Anionic vs natural surfactant: Influence on skin barrier properties

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Introduction

Surfactants, widely used as components of personal care products and drug delivery systems, are recognized to diminish the barrier properties of the stratum corneum. The physical presence of an excipient is related to skin barrier function and the uptake and distribution of surfactants in the stratum corneum is therefore of major interest [1]. Combined with a tape stripping procedure, ATR-FTIR spectroscopy provides a useful tool for semi-quantitative analysis of exogenous substances in different layers of the stratum corneum. With the help of this technique, the skin penetration of sodium lauryl sulfate (SLS), was compared to that of an alkylpolyglycoside (APG), a skin friendly nonionic surfactant derived from a natural sugar unit and a fatty alcohol.
Moreover, the impact of these two surfactants on the removal of corneocytes during the tape stripping procedure was analyzed in detail.

Experimental Methods

Combined ATR-FTIR and tape stripping experiments
Full-thickness porcine ear skin samples were incubated for 1h at 32°C with 0.5 molar aqueous solutions of either SLS or APG. 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-absorbance 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.
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 APG, the measured absorbances were additionally related to the corresponding absorbances of 0.5 molar aqueous solutions of SLS and APG.

Results and Conclusion

In Fig. 1, characteristic bands of SLS, like the alkyl sulfonate stretching bands at ~ 1210 cm^{-1}, were an indicator of SLS incorporation into the stratum corneum. On the contrary, the spectrum of porcine skin incubated with APG is similar to the control spectrum and showed only a slight intensity increase of characteristic carbohydrate bands ~ 1050 cm^{-1}. Subtraction of untreated skin spectra from surfactant treated skin at equivalent depths resulted in spectra similar to those of the respective surfactant in water (Fig. 1 inset). The intensity and frequency shifts of the asymmetric and symmetric CH_2 stretching absorbances at 2920 cm^{-1} and 2850 cm^{-1} were analyzed in addition (Fig. 2). Taking together these results, a significantly higher stratum corneum incorporation of SLS compared to APG was found. Moreover, SLS penetrated into deeper layers of the stratum corneum and was still detectable after removal of 20 strips, which corresponds to a stratum corneum thickness of 53 ± 7%. In contrast, the determined penetration depth of APG was only 30 ± 5% of entire stratum corneum thickness.
Interestingly, less corneocytes were removed after treatment with SLS compared to APG or water (Fig. 3). This might be ascribed to impaired tackiness of the tapes by interaction with SLS. However, these findings underline the importance of exact determination of removed corneocytes, especially if different excipients are applied. Otherwise, wrong conclusions regarding skin penetration of substances might be drawn.

