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Silicone Adhesives

An Answer to Gentle Skin Adhesion

Medical Materials & Technologies

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Introduction

The goal, when adhering to skin, is to hold the device in place until it is time to remove it and to not damage the skin, either during wear or at the time of removal. Using methods developed for determining the surface energy of plastics and other materials, the surface energy for human skin has been measured in the low twenties [dynes/cm] – in other words, skin is as difficult to stick to as untreated polyolefins or even fluoropolymers. Low surface energy, as a property of human skin, is generally great for most of the things skin is expected to do, such as easy removal of contaminants with simple soap and water. The downside is that tapes must balance between adequate adhesion levels for the majority of users – the middle of the bell curve – and the ends of that curve. When the adhesion is too low, the device may not stay in place long enough for the full therapeutic effect and if it adheres too well, the tape may cause some mechanical trauma at removal.

Substrate	Surface Energy [dynes/cm]
Aluminum	840
Polyester [PET]	43
Polyurethane [PUR]	43
Polycarbonate [PC]	42
Polystyrene [PS]	36
Polyethylene [PE]	31
Polypropylene [PP]	29
Human Skin	25
PTFE	18

Table 1 - 3M Converter & Health Care Markets Data

Medical silicone adhesives have been designed to excel at that balancing act, achieving adequate adhesion levels to a wide range of skin types during device attachment, yet causing low mechanical trauma during removal. Until a few years ago, there were limited choices for skin-safe medical silicone pressure sensitive adhesives even though their gentleness and adhesion to skin profiles are often considered the “gold standard” for device attachment.

Selecting Silicone Rationale

Pressure sensitive silicone adhesives tend to be the highest priced alternative but do have some special properties that may make them worth the extra price for select applications.



Among those desirable qualities is low trauma adhesion to skin. Mechanical irritation to some degree is usually the outcome of taping to the skin surface. Even the most careful caregiver, using the best technique possible, will remove some hair and surface skin cells when peeling most tape products from skin. Skin condition/health, wear time, device location, climate, etc. all have an impact on the level of adhesion during the time the device is attached.

The therapeutic need for holding devices to the skin, often for several days, may offset often relatively minor discomfort. Silicone adhesives are well known to exhibit low negative impact to the skin surface. They do not stick very well to hair follicles, so silicone adhesives rarely pull out hair when removed – one of the “pain points” for tape removal. They also exhibit a low affinity to attract dry or dead skin cells that populate the surface leaving the skin area virtually intact, possibly lowering the chance of infections that can occur when the upper layer or layers of skin are stripped away with the tape. This can be a very important factor when designing devices for the very old, the very young and other populations who have delicate or compromised skin.

Different silicone formulations can be used for a wide variety of applications. From very short-term wear, often measured in minutes or hours, and newer formulations that can offer higher securement for longer wear time, even up to seven days. Even though the new higher securement levels can hold heavier devices for longer periods of time, they still offer the gentle removal and low skin trauma properties designers have come to expect from silicone. No need to clip hair from delicate areas before device attachment since the adhesives won't develop a bond during wear that would result in increased risk of hair removal or severe skin stripping. All reasons for better patient compliance when attaching devices for remote monitoring as well as in a clinical setting.

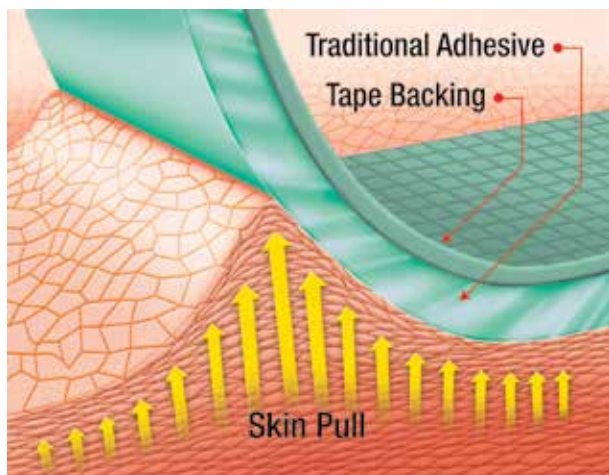
Skin Health Benefits

Upon removal from skin, silicone adhesives are less likely to become contaminated with hair follicles and skin cells that would normally interfere with reattachment/readhesion of the tape to the skin. A contaminant-free adhesive surface often results in a tape or device that can be removed

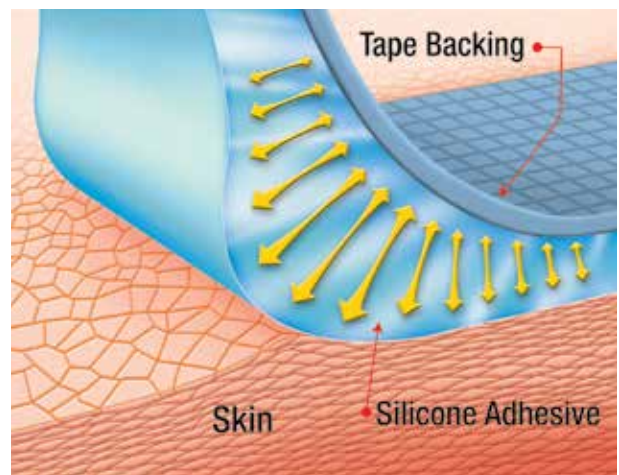
and repositioned multiple times, on some skin types/locations, without replacing the tape. Caregivers may then be able to adjust placement, check under a device or even remove a device, clean the area, and then attach it again without having to use a new device or piece of tape. These factors not only can save money, they can also help maintain the health of the skin under the device. Device designers and manufacturers should consider a few things when working with silicone adhesives, other than just the price differential. These adhesives could allow devices to be used on skin types and patient populations that may not have been able to tolerate traditional medical adhesives such as the elderly and neonates. Silicone-based adhesives are also known to transport moisture vapor well and allow the skin to maintain normal breathability, properties that can be inhibited by some common medical adhesives.

Traditional Adhesives Versus Silicone Adhesives

Removal of Traditional Adhesive Tape



Removal of Silicone Removal Tape



OEM Converting Considerations

OEM device manufacturers typically run long rolls of adhesive tapes from a station or stations of their converting line, laminate multiple layers together and cut custom parts. The adhesive parts can then be used as components for assembly of specialty drapes and other devices for fragile skin areas of patients, who will appreciate the special qualities that silicone adhesives can provide. Converters may want to have dedicated rotary dies and be careful to wrap any adhesive contact points with low release non-silicone sheeting or tape to avoid any type of change-over residue or “sticking” points. Designers & engineers should also remember to review their choices of release liners when working with these adhesives. They should not expect to be able to insert one of the usual release liners that use silicone-based chemistry when working with these tapes – silicone adhesives require special non-silicone release surfaces to work correctly and this effect may only become evident during/after aging studies.

Summary

Taking all these factors into account, silicone pressure sensitive adhesives have an important niche to fill in the medical and retail device industries by providing gentle, secure adhesion to skin for specialty applications. As innovators, design engineers and converters become aware of these special properties and design with them in mind, new devices with improved compliance and less trepidation on the part of caregivers and the end- users may be possible.

For more information, please see [3M.com/ScienceofSilicones](https://www.3M.com/ScienceofSilicones)



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