Silicone Carbinol Fluid: Beyond Aesthetics for Color Cosmetics

Adriana Urrutia
Heidi M Van Dort
Gerald Brissette
Paul Pretzer
Roxanne Haller
Isabelle Van Reeth
Virginie Caprasse

Dow Corning Corporation

DOW CORNING

Silicone Carbinol Fluid: Beyond Aesthetics for Color Cosmetics

Adriana Urrutia, Heidi M Van Dort, Gerald Brissette
Paul Pretzer, Roxanne Haller, Isabelle Van Reeth, Virginie Caprasse

Dow Corning Corporation

As consumers look beyond the visual effects of color cosmetics, formulators are challenged to create more sophisticated product forms and delivery systems that answer consumer needs beyond beauty and appearance. With the maturity of the facial makeup market and the increasing number of brands in the marketplace, innovation will be the key to maintaining growth.

The lines between color cosmetics and skin care continue to blur as more products are developed in both segments to provide multiple benefits such as anti-aging treatment, moisturization, long-lasting effects, UV-protection, convenience and ease of use. Trends in appearance range from a natural, healthy look to dynamic color, shine and luminescence. More sophisticated products are also being created using polymer and optical technologies. Meanwhile, consumers also demand cosmetics that offer a variety of skin sensations.[1] Today's color cosmetics market offers a realm of textures, skin feel, optical effects and additional benefits that appeal to individual preferences for one brand over another.

In the midst of these trends, global color cosmetic sales exceeded $25 billion in 2002, making this the third largest sector of the cosmetics and toiletries market. The segment comprises facial makeup (35%), lip products (29%), eye makeup (25%) and nail products (11%). According to Euromonitor, the color cosmetics market is expected to grow 16% between 2002 and 2007.[2]

Silicones continue to be valuable ingredients in these products. Based on data from Cosmetic Research International, a large percent of new products introduced in 2002 contained silicone (72% in France and 50% in the US).[3]

Silicones have become ubiquitous in color cosmetics because they provide a soft feel and nonoily appearance during and after application. At the same time, their multifunctional properties offer flexibility for developing new textures and stable systems. In the most contemporary color cosmetics, silicones are more than simply sensory additives. Because of their physicochemical properties, silicones also offer important benefits in formulation and processing.

Among the silicones that can lead to next-generation color cosmetics, bis-hydroxyethoxypropyl dimethicone[a] is a versatile silicone carbinol fluid that acts as a wetting agent while also providing moisturization and fragrance retention. This article reviews some of the important

[a] Dow Corning® 5562 Carbinol Fluid

concepts of color cosmetic formulation, then relates these factors to the useful properties of the new silicone material.

Key Elements of a Color Cosmetic Composition

Three key elements are required for optimum performance of a finished color cosmetic composition. These include: the color film being formed on the skin, the pigments used to formulate the product and the structure or texture of the cosmetic. Each of these elements requires specific attention to its fundamental behavior, as each interacts with the others, causing different behaviors and results that can affect performance of the final color product.

Films. Uniform film formation is one of the most critical requirements for a color cosmetic. Without uniformity, color development will not occur, film gloss will be affected and the final product will show poor performance.

Films can be formed in several ways. One approach is to dissolve all the ingredients in a solvent or solvents to achieve the desired application viscosity, then apply the product on the skin and allow the solvent to evaporate. However, several factors affect film formation including wettability, compatibility, rheology, pigment content, substrate properties and solvent system properties. Control of these factors allows formulators to create films with useful properties such as slipperiness, resistance to mild abrasion, leveling, good spreadability, water resistance, adhesion and gloss.

A good film depends on three key factors: compatibility, viscosity and wettability.

Compatibility. In a stable system, various components exist without interaction. These components should form a homogeneous (one-phase) mixture at a given ratio (thermodynamic compatibility).[4] The system should not present separation of any ingredient (two or more phases), precipitation or the presence of any suspended agents that result in graininess or clumping. The system may be clear or transparent (soluble), hazy or opaque, but all ingredients should coexist in one phase. The formulation should form a homogeneous film on the substrate. If the ingredients used in the composition are only partially compatible (i.e., they have miscibility limits), a compatibilizer is needed to maintain the homogeneous state of the composition.

