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abstract

As consumers become increasingly eco-conscious, the personal care and cosmetics market is seeing a rise in demand for bio-based and sustainable products. This article presents four new silicone gum blends developed by Dow that are designed to meet these demands without sacrificing performance within hair care formulas. As the market sees growing demand for products that achieve the same performance associated with silicone gum blends using alternative carriers including bio-processed materials and renewable sources, four new blends are now available, designed to meet this need and built from the same silicone gum as traditional blends using cyclopentasiloxane as a carrier. The four blends provide formulators with a new level of flexibility of variety and criteria, including volatility, manufacturing process and the sustainability profile. The blends also now offer a carrier toolbox approach built around the same dimethiconol gum. Hair care formulations created with these blends can achieve smoothness and conditioning while also reaching modern environmental standards. Combining these blends creates additional options for formulators and allows for fine-tuning for specific sets of desired formulation properties and benefits, beyond the traditional performance of silicone gum blends.

Introduction

Silicone gum blends have been used for decades in the hair care and skin care segments, offering a wide range of benefits including hair conditioning, hair shine, heat protection, frizz control and sensory advantages. Recently, the market has seen a rise in demand for products that achieve the same performance associated with silicone gum blends using alternative carriers, including bio-processed materials from renewable sources. Four new blends are now available, designed to meet this need and built from the same silicone gum as traditional blends using cyclopentasiloxane as a carrier. Each carrier was chosen to create a new sensorial experience with no need to compromise on hair conditioning and smoothness. **Fig. 1** provides a summary of the key characteristics of those news blends.

Key Characteristics

- A bio-based and renewable sourced carrier, 0.76 Natural Origin Index (ISO-16128-2, December 2017) option in C13-15 Alkane
- A low viscosity and high volatility blend option in isododecane
- A viscosity-building, similar-to-cyclopentasiloxane volatility option in a combination of C11-13 Isoparaffin and Isohexadecane

Gum	Carrier	% Active gum	Blend volatility (vs cyclopentasiloxane carrier blend)	Blend viscosity in cPs (vs cyclopentasiloxane carrier blend)	Carrier	Reference
Dimethiconol	C11-13 Isoparaffin, Isohexadecane	27	Similar	Higher [20,000-32,000]	Non-silicone Volatility close to D5 Readily biodegradable	DOWSIL™ PMX-1504 Fluid
Dimethiconol	Isododecane	15	Higher	Lower [700-1,200]	Non-silicone High volatility Readily biodegradable	DOWSIL™ PMX-1505 Fluid
Dimethiconol	2 cSt PDMS	18.5	Slightly lower	Similar [5,200-8,400]	Silicone Volatile	DOWSIL™ PMX-1507 Fluid
Dimethiconol	C13-15 Alkane	20.5	Lower	Similar [5,200-8,400]	Non-silicone Inherently primary biodegradable 96% natural origin content (ISO 16128)	DOWSIL™ PMX-1508 Fluid

Fig. 1 New silicone gum blends overview.

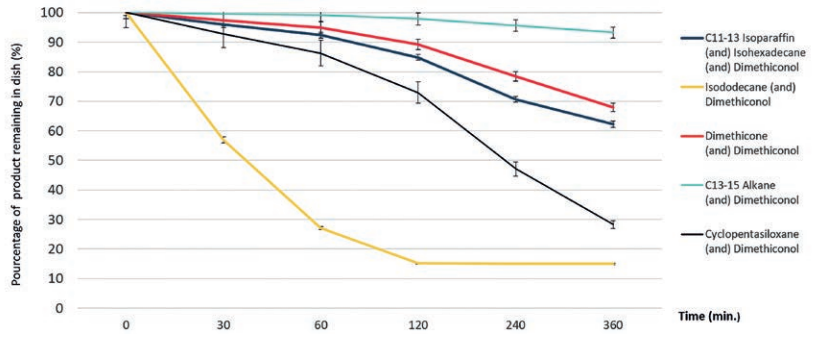

Fig. 2 Volatility profiles (32°C) of new silicone gum blends in comparison to a cyclopentasiloxane-based blend.

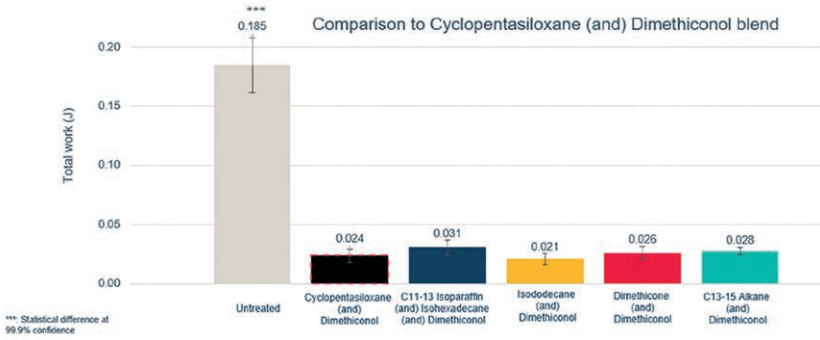

Fig. 3 Hair combing performance of new silicone gum blends in comparison to cyclopentasiloxane-based blend.

