The additional phase transition of DPPC monolayers at high surface pressure confirmed by GIXD study

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INTRODUCTION

DPPC is the dominant lipid (45wt%) [1] in the alveolar monolayer (Fig.1). It is the only known lipid that can be compressed to ~70mN/m without monolayer collapse.

Here we present results from grazing incidence X-ray diffraction (GIXD) experiments. They reveal two distinct structural transitions in the chain lattice of DPPC. This confirms previous results from Langmuir isotherm measure-ments. Especially, the structural details of the second phase transition at high surface pressure (Π ~ 50mN/m) were not reported so far. The physiological relevance of the findings is still under discussion.

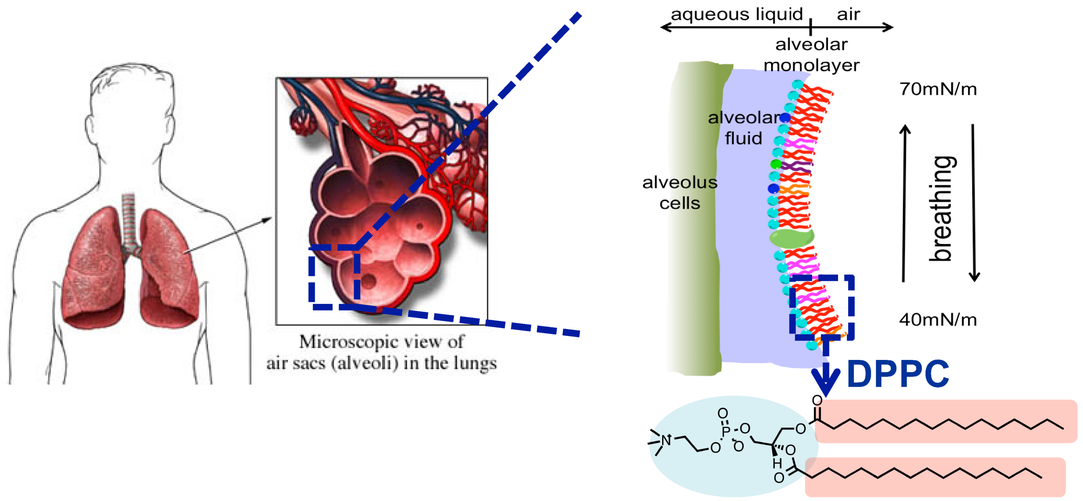


Fig. 1: Schematic view of the lung alveoli [2] (left), a model alveolar monolayer and its surface pressure variation during breathing process [1] (right), the structure of a DPPC molecular (below)

GRAZING INCIDENCE DIFFRACTION

GIXD experiments were performed at DORIS III (Hamburg, Germany) using beamline BW1.

The off-specular diffraction intensity $I(Q_z, Q_{xy})$ (Fig.4) is proportional to the structure factor $S(Q_{xy})$ of the lateral lattice of the alkyl chains and to their molecular form factor $F(Q_z, Q_{xy})$.

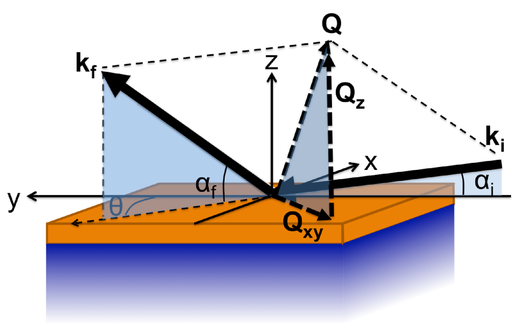
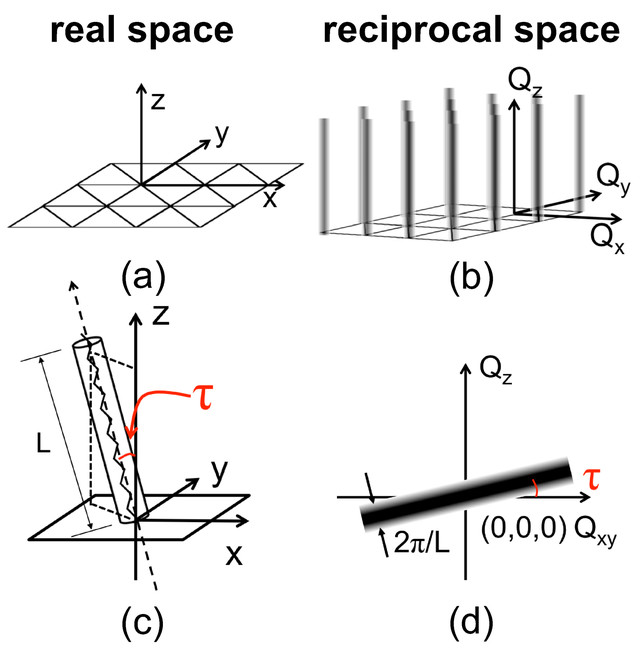


