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SINGLE CRYSTALS OF TOTALLY SYNTHETIC AMPHIPHILES, DIALKYLDIMETHYLAMMONIUM BROMIDES

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It has been shown by optical microscopy and X-Ray diffraction method that dimethylammonium bromides having two long alkyl chains (n=16, 18) form single crystals. This finding is the first example of the formation of single crystals of totally synthetic amphiphiles. The unit cell dimensions of the crystals of these compounds were similar to one another.

It is known that the lipid bilayer structure is an integral part of biological membranes and a detailed knowledge of their preferred molecular conformation and packing is essential for better understanding of the membrane assembly, architechture and properties. It has, however, been difficult to get single crystals of amphipathic lipids suitable for X-Ray structure analyses which could provide the most detailed and accurate information on molecular and crystal structures.[1)]

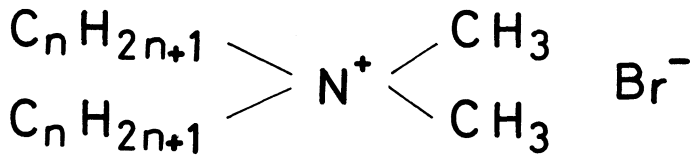
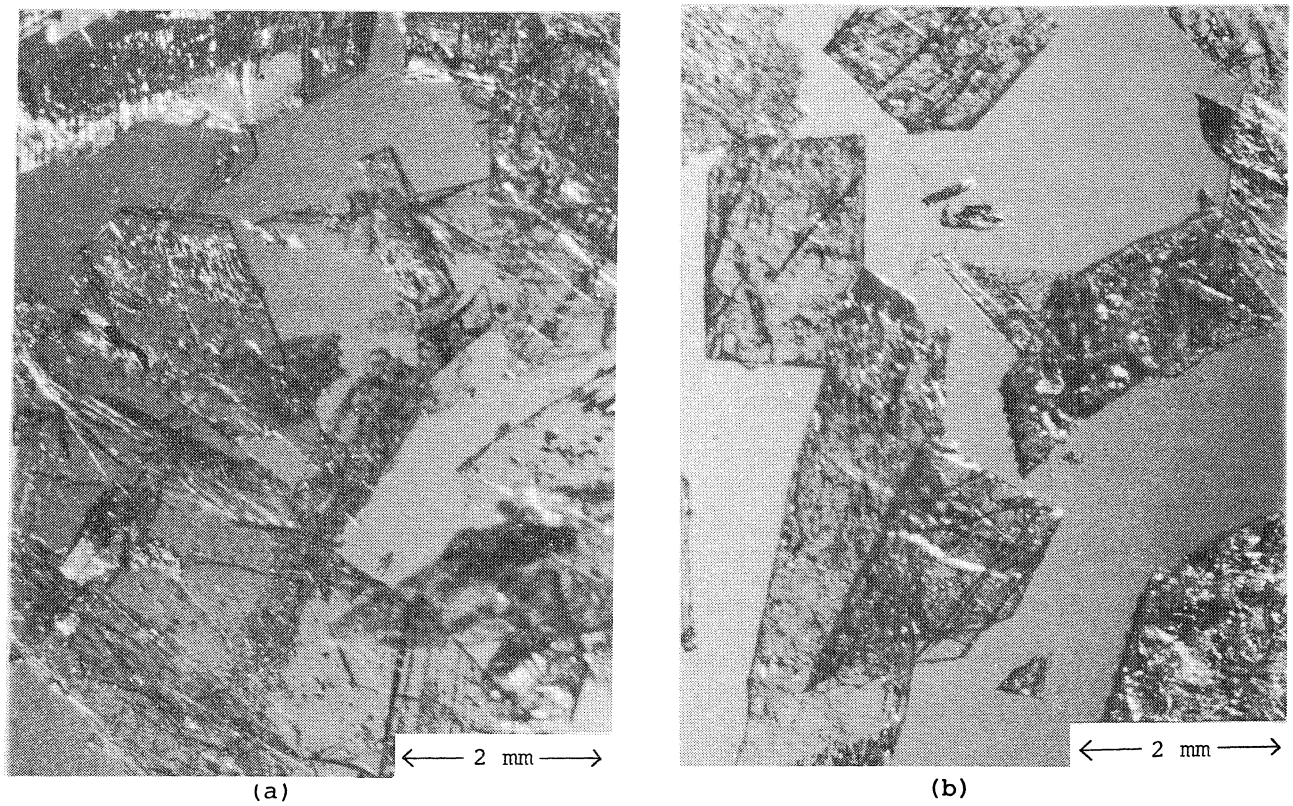


