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Phase behaviour of dipalmitoylphosphatidylcholine/surfactant/water systems studied by infrared spectroscopy

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Abstract

Phospholipids are the most important components of membranes taking part in stabilization of the functional structure of biological cells. The main aim of the present study is to determine the influence of selected antimicrobial surfactants on the phospholipids structure. The water solutions of dipalmitoylphosphatidylcholine (DPPC) in the presence of two quaternary ammonium surfactants: dodecyldimethyl(hexyloxymethyl)ammonium chloride (HMDDAC) and (decyloloxymethyl)dodecydimethylammonium chloride (DMDDAC) were studied using FTIR spectroscopy. The thermal behaviour of these systems was analyzed using spectral parameters of CH_2 and C=O vibrations bands. We have observed a lowering of temperature corresponding to the main phase transition of the surfactant/DPPC systems due to disordering of the phospholipids structure by the surfactants and phospholipids interaction.

Keywords: DPPC; Surfactants; FTIR

1. Introduction

Phospholipids are the main components of biological membranes. They consist of the hydrophobic chains and hydrophilic head groups and exhibit strong polar properties. In water environment these molecules can form the bilayer structures, which determine biological activities of cells and are responsible for creation of cellular compartments.

The structural stability of membranes is strongly affected by temperature. Dipalmitoylphosphatidylcholine (DPPC) features three thermal phase transitions: subtransition at 290 K, pretransition at 308 K, and main transition at 315 K, which can be associated with four different phase modification of the compound, namely: lamellar crystalline orthorhombic, lamellar orthorhombic, hexagonal periodical, and disordered liquid crystalline phase [1]. The main transition in lipids, often called a chain-melting, is in general associated with the transition from the gel or crystalline to the fluid phase. It may be ascribed to creation of the *gauche* conformers as a consequence of increasing temperature [2,3].

Apart from temperature there are other agents such as e.g. surfactants, which can interact with phospholipids and exert influence on their organization. Surfactants are known for their ability to destroy lamellar structure of lipids as a result of the lipid membranes dissolution and formation of surfactant/lipid micelles [4]. This important property is utilized in medical applications of surfactants e.g. long chain quaternary ammonium compounds in an antibacterial and against fungi and protozoa activity [5].

2. Experimental

2.1. Materials and sample preparation

The dipalmitoylphosphatidylcholine (DPPC) was obtained from Avanti Polar Lipids. The dodecyldimethyl(hexyloxymethyl)ammonium chloride (HMDDAC) and (decyloloxymethyl)dodecydimethylammonium chloride (DMDDAC) were prepared according [6]. The homogeneous 10% 20 mM K_2HPO_4 deuterium oxide solutions of DPPC and 0.1, 1 and 5% surfactant/DPPC suspensions were prepared by the cyclic sonification at 293 K for 30 min and cooling at 278 K.

2.2. FTIR—spectroscopic measurements

Infrared spectra of DPPC solutions in the temperature range from 288 to 323 K were recorded on a BRUKER IFS 66s

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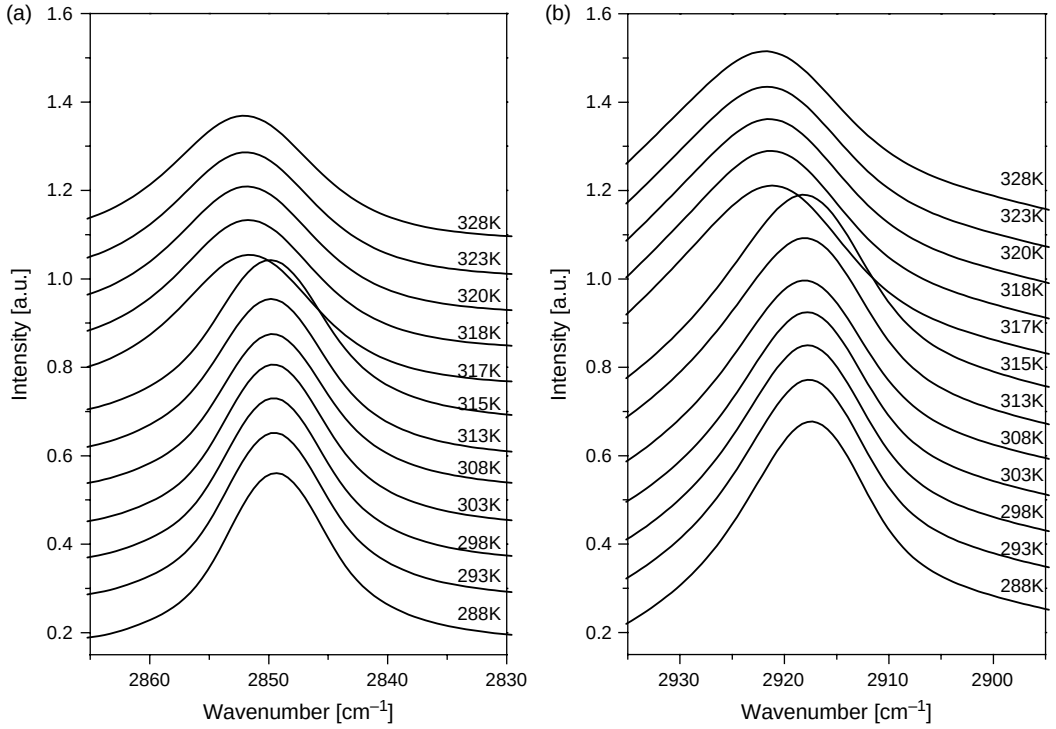

