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Science of Skin:

Meeting the challenges of skin.

Medical Materials & Technologies

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The skin is a dynamic organ, reflecting who we are and often telling the story of our health. Changes to the skin can be an early sign of a health condition or disease.

When skin is damaged, it can negatively impact our psychological and physical health.[1,2] The skin's ability to act as a barrier depends on a variety of factors, including: structure of skin, genetics and lifestyle, environmental factors, skin changes over our lifetime and underlying conditions and diseases.

Skin is our largest organ and it is critical to maintaining our bodies and our health. Our skin does an amazing job of protecting us from damage and infections. Recent research has shown that we live in harmony with the bacteria in our environment.[3] In fact, we rely on bacteria to keep us healthy and bacterial communities are part of normal skin function.

Skin is the body's first line of defense, but for a scientist or design engineer, it can be a complex puzzle to design adhesives, dressings and devices for both healthy and compromised skin. As a living, breathing organ, skin sweats, stretches and grows hair. It can behave differently based on conditions including age.

Our changing skin

As we age, our skin changes. We may not fully understand why these changes occur, but scientists have been tracking and documenting them for decades.

When babies are born premature, their skin can be fragile. Babies born before a full 40 weeks of gestation have an increased risk of infection due to an imbalance in the skin's microbiome. [4] They are also at higher risk for Medical Adhesive-Related Skin Injury (MARSI) because their skin is not fully developed.

Using a tape designed for healthy skin can cause trauma due to the nature of the adhesive or upon removal.

As we age, the epidermis flattens and thins. This means an increased risk for older patients when any adhesive is attached to their skin. Damage, including MARSI, tension blisters, skin stripping and skin tears can be a painful reality when a device or dressing is removed. This happens when the strength of the adhesive is greater than the strength of the bond between the skin cells.[5] That's why it's important to maintain a balance between performance of the adhesive and the maintenance of skin integrity.

Sticking to skin: solving the puzzle

As we advance new technologies, the demand for adhesives and devices that attach to our skin increases – from wound care dressings to drug delivery solutions and wearable sensors. Scientists and engineers must answer complex questions when choosing the right adhesive system for these devices, such as: How long will the adhesive or device remain on the patient? Where will the adhesive or sensor be placed on the body? What skin types or conditions will be encountered for typical users?

The impact of MARSI on wearable device selection

When designing stick-to-skin medical devices, skin can be a fierce adversary. Any wearable substrate that adheres to the skin is likely to require a medical-grade pressure-sensitive adhesive. When you select the adhesive, it is important to consider the activity, age and health of the patient, as well as skin allergens.

Additionally, patients with fragile skin, such as newborns and the elderly, can be vulnerable to MARSI.

Constant contact with moisture can also make skin vulnerable to injury. Designers must take care to select quality materials during the concept stage of wearable device development. In addition to being of high quality, the materials must take into consideration common skin allergens and irritants and be tested to industry safety testing standards.

The choice of one material layer can also affect other materials of construction. For example, certain polymers from one layer can interact with adhesives in another layer after assembly, causing them to fail. Biological factors that can make sticking to skin difficult include age, moisture and hair. An improperly

selected or applied adhesive can even cause hair follicles to become inflamed, which is a condition called folliculitis. Just as wearable devices must be tested to ensure the safety of the user, so should the adhesive be tested on human skin and pass biocompatibility tests.

Fortunately, scientists have made significant advancements to protect and maintain skin health. In cooperation with clinicians, skin disease experts, medical manufacturers and experts researching the structure of skin have developed innovative solutions that help reduce the risk of skin damage.

Alcohol-free barrier film

Skin barrier products provide a protective interface between the skin and adhesives to reduce the risk of MARSI and protect the skin from body fluids. Users can apply alcohol-free barrier film and allow them time to dry prior to applying adhesive products, particularly if the patient is at high risk for skin injury.[6]

Alcohol-free barrier films help reduce the incidence of red, irritated skin (erythema) and skin stripping after medical adhesives are removed, including in newborns.[7,8] They also help protect skin around wounds.[9,10]

Polymer chemistry

A novel cyanoacrylate polymer formulation has been proven to protect the skin by creating a highly durable, ultra-thin, transparent, breathable and flexible barrier. This elastomeric film protects the underlying tissue from fluids, so it can heal and regenerate.[11,12] It protects patients under challenging conditions and is able to attach to wet, weepy, damaged skin surfaces.[13] This film allows easy, gentle cleansing, can be applied quickly and lasts up to seven days.[14]

Silicone adhesives

Silicone adhesives and tapes have been shown to be gentler to skin than other adhesive products and decrease the risk of MARSI. Silicone tape provides immediate adhesive strength and is soft and flexible enough to conform to uneven surfaces. Plus, it maintains constant strength for as long as it's left in place. In addition, the gentle adhesion of silicone pressure-sensitive adhesives (PSAs) do not cause skin trauma when properly removed and work well for repeat applications or repositioning a medical device.

Acrylic adhesives

Acrylates are customizable and demonstrate adhesion that increases over time as they warm against the body into the nooks and crannies on the top layer of skin and increase the surface area they bond with. They're also breathable and, overall, a better choice than synthetic rubber adhesives.

Putting skin first

Scientists and health care specialists are working hard to advance clinical practice and to better understand the science of skin. Clinicians, skin injury and infection experts, industrial manufacturers and science companies have collaborated to develop better ways to assess different patients. They are improving practice standards, creating better processes and team approaches, and inventing better products and therapies to help protect the skin.

Skin should not be an afterthought. Instead, it should be a core consideration for the use of any medical device that interacts with or adheres to the skin. Consider these key questions before beginning product development:

- What type of securement is required?
- Have you considered the pros and cons of multiple types of adhesives, including how they stick to the skin, gentleness, and ability to adhere for different lengths of time?
- How will your product be tested and how will testing integrate skin safety?
- Does your team have experience in skin science and knowledge of best practices?
- Would the use of a barrier film effect the device?

By understanding why skin matters, what can happen when skin is not considered or maintained, and how scientific advancements can play a role in improving skin health, you can make a different commitment to care. One that starts with skin and considers people from the outside in, not just the inside out.

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