- A 100% silicone-based option in 2 cSt linear polydimethylsiloxane (PDMS)

Both active gum content and carrier volatility can impact performance, underlining the important parameters to consider when formulating with these new blends. Gum active content ranges from 15% to 27%, which provides a large array of blend viscosities for formulators to choose from. With its high gum active content, the blend in C11-13 Isoparaffin and Isohexadecane can be useful in building viscosity in anhydrous hair oil formulations. Carrier volatility varies from isododecane to low volatility C13-15 Alkane, allowing an array of transient and/or final sensory properties on hair or skin in the final formulations. The 2 cSt blend offers an alternative when a 100% silicone profile is targeted. Lastly, the addition of the sugar-cane sourced C13-15 Alkane-based blend helps enhance this product's sustainability story in response to consumer trends toward more naturally-based products.

Overall, the four blends provide flexibility of variety of criteria, including volatility, manufacturing process and sustainability profile, as the carriers in which the silicone gum is dispersed have different levels of classification regarding biodegradability and/or natural content. Additionally, these now offer a carrier toolbox approach built around the same dimethiconol gum. Combining these blends can create even more options for formulators and allow fine-tuning for specific sets of desired formulation properties and benefits.

Materials and Methods

Sample Preparation

For all hair care tests except Heat Protection, all blends were diluted to the same gum active level using the following protocol:

- Each blend was first diluted to a 12% gum active level using its own carrier as a diluent (e.g. isododecane or 2 cSt PDMS), then further diluted from 12% to 9% active level using the same common diluent for all blends.
- The common diluent was an isohexadecane/isododecane mix selected based on its similar volatility profile to cyclopentasiloxane.
- Heat protection testing was performed using a 4% active gum dilution in cyclopentasiloxane and exposing hair during 100 sec. to heat (130–230°C).
- For skin care sensory, blends were used without any dilution process.

Hair Care Testing

- Slightly bleached Caucasian hair was used except for volume control (Caucasian frizzy hair).
- Testing was done in triplicates, with untreated hair washed with 9% SLS solution as a control.
- Non-instrumental testing included 18 panelists and paired comparison t-test statistics treatment.

Volatility Profile

- 1g of product was placed into aluminum cups at a temperature of 31±1°C in ventilated oven.
- Weight was then measured at 0, 30 minutes, 1 hour, 2 hours, 4 hours and 6 hours.
- Testing was done in triplicates.

Volatility Valued

To characterize the blends based on the volatility of their respective carriers, profiles were generated by monitoring the loss in weight with time of a defined quantity of blend placed into standardized temperature and humidity conditions for 6 hours and allowed to evaporate. **Fig. 2** displays the volatility

data generated at 32°C, corresponding to the temperature of the skin.
After 6 hours, isododecane had essentially fully evaporated and only the silicone gum fraction remained. The combination of C11-13 isoparaffin and isohexadecane blend was slightly less volatile compared to cyclopentasiloxane, similarly to the 2 cSt equivalent. Lastly, the C13-15 Alkane blend can be considered nearly non-volatile, with only a small percent of the carrier having evaporated after 6 hours.

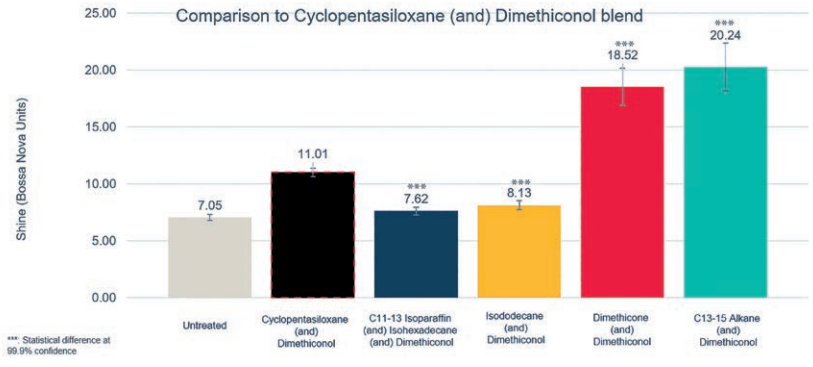

Fig. 4 Shine performance of new silicone gum blends in comparison to a cyclopentasiloxane-based blend.

