Beyond Skin Feel: Innovative Methods for Developing Complex Sensory Profiles with Silicones

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In today’s beauty and personal care market, formulators strive to meet consumer demand for products that combine superior performance, visual impact and unique aesthetics. While skin feel has always been a key parameter, consumers increasingly select skin care products based on a more complete sensory experience. They look for sensory effects in product texture, appearance, skin feel and scent. They also want products that contribute to a sense of well-being, through visual aesthetics in the container, tactile effects on application, fragrance, and the performance of active ingredients such as vitamins or sunscreen.

Sensory expectations are related to culture, age, skin type, gender, setting and climate. In the case of climate, for example, light, dry products with minimal residue are often preferred for day wear, particularly in warm regions. In contrast, rich, substantive creams designed for moisturization or protection are often sought for night wear or during cold weather. For a skin care product to be successful, its sensory characteristics must be carefully designed, then communicated in a way that appeals to consumers’ buying behavior.

Because the sensory aspects of skin care products are so complex, material suppliers must find ways to explain the benefits their ingredients provide. Thus, it is critical to consider the many aspects of a skin care product’s sensory characteristics, or its sensory profile, before, during and after application. Consumers’ first impressions are based on what they see and smell in the container and how it feels on their fingers. Next, they may rub their fingers or hands together, then apply the product to their skin and notice the feel…its texture, spreading qualities and afterfeel. Later, they may note the lingering characteristics of the formulation…softness, a protective feel and residual fragrance.

Sensory parameters have become increasingly important factors for product differentiation, and successful products stand out from their competition by looking, feeling and smelling unique. Researchers at Dow Corning combine formulating expertise with a variety of innovative approaches to characterize and develop silicone materials for the skin care industry. The result is optimized sensory properties for highly specialized formulation requirements.

This paper reviews approaches employed by Dow Corning, which when combined with sensory evaluation and formulation expertise, can be used to develop a more complete sensory experience, respond to consumer trends or meet specific regional preferences. It also describes how silicons can be used to obtain new product appearances and textures, skin appearance, and feel, based on the wide range of rheological behavior and product forms among these materials.

Creating a Sensory Experience

Dow Corning employs several approaches to maximize and differentiate sensory effects. These capabilities can be used to develop state-of-the-art consumer products that meet special needs and correspond to manufacturers’ individual product positioning. For example, our experience has shown that a general preference among consumers in some regions is for formulations that leave a soft, moisturized feel on the skin, with little residue. Traditionally, these formulations have been low in viscosity with very light texture. In contrast, a recent consumer trend is toward thicker products that have a well-bodied, nourishing feel on the skin. With sensory evaluation, testing and formulation expertise, it is possible to design formulating technologies and ultimately, consumer products, that incorporate these different textural characteristics while still imparting a light skin feel without residue.

A variety of marketing analyses and technical methods are valuable for gaining an in-depth understanding of market needs, foreseeing market trends and ultimately selecting new silicone technologies for the market. Because consistency and accuracy in testing are so critical, a set scale using clearly defined parameters, established benchmarks and a measurable sensory lexicon including terms such as greasy, powdery, or smooth helps determine relative sensory comparisons between formulations. Relative comparisons allow mapping of various formulations based on combinations of words that are meaningful to consumers. Approaches of this type allow skin care marketers to translate subjective trends into technical words and models that formulators can use in the product development process, and that can be communicated to consumers.

