Effectiveness of the DreamSkin® garment on relieving symptoms of Eczema/Dermatitis using electrical and spectroscopic methods: a case study

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Abstract— **Eczema, is a common skin inflammatory disorder particularly among children. The treatment of which usually consists of the application of emollients and moisturisers to maintain skin moisture and to reduce the risk of inflammation, infection and exacerbative factors. Recently, DreamSkin® Health Limited has developed a unique polymer treatment for eczema. The polymer has been applied to medical grade silk clothing as a means of delivering the therapeutic benefits to the sufferers' skin. They claim that the polymer reduces the loss of moisture caused by evaporation from damaged skin; acts as a barrier against external irritants and helps to restore the skin's natural temperature management process. The aim of this study was to assess the products effectiveness at providing symptomatic relief for a volunteer with confirmed Eczema and Atopic Dermatitis over a period of 14 days. Both skin capacitance and NIR spectra were collected during the course of the study, using the Corneometer® CM 825 and a spectrophotometer equipped with a customized reflectance probe for measurements in the Near Infrared region. The treated area showed visibly improved skin and overall results from both techniques showed a noticeable increase in skin water content after 14 days, peaking on the 7th day. However, slight differences were observed in the magnitude of increase between the two instruments. Future work will focus on expanding this study to include more cases as well as performing statistical analysis to build upon our previous work in the area of skin hydration determinations using Near Infrared Spectroscopy.**

I. INTRODUCTION

Eczema and Atopic Dermatitis (AD) are inflammatory skin disorders with strong links to genetics, which usually appear in early life, with a high incidence reported among children [1–4]. Eczema and AD come under the category of spongoitic dermatitis, which is a descriptive name for a set of skin conditions that clinically appear as an erythematous and papulovesicular eruption. Their reaction is characterized by intraepidermal and intercellular edema [4,5]. They are recognized as major health issues worldwide [6], and their prevalence is rising, currently affecting 15-20% of school children and 2-10% of adults in the UK [7]. Moreover, although their symptoms tend to improve with age, most patients continue to possess features of AD and eczema throughout their adult lives [4,8]. This is because the inflammation produces severely dry, scaly, and brittle skin resulting in a skin barrier that is insufficient at protecting against environmental irritants and allergens [8]. Typically, such conditions are treated with humectants and occlusive agents that smooth the rough surface of the Stratum Corneum (SC) and normalize its moisture levels [1,8]. However, moisturising agents only aim to reduce trigger factors and maintain skin hydration, and the need to apply them several times a day can be a tedious task.

The aim of this study was to determine the effectiveness of the DreamSkin® polymer in improving moisture levels of skin affected by Eczema, Dermatitis, dry or irritated skin. This was carried out by measuring skin electrical capacitance using the Corneometer® CM 825 and Near Infrared (NIR) spectra over a 14 day treatment period.

The polymer is permanently bound onto 100% silk garments through ionic coupling, creating a firm bond between the fibres and the polymer [9]. During the drying process, the molecules rearrange into a lamella structure similar to that of the polar group of phospholipids in the human cell membrane. The polymer contains phospholipid-analogue agents including phosphorylcholine polymers, which have been utilized previously in the medical world for coating medical devices such as catheters and in certain moisturiser preparations. The final multi-layer lamella structure formed with these polymers is both hydrophobic and hydrophilic. The hydrophobic element is thought to act as an external barrier effective against irritants, whilst the hydrophilic is claimed to provide a moisture retaining and enhancing property [9].

The Corneometer® CM 825 (a technique based on electrical capacitance) was selected for the measurements in order to assess the effectiveness of the DreamSkin® polymer. This technique has been accepted internationally as a suitable instrument for determining SC water contents. On the other hand, many studies have shown the possibility of accurate detection of water using NIR spectroscopy by using the intensities of overtone and combination bands of OH and HOH occurring in the NIR region [10–15]. Therefore, this method was also included here and is aimed to support our ongoing research on possible implementation of this technique in determinations of skin hydration [16-17].

II. MATERIALS AND METHODS

City University London Senate Research Ethics approval was sought prior to performing any measurements on individual(s) or collecting any personal details, and the

experiment was conducted during the autumn season of November, with average UK temperatures of 5.5 °C.

A. Case

The volunteer was a 30 year old female of white heritage with a confirmed diagnosis of Eczema. She has been suffering from atopic eczematous symptoms on her entire body since childhood, and often experiences breakouts and infections on her skin. In these cases, antibiotics and steroid creams have been routinely prescribed for treatment.

