Washing Away the "Bad Hair Day" with Silicone Solutions

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abstract

Hair is exposed to many damaging processes, including: repeated washing, combing and heat styling; bleaching and coloring; air pollution and the sun's UV rays. These factors can lead to hair that is: more difficult to manage and comb; susceptible to breaking easily; dull and rough in appearance; more water absorbent and porous; and more prone to color fading. Consumers are increasingly demanding product solutions that provide long-lasting protection from hair damage. To determine how silicone solutions can help formulators and brand owners meet this growing demand, Dow recently conducted a variety of tests to measure the ability of silicones to durably restore hair's hydrophobic state and protect against breakage.

Consumer Perception and Needs

With so many consumer behaviors and external environmental factors that can lead to hair damage, the demand for hair care solutions is consistently high. In fact, studies have shown that "damaged hair" is repeatedly among the top five claims in new hair care product launches every year according to Euromonitor and Mintel [1, 2]. Consumers today desire "long-lasting" solutions and not just short-term "beauty-enhancing" benefits. The challenge that consumers face is that many of today's hair repair solutions only target damaged sites on the hair cuticle, rather than protecting the total hair strand. For consumers, this can provide short-term fixes, rather than long-lasting results.

Silicone Technologies

To assess the ability of silicone solutions to fulfill the consumer need for long-lasting protection and repair of damaged hair, Dow put its silicone technologies to the test against the most challenging hair conditions. Specifically designed hair care testing protocols were developed to assess different silicone technologies to determine which were most effective in delivering:

1. Restoration of hair's hydrophobic state
2. Long-lasting hydrophobicity and conditioning
3. Protection from hair breakage
4. Silicone distribution and quantification

The technologies tested include:

- DOWSIL™ CE-7081 Smart Style formulation – This formulation has a unique cross-linked structure with amino and quaternium functionality that provides ease of conditioning and styling. It has been designed for leave-in conditioners and hair styling applications such as mousses, hair sprays, creams and gels. DOWSIL™ CE-7081 Smart Style formulation reduces friction, provides curl definition and retention, controls frizz, and creates flexible hold.

- DOWSIL™ 969 Emulsion – This formulation is a 30% cationic emulsion of an amino functional silicone polymer that can be used in hair care applications such as: rinse-off conditioners, leave-in conditioners, shampoos, hair colorants, hair perm, and styling products. DOWSIL™ 969 Emulsion protects against heat damage, delivers fast drying, and provides ease of styling and long-lasting hold.

- DOWSIL™ 8500 Conditioning Agent – This formulation is an amino glycol copolymer. It combines the substantive conditioning of an amino silicone with the low yellowing and ease of formulation of a silicone glycol. DOWSIL™ 8500 Conditioning Agent enhances volume, protects color, provides heat protection and any hair care application can benefit from its use. It also allows for the formulation of clear systems.

Restoration of Hair's Hydrophobic State

Healthy hair is hydrophobic, meaning it naturally repels water. Using a combination of absorption and sink testing, Dow has demonstrated the ability of specific silicones to restore damaged hair's hydrophobic state.

Water Absorption Test

To test absorption, water droplets were deposited on damaged hair tresses, and the time required for the water to be absorbed was measured. The test analyzed hydrophilic bleached, damaged hair against the same hair treated with DOWSIL™ CE-7081

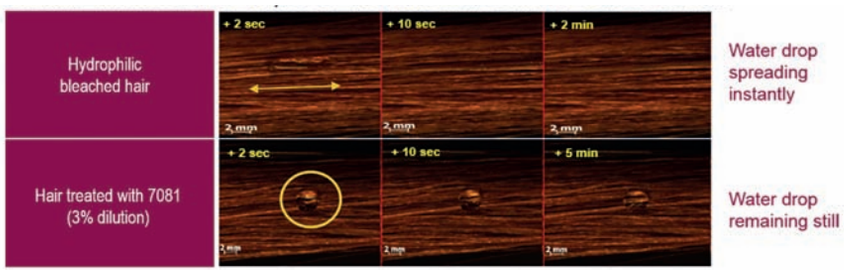

Fig. 1 Water absorption test: Measure time for a water drop to be absorbed on the surface of bleached hair

Smart Style formulation at a 3% dilution over the course of two seconds, 10 seconds and two minutes. As shown in **Fig. 1**, tresses treated with DOWSIL™ CE-7081 Smart Style formulation demonstrated a much higher degree of hydrophobicity as evidenced by the longer time required for absorption.

Hair Sink Test

Furthermore, researchers studied the buoyancy/porosity of virgin hair, untreated damaged hair, and damaged hair treated with DOWSIL™ CE-7081 Smart Style formulation. Portions of hair tresses were released in beakers of water, and the hair's behavior was observed. The results shown in **Fig. 2** demonstrate that damaged hair treated with the dilution of DOWSIL™ CE-7081 Smart Style formulation behaves like virgin hair, remaining on top of the water and demonstrating natural hydrophobicity.