Viscosity. The viscosity of a coating also influences wetting and surface defect formation. The rate of wetting is dependent on viscosity as well as surface tension. Even if other conditions are favorable (e.g., surface tension and contact angle), spontaneous spreading or dewetting may not occur if viscosity is too high. Surface defects may or may not form, depending on viscosity.[5]

Wettability. Wetting involves the interaction of a liquid with a solid, such as the spreading of a liquid over a surface, the penetration of a liquid into a porous medium or the displacement of one liquid by another.[6]

Pigments. Pigments are an essential component in every color cosmetic product. A pigment is a finely divided crystalline solid that is used to impart color to a substrate. They are typically insoluble in most solvents, including water and organic solvents and chemically inert. Particle size, crystal structure and surface characteristics are important for pigment function. Pigments also affect film qualities and application properties. The balance between the volume fraction of binder and volume fraction of pigment will affect the optical and mechanical properties of the film.[7] Because each pigment varies in its wetting and dispersion characteristics, oil absorption values should be previously determined to obtain the wetting requirements that provide ideal consistency.[8] Pigments are regulated by government organizations around the globe, and the European Union, U.S. and Japan each have very different rules. For example, each country has different nomenclature, approved colorants, pigment definitions, use restrictions and acceptable levels of pigment purity.[9]

Structure. Each color cosmetic may be presented in a variety of physical forms. The final consistency of the product depends on the physicochemical properties of the rheology modifiers used in the formulation and the appropriate balance of all the ingredients (additives, pigments, oils, fats and waxes). One lipstick may have a hard outside layer with a softer inner core, while another may be extremely dry and hard.[8] Because of this, perfect equilibrium among the formula's components is necessary in order to successfully achieve the principal characteristics of the final color cosmetic. For example, a lipstick base should have an acceptable breaking, softening and melting point.

Overview: Bis-Hydroxyethoxypropyl Dimethicone

Bis-hydroxyethoxypropyl dimethicone is a low viscosity, hydrolytically stable silicone fluid that is easily incorporated into a variety of personal care formulations. Also referred to as carbinol-functional silicone or silicone carbinol fluid, this material shows a unique ABA structure. Its small organic component (EO_1), provides a novel polar/nonpolar compatibility profile. It also imparts hydrophilicity and wetting characteristics. Although the fluid offers both polar and silicone functionality, its behavior is considerably different from existing polar silicone materials such as silicone polyethers and silanol fluids.

The silicone carbinol fluid functions well as a wetting agent in pigment dispersion preparations, has a good compatibility profile with film-formers such as silicone resins, and shows good properties as a binder for powder cosmetics, without requiring the use of the multiple ingredients typically used to bind pigments.

Compatibility Profile

Compared to many polar organic materials, the silicone carbinol fluid is nonirritating. In terms of formulation ease, the material is compatible with a wide range of cosmetic raw materials, both polar and nonpolar solvents, including most organic esters, alcohols and silicones, resins and waxes. Table 1 describes the compatibility of the silicone carbinol fluid with raw materials commonly used in cosmetic products.[10]

Table 1. Compatibility of Carbinol-Functional Silicone with Commonly Used Ingredients in Cosmetic Products

Cosmetic Material	Silicone Carbinol Fluid
C12-15 alkyl benzoate	C
Caprylic/capric triglyceride	C
Coco-caprylate/caprate	C
Diisopropyl adipate	C
Diisostearyl fumarate	C
Diisostearyl malate	C
Isocetyl stearate	C
Isopropyl isostearate	C
Isopropyl laurate	C
Isopropyl myristate	C
Isopropyl palmitate	C
Isopropyl stearate	C
Isostearyl benzoate	PC
Myristyl ether acetate w/ propylene glycol	C
Myristyl lactate	C
Octyldodecyl stearoyal stearate	NC
Octylpalmitate	C
Octylstearate	C
Tridecyl neopentanoate	C
Triisocetyl citrate	C
Lauryl alcohol	PC
Oleyl alcohol	PC
Glyceryl trioctanate	C
Polyglyceryl-3 diisostearate	NC
Mineral oil	PC
Ethanol, 200 proof	PC
Propylene glycol	NC
Water	NC
Dipropylene glycol	NC
Glycol ether	C
Glycerin	NC
Isopropanol	C
Octyldimethyl PABA	PC
Octyl methoxycinnamate	PC
Castor oil	NC
Lanolin oil	NC
Sunflower oil	NC
Isododecane	C
C11-12 isoparaffin	C
Polydecene	NC

Wetting Profile

Before reviewing the benefits of bis-hydroxyethoxypropyl dimethicone, it is helpful to consider some concepts related to the wetting process. The angle of contact (θ) that a sessile or resting drop makes on a solid most often describes wettability.[11,12] A low contact angle indicates high wettability and a high contact angle poor wettability. A liquid droplet on a solid surface causes interfacial tension described as force vectors acting on the three-phase contact line. At equilibrium, these forces must balance as described by the Young equation:[13]

$$\gamma_{sv} = \gamma_{ls} + \gamma_{lv} \cos \theta$$

in which γ_{sv} is the interfacial tension at the boundary of the solid and vapor, γ_{ls} the interfacial tension at the boundary of the liquid and solid, γ_{lv} is the interfacial tension at the boundary of the liquid and vapor (surface tension), and θ is the contact angle. The term γ represents the force needed to stretch an interphase a unit distance. If the contact angle is less than 90 degrees, there is an unbalanced Young's force at the three-phase contact line, which should lead to spreading. This situation is often described in terms of the spreading coefficient, S_{sl}:[14]