Due to her condition, the subject has regularly applied sunscreen creams and has been using moisturizers on a daily basis.

B. Experimental Design

The volunteer was recruited and asked to complete a medical questionnaire on her skin health prior to performing any tests. Then, capacitance measurements were obtained by placing the head of the Corneometer® probe on the external right arm, on a site where damaged eczematic skin was clearly observed. This was followed by placing the optical probe on the same site to record NIR spectra. Initial recordings from both instruments were to serve as a baseline before starting treatment. Once measurements were obtained, treatment was started immediately with the Dreamskin® garment, which was in the form of a sleeve. The volunteer was given 4 sleeves in total in case changing was required, and was asked to wear the garment on the test site at all times except during washing. Follow-up measurements were taken on the 7th and 14th day from the start of the treatment. On each recording, 3 readings were taken from both devices for averaging purposes. Further analysis was later carried out on the resulting capacitance values and on the group spectra from each category in order to examine and compare the response.

C. Instrumentation

Skin capacitance measurements were performed using the Corneometer® 825 (Courage-Khazaka electronic GmbH, Koln, Germany) whose output is an arbitrary number deduced by determining the change in the dielectric constant due to skin surface hydration changing the capacitance output. All values obtained were then transferred to Excel, Microsoft.

As for the NIR skin spectra, these were collected using the Lambda 1050 dual beam UV/Vis/NIR spectrophotometer (Perkin Elmer Corp, Massachusetts, USA) at increments of 2 nm in the spectral region of 900-2100 nm, with an InGaAs detector operating throughout the entire region. Light was provided by a tungsten lamp and a gain setting of 3 was also added. The scanning period for each interval was set at 0.2 secs, as this value seemed to give a reasonable balance between sensitivity and scan time.

Attenuator settings were kept constant at 1% for the reference beam to improve noise levels at high absorbance, and at 100% attenuation for the sample beam. Slit size controls for the InGaAs detector were set on "servo mode" so that the system could oversee the reference beam energy and select the slit size accordingly. Initial baseline corrections were also performed at 100 % T/0A, and at 0 % T/blocked beam to eliminate irrelevant bands and background noise especially evident in highly absorbing media such as skin.

In order to acquire reflectance measurements, the sample holder compartment was replaced with a universal reflectance accessory that permitted the attachment of a fibre optic probe (Ocean optics, Duiven, The Netherlands). This probe consists of a bundle of 7 optical fibres in a stainless steel ferrule, with 6 of them as illumination fibre, all around 1 light detecting fibre. However, the probe was employed with the single fibre acting as the source of radiation and the other 6 as detectors. The fibre core diameter was 600 μm.

It was essential to introduce a small gap between the probe and the test site for two reasons: to firstly prevent blockage of light from leaving, and secondly because occlusion can lead to the build-up of water and increase hydration. Therefore, the reflectance probe was slightly modified by enclosing its tip with a Perspex tube layer that was longer than the end of the probe by 1.5 mm. This coating ensured that the desired separation distance was maintained throughout all tests. In addition, this particular coating was overlaid with another white coating to eliminate interference from ambient light whilst scanning.

NIR spectra obtained were pre-treated using the UVWinlab Data Processor and Viewer software (Perkin Elmer Corp, Massachusetts, USA), where smoothing, R% to Absorbance conversion and Standard Normal Variate (SNV) scatter correction were applied. Further data processing was later finalized using the Matlab software (Mathworks Inc., Novi, MI).

III. RESULTS AND DISCUSSION

After wearing the DreamSkin® sleeve for 14 days, the volunteer did not express any side effects and claimed that the itching had been reduced compared to parts of her body where the sleeve was not worn. This was also visibly clear, as the right arm of the volunteer appeared more moist, and smoother compared to her left arm. Furthermore, this claim was consistent with skin capacitance values obtained over the treatment period, as shown in Fig 1. Looking at this chart, it can be seen that moisture levels were lowest at the baseline
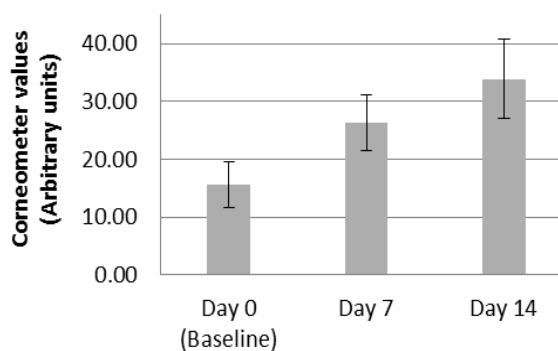

Figure 1. Skin capacitance values obtained from a volunteer with confirmed Eczema and AD taken on the 0th, 7th and 14th day of treatment with a DreamSkin® sleeve. Error bars denote standard deviation.

measurement that was taken prior to the start of treatment, and which consistently increased on the 7th and 14th day of treatment. Results also identify the peak effect of the product being in the first 7 days of treatment.