Fig. 1. FTIR spectra of symmetric (a) and antisymmetric (b) CH_2 stretching vibrations of DPPC deuterium oxide solution at various temperatures.

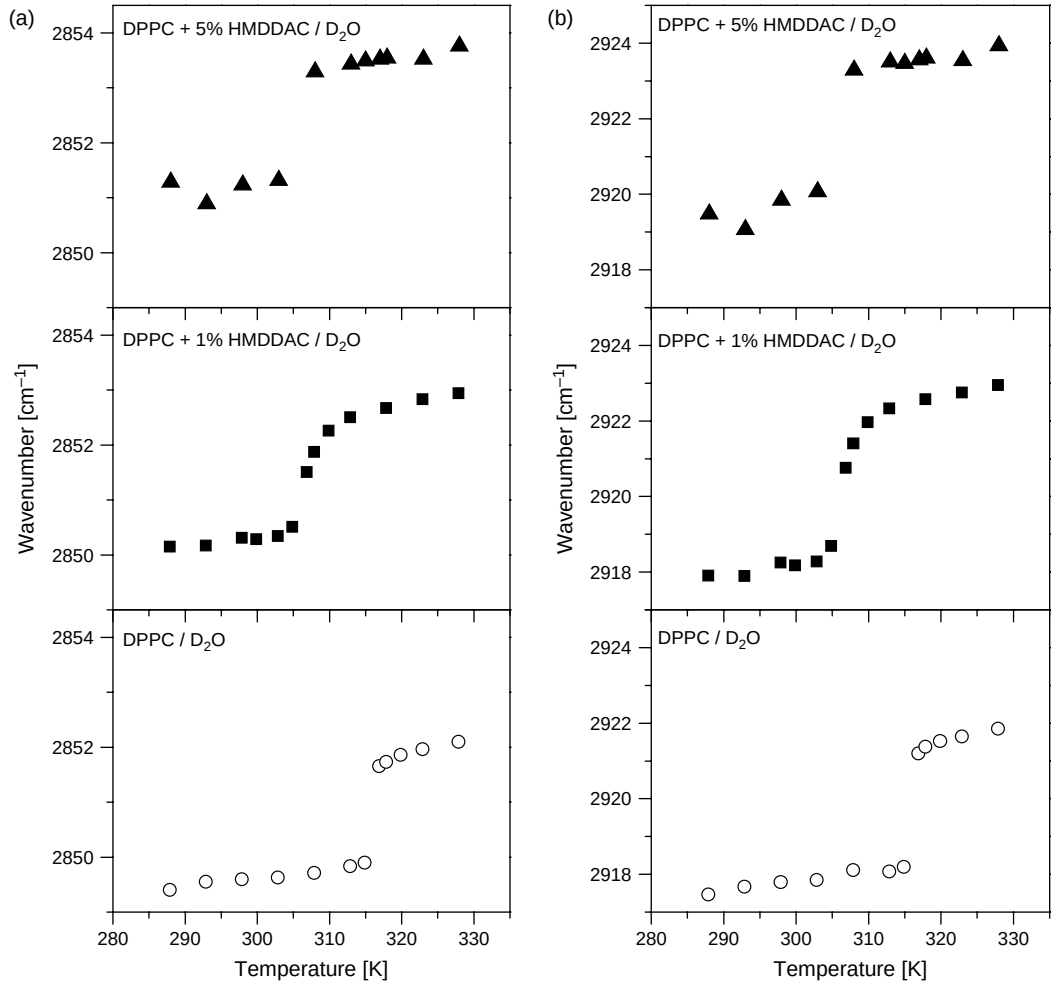

Fig. 2. Temperature dependences of the symmetric (a) and antisymmetric (b) CH_2 band frequencies for DPPC in D_2O and 1% and 5% HMDDAC/DPPC/D_2O solutions.