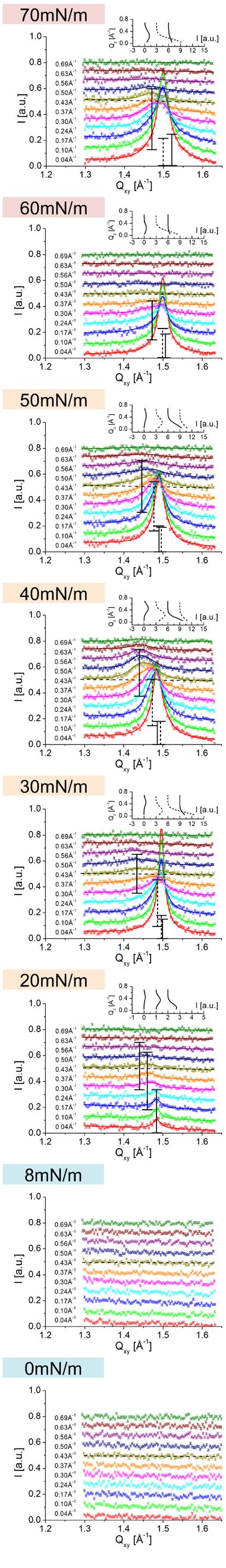
Fig. 2: Geometry of a GIXD experiment. The value of the angle of incidence α_i is about 85% of the value of the critical angle α_c. The off-specular diffraction pattern reports on the in-plane lateral organization of the interfacial region (in orange).

Fig. 3: Representation of the monolayer as a 2D-crystal, in real and in reciprocal space

a. in-plane lateral lattice of alkyl chains (see also fig. 6)
b. $S(Q_{xy})$
c. cylinder model of a chain tilted by angle τ
d. $F(Q_z, Q_{xy})$



LATERAL STRUCTURES of DPPC MONOLAYERS



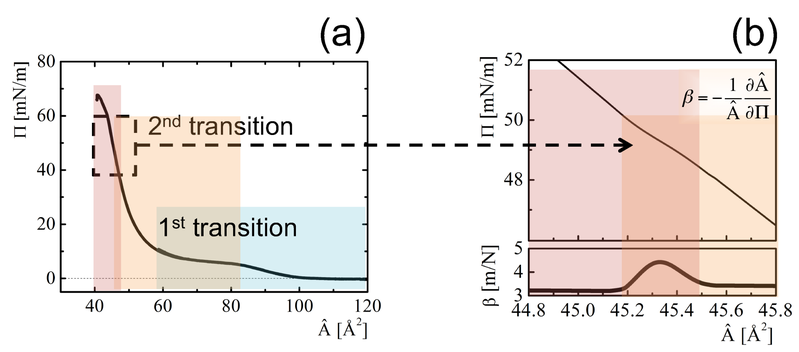


Fig. 4 : Phases of DPPC monolayers
a. Langmuir compression isotherm
b. zoom in to Langmuir isotherm, with corresponding compressibility β

color code:

ordered liquid B	ordered liquid A	disordered liquid

Fig. 5 (left): 2D-diffractograms of DPPC monolayers at several compression states. Bars denote the positions and the widths of the diffraction peaks. Solid and dashed pattern mark coexisting lattices.

