Evaluation of dynamic viscoelastic properties of UV-irradiated dorsal skin tissue of hairless mice

Takenobu Sakai*, Miho Katsuragi*, Kensuke Kageyama* and Ei Yamamoto 2
1Graduate School of Science and Engineering, Saitama University, 255 Shimo-Ohkubo, Sakura-ku, Saitama-shi, Saitama, Japan
2 Biology-Oriented Science and Technology, Kindai University, 930 Nishimitani, Kinokawa City, Wakayama, Japan
*sakai@mech.saitama-u.ac.jp

Introduction. The dermis has an important role to support the skin. The dermis mainly consisted of the collagen and elastin fibers secreted by fibroblasts in the dermis layer (1). Collagen fibers have high stiffness, and elastin fibers have low stiffness. A number of investigators have reported success in the development of histological animal models for photo ageing skin (2, 3). Moreover, changing in the properties of both fibers due to the injury and their recovery stage. In previous study, it was reported that the elasticity of wounded dermis of hairless mice was recovered by applying and impregnating the lotion with elastin component from surface of the skin.

In this study, DMA (Dynamic Mechanical Analysis) tests were carried out to understand the effect of wounded and UV-irradiated on the viscoelasticity of the hairless mice skin.

Specimen. The dorsal skin of hairless mice (Hos: HR-1) were used in this study. Hairless mice were divided into two group as the wound group (age 26 weeks) and the UV-irradiated group (UV group; age 45 weeks). The control groups were also prepared for each group. In the wound group, hairless mice hairless mice were slaughtered after 5 weeks since wound creation. The UV-irradiated mice were exposed to ultraviolet radiation (every two days, 26 weeks) from Funakoshi lamps (Model UMV-57) and placed 7.6 cm above the back of each mice (irradiance of UV was approximately 1.5 mW/cm2).

Rectangular specimens were dissected from the dorsal skins. The dimension of specimens was 30 × 10 × ~0.8 mm. The cross-sectional area of each specimen was measured by a non-contact method using a laser micrometer.

Experimental. Dynamic Mechanical Analysis testing was carried out to evaluate the viscoelasticity of each skin by using a DMA apparatus (Rheovibron DDV-25GP, A&D Co., Ltd.). The testing conditions were the frequency of 0.4 to 25 Hz at the room temperature. DMA testing was performed nine times repeatedly. The average of value of the experiment obtained each testing. The applied static tensile stress was 60kPa for each dynamic testing. The strain of applied dynamic displacement was 0.25%. Obtained data were storage modulus $E'$, loss modulus $E''$, and loss tangent as the ratio of storage and loss moduli tan$\delta$.

In addition, DMA testing was carried out changing in the static stress from 60kPa to 200kPa in the UV and control group to understand the effect of elastin and collagen fibers.

Results of DMA testing. As the result of viscoelastic testing of control group, the storage and the loss modulus, and loss tangent increased with the increase in measurement frequency. This tendency is same as the viscoelastic behavior of polymers, and it was seen in wound and UV group.

Effect of static stress for DMA measurements, DMA tests with different static stress (60kPa, 100kPa, and 200kPa) were carried out and compared between UV and control groups. The storage modulus of them was shown in Fig. 1. Each value increased with the increase in the static stress. In addition, the storage modulus of UV group was lower than that of control group, and the larger the static stress was, the larger the differences between UV and control group.

Conclusions. In this paper, DMA measurement was carried out to evaluate the effect of UV-irradiation of the skin on the viscoelasticity of hairless mice skins, the viscoelasticity of hairless mice skins were evaluated by using DMA testing apparatus, and they showed frequency dependency. And there was a significant difference in viscoelastic properties between UV and control groups and it was larger with increase in static stress.

References.
(1) Oikarinen A et al., Photodermatology, 2 (1985), 15-26.
(2) Smith JG, et al., J Invest Dermatol, 39 (1962), 347-350.
(3) Sams WM, et al., J Invest Dermatol, 4 (1964), 467-471.