Contact Angle Test

Contact angle tests are often used to quantify hydrophobicity. A higher contact angle means a water droplet remained intact on the surface of hair rather than spreading out across a strand. Measurements of contact angle were taken between a water drop and the surface of bleached hair tresses treated with rinse-off conditioner containing 2% silicone active versus the surface of tresses treated with a control conditioner (no silicone) and with two commercial benchmarks. The measurements were repeated after six, 10 and 15 washes with diluted surfactant solution. As shown in **Fig. 3**, tresses treated with Dow silicones demonstrated durable hair hydrophobicity compared to tresses treated with the control or with the commercial benchmarks; additionally, this benefit was maintained for up to 15 washes.

Long-lasting Hydrophobicity and Conditioning

Efficient conditioning reduces combing forces and can help reduce hair breakage over time. Scientists conducted combing trials to test the level of conditioning versus hair breakage after multiple washes.

Wet and Dry Combing Test

Tresses of bleached hair were treated with rinse-off conditioner containing 2% silicone active versus tresses treated with a control rinse-off conditioner (no silicone). Combing forces were measured using a Dia-Stron automated combing instrument; measurements were repeated after 15 washes with diluted surfactant solution. As demonstrated in **Fig. 4**, rinse-

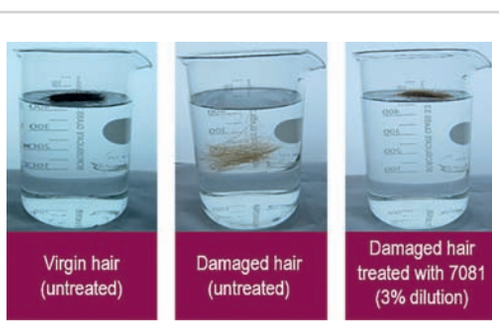

Fig. 2 Measure time for a water drop to be absorbed on the surface of bleached hair

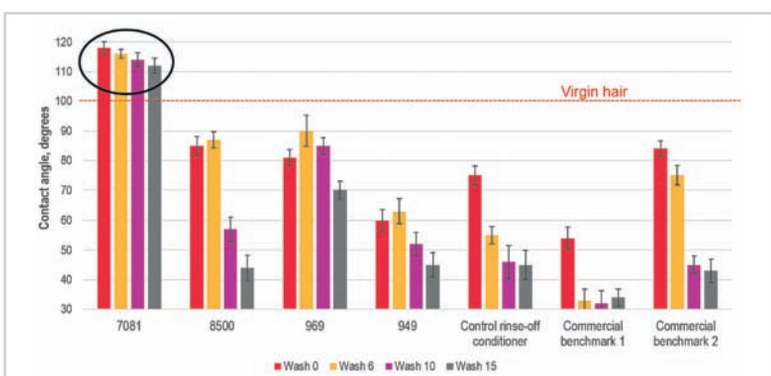

Fig. 3 Rinse-off conditioner with 2% silicone active; bleached Caucasian hair; multiple washes with SLS

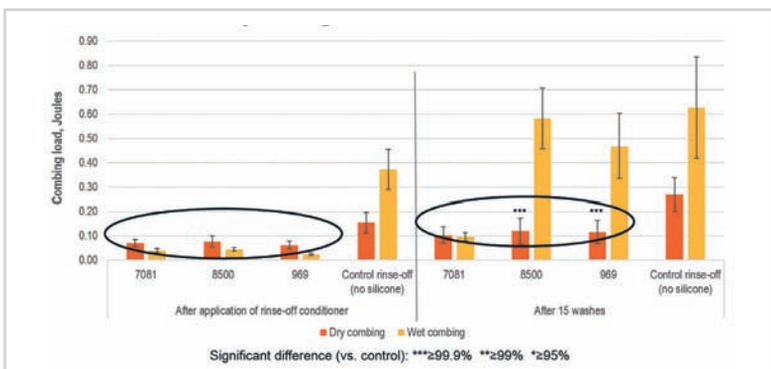

Fig. 4 Wet and dry combining forces on bleached Caucasian hair > long lasting conditioning efficacy

off conditioner containing Dow silicones significantly reduced both wet and dry combing forces compared to the control. Additionally, the dry combing force reduction benefit persisted after 15 washes.

Protection from Hair Breakage

Anti-breakage is one of the most popular claims made for damage care products. The film formed by silicone on the hair can prevent damage caused by everyday grooming – thus significantly reducing hair breakage.

Repeated Combing Test

To test how hair stands up against repeated combing, bleached hair tresses were treated with rinse-off conditioner containing 2% silicone active and with a control rinse-off conditioner (no silicone). Treated tresses were subjected to 10,000 comb strokes at a speed of 80 strokes/minute; the broken hairs were weighed, and percent reduction in broken hair (versus the control) was calculated. The results, shown in **Fig. 5**, demonstrated that tresses treated with rinse-off conditioner containing the silicones displayed significantly less breakage than the tresses treated with the control.

Silicone Distribution and Quantification

Deposition is a key element of hair protection. To work most effectively the products must deposit evenly – from the root of the hair to the tip.

