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FINAL TECHNICAL REPORT

Grant #: N00014-89-J-3002 R&T CODE: 4414912
PRINCIPAL INVESTIGATOR: Max Berkowitz

INSTITUTION: University of North Carolina at Chapel Hill

GRANT TITLE: Structure and Dynamics of Aqueous Solutions Next to and Between Membrane Surfaces.

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OBJECTIVE: To investigate structural and dynamical properties of aqueous solutions next to and between surfaces of biological macromolecules, particularly membranes.

APPROACH: In order to understand the structure and dynamics of water between layers of phospholipid molecules we performed molecular dynamics computer simulations on a system composed of water molecules embedded between surfaces of phospholipid molecules.

ACCOMPLISHMENTS: To understand the role of water in the hydration force acting between the membrane molecules we performed molecular dynamics computer simulations on the DLPE/water system in lamellar arrangement and DPPC/water system also in the lamellar arrangement. The simulations were done on DPPC/water in gel and liquid crystal phase and on DLPE/water in liquid crystal phase. To perform these simulations we refined the force fields available in the literature to describe water/phospholipid interactions and also refined the Particle Mesh Ewald method to include the long ranged forces.

Based on the analysis of the results from our simulations we concluded that the DLPE membranes are separated by two layers of water on average at the full hydration limit. Removal of these water layers contributes to the repulsive force. Due to ragged character of the membrane surfaces the steric interactions between them are also contributing to the force. The DPPC membranes are separated by four layers of water on average (two from each side of the membrane) at the limit of full hydration. Our simulations indicate that only one layer of water next to the membrane is substantially perturbed. Therefore we think, that the contribution of water into the total repulsive force comes into play only when we remove this hydration layer, which means that the true hydration force is probably appearing to act at distances d_w below 0.8 nm in agreement with the experimental assesment given by McIntosh and Simon. As in the case of DLPE

membranes, the raggedness of the surface can contribute to the repulsive force. Our simulations also reveal the difference in the water structure around the membranes with PE vs PC headgroups (in case of membranes with PE groups we observe the presence of water bridging the opposing groups, while around PC groups we observe clathrate structures of water). We connect the observed in the simulations microscopical structural difference to the difference in the hydration limit of such membranes, observed in macroscopic experiments.

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