Contribution ID: **52** Type: **Poster**

Evolutionary significance of the bilayer properties for the disappearance of betaine lipids in seed plants

Betaine lipids are non-phosphorus glycerolipids and can represent up to 40% of the membrane lipid content. There are three basic types of betain lipids: DGTS, DGTA and DGCC distributed in photosynthetic organisms such as ferns, mousses macro- and microalgae. In contrast, it is interesting to notice that there are no betaine lipids in seed plants (angiosperms and gymnosperms). Under phosphate starvation, a replacement of phospholipids with non-phosphorus lipids occurs in photosynthetic cells. In particular, in extraplastidial membranes of higher plants phospholipids are replaced by glycolipids and in microalgae by betaine lipids.
In this work, we would like to understand the physicochemical properties of phospholipids and betaine lipids, to understand the substitution between these two lipids in membranes in phosphate starvation. We focus our work on DGTS it is the only betaine lipid commercially available. Using neutron diffraction and molecular dynamic simulations of two synthetic lipids with two fatty acid chains in 16:0: the phospholipid dipalmitoylphosphatidylcholine (DPPC) and the betaine lipid dipalmitoyl-diacylglyceryl-N,N,N-trimethylhomoserine (DP-DGTS), we found that DP-DGTS bilayers are thicker by 6 Å than DPPC bilayers and therefore are more rigid. Furthermore, DP-DGTS bilayers exhibit a more long-ranged repulsion, and at defined hydration, coexist in gel and fluid phase. Then, we also compared the fatty acid composition of PC extracted from higher plant and DGTS extracted from different microalgae. In organisms with only one of the two lipids (PC or DGTS), the fatty acid composition is in C16 and C18. However, organisms with the coexistence of PC and DGTS exhibit a high diversity of very long chain poly-unsaturated fatty acids (VLC-PUFA) in DGTS lipid. These results (the difference of sensitivity to hydration and the difference of fatty acid composition between PC and DGTS) could be an explanation for the diversity of betaine lipids observed in marine organisms versus their disappearance in seed plants.

Session

Molecular interactions at the membrane surface

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Session Classification: Clip Session