SOUTENANCE DE THESE

THESIS DEFENSE

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Unité de Recherche **: Laboratoire BMBI, Labex MS2T**

soutiendra sa thèse de **Doctorat** sur le sujet **:**

Caracterisation of nanomechanical properties of biological lipid membranes with circular mode Atomic Force Microscopy

A l'université de technologie de Compiègne

Le mardi 28 novembre 2017 à 14h00

Amphi L103 – Centre Pierre Guillaumat

Devant le jury composé de :

- M[me] Touria Cohen-Bouhacina, professeur des universités, laboratoire ondes et matière d'Aquitaine, université de Bordeaux
- M. Karim El Kirat, professeur des universités, laboratoire biomécanique et bioingénierie, université de technologie de Compiègne
- M[me] Marie-Christine Ho Ba Tho, professeur des universités, laboratoire biomécanique et bioingénierie, université de technologie de Compiègne
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- M. Denis Mazuyer, professeur des universités, Laboratoire de tribologie et de dynamique des systèmes, école centrale de Lyon
- M. Olivier Noel, maître de conférences HDR, institut des molécules et des matériaux du Mans, université du Mans

Abstract :

Cell membranes are involved in many cellular processes: drugs and ions diffusion, signal transduction, energy generation, cell development (fusion and fission). Phospholipid bilayers are the main components of cell membranes, they act as a dynamic barrier protecting cellular

biochemical reactions. The determination of biochemical and mechanical properties of lipid bilayers and their evolution with environmental conditions is necessary to study the nature of cellular processes and the influence of external agents (mechanical resistance, permeability, and biological response). To conduct such characterizations, simplified biomimetic membrane models, such as supported lipid bilayers (SLBs), were developed. Among the available characterization techniques, atomic force microscopy (AFM) has been widely used to study the nanoscale organization of SLBs under physiological conditions. AFM can yield high resolution images and it can also be used to quantify the mechanical resistance of SLBs by means of punch through experiments. For 30 years, AFM has been through many developments. Very recently, the Circular Mode AFM (CM-AFM) has been developed at the Université de Technologie de Compiègne. CM-AFM is able to generate a sliding movement of the AFM tip on the sample at high, constant and continuous velocity and to measure the lateral friction forces fast and accurately simultaneously with the vertical forces. For the first time CM-AFM is used to characterize biological samples under physiological conditions, allowing the simultaneous measurement of both the punch-through and the friction forces as a function of the sliding velocity. It offers for the first time the ability to describe the friction behavior of SLBs in complement of the punch-through force.

Due to the important need for quantitative measurement, optimization of the CM-AFM protocol has been done first. Protocol of scanner calibration has been successfully established to ensure the accuracy of sliding velocity. Besides, the protocol for tip calibration, based on wedge method and a scratched sample, is also made to determine the lateral force calibration constant. We have employed CM-AFM to measure the tribological properties of solid samples to improve the equipment under liquid medium. Then, the mechanical properties (punchthrough and friction forces) of SLBs were measured as function of the sliding velocity. Pure and mixed SLBs were prepared by the vesicle fusion method. Various media were also used to study the effect of monovalent cations to the mechanical properties of SLBs. In all cases, the friction force increases linearly with the sliding velocity allowing us to deduce the friction viscous coefficient. As expected both the punchthrough force and the friction viscous coefficient are influenced by the composition of lipid mixtures, by the nature of cations in liquid medium, and by the length of hydrocarbon chains but not in a similar fashion.

The interpretation of the evolution of the viscous friction force coefficient with the studied system is particularly tricky as the friction force could be influenced by interface or volume properties. This problematic will be the challenge for the next studies. Nevertheless, our results illustrate how powerful the CM-AFM technique is and it opens wide opportunities to characterize other biological samples (cells and tissues) to gain a better understanding of the elementary mechanisms of friction.