Chapter 10

Silicones in Personal Care Applications

Roy U. Rojas Wahl1,* , J. R. Nicholson1, and Judith L. Kerschner1,2

1GE Advanced Materials, Silicones, 771 Old Saw Mill River Road, Tarrytown, NY 10591
2International Flavor and Fragrances, Inc., 1515 State Highway #36, Union Beach, NJ 07735
*Corresponding author: roy.rojas-wahl@ge.com

Silicone fluids and modified silicone fluids can provide a range of benefits when formulated in various shower/bath products. The nature of these benefits is dependent upon the functionality on the silicone polymer and on the properties of the shower or bath product into which they are introduced. Thus, different silicones can be used to modify in-use product properties, enhance lather, and deliver a variety of post-use sensory experiences. Some silicone materials can assist in deposition from wash-off products. Others can be blended with organic oils, such as triglyceride oils, petrolatum, or mineral oil, to provide a novel after-wash feel while maintaining the occlusive or moisturizing properties of the organic material. To optimize the benefits of these silicones in shower/bath products, it is critical to understand the interactions of the silicone materials with the other standard formulation ingredients such as surfactants, emulsifiers, perfumes and polymers and how these interactions will affect the product performance. This work will highlight some of the key benefits that silicone fluids can deliver from a range of bath/shower product formats.
Introduction

Body washes and shower gels account for about 56% of the total of the bath and shower sector in the U.S. Traditionally, the use of silicone fluids in such personal washing applications has been limited to dimethicone oils, often for conditioning purposes. There remain, however, many unmet formulation needs such as actives or fragrance deposition, since much of those ingredients tend to be just washed away and are given only a very limited amount of time to approach or penetrate the skin. Also, enhanced moisturization with superior sensory properties is of high importance. These two and more arguments hold the need for new and innovative technologies. Here we show that multifunctional silicones can deliver perceivable benefits, including those aforementioned, and additionally, modify lather and deliver a variety of post-use sensory experiences. First, we introduce the unique characteristics of several polyether copolyols. Then we focus on head-space measurements for the investigation of fragrance deposition, which is enhanced by a combination of alkyl modified silicone waxes and high viscosity dimethyl fluids, showing unique synergistic benefits. Also, we show how the tackiness of a classic occlusive material such as petrolatum can be mitigated through the use of a superspreading trisiloxane without compromising transepidermal water loss, and we introduce sensory enhancing silicone crosspolymer gels and their effect on important sensory attributes such as tackiness, oiliness, silkiness and afterfeel.

Experimental

Fragrance Measurements (See Figure 1). Over Product: 500 mg of body wash product was added to a 20mL GC vial and left to equilibrate for 24 hours. Then samples were analyzed by GC-MS using Solid Phase Microextraction (SPME) sampling with an Agilent 6890 GC with 5973 MS Inert detector equipped with a Gerstel MPS-2 autosampler.

Over Skin: 1.0 g of body wash was applied to a wet volar forearm and the arm was washed for 30 seconds, rinsed for 10 seconds and patted dry. A specially designed round-bottomed flask equipped with a “sealed cap” was fitted over the arm and an SPME needle was inserted into the flask. The headspace above the arm was sampled for 30 minutes and then the SPME needle was injected into an Agilent 5890 GC with a 5970 MDS detector. The total fragrance areas were then calculated and compared across products (Figures 5 & 6).

Sensory Measurements. A 12 person naïve internal panel was asked to apply a small amount of material on the forearm and then rank 5 different skin feel sensory attributes on a scale of 1-10. Sunflower Oil was used as a standard and set to a score of 5 on each attribute. The panelists then scored the other...
Figure 1: a) SPME needles coated with PDMS/Carboxen to absorb volatiles from atmosphere. 
b) Sampling from product itself. c) Sampling of deposition on skin after wash.
products based on the standard (i.e. less tacky than sunflower oil, score <5). The scores from each product were averaged and recorded in Figure 9.

