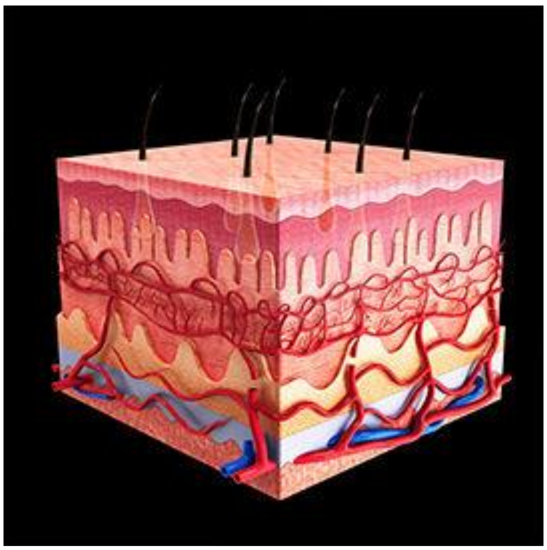
The science of adhering to skin – it’s trickier than you think

By Janna Fischer, 3M

It’s an important job, to say the least. Our skin – the largest and fastest-growing organ in our bodies – is designed to protect us.

It shields us from microbes and the elements. It keeps us warm when we’re cold and cools us off when we’re hot. Our bodies are constantly making new skin cells and sloughing off old ones. And, in merely one inch of our skin, we have about 1,000 nerve endings, according to the **American Academy of Dermatology**.



So when it comes to sticking things to our skin, it can get a bit, well – sticky.
As technology advances, the demand for devices that attach to our skin increases – from wound care dressings to drug delivery solutions to wearable sensors. Scientists must pose countless questions when choosing the right **adhesive system for these devices**: How long will the device remain on the patient? Where will the sensor be placed on the user’s body? What skin types or conditions will be encountered?

It’s critical that scientists and engineers understand the true functional characteristics of the skin when it comes to designing wearable devices. Our skin is constantly changing, always presenting a new surface. It’s getting rid of irritants, healing itself and pushing old cells out of the way so new ones can come to surface.

“It’s that constant skin renewal that designers of these products have to think about,” says Kris Godbey, senior technical support engineer, 3M Medical Materials & Technologies. “Either you keep the skin healthy by allowing it to breathe, sweat and change, or you wind up blocking it, and your skin is going to do whatever it can to get that adhesive off faster.”

Materials matter

Designers must take care to select quality materials during the concept stage of wearable device production. Not only must the materials be of high quality, they must take into consideration common skin allergens and irritants and meet FDA safety testing standards. The choice of one material can also affect other materials of construction. For example, certain polymers can interact with adhesives after assembly, causing them to fail.

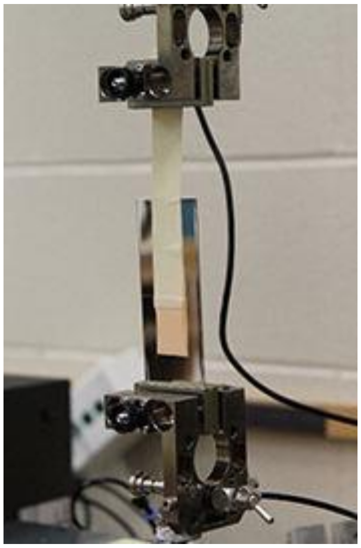
"By keeping usability factors in mind," says Kris, "product designers and materials engineers can select components that function well together and help the skin in contact with the device remain healthy."

Take **Breathe Right nasal dilator strips**, for example. Even in a seemingly simple product, unique engineering considerations were taken into account to make it an effective tool for **managing nighttime congestion** due to colds, allergies and deviated septum, while also improving sleep. These nasal strips can also **reduce or even stop snoring**.

Breathe Right nasal strips are made of three layers of 3M medical materials. The underside of the strip is a hypoallergenic nonwoven medical tape that attaches to the skin, allowing the skin to breathe for the six to eight hours that it's adhered to the nose. The middle layer is an adhesive-coated polyester film. This flexible, yet stiff, polyester material always wants to go back to its original flat shape, so when it's bent to conform to the nose, it springs back, creating a constant lifting action.

The top layer is made of an adhesive-coated rayon nonwoven designed to give the product a cleaner look.

Those little nasal strips are surprisingly multifaceted. So you can imagine the engineering considerations that go into the complex, multi-layered sensors that serve numerous functions like monitoring things like heart rate and blood glucose levels.



Lab screening of adhesive performance on stainless steel

Putting the tape to the test

Before any wearable devices are brought to market, engineers must carefully test to ensure the safety of the user. But how do you test for adhesion on an uneven, elastic surface that is always changing and renewing itself – like skin?

According to Kris, you can get an initial adhesion level by placing the adhesive onto some of the plastics that are similar to human skin surface energy such as polypropylene or low-density polyethylene. These surfaces do work as guides, at least for the first hour or two of adhesion. But she says they won't tell you what it's going to do in two days or a week.

The best way to test the products? On human skin.

"If you want to have a product used on intact skin, there are requirements by the FDA to have certain testing standards in place," says Kris. "First, we run biocompatibility tests following ISO:10993 protocols on the adhesive. If we pass those tests, we get approval for clinical testing."

Clinical test panels at 3M are typically limited to healthy adults with ages ranging from 18 to older than 65. But the results will give a good idea how well the tapes hold on this limited population sample at the time and place it was run – which is a great improvement over plastic or stainless steel.

As with most things, trial and error is the name of the game.

"When we're looking for new adhesives, we need to find something that's soft and that's going to conform to the skin," explains Kris. "And also something that's not going to stick so well that it's going to take off the whole outer layer of your skin once you remove it. It's really something of a balancing act."

For Kris, the end user is always priority number one.

"As we design these high-tech, next-generation wearable inventions, we need to remember just what we're dealing with: human skin – which hasn't really changed much over the generations."