Comb Comfortably: Hair Combing Benefits

A major benefit typically associated with silicone gums is better hair combing. Hair swatches were treated, allowed to air dry, entangled and the force needed to pass a comb through the tresses was then quantified. **Fig. 3** shows the dry combing performance of the new silicone gum blends in comparison to a cyclopentasiloxane-based gum blend and untreated hair. All silicone gum blends performed significantly better compared to untreated hair, highlighting the key impact of the silicone gum on this performance aspect.

Shine On

Along with hair combing, hair shine is another ubiquitous component of hair conditioning. During testing, hair swatches were treated, allowed to dry, combed and their shine level was then quantified. **Fig. 4** shows how each of the new blends performs relative to a cyclopentasiloxane-based equivalent.
In this case, volatility significantly impacted performance, driving the amount of high refractive index material ultimately remaining on hair. Lower volatility blends (C13-15 Alkane, and to a lesser extent 2 cSt PDMS) led to higher shine levels compared to their more volatile equivalents (isododecane).

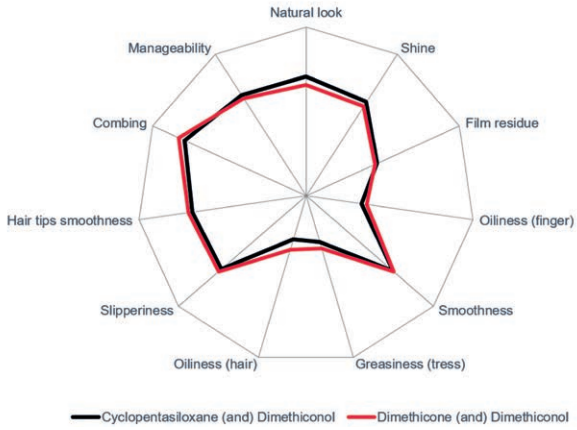

Fig. 5 Sensory on hair of 2 cSt gum blend in comparison to a cyclopentasiloxane-based blend.

Silky Smooth: Hair Sensory Benefits

Sensory is a third major component of hair conditioning. The volatility level of the carrier will play a key role in this case as well. Hair tresses were treated, allowed to air dry and submitted to panelists for evaluation against typical sensory descriptors. Silicone gums are well-recognized for the non-greasy, smooth feel they can provide to hair. With very low volatility carriers as an exception, it was possible to achieve similar sensory to cyclopentasiloxane blends with the new carriers used. **Fig. 5** illustrates this using 2 cSt PDMS. Results suggested an exact sensory match between the two materials, suggesting the dimethicone-based blend as an attractive option for hair care products with sensory as a key driver.
Beyond sensory, visual aspects of hair such as volume control is also an important performance criteria, especially for those with frizzy hair. The dimethiconol gum dispersed in C13-15 Alkane leads to significantly decreased volume compared to untreated hair.

Go for Smoothness: Coefficient of Friction

Hair friction properties correlate well with consumer attributes such as smoothness, therefore coefficient of friction measurements were carried out to get a picture of hair conditioning performance. **Fig. 6** shows the associated results:
All silicone gum blends were shown to have lower coefficients of friction, statistically significantly lower than untreated hair. Among the new blends, the C11-13 Isoparaffin (and) Isohexadecane (and) Dimethiconol candidate was shown to have a lower coefficient of friction versus its cyclopentasiloxane equivalent (95% confidence).

Look After Your Locks: Heat Protection

Silicone gums blended with silicone carriers were shown to have improved heat protection benefits compared to organic carriers. Proof of concept experiments demonstrated that optimum heat protection can be reached thanks to multifactorial physical and chemical variables of the film formed on the fibers' surface. These variables include factors such as full coverage of fibers by a vapor permeable and thermo-stable film, safeguarding sensitive cuticle zones, and minimization of fly-away (Marchioretto, 2016). Hair tresses were treated, exposed to heat and then to repeated combing. The amount of resulting broken hair was collected as a marker for heat protection performance. **Fig. 7** shows the corresponding results:
All new silicone gum blends also demonstrated heat protection benefits versus untreated hair, with a statistically significant decrease in the amount of broken hair. The 100% silicone 2 cSt PDMS blend was the best performer within that set.