As mentioned earlier, NIR data was collected alongside the Corneometer® values throughout the study. Fig 2 shows the resulting absorption spectra acquired from the subject on the 0th (Baseline), 7th and 14th day of treatment after undergoing the pre-treatment process. For averaging purposes, 3 spectra were collected during each test and it is the average of these that is presented here. In order to appreciate the difference between skin that is damaged and non-damaged due to spongiotic dermatitis conditions, a spectrum collected previously from 5 healthy individuals on the volar aspect of their forearm was included in the figure. These individuals had not applied any form of cream on their right arm in the 2 weeks prior to measurement.

Fig 2 shows a clear distortion of the normal human spectrum in the eczema-damaged area, particularly in the longer NIR range which is usually distinctly marked by a large OH combination band around 1900 nm. Instead, the damaged skin shows a huge decrease and the two bands around 1900 and 1970 are no longer resolved. On the other hand, a shoulder that normally appears around 2000 nm and is indicative of bound water, becomes far more prominent than it usually is in normal skin, but less so by the 14th day of treatment as it begins to resolve with adjacent bands.

Nevertheless, it becomes notable that during the course of treatment, the spectrum of the damaged area began to improve, with observed increases in both the OH stretching overtone and combination bands of water around 1450 and 1900 nm. The latter also starts to become resolved by the 14th day of treatment.

Second derivative spectra of those in Fig 2 were also calculated and are shown here in Fig 3, but only include spectra collected from the single volunteer with eczema and AD. In this case, the minima equivalent of the OH overtone

Figure 3. Second derivative spectra obtained from transforming the absorption spectra acquired on days 0, 7 and 14 from a volunteer with eczema and AD undergoing treatment with the Dreamskin® garment.

at 1450 nm markedly differs in magnitude in accordance with the date of measurement during treatment. However, unlike the capacitance readings which show consistent increments over the 14 days, NIR peak values are instead highest on the averaged spectrum recorded on the 7th day of treatment. Beyond 1500 nm, the characteristics of the three spectra begin to variably quite considerably, where the minima equivalent of the water band near 1900 nm becomes nearly non-existent in the spectrum taken on the final day of treatment. This is possibly due to an observed increase in the bound water band and the spectrum becoming more resolved with adjacent bands in this region. As for the baseline and 7th day spectra, a clear increase is evident around 1900 nm, but with peak shifts occurring towards longer wavelengths in the 7th day spectrum.

Moreover, the relationship between capacitance values and second derivative NIR spectra was examined by analyzing the correlation coefficients between all the readings obtained prior to averaging. For the NIR peaks, values of the minima near 1460 nm referring to the 1450 nm water overtone were used here rather than at 1900 nm, as those varied significantly between measurements.

