Effect of hydration layers at soft contact lens surface on friction properties by using FM-AFM and Nano tribometer

Ayaka Nakajima[1)], Yuko Sato[1)] , Kaisei Sato[1)] , Seiya Watanabe[2)] , Shinya Sasaki[2)*]

[1)] Graduate School of Tokyo University of Science, 6-3-1 Niijyuku, Katsushika-ku, Tokyo, Japan
[2)] Tokyo University of Science, 6-3-1 Niijyuku, Katsushika-ku, Tokyo, Japan
*Corresponding author: s.sasaki@rs.tus.ac.jp

Friction between a soft contact lens (SCL) and eyelid filled with tears has a close relationship with the wearing comfort. It is known that hydration structure formed by tears on a SCL, which is called tear film, plays an important role in friction reduction between a SCL and eyelid. Hence, in order to achieve further improvement of wearing comfort, it is crucial to understand the detail of tear film structure. In this study, we utilized Frequency Modulation Atomic Force Microscope (FM-AFM) to analyze the hydration layer formed on SCL surfaces, and investigated its relationship with frictional property.

Keywords: Nano Tribology, Contact lens, Hydration layer, FM-AFM

1. Introduction

Soft Contact Lens (SCL) is widely used as a medical device for vision correction. However, wearing SCL sometimes induces discomfort or certain symptoms such as ocular irritation. it has also been estimated that 30%-50% of users complains of discomfort [1]. These issues are related to the frictional properties of tear film between the lens and eyelid [2]. In order to achieve further improvement of wearing comfort, it is important to reveal the mechanism how tear film affects the frictional properties of SCL.
Frequency Modulation Atomic Force Microscope (FM-AFM) is an analysis technique to directly observe the interfacial structure with high sensitivity. Kimura et al. demonstrated that FM-AFM enables to visualize the hydration layer on the surface of the muscovite mica [3]. In this study, we utilized FM-AFM to analyze the hydration layer formed on SCL surfaces, and investigated the relationship between the structure of hydration layer and frictional property.

2. Materials and Methods

2.1. Contact lens and solution
Commercially available silicone hydrogel contact lenses (ACUVUE OASYS, Johnson & Johnson, USA) were used. The lens is made of senofilcon A with no surface modification, and the water content is 38 %. The base curve of the lens is 8.4 mm. 0.9% saline solution was used to mimic human tears.

2.2. Friction tests
Table 1 shows the sliding test conditions to simulate blinking [2]. Nano tribometer (NTR^2, Anton Paar, Austria) was used to evaluate the friction coefficient with sliding times.

Table 1: friction test conditions

Normal forces [mN]	0.1
sliding speed [m/s]	0.1
stroke length [mm]	1
Solution	0.9% saline

2.3. FM-AFM measurement
To analyze the structure of the hydration layer at SCL surface, FM-AFM (SPM-8000, Shimadzu Corporation, Japan) measurements were performed on SCL surface in a 0.9% saline solution. The force mapping in Z-X plane was obtained before and after friction tests. Figure 1 shows a schematic diagram of FM-AFM measurement. The SCL is fixed on PTFE spherical part with a curvature radius of 7.9 mm by O-ring. The bath for the solution consists of polypropylene resin (PP). A single crystal silicon cantilever (spring constant: 47-50 N / m, resonance frequency: 325-332 kHz, NCHR, NanoWorld AG, Switzerland) was used.

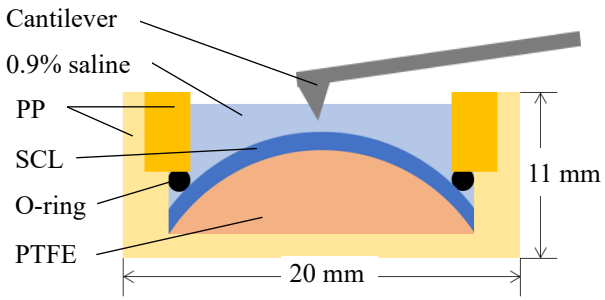

Figure 1: Schematic diagram of FM-AFM measurement

In the presentation, we are going to discuss the structural change in the hydration layer at SCL surface induced by shear and the difference in frictional property between them.

3. References

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