Experimental report

15/06/2022

Proposal: 9-13-921 **Council:** 4/2020

Title: Membrane Dynamics in MultilamellarVesicles Containing Glycolipids

Research area: Soft condensed matter

This proposal is a new proposal

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Samples: D2O
C36H72NO8P (DMPC)
C75H132O15 (DGDG)
C42H79NO13 (Lactosylceramid)

Instrument	Requested days	Allocated days	From	To
D11	1	0		
IN15	5	5	14/02/2021	19/02/2021
D22	1	1	15/02/2021	16/02/2021

Abstract:

Naturally occurring membrane stacks, such as myelin sheaths or thylakoids (photosynthetic membranes), contain high amounts of glycolipids which are hypothesized to stabilize multilayered architectures. An aspect that has been so far neglected in the biological context is the effect such sugar-sugar binding may have on membrane dynamics. While the dynamics of the membrane are essential for its functionality, only very little known is about the change of membrane dynamics when going from a unilamellar to a multilamellar system. We propose to perform NSE measurements to elucidate that question.

EXPERIMENT N° **9-13-921** INSTRUMENTS **IN15, D22**

DATES OF EXPERIMENTS **15/02/2021** to **20/02/2021**

TITLE Membrane Dynamics in Multilamellar Vesicles Containing Glycolipids

EXPERIMENTAL TEAM

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Date of report: June 15, 2022

Naturally occurring membrane stacks contain high amounts of glycolipids, which are hypothesized to stabilize multilayered architectures. Recent studies [1, 3, 2] have demonstrated that already small fractions of glycolipids can induce pronounced cohesion between lipid membranes even against repulsive forces.

Experiment 9-13-921 was aimed to investigate the effect of such sugar-sugar binding on membrane dynamics in multilamellar systems. SANS and NSE measurements were conducted on oligolamellar vesicles containing the phospholipids POPC and two types of chain-unsaturated glycolipids with disaccharide headgroups, one with a lactose headgroup (LacCer) and one with a digalactose headgroup (DGDG). For each lipid composition, one sample was created by extrusion through a membrane with 200 nm pore size and one by extrusion through a membrane with 400 nm pore size. Five different lipid compositions were studied: pure POPC, POPC+10% LacCer, POPC+20% LacCer, POPC+10% DGDG, and POPC+20% DGDG. The SANS measurements were conducted at D22, while NSE was measured at IN15.

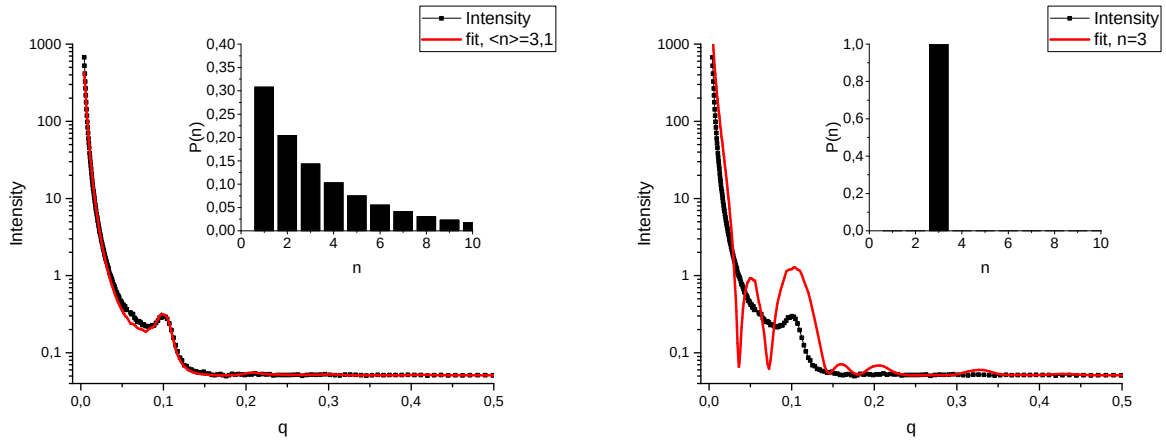

Figure 1: (A) SANS data obtained with POPC+10% LacCer extruded through 400 nm pores. The solid line indicates a fit assuming oligolamellar vesicles with a broad distribution of the number n of lamellae, with $\langle n \rangle = 3.1$. The corresponding distribution is shown as inset. (B) An unsuccessful attempt to fit the data set with a monodisperse number of lamellae ($n = 3$, see inset).

Fig. 1 A exemplarily shows the SANS data obtained for POPC+10% LacCer and extrusion through 400 nm pores together with a fit based on a broad distribution of the number of lamellae n of the oligolamellar vesicles. The corresponding distribution is shown as a figure inset. As

shown in Fig. 1 B, attempts to fit the data with a monodisperse number of lamellae remain unsuccessful. The samples obviously exhibit a broad distribution of lamellarities, which can be determined rather well from the SANS data analysis but also renders the analysis of the NSE data nontrivial. Namely, depending on q, different lamellarities have different weights for the NSE signal. To overcome this problem, we model the NSE data in a rigorous fashion based on the obtained histograms of n and on their q-dependent intensity-weighted contribution. This procedure yields meaningful values for the bending rigidity of individual lipid membranes, κ_0. Fig. 2 shows the NSE data obtained with POPC+20% LacCer and extrusion through 400 nm pore for various q values. The solid lines, which reproduce the experimental data reasonably well, correspond to a common model in which $\kappa_0 \approx 6\ k_\mathrm{B}T$ and in which the bending rigidity of an oligolamellar layer scales with n^α, where $\alpha \approx 2$.

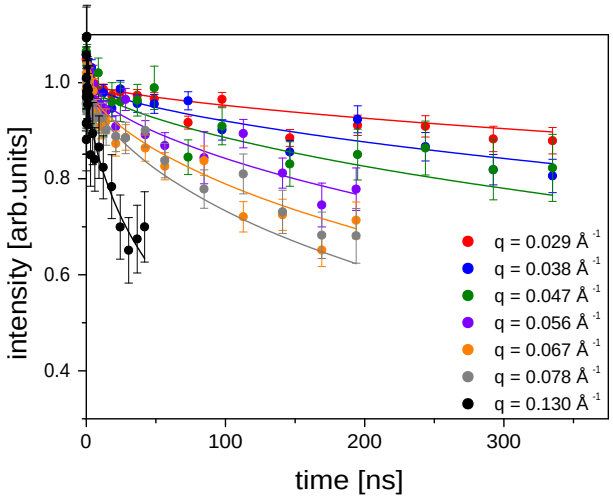

Figure 2:

The data are currently being systematically analyzed in this way and we expect that the influence of the glycolipids on κ_0 and α can be interpreted in terms of intra- and inter-membrane sugar interactions.

References

[1] Matej Kanduč, Alexander Schlaich, Alex H. de Vries, Juliette Jouhet, Bruno Demé, Roland R. Netz, and Emanuel Schneck. Tight cohesion between glycolipid membranes results from balanced water–headgroup interactions. Nat. Comm., 8(14899), 2017.

[2] Batuhan Kav, Andrea Grafmüller, Emanuel Schneck, and Thomas R Weikl. Weak carbohydrate–carbohydrate interactions in membrane adhesion are fuzzy and generic. Nanoscale, 12(33):17342–17353, 2020.

[3] Victoria M. Latza, Bruno Demé, and Emanuel Schneck. Membrane adhesion via glycolipids occurs for abundant saccharide chemistries. Biophysical Journal, 118(7):1602–1611, 2020.