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Observation of Varying Stratum Corneum Behavior with Atmospheric Microplasma Irradiation

大気圧マイクロプラズマ照射による角質層変化の観察

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Medical applications using atmospheric plasma have been intensively researched in recent years. These applications are using ions and active species generated by atmospheric plasma. It is not yet fully understood how the atmospheric plasma interacts with biological matters. In this study, porcine skin was used as a biological matter, which was exposed to atmospheric microplasma. As shown by the FT-IR spectroscopy evaluation, the thickness of stratum corneum of the porcine skin was decreased as a result of the atmospheric microplasma irradiation.

1. Introduction

In recent years, medical applications with atmospheric plasma have been intensively studied [1]. Fields of these applications are sterilization [2] and inactivation of cancer cells [3]. These applications are using ions and active species generated with atmospheric plasma. Dermatology is one of the application fields. Wound healing, skin rejuvenation and treatment of wrinkles also have been studied [4]. Although many researchers studied the medical application using atmospheric plasma, it is not clearly revealed how the atmospheric plasma operates and interacts with biological matters. In these experiments, atmospheric microplasma was irradiated to porcine skin as a biological matter, which was analyzed by ATR method.

2. Experimental Setup

2.1 Microplasma irradiation

Fig.1 shows the experimental setup for microplasma irradiation process. A negative pulse voltage set at about 1 kV was applied to a film electrode attached to a microplasma probe. The film electrode consisted in conductive part, dielectric layer and insulation layer. Fig.2 shows the procedure of making a porcine skin sample. Yucatan Micropig skin (female, 6 months) was used as a biological sample. The porcine skin was put on the film electrode and exposed to the atmospheric microplasma with flowing argon gas as a process gas. Exposed time was set at 1 and 5 min to compare the control sample (without irradiation).

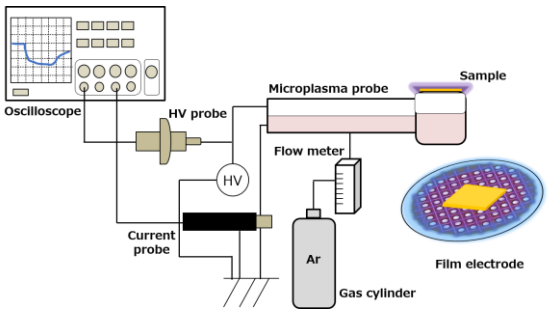

Fig.1. Experimental setup for microplasma irradiation process

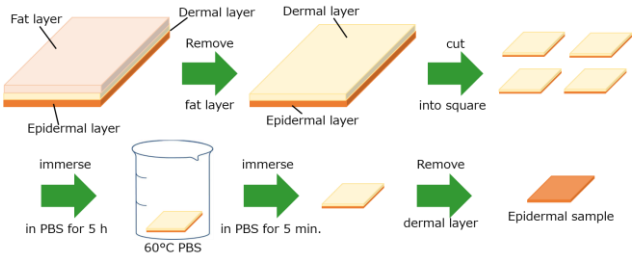

Fig.2. Preparation procedure of the porcine skin sample

2.2 Measurement with FTIR-ATR spectroscopy

After the microplasma irradiation, the porcine skin sample was analyzed with FTIR-ATR (Attenuated Total Reflection) spectroscopy. The measuring wavenumber was set from 2800 cm^{-1} to 3100 cm^{-1} , which indicates CH_2 symmetric and asymmetric stretching mode [5]. Resolution and cumulated time were 1.0 cm^{-1} and 64 , respectively.

2.3 Tape stripping Test

Tape stripping test is a representative evaluation method of a stratum corneum barrier performance [6]. Scotch tape was stuck to the surface of stratum corneum layer and peeled off for 10 ~ 20 times. The tape stripping porcine skin samples was analyzed with FTIR-ATR spectroscopy in order to compare with the result of microplasma irradiation.

3. Results

3.1 Tape stripping test

Fig.3 shows CH_2 spectra of the porcine skin samples conducted tape stripping tests. Absorbance of CH_2 peak of the porcine skin samples were decreased as the number of the tape stripping was increased. The result indicates that the barrier performance of stratum corneum (SC) was declined because SC layer was removed by applying and peeling scotch tape [5].

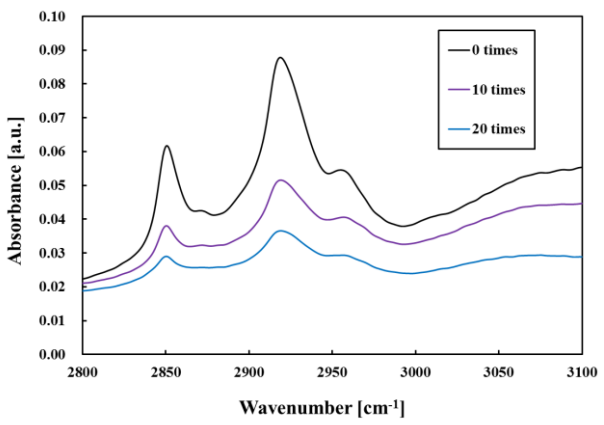

Fig.3 CH_2 Spectra of the porcine skin samples treated tape stripping test analyzed by the FTIR-ATR spectroscopy

3.2 Microplasma irradiation to the porcine skin

Fig.4 shows the spectra of the porcine skin samples exposed to the atmospheric microplasma. The absorbance of the skin samples was decreased as the exposure time of the atmospheric microplasma increased. This could be SC layer was shaved by the atmospheric plasma irradiation. From this result, it is expected that the atmospheric microplasma has the potential to enhance the drug penetration through the skin because the SC layer performs as a barrier.

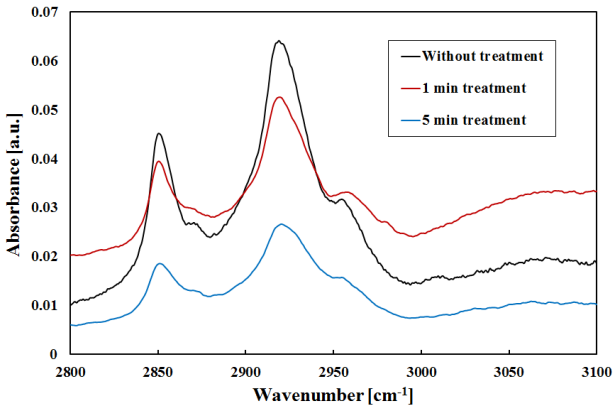

Fig.4. Spectra of the porcine skin samples treated by the atmospheric microplasma irradiation

4. Conclusion

The porcine skin samples were exposed to the atmospheric microplasma and the following conclusions were obtained.

1. The absorbance of the CH_2 peak of the porcine skin sample was decreased as the exposure time was increased.

2. In comparison to the result of tape stripping test, stratum corneum layer was decreased by the atmospheric microplasma irradiation. This result suggested to enhance the drug penetration through a skin.

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