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Quantifying the structural effects of ionic liquids on model cellular membrane

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1 Introduction

An ionic liquid (IL) is a salt in the liquid state below 100°C. These molecules are non-explosive, non-flammable, and are having good electrical and thermal conductivities. They do not pollute air as they have low vapor pressure. Because of these properties, they have a large number of industrial applications. Numerous recent studies have revealed the lysing effect of these molecules on environment-friendly microorganisms living in soil and water. Even though there are various studies of toxic activities of ILs, the exact molecular mechanism of these activities are not well understood. When an IL interacts with a living organism, it has to interact first with the outer layer of the cellular membrane. Recently, there has been significant research interest in understanding the interaction of ILs with the cell membrane to comprehend the adverse activities of these molecules to living organisms.

2 Experiment

A cellular membrane, which is mainly composed of phospholipids and proteins, is the outer layer of a cell that protects the inner components and takes part in signalling processes. Such a membrane is mimicked here with a zwitterionic lipid, 1,2-dipalmitoyl-sn-glycero-3-phosphocholine(DPPC), and an anionic lipid 1,2-dipalmitoyl-rac-glycero-3-phospho-L-serine (DPPS). X-ray reflectivity (XRR) technique for soft supported lipid bilayer [1, 2] and small angle x-ray diffraction (SAXD) for multilayer vesicles [3] have been used.

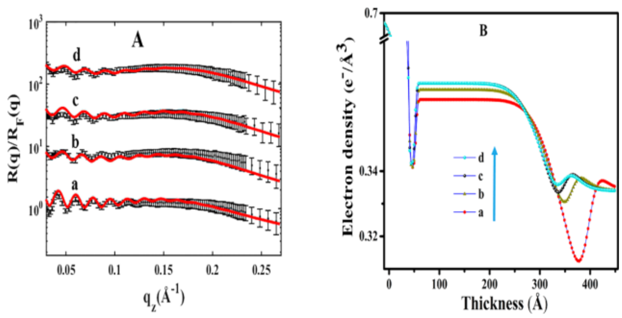

Fig 1: (A) XRR measurements at 48 °C from lipid bilayers formed on a polymer cushion: (a) DPPC bilayer, (b) DPPC bilayer with 5mol % [BMIM][BF4], (c) bilayer with 10 mol % of IL, and (d) bilayer with 15 mol % [BMIM][BF4]. For clarity, the curves are shifted vertically. The solid lines are the fits to the data. (B) Corresponding electron density profiles extracted from the fits of the above curves (a− d, respectively) [1].

3 Results and Discussions

The electron density profile has been obtained by a box model fit to XRR data using a MATLAB code that utilizes semi-kinematical approximation. The thickness of the pure DPPC bilayer is found to be 47.4 Å with an electron density of 0.288 $e^{-}/\text{Å}^3$. With the insertion of ILs, the bilayer thickness is found to decrease systematically and corresponding the electron density of the bilayer increases (Fig. 1). To gain more insights of the molecular level description of the IL-membrane interaction, multilamellar vesicles of DPPC with a combination of negatively charged lipid DPPS, have been used as model membrane. For DPPC/DPPS sample, no Bragg peak was observed in the SAXD measurements (Fig. 2 A). However, in the presence of IL, the sample displayed a set of Bragg peaks exhibiting the formation of MLVs. The interbilayer spacing is observed to decrease with increase of concentration of IL (Fig 2 B).

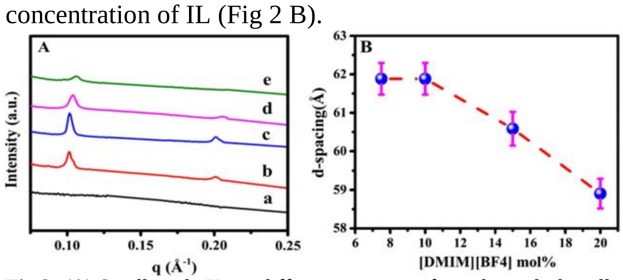

Fig 2: (A) Small angle X-ray diffraction patterns from the multi lamellar vesicles (MLV) formed in the aqueous solution of DPPC/DPPS (a, black) and in the presence of 7.5 (b red), 10 (c blue), 15 (d pink) and 20 (d, green) mol% of the IL. The curves are shifted vertically for clarity. (B) The corresponding variation in lamellar repeat distance (d-spacing) [3]

4 Conclusion

This study has unveiled the reorganization of self-assembly of lipid molecules in a model bio-membrane in the presence of ionic liquids. The structural perturbation in the membrane may be the cause of the ionic liquids to behave as the toxic elements to living organism.

5 Acknowledgement

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