Unbinding kinetics of multi-stacked phospholipid bilayers

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リン脂質ジャイアントベシクルの形成メカニズムを明らかにするため、時分割X線小角散乱を用いて基板上に多重に積層したリン脂質二重膜の水和過程を観測した。その結果、水和過程は三つの段階を経ながら進むということがわかった。初期段階では水分子が膜間に浸透してゆく。次に積層膜の膜間は膨潤し、準安定状態へと緩和する。その後二重膜が徐々に剥離し、ベシクルが形成する。後期過程（膜剥離過程）のKineticsはKramers理論を用いたモデルにより議論する。

1 Introduction

Phospholipid giant vesicles, exceed 1 μm in size, are actively investigated as a model cell system since the structure and the size are comparable to that of common cells. Giant vesicles are usually formed under the natural swelling method [1], where multi-stacked phospholipid bilayers on a solid substrate are calmly hydrated. Although this method has been well known, the mechanism of the vesicle formation by this method remains to be solved. Since each phospholipid bilayer should peel off from the stack on a substrate in this process, the hydration process of dry phospholipid bilayers is thought to relate with the unbinding transition of multi-stacked membranes, which is the phase transition between a bound state and a dispersed state of stacked bilayers.

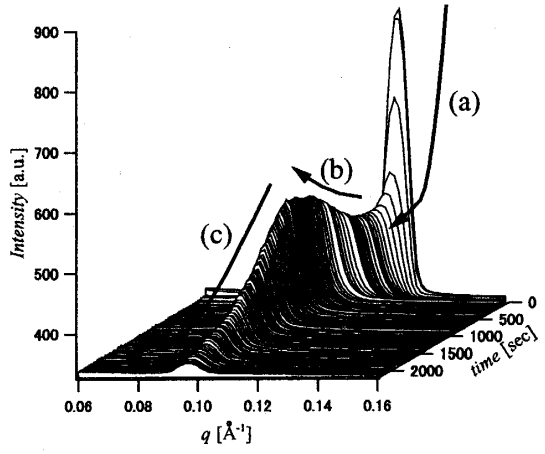

Figure 1: Time-resolved SAXS profile for hydration process of multi-stacked phospholipid bilayers. The Bragg peaks correspond to the regular stacking of bilayers. There are three stages (a), (b) and (c).

In the present study, we tried to observe the hydration process of multi-stacked phospholipid bilayers by means of time resolved small-angle X-ray scattering (TR-SAXS) with a special cell at BL40B2, SPring-8, JASRI, Japan [2].

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2 Results and Discussion

From these experiments, it has been observed that the vesicle formation proceeds with three stages (Fig.1). In the early stage, water molecules penetrate into the stack, and in the intermediate stage the multi-lamellar structure is swollen to reach a quasi-stable state. In the following late stage, each bilayer gradually peels off from the stack to form giant vesicles (Fig.2). The kinetics of the late stage (peeling-off stage) was analyzed with a model of the Kramers method. The result indicates that the effectively large fluctuation of the outermost bilayer in the stack induces the unbinding of bilayers to form giant vesicles.

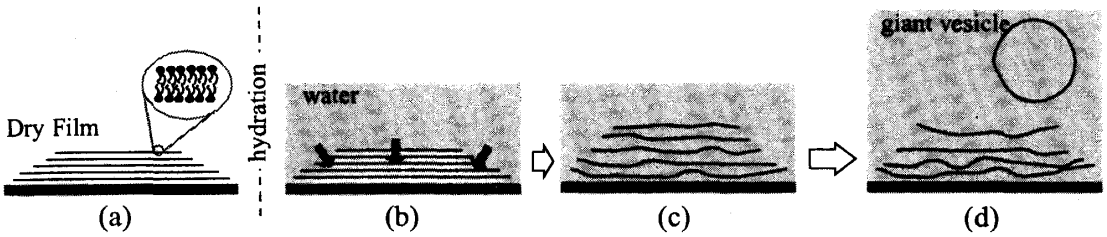

Figure 2: Hydration process of stacked bilayers. When the dry film (a) is hydrated, water molecules penetrate into the stack (b). Next, the multi-lamellar structure is swollen and reaches a quasi-stable state (c). Following, each bilayer gradually peels off from the stack to form a giant vesicle (d).

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References

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