Fig. 1. Chemical formula of dialkyldimethylammonium bromide.
n=18: Dioctadecyldimethylammonium bromide.
n=16: Dihexadecyldimethylammonium bromide.

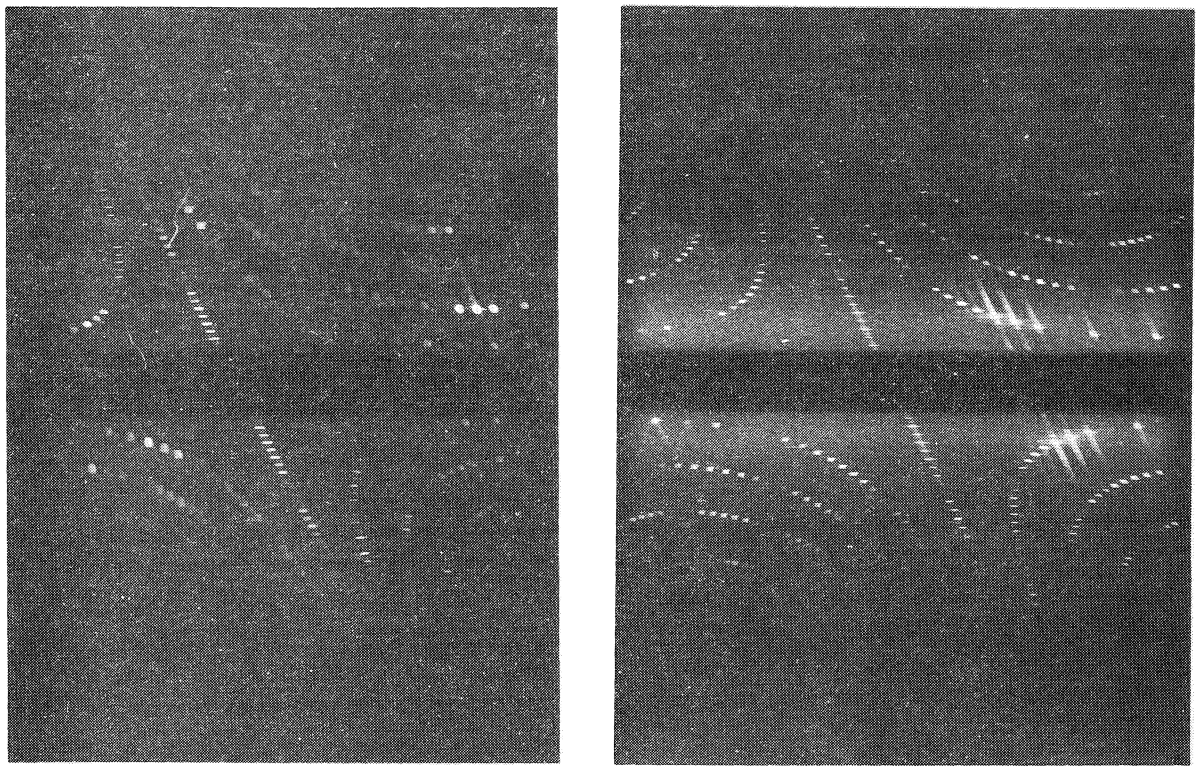
One of the authors (T. Kunitake) succeeded in formation of the biological membrane-like bilayer structure from totally synthetic amphiphiles, dialkyldimethylammonium bromides.[2] Recently, we also succeeded in growing well-ordered crystals of these synthetic amphiphiles. X-Ray investigation of these crystals is now undertaken to obtain detailed structural knowledge on their bilayer structures. In this communication we report the formation of the single crystals of dialkyldimethylammonium bromides and preliminary results of their X-Ray diffraction studies.