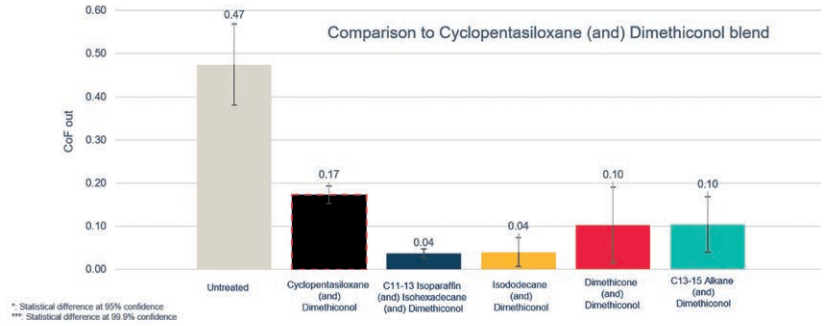

Fig. 6 Coefficient of friction performance of new silicone gum blends in comparison to a cyclopentasiloxane-based blend.

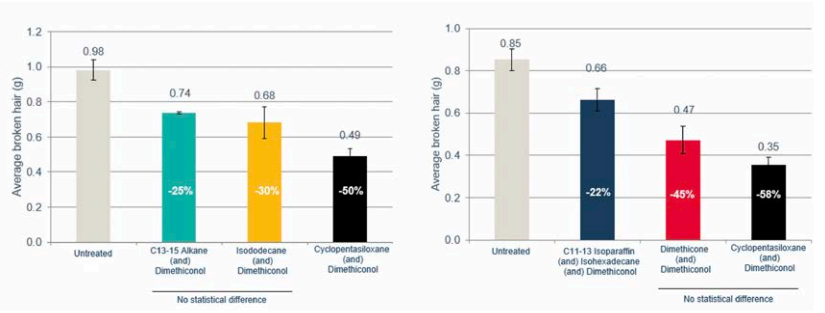

Fig. 7 Heat protection performance of new silicone gum blends in comparison to a cyclopentasiloxane-based blend.

A Win For Skin

The sensory attributes of silicone gum blends are also leveraged in skin care in a variety of sub-segments. Non-diluted blends were applied on panelists' forearms and evaluated one-to-one against typical descriptors, both during and after absorption of the product on skin. All blends were compared to their cyclopentasiloxane carrier equivalent. Comparisons were performed on a non-diluted commercial material basis to allow for an exact mapping of those blends as supplied versus their cyclopentasiloxane equivalent. The C13-15 Alkane-based blend was shown to have a better spreadability before absorption and lower tackiness, with no difference on key descriptors such as smoothness (**Fig. 8**). The higher spreadability and lower tackiness may be associated with the lower carrier volatility. The 2 cSt PDMS blend was shown to have a sensory profile close to its cyclopentasiloxane equivalent. The isododecane-based blend was shown to be easier to spread, less tacky and have similar smoothness and lower greasiness after absorption. In contrast, the C11-13 isoparaffin/isohexadecane-based blend was more difficult to spread, tackier and less smooth. This particular behavior can be explained by the considerably higher viscosity and gum active content between both materials in their commercial form and may evolve significantly once formulated.

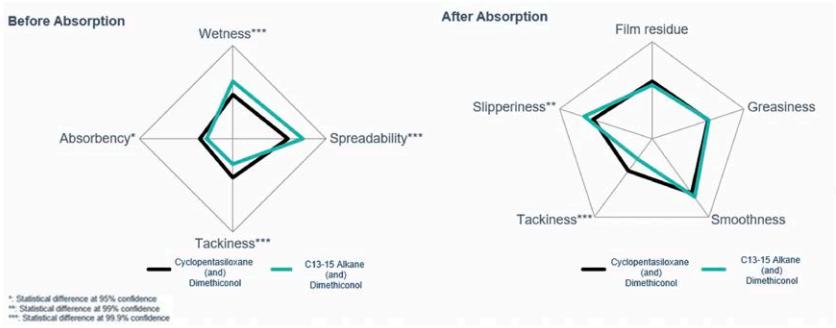

Fig. 8 Sensory profile of C13-15 Alkane-based silicone gum blend in comparison to a cyclopentasiloxane-based blend.

The 2 cSt-based blend was also compared to its non-volatile 5 cSt carrier equivalent, to which it was shown to be an exact sensory match.

Conclusion

New versatile silicone gum blends are now available to help formulators create leave-on hair and skin care products that provide unique experiences like enhanced shine and smoothness, easier wet and dry combing, frizz control as well as heat protection. From a regulatory standpoint, they can be formulated globally, including Europe, and the INCI names are also listed on the China catalog of cosmetic ingredients. With the carrier toolbox approach, the different carriers, gum active content and viscosity enable considerable flexibility that can be achieved whether in terms of cosmetic performance, formulation or manufacturing process.

References

Marchioretto, S. (2016). Heat Protection Getting Warmer: Specialty Silicones for Hair. Cosmetics & Toiletries.

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