Skin Water Loss Measurements. Vitro Skin™ was cut into 1.5x6.5 cm rectangles and hydrated for 24 hours (glycerol/water). Each piece was mounted on top of a microscope slide coated with a film of petrolatum, and then 0.02g of the different oils or oil blends were spread over the top of the Vitro Skin. Water loss measurements were taken over time (1 data point/second) using a Courage and Khazaka TEWLmeter. 

Results and Discussion

Shower gels and body washes are cleansing formulations containing a blend of synthetic surfactants such as sodium laureth sulfate, cocoamidopropyl betaine and others in a product form that has become increasingly popular over the last decade. Isotropic shower gels contain 10-20% surfactants along with other minor ingredients such as fragrance, color, preservatives, emotive ingredients and/or particles for sensory or visual effects. Body washes are differentiated from shower gels by the high oil levels employed, mainly to support stronger deposition and moisturization claims. All of these formulations require a certain viscosity profile that makes them easy to pour from the bottle, but also easy to use and apply in the shower. The viscosity of simple surfactant blends in shower gels can be modified using salt (NaCl) which alters the surfactant physical chemistry or with various hydrophilic polymers such as polyacrylates which can be used to both thicken and/or suspend droplets or particles in the product. Body washes use a surfactant structuring mechanism or different polymers to provide the high viscosity, lotion-like product properties that consumers prefer from these body cleansers.

Water-soluble silicones for modified lather and skin feel. Dimethicone polyether copolyols such as Silsoft® 895 and Silsoft 870 can be added to liquid body cleansers to modify lather properties to provide rich and creamy lather. These products are water soluble and they are typically added to shower gel formulations at 0.5-2% to modify lather during product use. Several silicone polyethers that can be used the for fine tuning of foam & lather and other specific characteristics of personal wash products are depicted in Figures 2 & 3. Also, silicone amines and quats such as Silsoft Tone, Silsoft A-553 and SME253 can also be added at similar levels to modify lather properties and in-use sensory performance as well as provide post-wash sensory benefits through deposition onto the skin during the shower. Their structures are depicted in Figure 4.

Since these modified silicones are water soluble and most likely are found as part of the surfactant system, they can impact the salt thickening capability of isotropic shower gel formulations. In these cases, polymeric viscosity modifiers such as carbomers are required to formulate a user acceptable final product.
Silicones in Shower/Bath Products
Silicone Polyether Overview

Figure 2: Silicone polyethers: Correlation architecture - functional benefits. PE = Polyether (PEG and/or PPG)
**Silsoft** * Copolyols as Foamants

**Foam Height**

![Graph showing foam height as a function of PEG content.](image)

*Figure 3: Foam height\(^6\) as a function of PEG content*

**Silicones in Shower/Bath Products**

**Silsoft** * Tone (Polysilicone-18 Cetyl Phosphate): Linear silicone aminopolyalkyleneoxide copolymer containing silicone and polyether blocks neutralized with cetyl phosphate

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
\text{[-[R - Si - O - (Si - O)\_x - SI - R\_\_y NR\_\_y[R\_\_y(C\_nH\_\_2\_2O)\_\_y R\_\_y NR\_\_y]\_\_y - x [C\_nH\_\_2\_2 OP(O)(OH)\_2]_\_y}
\end{align*}
\]

**SME253 (Amodimethicone Microemulsion)**

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
\text{[-[R - Si - O - (Si - O)\_x - SI - R\_\_y NR\_\_y[R\_\_y(C\_nH\_\_2\_2O)\_\_y R\_\_y NR\_\_y]\_\_y - x [C\_nH\_\_2\_2 OP(O)(OH)\_2]_\_y}
\end{align*}
\]

**Silsoft** * A-553 (Polysilicone-18): Block-copolymer of aminosilicone and polyalkyleneoxide

*Figure 4: Structural depictions of amino silicones and quats*
Silicones to modify the in-use and post-use sensory properties of moisturizing body washes. Moisturizing body washes typically contain high levels of petrolatum, triglyceride oils or other organic ingredients which are incorporated into the product at high levels to assure some deposition of the oil onto the skin. Various high viscosity silicone fluids (eg. SF96-1000) can also be formulated into moisturizing body washes to provide a differentiating in-use and/or post-use sensory benefits. Also, modified silicone fluids such as Silsoft*034, SF1642 and SF1632 can be blended with organic oils or high viscosity silicone oils to improve the feel of those ingredients when deposited on skin and still provide important skin moisturization benefits.