Dialkyldimethylammonium bromide (DAAB) was prepared by step-wise alkylation of dimethylamine.[2] The chemical formula of DAAB is shown in Fig. 1. A 50 mg of DAAB was dissolved in 2 ml of chloroform. After complete dissolution, 8 ml of n-hexane was added. By considering of the phase transition temperatures of specimens,[3] a solution of dioctadecyldimethylammonium bromide (DOAB) was left at room temperature (20 °C), while that of dihexadecyldimethylammonium bromide (DHAB) was kept in the refrigerator at about 8 °C. In both cases, plate-like crystals formed at the bottom of the vessel after several days. They were transparent and thin crystals. The size of the large crystals reached 5 mm x 5 mm x 0.1 mm (thickness). Many of these crystals were composites of several single crystals with a common axis perpendicular to the plate surfaces. Large plate-like crystals were divided into small pieces in order to obtain single crystals available for X-Ray diffraction study. Resultant fracture crystals were shown in the optical microscopic photographs (Fig. 2). After many trials of X-Ray investigation of such crystals, single crystals of both compounds were found. Their Weissenberg photographs (Fig. 3) suggest that one of the axes of DAAB crystal is about 3.5 nm, which probably corresponds to the thickness of a bimolecular layer. Taking into account of the extended molecular length of DAAB (DOAB: *ca.* 2.6 nm and DHAB: *ca.* 2.3 nm), the molecular axes seem to be considerably tilted to the bilayer surface. Detailed lattice constants were obtained by using a full-automatic four-circle goniometer. It was found that the single crystals of DOAB and DHAB are both triclinic with the unit cell dimensions of a=3.811(2) nm, b=0.7890(2) nm, c=0.7418(2) nm, α=104.37(3)°, β=103.06(4)°, γ=74.93(3)° and a=3.428(2) nm, b=0.7873(2) nm, c=0.7459(3) nm, α=104.48(4)°, β=103.32(4)°, γ=79.67(4)°, respectively. These lattice dimensions are very similar to one another except for slight differences in a and γ values. The structural meaning of these differences will be clarified after complete crystal analyses. Either P1 or $P\bar{1}$ is a plausible space group for



(a) (b)

Fig. 2. Optical micrographs of (a) DOAB and (b) DHAB crystals.



(a) (b)

Fig. 3. Weissenberg photographs of (a) DOAB and (b) DHAB single crystal.

both cases and definite determination is not possible at this stage of analyses.

Density was measured by a flotation method using aqueous solution of sodium chloride. On the basis of the measured density (DOAB: 1.04 g cm^{-3} and DHAB: 1.02 g cm^{-3}) and an unit cell volume (DOAB: 2.06 nm^3 and DHAB: 1.88 nm^3), the unit cell consists of two DAAB molecules in both cases. Furthermore, two water molecules seemed to be contained in each unit cell of the DOAB crystals (*i.e.*, $1H_2O$/DOAB). This expected monohydrated structure was also confirmed by the elemental analysis (Calcd for $C_{38}H_{80}NBr$: C, 72.34; H, 12.78; N, 2.22%. Calcd for $C_{38}H_{80}NBr \cdot H_2O$: C, 70.33; H, 12.74; N, 2.16%. Found: C, 70.18; H, 12.75; N, 2.12%). Structural analyses based on three-dimensional X-Ray intensity data are in progress.

The present finding is the first successful attempt to obtain single crystals from totally synthetic amphiphiles which can form bilayer membranes. The crystals should make it possible to establish the bilayer structure in greater details than has been possible to date.

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