HEARING AID QUALITY: IMPROVING MOISTURE AND WAX PROTECTION

Kevin Marshall, MBA

Background

One of the most common problems with hearing aids is their ongoing exposure to moisture, wax and other foreign materials. Even brief exposure to these harsh environments can degrade and eventually interfere with proper hearing aid functionality. These issues may be accelerated for patients with more active lifestyles. As a result, almost all hearing aids now contain some kind of water-resistant design to repel water, delaying or avoiding the detrimental effects of moisture. Starkey Hearing Technologies has developed a new protective hearing aid technology called HydraShield®2, which not only improves upon existing water-resistant properties, but also adds resistance to waxes, oils and other liquids.

Modeled after Nature

HydraShield2 is based on nanotechnology that significantly modifies a surface's interaction with moisture, sweat, earwax, oils and other fluids. The technology is invisible and biocompatible. Interestingly, the scientific basis for HydraShield2 technology is derived from nature. On a lotus plant water droplets form spheres and completely roll off the leaves, carrying dirt with them. This self-cleaning, or *Lotus Effect*, is achieved through a combination of microscopic hairs (which provide surface roughness) and the intrinsic non-wetting nature of the surface layer covering these hairs.

Hydrophobic and Superhydrophobic

The degree of water repellency of a surface, or hydrophobicity, can be characterized by measuring the contact angle of a small water droplet on a level surface (see Figure 1). Water with a low contact angle will spread across a surface, seeping into small gaps (see Figure 2). A surface is deemed hydrophobic if the water contact angle is greater than 90 degrees. On a hydrophobic surface, water beads up and easily rolls off the surface. As hydrophobicity increases, the contact angle between the surface and liquid increases. A surface is superhydrophobic if the water contact angle is above 150 degrees. A surface with a contact angle of 180 degrees would mean that water sits on it as a perfect sphere. Currently, most industry hearing aids are only hydrophobic.

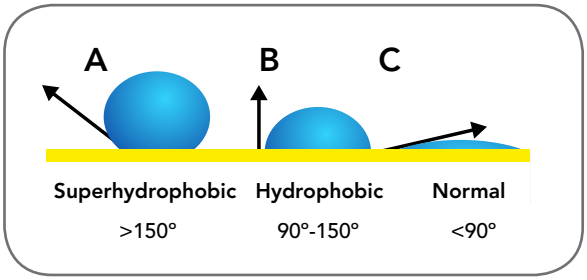

Figure 1: Contact angle is the angle at which a liquid interface meets a solid surface.

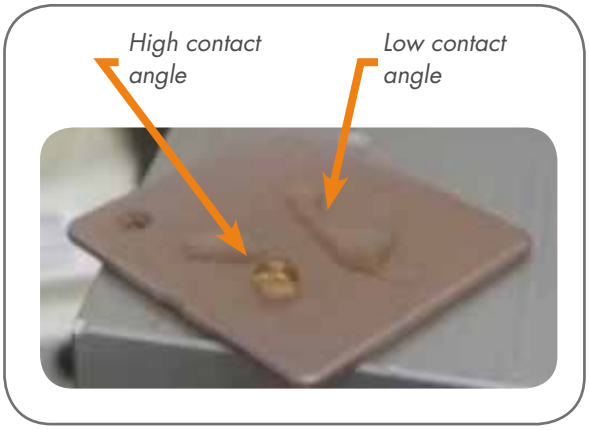

Figure 2: Water with a low contact angle will spread out on a normal surface. On hydrophobic surfaces, water exhibits a high contact angle and will bead up.

With the introduction of nano-sized textures onto hearing aid surfaces, HydraShield² technology improves the hearing aid surface behavior to superhydrophobic. Water drops form an almost perfect sphere and roll off with almost no surface friction.

Oleophobic

In addition to an enhanced superhydrophobic surface, HydraShield² also provides a unique oleophobic (from the Greek "oleo," meaning "oil") surface, which effectively mitigates ingress of sweat/moisture, earwax and other oily substances. Patients benefit through less frequent hearing aid repairs and longer times between changing microphone covers and receiver wax guards.

Most hearing aid hydrophobic coatings only offer about a 70-degree contact angle for oily liquids (see Table 3). This allows oils and earwax to seep into small crevices or clog up acoustic mesh, degrading the hearing aid's performance. On the other hand, HydraShield² causes oily or waxy fluids to form spheres, which either roll off surfaces or fail to penetrate acoustic mesh (see Figure 4).

Where is HydraShield² used on a hearing aid?