A technique developed by Dow Corning helps marketers and formulators analyze skin care trends and product aesthetics, then focus on specific silicons to help position products ranging from natural to very sophisticated (1). By evaluating the print advertising of leading skin care products, this method can help formulators define and classify some of the highly subjective trends and product characteristics that motivate consumers. The method comprises three steps:

1. Analyze
2. Formulate
3. Validate

More than 200 skin care print advertisements in Europe and North America served as a foundation for developing the design and format for this method. The advertisements were presented to skin care industry experts, who were asked to give flash responses, and repeated key words in their responses were recorded. Based on the key words, and to simplify consumer needs, the market was seg-

Figure 1. Two axes define four sensory dimension quadrants.
ment based on two axes that define four sensory dimensions:

- Light, airy and transparent
- Sophisticated, technical and scientific
- Rich, creamy and nourishing
- Natural, fresh and water-like

Individual products matching the profiles of each of the segments were then “mapped” graphically, and key commercial products were chosen as most representative of each quadrant. Figure 1 illustrates the two axes and the resulting four quadrants. Areas outlined within each quadrant correspond to clusters of mapped products, and in each of those areas, one representative commercial product has been chosen, as indicated by the arrows.

Based on the characteristics of these key commercial products, Dow Corning developed four prototype skin care products using various types of silicones and a range of currently popular cosmetic raw materials. The prototype products were designed to match consumer expectations within each of the four quadrants. For each of the prototype formulations, the perfume house Mane & Fils developed a fragrance that complemented the individual product positioning. The four prototypes include:

- Fresh Wave, a cooling and silky cream with the feel of a hydrogel. It has a fresh and natural fragrance.
- Tender Delight, a light, silky, vitamin-enriched cream with a lively, playful fragrance.
- Radiant Beauty, a firm, nourishing and protective cream with an estimated SPF of 8 to 10. It has a comforting, warm fragrance.
- Velvet Peace, an ultra-rich cream with natural ingredients and a voluptuous, sensual fragrance.

Figure 1 also maps these four prototypes in their respective quadrants. The four quadrants essentially translate consumers’ sensory requirements into objectives for the formulating chemist. For example, if a marketer’s objective is to produce a skin cream that is light, airy and transparent, chemists now have a well-defined starting point for applying their technical expertise in the laboratory. In addition, a well-defined commercial benchmark cream can serve as a reference point for their formulating objectives.

Taking the method a step further, based on the substantiated benefits of specific silicones, it is also possible to correlate individual silicone materials with the sensory characteristics of each subjective quadrant. Once product developers choose the marketing position for a new product, Dow Corning scientists can identify specialty silicones whose properties deliver the appropriate aesthetics and functions associated with that particular quadrant. In short, by using this method, it is possible to help formulators maximize the versatility of silicone materials to meet any market trend they choose.

To confirm the ideal group of properties that define each quadrant, researchers also evaluated the prototype products by objective sensory profile analysis. Four basic characteristics (as defined by several related properties) were investigated by the sensory testing:

- Visual appearance of the formulation in the jar (gloss, lightness, transparency and water-like appearance)
- Feel of the cream in the jar (firmness, slipperiness, peaking and stickiness)
- Skin feel during absorption (ease of spreading, cooling effect, absorbency, thickness, rich feel and wetness)
- Skin feel after absorption (gloss, slipperiness, film residue, rich feel and stickiness)

Observations were plotted on sensory profile graphs, and it was confirmed that the profile of each cream corresponds with its respective quadrant. These “spider” diagrams are helpful for profiling differences between raw materials or formulations. Based on ranking tests, any number of sensory characteristics can be plotted to visualize or compare the sensory profiles of one or more samples. Figures 2 through 5 illustrate sensory results based on the four points above. Figures 7 and 10, presented later in this paper, are additional examples of spider diagrams.

In the case of visual appearance of the formulation in the jar (Figure 2), notice that Fresh Wave exhibits greater gloss, lightness, transparency and water-like characteristics than the other three creams. Comparing feel of the cream in the jar (Figure 3), results for Radiant Beauty show prominent firmness and peaking, while Fresh Wave and Velvet Peace show no stickiness. Sensory results during absorption (Figure 4) indicate wetness and a cooling effect for Fresh Wave and thickness with a rich feel for Velvet Peace. Finally, observing skin feel after absorption (Figure 5), Fresh Wave exhibits a high gloss, while Tender Delight leaves a slippery, silky feel on the skin. Results again correlate with the subjective properties related to the various quadrants. These data demonstrate that it is possible not only to design new products that respond to trends identified by the mapping technique—but whose aesthetic properties are consistent with the measurements obtained through objective sensory profile analysis.