Silicone polymers can also be effective in providing enhanced fragrance deposition and longevity in traditional shower cleansing formulations, something that has always been difficult to achieve. One way to improve the fragrance properties of these products is to use the high levels of oils to carry fragrance to the skin. To achieve this goal, it is critical to ensure that the fragrance is solubilized by the oil phase and not just the surfactant phase. If the fragrance does partition into the oil phase, the oil can act as a carrier for the fragrance as it is deposited on the skin during the wash.

When a blend of high viscosity silicone oils, such as SF 96-1000 and alkyl modified silicones such as SF 1642 are formulated in a standard body wash, the silicone blend is deposited on the skin during the wash. This blend of SF96-1000 and SF1642 (4:1) is also an excellent carrier for fragrances to enhance fragrance deposition and longevity after wash as highlighted in Figures 5 & 6.

Data in the graphs presented in Figures 5 and 6 were obtained using SPME (solid phase microextraction) over samples of the body wash product itself or
over arms that had been washed (rinsed and dried) with the different body wash products. In this case, the body wash formulations contained 20% of the silicone blend (SF 96-1000/SF 1642 (4:1)) or 20% of petrolatum. Both oil matrices solubilized the fragrance resulting in less fragrance in the headspace over the product (Figure 5). These results indicate that some of the fragrance has partitioned into the oil phase, and therefore if the oil is deposited on the skin, it will carry the fragrance with it. The results in Figure 6 show that the amount of fragrance released from the skin after wash was much higher with the blend SF96-1000/SF1642 (4:1) than with the petrolatum indicating that the silicone oil blend is a more effective fragrance carrier than petrolatum in this application. These fragrance measurements should correlate directly with the fragrance impact the consumer actually perceives on their skin after using the product.

Figures 7 and 8 show the chemistries behind Silsoft 034, SF-96-1000, SF1632 and SF1642.

**Silicones for shower conditioners.** A new offering in the shower product market are shower conditioners or in-shower body lotions. These products are to be used after cleansing in the shower to provide moisturization and fragrance benefits. Similar in concept to hair conditioners, these products are formulated with different oils and emotive ingredients, with typically only enough surfactant to emulsify the oil. Therefore these systems are quite high depositing formulations and the delivery of reasonably high levels of moisturizing ingredients to skin in the shower is possible.

While moisturization benefits are the basic claims for these products, good aesthetics both on wet and dry skin are critical for consumer acceptance. Some
Silicones in Shower/Bath Products

**Silsoft® 034:**
Caprylyl Methicone

![Chemical structure of Silsoft® 034](image)

- **Product Attributes/Performance Benefits**
  - Low Viscosity Oil
  - Semi-Volatile
  - Compatible With Cosmetic Oils
  - Lowers Surface Tension of Oils
  - Improves Spreading
  - Emolliency
  - Silky Soft Feel

*Figure 7: Structural depiction of Silsoft®034*

Silicones in Shower/Bath Products

![Chemical structures of SF96-1000, SF1632, SF1642](image)

- **SF96-1000**
- **SF1632; R = Cetearyl**
- **SF1642; R = C30-45**

*Figure 8: Structural depictions of SF96-1000, SF1632 and SF1642*
specialty silicones from GE can provide unique sensory benefits both during and after use of the shower conditioner. Therefore, sensory panel evaluations were conducted to determine the impact of a typical silicone gel and modified silicones either by themselves or blended with organic oils. The panelists were asked to rate sensory attributes during application on the forearm on a scale of 0-10. The following graph (Figure 9) summarizes the results of 12 naïve panelists.