The most common failure mode for hearing aids is damage due to foreign materials, such as earwax. Due to its oleophobic properties, HydraShield² significantly increases the lifetime of the receiver, as well as the entire hearing aid.

	Untreated Hearing Aid Surfaces	Typical Hydrophobic Surfaces	HydraShield² Nanotechnology
Water	80 degrees	90 - 110 degrees	150+ degrees
Olive Oil (comparable to earwax)	20 degrees	70 degrees	90-110 degrees

Table 3: Contact angles measured on different painted hearing aid surfaces.

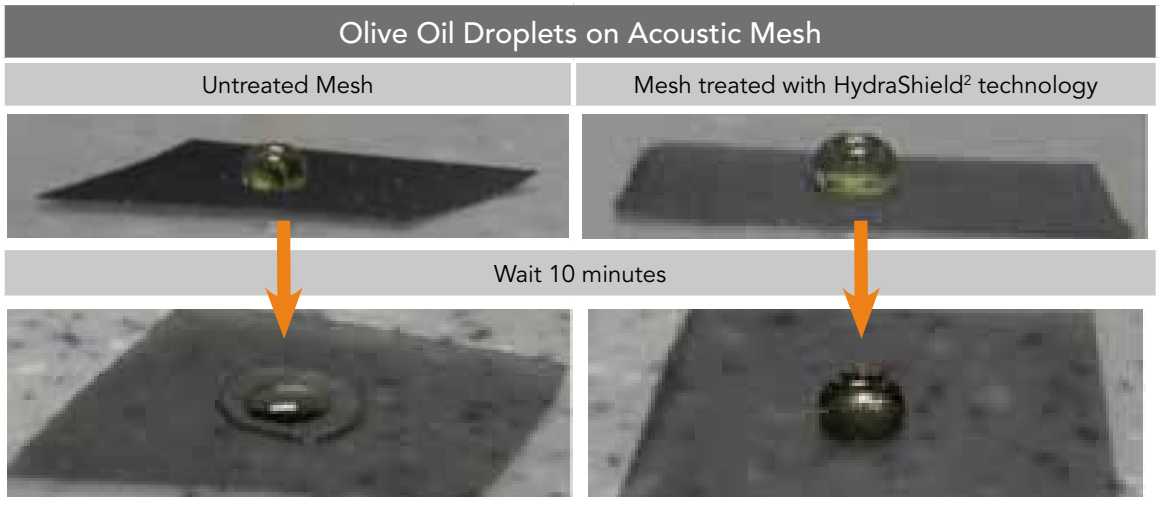

Figure 4: Mesh treated with HydraShield² technology continues to repel olive oil. Untreated mesh quickly becomes clogged with oil.

Receivers: With their position in the ear canal, custom devices, receiver-in-canal (RIC) and custom earmold receivers are heavily exposed to foreign materials. To protect receivers, a newly designed Hear Clear™ wax guard can be inserted in front of the receiver. This new wax guard design swaps out the acoustic mesh for a wax guard completely made of plastic. With its HydraShield² oleophobic properties, the Hear Clear wax guard is less prone to getting clogged with oily/waxy residue. In addition, it repels waxes and other foreign material, keeping them away from the receiver electronics. Patients report improvement by a factor of two to three times in the time between replacing wax guards. Hear Clear wax guards are readily identifiable by their red application stick, as compared to the original blue Hear Clear application stick (see Figure 5).

Cases and battery doors: HydraShield² is currently used on all new behind-the-ear (BTE) and RIC cases, as well as the battery doors, to provide protection against liquid seeping into small holes, seams and crevices. HydraShield² reduces damage to mechanical components, zinc-air battery corrosion and electrical circuit malfunctions.

Microphone covers: HydraShield² is used on all BTE, RIC and custom microphone covers to protect the internal microphone from damage due to body oils and sweat. As seen in Figure 4, HydraShield² repels moisture and oily or waxy fluids to protect the microphone and prevent degradation of performance.

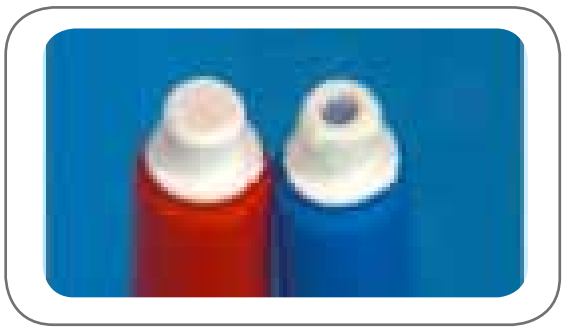

Figure 5: The new Hear Clear wax guard applicators are red, while the original Hear Clear application sticks are blue.