The approach described here brings together the very different expertise of scientists and marketers in a complementary and synergistic way. Most important, it
allows formulators to screen the extensive and versatile family of silicones to focus on specific materials that meet defined consumer needs. Also, because this method is based on objective measurements and a combination of subjective and emotional perceptions, product developers can use it beyond the formulating process. For example, the method can also serve as a resource for the overall creative approach to a new product. Various aspects of development such as product naming, fragrance selection, package design and advertising strategy can all be linked back to properties initially defined in the four sensory dimensions.

By using the graphic technique, marketers and formulators can translate sophisticated product claims into subjective sensory descriptors. As a result, a useful product development brief can be easily communicated to formulation scientists. By combining various sensory evaluation techniques including sensory difference testing (e.g., paired-comparison testing, triangle testing and ranking tests), one can fine-tune product sensory characteristics. The addition of sensory descriptive testing methodology (e.g., Quantitative Descriptive Analysis) allows one to detect the qualitative and quantitative aspects of the product sensory parameters. With the aid of these sensory profiling and difference-testing techniques, formulation scientists can create a new product that exhibits exactly the characteristics of a benchmark product. Although Dow Corning does not currently utilize a descriptive-trained panel, we employ a method called multiple-paired comparison, which allows us to compare and position up to four products against each other. This technique was used in the project illustrated in Figures 1 through 5. External expert panels are used to make certain the descriptors used are efficient, accurate, reproducible and understandable.

The basic quadrant concept can be adapted to differentiate a range of textures based on rheology and skin feel. Silicone structure and chemistry can impact the sensory characteristics of a formulation before, during and after its application. Figure 6 illustrates how two dimensions can be used to show different combinations of skin feel and rheology. As the horizontal axis shows, skin feel of the products can range from light to rich, while texture and rheology can range from water-thin formulations to thick gels and creams.

Rheology and texture impact how a for-
mulation is applied, its absorption behavior and the perceived afterfeel, such as suppleness of the skin. All these characteristics are examined before, during and after application. At this point, sensory evaluation tools can be used to assess the sensory benefits of both silicone and formulated products to ultimately meet consumer needs.

**Texture and Rheological Behavior: The Basis for Sensory Effects**

Silicones are well known for the distinctive skin feel they impart. However, as described above, their effects can be multifunctional and much broader. The techniques described are particularly useful because silicones can be used to create noticeably different effects in product texture and appearance, resulting in multiple types of skin feel profiles.

Based on their chemical characteristics, silicones can be used to manipulate the visual aspects of a product in its container, making it appear shiny, matte, firm, liquid, solid or gel-like. During application, silicones can provide a specific sensation upon first touch and removal from the container, then aid the product in spreading easily on the skin and help promote its absorption. They can provide a desired feel and appearance on the skin during application; for example, light or creamy. After application, silicones can contribute to skin smoothness, provide luster or a matte appearance, add a perception of moisturization, impart lubrication without tackiness, or give a soft, dry, even powdery feel. They can also be used to deliver fragrance and control its intensity and durability in the container, upon application and afterward.

Product texture is a significant factor in overall sensory effect. Fragrance and texture are the two most important criteria involved in the consumer buying decision process. Silicones can be used to obtain new and innovative types of textures, based on their wide range of rheological behavior and chemistry.

Viscosity is the most well-known expression of rheology. It is frequently used to monitor formulation stability over time and to define the formulation profile for best delivery as a novel product form or from specialized packaging. Rheology has become increasingly important because an understanding of its parameters has allowed formulators to optimize the sensory and performance attributes of personal care products. Studies also have demonstrated that formulation rheological parameters can be correlated to sensory attributes such as spreading, body consistency and greasiness of creams when they are applied to the skin.