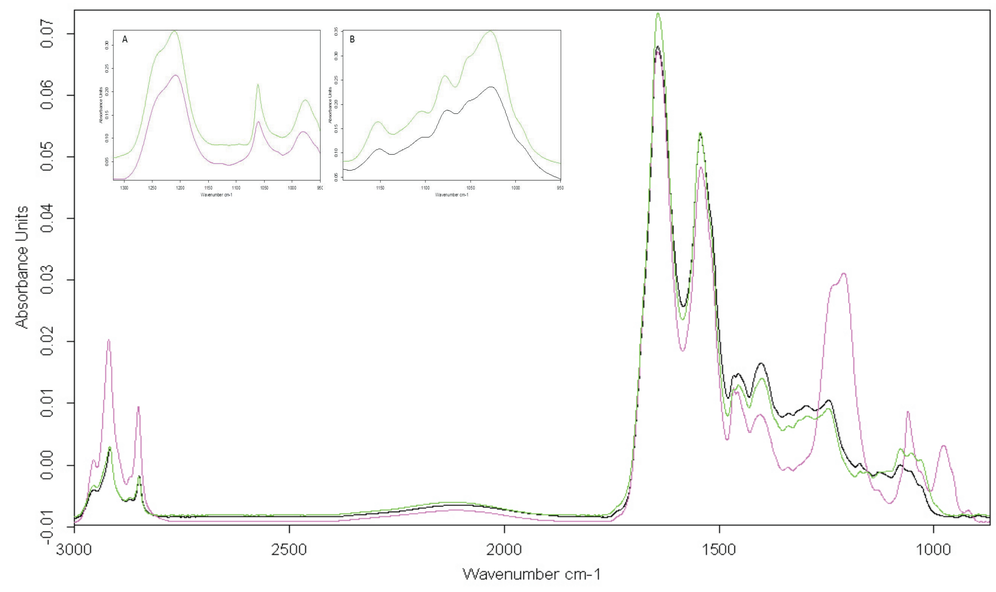

Figure 1: ATR-FTIR spectra of porcine ear skin treated with different surfactants after the first tape strip (n = 3)
pink: Spectrum of porcine skin incubated with SLS
green: Spectrum of porcine skin incubated with APG
black: Spectrum of porcine skin incubated with water
Inset: ATR-FTIR spectra of SLS (A) or APG (B) treated skin after subtraction of untreated skin. Green spectra: Control spectra of the respective surfactant in water.

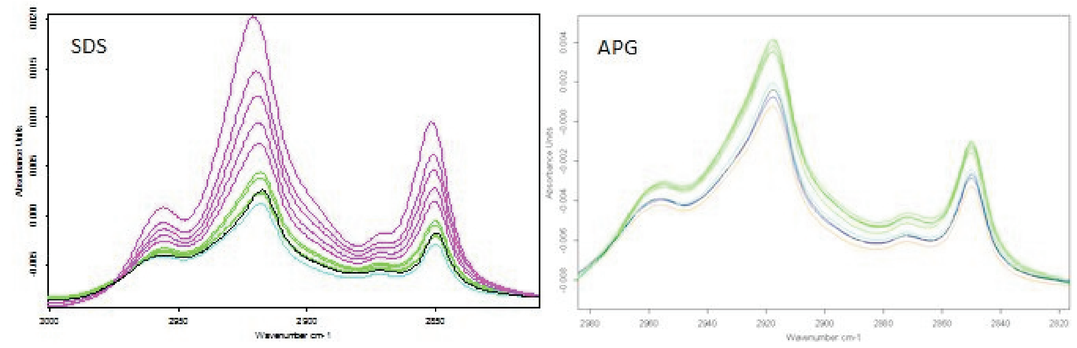

Figure 2: Decreasing peak intensities of the asymmetric and symmetric CH_2 stretching modes of surfactant treated porcine ear skin after removal of 20 tape strips (n = 3)
pink or green: after strip 1-5, light blue: after strip 10, dark blue: after strip 15, orange: after strip 20; black: water (control)

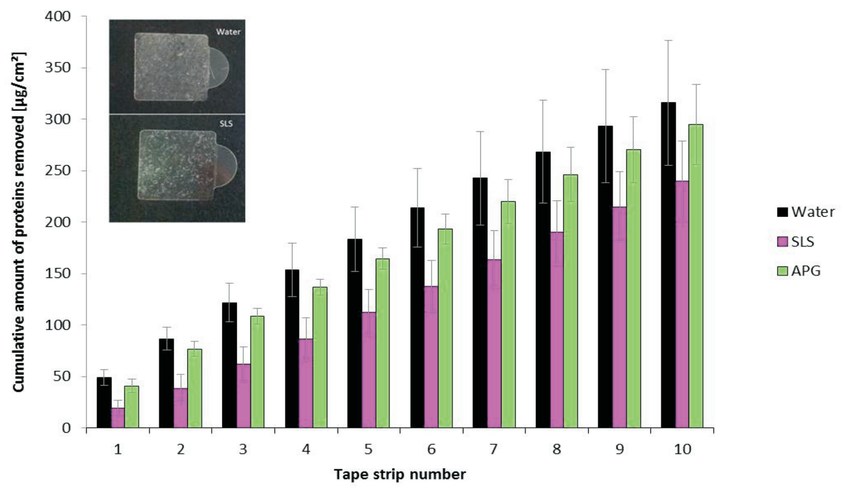

Figure 3: Cumulative amount of proteins removed by 10 sequential tape strips from porcine ear skin after treatment with different surfactants (n = 6). Inset: Representative example of first removed adhesive films

References
[1] Mao, G.; Flach C.R.; Mendelsohn, R. and Walters, R.M. Imaging the distribution of sodium dodecyl sulfate in skin by confocal Raman and infrared microspectroscopy. Pharm. Res., 29, 2189-2201 (2012)

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