Although the 1900 nm water region is more suited for this task as is not influenced by adjacent protein bands, the
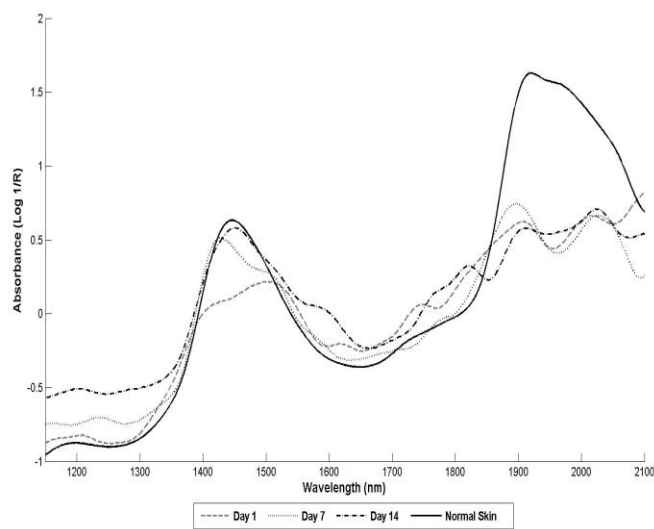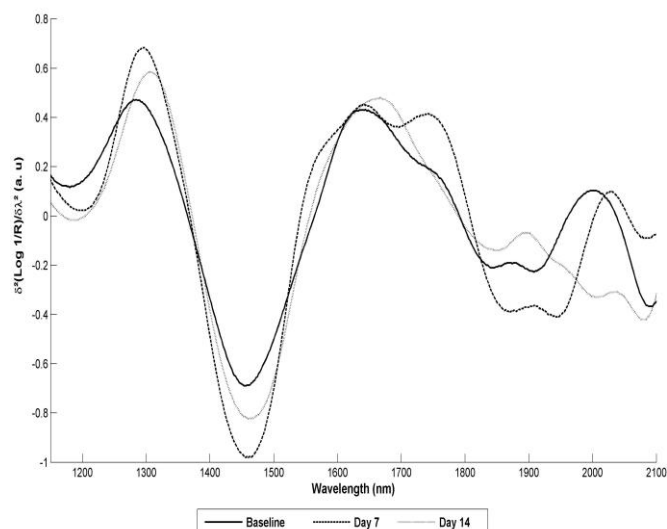

Figure 2. Averaged absorption spectra of an individual suffering from Eczema and AD taken prior to start of treatment (Day 1), then on the 7th (Day 7) and 14th day of treatment (Day 14), in comparison to a spectrum of non-moisturized normal skin.

TABLE I   CORRELATION COEFFICIENT BETWEEN CAPACITANCE AND NIR PEAK VALUES DURING VARIOUS STAGES OF TREATMENT

Stage of treatment	Correlation Coefficient
Day 0 (Baseline)	0.809
Day 7	-0.680
Day 14	0.997

1450 nm remains a good indicator of water contents and was deemed appropriate for the purpose of this analysis.

Table 1 summarizes the coefficients calculated for each day of measurement. The overall correlation was calculated to be 0.493 indicating a low correlation between the NIR overtone band of water and skin capacitance readings. Nevertheless, individually, baseline measurements and recordings from the 14th day of treatment in particular correlate the readings from the two instruments significantly, whereas the opposite is exactly true for the 7th day recordings

IV. CONCLUSION

The aim of the present study was to assess the effectiveness of a Dreamskin® product, in the form of a sleeve, in enhancing moisture levels in a volunteer with long term confirmed Eczema and AD, and examine whether the garment would benefit the subject by reducing the symptoms associated with these disorders. The study was carried out over a period of 14 days using both the Corneometer® CM 825 for skin capacitance measurements and a spectrophotometer operating in the NIR region for diffuse reflectance measurements, with readings taken prior to start of treatment, followed by the 7th and 14th day.

Overall, the Dreamskin® product seemed to yield a promising outcome as expressed by the volunteer, and moreover, results from both instruments are in accordance with this as both techniques demonstrated a significant increase in moisture levels at the end of the 14 day period. Nevertheless, whereas capacitance values produced results that were consistently increasing over time, peak values from NIR second derivative spectra showed highest peak values on the 7th day of treatment for the water overtone band and unclear results around the combination band near 1900 nm, which at this stage is assumed to be due to the bands in the region becoming more resolved. Moreover, readings from both devices correlated most for the 14th day measurements and least for the 7th day.

Although NIR spectra were mainly included here for research purposes and capacitance readings are the worldwide standard, it remains that the skin is a complex organ that is easily susceptible to external and internal influences. Therefore, it is important in characterizing the skin to obtain measurements using various techniques and approaches. In the future it is planned to extend this study to include more cases, in order to build a clearer understanding of the benefits of the Dreamskin® range and identify a correlation between the capacitance and spectroscopic methods. Data from a larger population will also allow qualitative and quantitative statistical analysis of the NIR spectra.

REFERENCES

[1] C. A. Akdis, M. Akdis, T. Bieber, C. Bindslev-Jensen, M. Boguniewicz, P. Eigenmann, Q. Hamid, A. Kapp, D. Y. M. Leung, J. Lipozencic, T. A. Luger, A. Muraro, N. Novak, T. a. E. Platts-Mills, L. Rosenwasser, A. Scheynius, F. E. R. Simons, J. Spergel, K. Turjanmaa, U. Wahn, S. Weidinger, T. Werfel, T. Zuberbier, the E. A. of Allergology, A. Clinical Immunology/American Academy of Allergy, and I. C. Group, "Diagnosis and treatment of atopic dermatitis in children and adults: European Academy of Allergology and Clinical Immunology/American Academy of Allergy, Asthma and Immunology/PRACTALL Consensus Report," *Allergy*, vol. 61, no. 8, pp. 969–987, 2006.