Enhanced Mechanical Designs

Starkey Hearing Technologies uses many design techniques to protect batteries and electronic components from foreign material ingress. The most straightforward way would be to completely seal the hearing aids. However, this is not practical as microphones would not be able to receive acoustic signals, receivers would not be able to deliver acoustic signals, and the battery would be starved of air and unable to provide power. The key is to find ways to keep foreign materials out but let air in. Typical forms of ingress management include mechanical barriers, gaskets and water-repellent meshes. These designs are primarily implemented within battery compartments, case seams, microphone modules and receiver areas. Given the small sizes involved, many good design techniques are constrained by physical size or assembly/repair considerations. Additionally, a small tear in a seal or a degraded mating part surface may negate any protection offered. Acoustically transparent meshes reduce the amount of unwanted substances that reach receivers and microphones; however, their performance is best optimized when used in conjunction with HydraShield² technology. Designing seams, gaps or holes less than 0.004 inch [0.1mm] in diameter provides excellent resistance to water and oil ingress when combined with HydraShield² technology. Supplementing the limitations of traditional design techniques, HydraShield² technology increases patient satisfaction through extended product reliability and reduced ingress of wax and other foreign materials.

Salt Fog

A salt fog test simulates how a hearing aid may perform long term in a humid and sweaty environment. This testing represents the real-world operating conditions that BTE and RIC devices may experience every day. Starkey Hearing Technologies has adopted the MIL-STD-810G (Method 509.5) standard, as it is widely used in the consumer electronic industry. Hearing aids are placed in the

salt fog environment for 48 hours at a temperature of 95° F [35° C] followed by 48 hours of drying time under typical ambient conditions.

HydraShield² has been proven to retain its superhydrophobic properties even when exposed to aggressive environments (Figure 6). Figure 7 highlights the corrosion protection provided by HydraShield² in the battery compartment and DAI contacts. These results portend fewer moisture-related problems and better reliability for hearing aids.

Figure 6: HydraShield² still exhibits superhydrophobicity after two salt fog cycles.

Figure 7: No corrosion was observed in the battery compartment or DAI contact area after two salt fog cycles.

Ingress Protection Rating

The hearing aid industry has adopted the ANSI/IEC60529 standard to demonstrate how "resistant to penetration" hearing aids are. Based on this standard, hearing aids are given an Ingress Protection (IP) rating. This rating begins with the letters "IP" and is followed by two digits: the first digit of the IP certification indicates the level of protection against foreign objects, such as dust or dirt; the second digit indicates the level of protection against water and moisture. If only one criterion is being tested, then an "X" replaces the other digit. For example, the IP rating scale for water goes from "IPX0" (not protected against moisture) to "IPX8" (protected against continuous water immersion). An IPX7 or IPX8 rating allows a hearing aid to be labeled water-resistant.

An independent lab recently tested each of Starkey's X Series™ and Wi Series® RIC hearing aids in the formal Water Intrusion Test. After being immersed in three feet [one meter] of water for 30 minutes, they showed no evidence of moisture intrusion, satisfying the IPX7 requirements. IP testing is considerably more rigorous than what would be expected in daily hearing aid use, giving patients the added moisture protection with HydraShield².

Conclusion

Hearing care professionals and patients want hearing aids that are resistant to water, sweat, earwax and other foreign materials. They desire hearing aids that work reliably in challenging environments and peace of mind in knowing that the sensitive electronics in their hearing aids are well protected throughout years of ownership. In recent years, hearing aids have integrated water resistance to reduce corrosion and improve reliability. Unfortunately, water resistance did little to address the most common failure mode – the ingress of foreign materials, such as oils and earwax. Through successful laboratory testing and actual patient experiences, HydraShield^2 technology offers an effective and comprehensive solution that is unrivaled in the industry. Not only does HydraShield^2 optimize moisture protection through superhydrophobicity, but it also adds oleophobic surface properties. Together, these features increase the longevity and durability of today's hearing aids, as well as enhance patient satisfaction.

Starkey® Hearing Technologies

A global hearing technology company headquartered in Eden Prairie, Minnesota, U.S.A.

Starkey Hearing Technologies
6700 Washington Avenue South
Eden Prairie, MN 55344-3476
800.328.8602

StarkeyHearingTechnologies.com