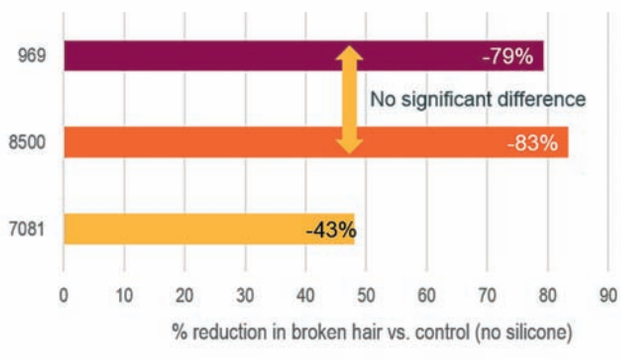

Fig. 5 Repeated combing test

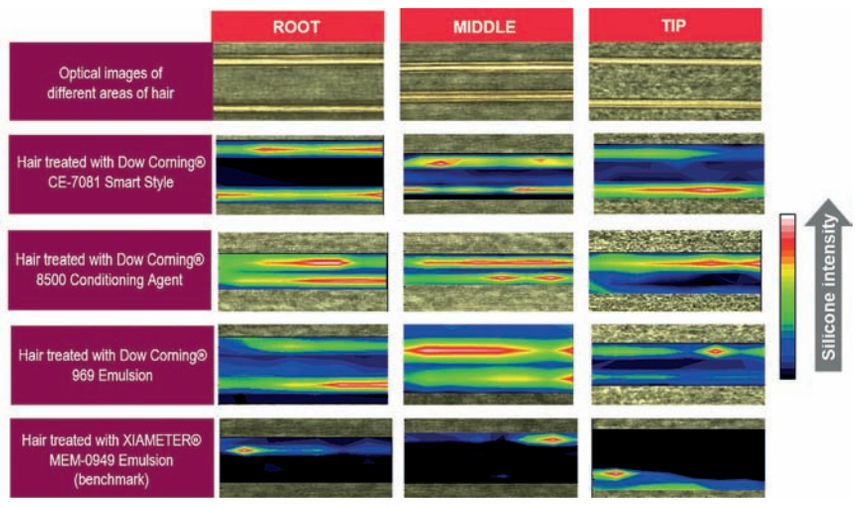

Fig. 6 Chemical distribution of Si-C band (1,258 cm^{-1}) for the root, middle and tip regions

Silicone Map Distribution Test

To test silicone distribution, bleached hair was treated with rinse-off conditioner containing 2% active silicone. Using FT-IR analysis, multiple hair fibers were analyzed to determine the distribution of silicone deposited on different regions of the hair. Test results, as shown in **Fig. 6**, demonstrated that DOWSIL™ CE-7081 Smart Style formulation deposited more evenly among the hair fibers than the benchmark.

Hair Care Silicone Solutions

Based on the test results of its three key silicones for damaged hair, Dow has developed a kit with four hair care formulations containing Dow Consumer Solutions ingredients. Formulators can use these to conduct their own test on how silicones can help restore hair's hydrophobic state, improve sensory profile and reduce combing forces and breakage to provide long-lasting performance.

1. Daily Rescue Shampoo

The Daily Rescue Shampoo contains DOWSIL™ CE-7081 Smart Style formulation and includes gentle cleansing with medium conditioning.

2. 3-in-1 Therapy Conditioner

The 3-in-1 Therapy Conditioner contains DOWSIL™ 969 Emulsion and is a custom, multipurpose conditioner. It can be used as a co-wash, rinse-off, or leave-in.

3. First Aid Booster

The First Aid Booster is a rinse-off conditioner cream that contains DOWSIL™ CE-7081 Smart Style formulation. It provides high conditioning for damaged hair with long-lasting effects, and root-to-tip coverage without build-up while restoring hair's hydrophobic state.

4. Quick-Fix, Protect Spray

The Quick-Fix, Protect Spray is a leave-in spray designed to protect from hair breakage, while providing light conditioning without a tacky residue. This leave-in spray contains DOWSIL™ 8500 Conditioning Agent and includes UVA and UVB sun filters to help protect from environmental damage.

Now a wholly-owned subsidiary of The Dow Chemical Company, Dow Corning is rolling out a new product brand name – DOWSIL™ – For its high-performance silicone-based products. The new DOWSIL product brand name represents the combined power of Dow and Dow Corning and emphasizes longstanding global expertise in silicone technologies across dozens of industries. Through a phased implementation over the next several months, Dow Corning® branded silicone products will move to the new DOWSIL name. Product descriptors that are part of the product names today will remain the same.

Conclusion

Through innovative test methods, selected DOWSIL™ high-performance silicone-based products were shown to durably restore hair's hydrophobic state and provide conditioning and care benefits. By forming an even coating on the hair, these silicones protect the entire shaft from hair breakage by remaining on strands for longer-lasting performance. From these findings, Dow developed a four-part solutions kit that can erase hair damage and provide protection against further environmental and behavioral damage. For formulators, this means providing products that are effective at low use levels and backed by substantiated claims through rigorous testing methods. For consumers, this means using technologies that can help keep hair in its most natural, beautiful state and providing "long-lasting" benefits versus short-term "beauty-enhancing" benefits.

Citations

[1] Euromonitor International, 2016
[2] Mintel GNPD, 2016

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