Molecular Adhesion and Transepidermal Water Loss of Liquid Skin Protectants

Debashish Chakravarthy, PhD
Martha Roman, BS
Max Kushner
Reid Schlesinger
Medline Industries, Inc.
Mundelein, IL

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INTRODUCTION

Maintenance of normal moisture level is important to sustain skin’s structure, toxin defense, and barrier function of skin.1-4 Under normal conditions, the epidermis regenerates new skin cells continuously.5,6 Loss of moisture from the skin results in dryness, which can cause the skin to lose its barrier function.7 Thus, normal moisture level is important to sustain skin’s structure and function.8

RESULTS

The cyanoacrylate skin protectant directly adhered to the epidermis and formed a robust coating on the pig skin (Figure 3A, C). The solvent-based polyacrylate barrier product formed a transparent film on the surface of the pig skin that is non-continuous and less robust (Figure 3B, D). Light microscope images and barrier quantification both revealed that the cyanoacrylate barrier is a significantly thicker barrier (P = 0.013, t-test), as shown in Table 1. Regions of the solvent-based polyacrylate barrier prepared areas are devoid of film, and the surface of the barrier where it exists is often jagged and uneven (Figure 3B). Conversely, the cyanoacrylate barrier directly adhered to the skin (Figure 3C) with consistency and high fidelity, as seen via light microscopy. The thin cyanoacrylate film adhered to the skin, as seen via light microscopy Figure 3C. fiber optic images similarly show that the cyanoacrylate barrier contours with the pig skin’s surface Figure 3A. However, consistent with the images seen in light microscopy, an observable separation exists between the polyacrylate barrier and the pig skin in the contact interface Figure 4. Fiber optic imaging further displays the effects of solvent evaporation over time, which leaves inconsistencies in the coverage in the interface with the epidermis, a phenomenon that is not seen in the cyanoacrylate Figure 4B.

In each subject, TEWL changes after skin protectant application was compared to levels of the same region at the baseline (Table 2). A drop in TEWL indicates less moisture is released from the skin upon barrier application, and suggests that the protectant owners were indeed present on the skin. One hour after application, both the polyacrylate and cyanoacrylate skin protectants had similar drops in TEWL (Figure 5, Table 2). Interestingly, after two hours, the TEWL values of the cyanoacrylate protectant coated skin returned to a near-baseline measurement of 6.9 g/m²/h, despite the presence of a visibly intact barrier. However, the solvent-based polyacrylate protectant coated skin continued to show a significant decrease in TEWL from baseline (P<0.05).

Table 1. Measured Barrier Thickness of Competing Skin Protectant Barriers

<table>
<thead>
<tr>
<th>Skin Protectant</th>
<th>Average Barrier Thickness (µm) ± SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent-Based Polyacrylate</td>
<td>3.072 ± 0.258</td>
</tr>
<tr>
<td>Cyanoacrylate</td>
<td>3.072 ± 0.258</td>
</tr>
</tbody>
</table>

DISCUSSION

The two skin protectants examined in this study have differences in their respective chemical makeup that may affect how they adhere to the skin. The direct chemical bond formation between the cyanoacrylate and the stratum corneum, which is the cornified, dead layer of the epidermis, likely leads to the high fidelity contact of the cyanoacrylate with the skin. The polymerization of cyanoacrylate creates a robust structure that uniformly covered the skin and also contained the natural unevenness of the epidermis. The solvent-based polyacrylate barrier presented as a non-uniform film seen by microscopy that varied in thickness across the application area possibly because of the non-uniform application thickness, coupled with the non-uniform evaporation of the solvent. Briefly, the cyanoacrylate polymers formed an epidermal barrier approximately four times the thickness of the polyacrylate film. This barrier, which could be attributed to the non-evaporation of the applied material since there is no solvent present in the cyanoacrylate material.

Higher TEWL values post product application at any time point indicate higher permeability of moisture vapor from skin. One hour after the application of the skin protectants, both products displayed a significant decrease in TEWL. However, two hours after the application of the skin protectants, the TEWL value of the cyanoacrylate protectant returned to near-baseline levels, no longer displaying a statistically different TEWL. The polyacrylate solvent-based skin product system still showed decreased TEWL levels compared to the baseline. This trend implies that the polyacrylate film decreases skin breathability over at least two hours, whereas the cyanoacrylate does not significantly decrease breathability two hours post application. In short, there is a return to normal TEWL with the cyanoacrylate product, and in this sense, despite being thicker when applied to skin in a typical application; it is also more breathable over time.

Molecular differences may explain the differential breathability profiles. The hydropathy of the nitrogel groups present in the cyanoacrylate product, which are not present in the solvent based polyacrylate protectant, may be responsible for its lower vapor permeability.

CONCLUSION

Microscopy revealed that the cyanoacrylate bound more intimately to skin and produced a continuous, contoured layer when compared to the solvent based polyacrylate product. The cyanoacrylate also formed a significantly thicker barrier with a breathability profile that matched near-baseline levels two hours post application. Though it may seem counterintuitive, both the higher thickness of applied product and a quicker return to normal breathability were associated with the cyanoacrylate product. Additional studies are warranted to evaluate whether there is additional clinical significance to these findings.

REFERENCES