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