![Figure 9. Naïve Sensory Panel Results for Oils and Oil Blends](image)

The sensory panel data suggests that blending a silicone gel such as the patented Velvesil® 125 and/or Silsoft® 034 with petrolatum, greatly diminishes the tackiness of the oil and provides a unique silky skin feel. Silsoft 034 is a trisiloxane that can lower the surface tension of organic oils and thereby promote the spreading of these materials on the skin, which has been reported to have beneficial properties for example in sun care.

Silicone gels are very different from organic oils in that they are very silky and powdery without the tack and oily characteristics of organic oils. Specifically here, Velvesil 125 is a GE proprietary silicone 3-dimensional-copolymer network swollen in cyclopentasiloxane, providing a soft, powdery and somewhat dry sensory experience, not unlike a mild “squeaky clean” perception. It is a slightly hazy product with high diffuse transmittance that is capable of blurring fine lines and wrinkles. Also, it carries a C>30 alkyl functionality, which renders it more compatible with organic oils, unlike many other conventional silicone gels. Velvesil DM is a similar gel with a shorter C<20 alkyl function, swollen in 5 cSt polydimethylsiloxane (PDMS). It is less hazy, and provides a very smooth and almost therapeutic sensory experience,
without exhibiting any negative perception of tackiness or oiliness. Both gels can easily be formulated into finished products and can be combined with other silicones, and are schematically depicted in Figure 10:

![Diagram of Silicones in Shower/Bath Products](image)

**Silicones in Shower/Bath Products**

**3D-Silicone Gels for Superior Sensory**

- **Velvesil® 125**: \( R = C_{30-45} \): Cyclopentasiloxane (and) C30-45 Alkyl Cetearyl Dimethicone Crosspolymer
- **Velvesil® DM**: \( R = C_{14-20} \); 5 cSt PDMS: Dimethicone (and) Cetearyl Dimethicone Crosspolymer

**Figure 10**: Structural depictions of Velvesil 125 silicone copolymer network and Velvesil DM siliconecrosspolymer network

Indeed, it has been found that when Velvesil 125 and Velvesil DM or Silsoft®/petrolatum blends are incorporated into a fully formulated shower conditioner, the products provide a unique feel on both wet and dry skin. The aesthetics are pleasing and the wet skin does not feel tacky and oily like conditioners formulated with petrolatum or other organic oils.

While the sensory properties of these products are definitely key to consumer acceptance, moisturization claims are also important, so that occlusives such as petrolatum must maintain this behavior when blended with different silicone ingredients. Using Vitro-skin™ as a substrate, trans epidermal water loss (TEWL) measurements over time were made by measuring weight loss from the skin and by using a TEWLmeter. In Figure 11, blank # 1 refers to untreated vitro skin, yielding TEWL values between 40 and 50 g/hm². When Velvesil DM was applied, the water loss is somewhat diminished, and lies
somewhere between 33 and 40 g/hm$^2$. Petrolatum itself shows the lowest TEWL values with about 5 g/hm$^2$, and when mixed with Silsoft 034 or Velvesil 125, the respective TEWL data increase only slightly to between around 8 (Velvesil*DM) and around 10 (Silsoft*034) g/hm$^2$. It becomes thus clear, that when put in perspective, this small increase in TEWL when having petrolatum-silicone mixtures over petrolatum alone are insignificant when compared to the TEWL values of the untreated substrate, even in the case where 33% of silicone is employed. Further studies of these oil blends using microscopy confirmed that there was still crystalline behavior of the petrolatum blend indicating that the silicone ingredients did not dissolve the higher molecular weight waxy portion of the petrolatum and hence most likely explains why the occlusive nature of this material is maintained.

![Figure 11. Skin water loss measurements using a TEWLmeter](image)

**Conclusions**

In summary, specialty silicone fluids and modified silicones available from GE offer numerous benefits when formulated into different shower products. They can modify the lather and vary the in-use and post-wash skin feel sensory enhancement of cleansing products. Silicone blends can provide enhanced fragrance deposition and longevity from cleansing products and can offer sensory modification of different organic oils. In general, product sensory attributes can be "dialed into" shower/bath products through careful selection of the type and level of the silicone and the overall composition of the base shower/bath formulation.
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* Silsoft and Velvesil are registered trademarks of the GE corporation.

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