[2] D. Y. Leung and T. Bieber, "Atopic dermatitis," *The Lancet*, vol. 361, no. 9352, pp. 151–160, Jan. 2003.

[3] S. Weidinger, T. Illig, H. Baurecht, A. D. Irvine, E. Rodriguez, A. Diaz-Lacava, N. Klopp, S. Wagenpfeil, Y. Zhao, H. Liao, S. P. Lee, C. N. A. Palmer, C. Jenneck, L. Maintz, T. Hagemann, H. Behrendt, J. Ring, M. M. Nothen, W. H. I. McLean, and N. Novak, "Loss-of-function variations within the filaggrin gene predispose for atopic dermatitis with allergic sensitizations," *J. Allergy Clin. Immunol.*, vol. 118, no. 1, pp. 214–219, Jul. 2006.

[4] J. A. P. MD, J. Plaza, and V. Prieto, *Inflammatory Skin Disorders*. Demos Medical Publishing, 2012.

[5] K. J. Busam, *Dermatopathology*. Elsevier Health Sciences, 2010.

[6] J. M. Hanifin, M. L. Reed, and Eczema Prevalence and Impact Working Group, "A population-based survey of eczema prevalence in the United States," *Dermat. Contact Atopic Occup. Drug*, vol. 18, no. 2, pp. 82–91, Jun. 2007.

[7] "Atopic Dermatitis and Eczema | Doctor PDF," *Patient.co.uk*. [Online]. Available: http://www.patient.co.uk/pdf/1144.pdf. [Accessed: 15-Mar-2014].

[8] J. M. Hanifin, A. A. Hebert, S. R. Mays, A. S. Paller, E. F. Sherertz, A. M. Wagner, M. R. Tuley, and M. D. Baker, "Effects of a low-potency corticosteroid lotion plus a moisturizing regimen in the treatment of atopic dermatitis," *Curr. Ther. Res.*, vol. 59, no. 4, pp. 227–233, Apr. 1998.

[9] "Dreamskinhealth," *Dreamskin®*, 15-Mar-2014. [Online]. Available: http://www.dreamskinhealth.co.uk/the-dreamskin-difference.html. [Accessed: 15-Mar-2014].

[10] P. L. Walling and J. M. Dabney, "Moisture in skin by near-infrared reflectance spectroscopy," *J Soc Cosmet Chem*, vol. 40, pp. 151–171, 1989.

[11] K. A. Martin, "Direct measurement of moisture in skin by NIR spectroscopy," *J.-Soc. Cosmet. Chem.*, vol. 44, pp. 249–249, 1993.

[12] I. Bodén, D. Nilsson, P. Naredi, and B. Lindholm-Sethson, "Characterization of healthy skin using near infrared spectroscopy and skin impedance," *Med. Biol. Eng. Comput.*, vol. 46, no. 10, pp. 985–995, Oct. 2008.

[13] H. Arimoto and M. Egawa, "Skin moisture measurement based on near-infrared spectroscopy and regression analysis," in *Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2003*, 2003, vol. 4, pp. 3438–3441 Vol.4.

[14] H. Arimoto and M. Egawa, "Non-contact skin moisture measurement based on near-infrared spectroscopy," *Appl. Spectrosc.*, vol. 58, no. 12, pp. 1439–1446, Dec. 2004.

[15] M. Egawa, "In vivo simultaneous measurement of urea and water in the human stratum corneum by diffuse-reflectance near-infrared spectroscopy," *Skin Res. Technol.*, vol. 15, no. 2, pp. 195–199, 2009.

[16] M. Qassem and P. A. Kyriacou, "Comparing the rates of absorption and weight loss during a desorption test using near infrared spectroscopy," *Skin Res. Technol. Off. J. Int. Soc. Bioeng. Skin ISBS Int. Soc. Digit. Imaging Skin ISDIS Int. Soc. Skin Imaging ISSI*, vol. 19, no. 2, pp. 137–144, May 2013.

[17] M. Qassem and P. A. Kyriacou, "In vivo optical investigation of short term skin water contact and moisturizer application using NIR spectroscopy," *Conf. Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. IEEE Eng. Med. Biol. Soc. Conf.*, vol. 2013, pp. 2392–2395, 2013