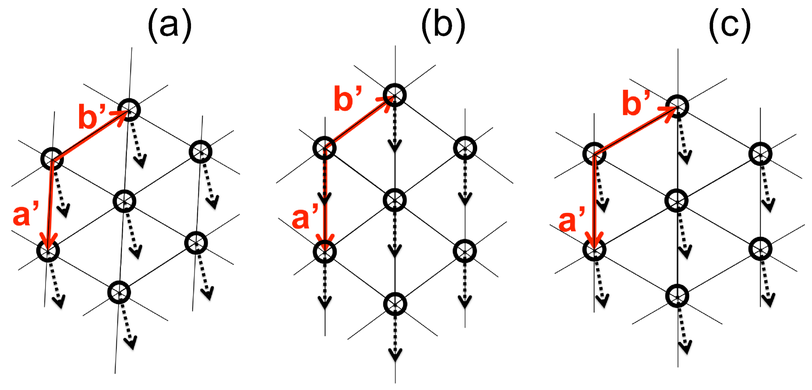


Fig. 6: Schematics of lipid chains packed in (a) an oblique, (b) a centered rectangular and (c) a rhombic 2D lattice. a' and b' represent distances between nearest neighbour chains. Dashed arrows denote the projection of tilted chains onto the xy-plane.

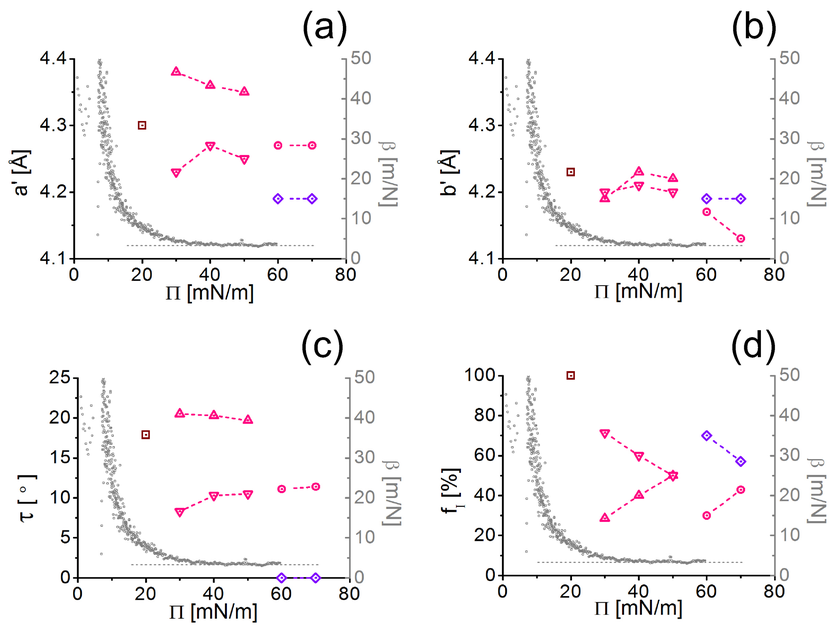


Fig. 7: The distances a' and b', the tilt angle τ, and the diffraction intensity fraction f_I of the (coexisting) chain lattices as function of surface pressure.

color code:

oblique	centered rectangular	rhombic

CONCLUSION

- The results from grazing incidence X-ray diffraction confirm the **second phase transition** of **DPPC monolayers** at ~ 50mN/m and reveal the **structural details** of the **phase diagram**.
- The peculiar thermodynamic and structural features of DPPC monolayers are possibly connected to **a specific functional role of DPPC in the alveolar monolayer**.

References

1.Schürch, S., M. Lee and P. Gehr (1992). "Pulmonary surfactant - surface-properties and function of alveolar and airway surfactant." Pure and Applied Chemistry **64**(11): 1745-1750.

2.Figure modified from "http://medicine.med.nyu.edu/pulmonary/node/674"

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