The viscosity of the basic polydimethylsiloxane (PDMS) polymer can be increased in two ways: by increasing the chain length in a linear manner with the addition of Si-O units, or by increasing chain length (and hence, molecular weight) and also employing a cross-linker. The latter approach results in significant rheology changes, allowing formulators to achieve novel formulations with unique sensory characteristics.

In general, PDMS exhibits Newtonian rheological behavior; that is, it becomes pseudoplastic with increasing polymer viscosity. The addition of functional groups on the siloxane backbone may also modify the rheology profile of these silicones (2, 3). Developments in organosilicone chemistry have led to new ingredients that can affect the rheology of formulations across a wide range of personal care applications. These new materials (i.e., alkylmethylsiloxane (AMS) waxes and silicone elastomers) provide a number of performance and sensory attributes. Depending on the product application and required benefits, formulating chemists can select the most appropriate materials from these two product categories.

In the case of AMS waxes, alkyl groups of different chain lengths can be chemically substituted for methyl groups on the siloxane backbone. Varying degrees of substitution can result in wax-like materials with a range of melting points. When added to emulsions for foundation creams or sun care products, these waxes can alter rheology, providing improved product performance and stability. Tests show that high melting point AMS wax helps stabilize water-in-silicone creams containing up to 15% pigment. Studies demonstrate that although the wax increases the viscosity of water-in-oil systems, it does not negatively affect sensory performance.

**Silicone Elastomers: A New Sensory Approach**

Silicone elastomer technology provides a means of increasing the viscosity of volatile silicones without sacrificing their desirable silicone aesthetics. In this category of materials, rheology change results from increasing the molecular weight of the material, both by adding Si-O units and by cross-linking. This new technology is based on a cross-linked elastomeric silicone made with cyclomethicone in situ.

The ingredients resulting from this patented technology allow other ingredients such as antiperspirant actives or mineral charges to be suspended in cyclomethicone while providing a dry, velvety feel that is quite different from the silky feel of conventional silicones. The rheology of these materials also is different, and they can be useful for achieving novel formulations with desired performance attributes and unique sensory characteristics. Another concept for the use of this new silicone elastomer technology is the suspension of essential oils, resulting in a new delivery form for perfume combining both sensory and olfactory sensation.

From a formulating perspective, the most important physico-chemical property of these materials is their ability to thicken
cyclomethicone (3). This effect results in improved stability and viscosity control of products where cyclomethicone is used as a vehicle. In addition, the desirable aesthetics of the cyclomethicone are maintained. Thickening systems of this type have additional benefits over conventional thickening ingredients such as organic thickeners, clay, silica and silicone gums (4, 5). Compared with organic materials, the effects of the silicone elastomer blends are perceived as silkier, less oily, and as having a well-bodied feel. Silicone elastomers eliminate the poor skin feel associated with silica, which can impart drag and a gritty feel. In the case of silicone gums, high levels are required to achieve the same level of thickening associated with silicone elastomers. At these levels, the silicone gum can make the product heavy and difficult to formulate.

In addition to their thickening ability, silicone elastomers can provide a distinctive sensory profile. Figure 7 summarizes the results of sensory panel testing. In this comparison of two water-in-oil creams, notice how the cream containing the silicone elastomer spreads more easily and is absorbed to a greater degree on the skin. In contrast, the cream containing the silicone gum is more tacky and greasy.

Silicone elastomers can also provide unique benefits for the formulator, which translate to improved sensory characteristics for consumers. A silicone elastomer that incorporates low viscosity dimethicone as a solvent shows promise for use in products that are frequently exposed to air by consumers. For example, the silicone elastomer can be used as a binder and aesthetic modifier in pressed powder cosmetics. Because the solvent is not volatile, the pressed powder will not dry during use, and potential cracking of the cake can be reduced.

Again, using a quadrant approach, Figure 8 illustrates how the silicone elastomers and an emulsion of ultra high molecular weight silicone can be used to create markedly different effects in product texture and skin feel after application.

