Microsc. Microanal. 8 (Suppl. 2), 2002
DOI 10.1017.S1431927602100286

Monitoring Skin Hydration and Product Induced Changes by Near-Infrared Spectroscopic Imaging

S.L. Zhang, T.M. Hancewicz, D.J. Palatini, P. Kaplan, M. Misra, and E.M. Attas[**]

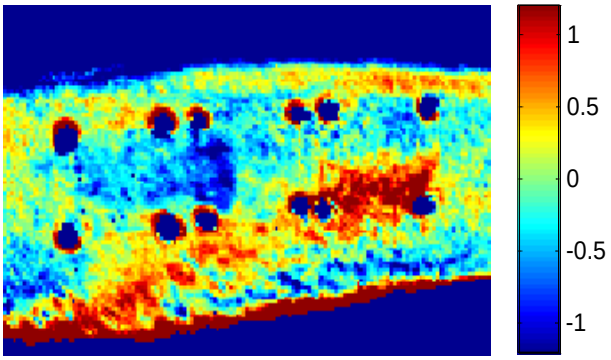
Unilever Research U.S., Edgewater Laboratory, 45 River Road, Edgewater, NJ 07020
[**] Institute for Biodiagnostics, NRC Canada, 435 Ellice Avenue, Winnipeg, MB, Canada R3B 1Y6

Skin hydration is a key factor in skin health. Hydration measurements provide diagnostic information on the health of skin and can indicate the integrity of the skin barrier function. Near-infrared (NIR) methods measure the water content of living tissue by its effect on tissue reflectance at particular wavelengths. NIR imaging is a rapid, non-contact and non-invasive technique and has the important advantage of showing the degree of hydration as a function of location.

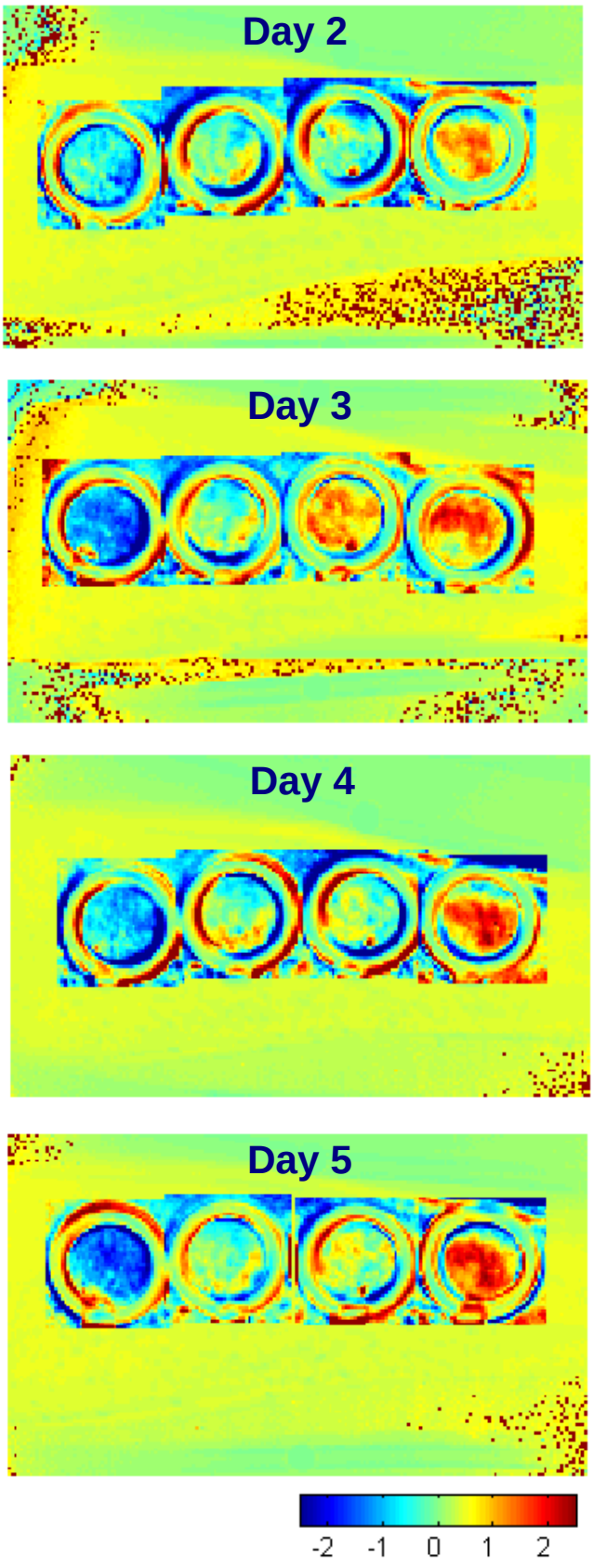
A near infrared spectroscopic imaging system has been developed [1]. It uses a liquid-crystal tunable filter (LCTF) in front of the objective lens and incorporates a 12-bit digital camera with a 320x240-pixel indium-gallium arsenide (InGaAs) array sensor. Reflectance images over the range of 960 to 1700 nm were used to monitor changes in skin hydration on delineated regions of the forearms and lower outer legs of volunteers following treatment with acetone, a commercial moisturizer, or other skin care products. Presented in this abstract are the results of the tissue water content obtained from the integrated intensity of the strong absorption band of water centered at 1450 nm. Other approaches to the data analysis of these NIR hydration images have also been attempted. They include cluster analysis, principal component analysis, and multiway methods.

Effectiveness of the new instrumentation for skin hydration measurement has been successfully demonstrated. A typical result from the previous study [2] is shown in Figure 1. NIR images were taken before product application (baseline) and 30, 90, 180, and 300 minutes after the forearm was treated with acetone and a moisturizer in the marked areas. One area was left untreated as control. Shown in the figure is the difference image between the 30-minutes image and the baseline image. Clearly, the acetone-treated left square close to the elbow treated with acetone shows the lowest water content, while the moisturizer-treated square on the right close to the wrist shows increased skin hydration, when compared with the middle, untreated area.

The NIR method has been extended to examine smaller but more realistic changes in skin hydration induced by daily use of personal care products and by seasonal effects from mild fall to cold winter. An example from the former is shown in Figure 2. In this study, the arms of eight volunteers were each marked with 4 circular areas. The baseline images were taken on the first day before product treatment. Three areas were treated twice a day following a standard protocol for 5 consecutive days with 3 different products, respectively. One area was left untreated as a control. NIR images were taken prior to the second treatment each day. Figure 2 shows typical results as difference images from the baseline. These images clearly indicate both positive and negative skin hydration changes induced by the products. More specifically, observed for this subject were increased hydration in the area treated with product 3 (far right circle), no change or slightly increased hydration in the product 2 area (2nd circle from right) and significantly decreased hydration in the product 1 area (far left circle). The control site is the 2nd circle from left.



(Above)
Figure 1. NIR hydration image of volar forearm using the 1450 -nm band, shown as the difference between images taken before and 30 minutes after product application. The scale indicates area of the absorption band in NIR spectrum. The left square close to elbow was treated with acetone, the right square on the right close to wrist was treated with moisturizer, and the middle one was untreated.



(Four panels on the right)
Figure 2. Changes in volar forearm hydration from baseline (day 1) during a 5 -day treatment with skin care products as measured by NIR imaging. Product application sites are (from left to right circles): Product 1, Untreated, Product 2, and Product 3. The color scale is defined similarly as in Figure 1.

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https://doi.org/10.1017/S1431927602100286 Published online by Cambridge University Press