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Monitoring the distribution of anionic surfactants in the stratum corneum by combined ATR-FTIR and tape stripping experiments

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Introduction

Anionic surfactants are recognized as skin irritants. Especially sodium lauryl sulphate (SLS) is known to diminish the barrier properties of the stratum corneum. Therefore, SLS is mostly replaced by its ethoxylated and milder analogon sodium laureth sulfate (SLES) [1]. Nevertheless, SLS is still widely used in personal care products.

Combined with a tape stripping procedure, the ATR-FTIR technique can be employed to detect exogenous substance in different layers of the stratum corneum [2]. However, this approach is rarely used since characteristic bands of exogenous substances appear in the less attention paid fingerprint region and mostly overlap with typical skin bands.

In this study, with the help of spectral subtraction of untreated from treated skin, it was possible to monitor the distribution of anionic surfactants in the stratum corneum without the need of deuterated compounds.

The suitability of this method of analysis was tested with solutions of either SLS or SLES in water. In addition, two commercially available hair shampoos were used in a consumer orientated washing procedure on pig ear skin, in order to investigate the effects of a brief exposure on the uptake of SLS and SLES into the stratum corneum.

Experimental methods

Formulations

15% aqueous solutions of either SLS or SLES were used for incubation of the skin samples. Water served as control.

In case of the washing procedure, two commercially available shampoos containing SLS or

SLES were tested.

Washing procedure
Appropriate cut porcine ear skin samples were rubbed with shampoo in circular motion for one minute. After careful cleansing under running water, the skin sample was blotted dry and tape stripped once. ATR-FTIR spectra were recorded and analyzed as described.

Combined ATR-FTIR and tape stripping experiments
Full-thickness porcine ear skin was incubated with the respective surfactant solution for one hour at 32°C. Spectra were recorded on a Tensor 27 (Bio-ATR I tool, Bruker Optics, Germany) and analyzed with the software OPUS 5.5. The uppermost layers of the skin were removed with 20 consecutive adhesive films (Tesa film crystal clear sticky tapes, Tesa AG, Germany). The pseudoabsorption of the pooled corneocytes fixed to the individual tapes was determined with the SquameScan®850A (Heiland electronic GmbH, Wetzlar, Germany). Due to dependency of the ATR-spectra intensity on the degree of contact between the crystal and the sample, the absorbance of interest was normalized against the amid II absorbance. A skin sample incubated with water was tape stripped in the same manner and served as control.

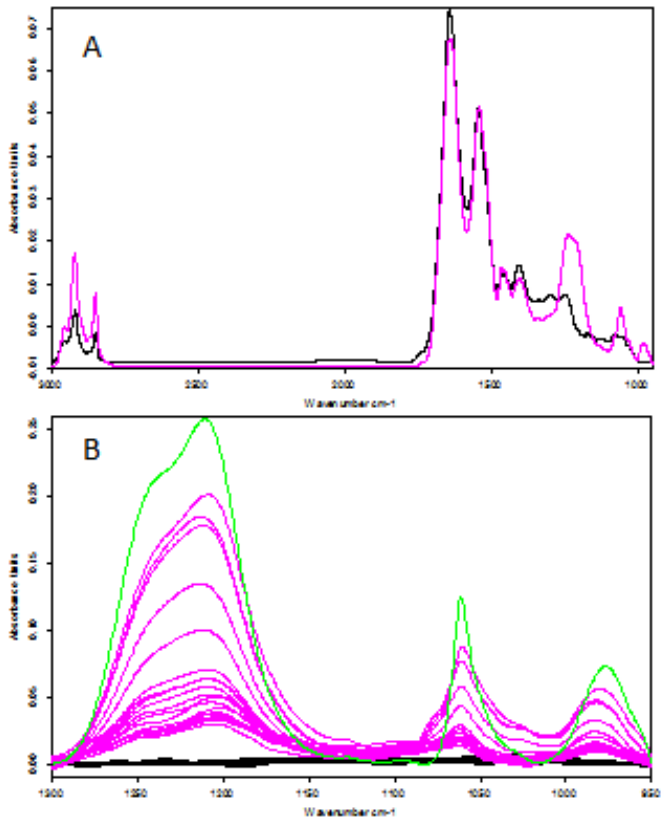

Figure 1:
(A) ATR-FTIR spectra of untreated porcine ear skin (black) and porcine ear skin incubated with SLS (pink); (B) Green: ATR-FTIR spectra of 15% SLS in water; Pink: ATR-FTIR spectra of SLS treated skin at different stratum corneum depth after subtraction of untreated skin Black: ATR-FTIR spectra after subtracting two different untreated skin samples from each other at different stratum corneum depth (control)

In order to monitor and compare the stratum corneum penetration depth of both surfactants, spectra of the control sample were subtracted from the treated sample. Due to different absorption coefficients of the evaluated absorption bands of SLS and SLES, the measured absorbances were additionally related to the corresponding absorbances of 15% aqueous solutions of SLS and SLES.

Results

Similar results were obtained after incubation with either SLS or SLES. As seen in Figure 1A for SLS, characteristic bands, like the alkyl sulfonate stretching bands at ~ 1210 cm-1, were an indicator of SLS incorporation into the stratum corneum. Subtraction of untreated skin spectra from SLS treated skin at equivalent depths resulted in spectra similar to those of the respective surfactant in water (Figure 1B). Both SLS and SLES were still detectable after removal of 20 tape strips, which corresponds to a stratum corneum thickness of about 50%. To prove the suitability of this method, we made a correlation of the deep-depended absorbances of two different absorption bands for both surfactants resulting in excellent linear correlations with coefficients of determination of 0.9956 for SLS and of 0.9863 for SLES, respectively.

With the help of this method, an uptake of SLS and SLES into the stratum corneum even after a short washing procedure with commercially available shampoos was observed.

References

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