The six prototype products shown on Figure 8 illustrate an array of sensory characteristics:

- Peaches and Cream, a light and powdery anti-aging cream with enhanced fragrance. The silicone-in-water cream incorporates a silicone elastomer for enhanced texture, skin softness and smoothness.
- Fresh, Energising Lotion, a cooling lotion that leaves skin feeling hydrated, smooth and clean, with reduced shine. The silicone elastomer in this formulation also provides sebum control.
- Dual-Feel Emulsion, a product that incorporates silicones and fragrance in a concept developed by Etablissements V. Mane Fils SA. Contains a silicone elastomer, silicone formulation aid and volatile silicone fluids. The formulation is rich and creamy upon first touch, but becomes very light upon application, for a distinct and surprising transformation.
- Pink-a-Chew Cream, a rich cream with cushion, emolliency, smooth afterfeel and a chewing-gum type of texture. Contains an emulsion of ultra high molecular weight silicone.
- Refreshing Rain, a glittering gel that is quickly absorbed and has a smooth afterfeel. An anhydrous formulation based on a silicone elastomer blend.
- Clear Body Sheer, a hydrating gel with a dry, nontacky sensation. This moisturizing gel incorporates a silicone elastomer blend for enhanced texture and reduced wetness.

New Delivery Effects from Silicone Technologies

Recent studies with wet wipes demonstrate that silicones can be used to deliver tactile effects from the substrate of the wipe (6). Panelists in sensory evaluations determined that wipes treated with an emulsion of ultra high molecular weight...
silicone\(^a\) left a very subtle and soft film on the skin. Other silicones (such as a volatile cyclic silicone\(^b\) and a silicone elastomer suspension loaded with various other ingredients\(^c\)) demonstrated an ability to provide functional benefits such as film barrier properties, a moisturizing effect, resistance to wash-off, improved cleansing, or delivery of active ingredients to the skin. Figure 9 summarizes the results of these evaluations.

Novel silicones can also be used to impart tactile characteristics from products that until recently could not deliver such effects. For example, when incorporated in rinse-off products such as body washes or facial cleansers, the emulsion of ultra high molecular weight silicone described above leaves a soft, residual film on the skin that suggests a moisturizing and nourishing feel. This effect was previously not possible from rinse-off products\(^d\). In addition to its tactile benefits, the silicone emulsion offers formulators an innovative way to incorporate ultra high viscosity silicone polymer into aqueous systems.

Figure 10 illustrates the sensory effects of 5% silicone emulsion in a facial cleanser formulation compared to a control formulation without silicone. The diagram also notes the comparisons that show a significant difference at the 95% and 80% confidence levels.

**Summary and Conclusions**

Silicones help formulators create noticeably different effects in product texture and appearance, and they can be used to modify any formulation rheology. They can enhance the delivery of actives and fragrance and improve formulation stability, and they can also be used to develop multiple types of skin feel profiles. By acting in these multifunctional roles, silicones enhance the well-being of consumers in a number of ways.

Using our range of products, technologies and formulating expertise, and based on sensory evaluations, key market trends and consumer needs related to skin feel, Dow Corning’s objective is to help formulators capitalize on the formulation benefits of silicone while helping to define and focus the development of breakthrough consumer products. The resulting personal care products hold promise for imparting innovative and highly differentiated sensory characteristics that will bring consumers a unique sensory experience and provide marketers with a competitive edge.

**References**


\(\text{a QDA}^a\), Tragon Corp., Redwood City, CA

\(\text{b Dow Corning}^b\) HMW 2220 Nonionic Emulsion

\(\text{c XIAMETER}^c\) PMX-0245 Cyclopentasiloxane

\(\text{d Dow Corning}^d\) 9509 Silicone Elastomer Suspension (loaded with XIAMETER\(^e\) PMX-0245 Cyclopentasiloxane, Dow Corning\(^f\) 2502 Cosmetic Fluid, XIAMETER\(^g\) PMX-200 Silicone Fluid, 50 cSt, or glycerin)

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*Figure 9. Summary of results from evaluations of silicones with wet wipes.*
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