$$S_{sl} = \gamma_{sv} - \gamma_{lv} - \gamma_{ls}$$

A positive spreading coefficient means spreading is energetically favored. A surfactant absorbs to both the liquid-solid and liquid-vapor interfaces and lowers the interfacial tension; hence, it reduces the γ_{lv} and γ_{ls} values. Neither γ_{sv}, nor γ_{ls} can be directly measured experimentally for solid surfaces, but a Zisman plot can be used to empirically determine these parameters. This technique measures advancing contact angles on well characterized, low energy substrates.[15] The critical surface tension (γ_c) corresponds to the surface energy of the liquid that will just spread onto a solid surface with a zero contact angle (under those conditions, $\gamma_{sv} > \gamma_{ls} + \gamma_{lv}$ and the $\cos \theta = 1$).[16] The Young´s equation shows that spreading requires both a low surface tension for the wetting fluid and a low interfacial tension between the liquid and the substrate.[17]

Silicone fluids have a very low surface tension and because of this they are good wetting agents and show good spreadability properties. The liquid surface tension of polydimethylsiloxane (21 dynes/cm) is lower than the critical surface tension of wetting (24 dynes/cm). This causes the polymers to spread over their own adsorbed films. The ability of silicone to promote spreading also depends on its compatibility with other components from the formulation. Oil soluble siloxane surfactants improve the spreading ability of organic oils and waxes and as such are used in makeup and skin care formulations. Table 2 shows the surface tension and critical surface tension of some common cosmetic materials.

Table 2. Surface Tension and Critical Surface Tension of Some Materials [5,18]

Ingredient (liquid)	Surface Tension: γ_{lv} dynes/cm	Ingredient (solid)	Critical Surface Tension: γ_c dynes/cm
Water	73	Polydimethyldsiloxane	24
Glycerin	66	Skin	27
Castor oil	36	Yellow iron oxide	>73
Olive oil	33	Talc	48
Capric caprylic triglyceride	30	Red iron oxide	28
Polydimethylsiloxane	21	TiO_2	Ave. 36
Bis-hydroxyethoxypropyl Dimethicone	24		
Silicone polyethers	21-37		
Hexamethyldisiloxane	16		

Bis-hydroxyethoxypropyl dimethicone is a silicone that shows low surface tension and good compatibility with other organic materials. This silicone carbinol fluid has a contact angle of 47º on Teflon and 54° on glass (contact angle measured via VCA-200 Video Contact Angle System from Advanced Surface Technology, Inc., Billerica, MA 01821). Its ABA structure with an EO1 substitution gives the fluid polar and nonpolar properties that translate to an excellent compatibility profile with a variety of polar and nonpolar cosmetic ingredients. The carbon linkages (EO1) in comparison with silanol linkages (OH) make this molecule stable in acid and base environments. Its silicone backbone also lends a distinctive sensory profile.[19]

On a given surface, a coating will spread or withdraw, depending on the surface tension values. When the surface tension of the coating is higher than that of the substrate, the coating withdraws on the substrate in order to obtain the lowest possible common surface with the substrate. Bis-hydroxyethoxypropyl dimethicone can be used to reduce the differences in interfacial tension between coating and substrate, thus reducing the defects in the surface constitution of the film. In the same way, the silicone carbinol fluid can be used as wetting agent in the preparation of pigment dispersions.

Table 3 shows the results of applying the silicone carbinol fluid as wetting agent at 10% as part of the composition of an unpigmented coating, where a silicone resin was used in the formulation at 20% solids. The carriers used were cyclopentasiloxane and isododecane. The coating was applied to a Leneta opacity chart (Leneta Co, Manwah, New Jersey) using a Myer coating rod No 8. (Paul N. Gardner, Inc., Pompano Beach, Fl).

Characterization of the films was made visually, and measurements of 60º gloss were obtained with a Gardner Tri-Gloss Meter (cat. #4520, BYK Gardner, Columbia, MD) if the coatings were uniform. The silicone carbinol fluid was compared with other materials used as wetting agents within the color cosmetic industry.[10]

Table 3. Characterization of Films[10]

Wetting Agent	Castor Oil			SPE Fluid			Carbinol Fluid			PTIS		
Resin	A	B	C	A	B	C	A	B	C	A	B	C
Carrier	D5	Iso	D5	D5	D5	D5	D5	D5	D5	D5	Iso	D5
System Compatibility (>24 hr result)	Fail	Fail	Fail	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass
Film Characterization (Leneta)	NA	NA	NA	Pass	Fail	NA	Pass	Pass	Pass	Pass	Fail	Pass
Gloss	NA	NA	NA	68.3	NA	NA	62.7	75.6	25.4	60.7	NA	19.2

D5 = cyclopentasiloxane
Iso = isododecane
SPE fluid = PEG 7 trisiloxane
PTIS = pentaerythrityl tetraisostearate
A = cyclopentasiloxane (and) trimethylsiloxysilicate
B = proposed INCI name silsesquioxane/dimethiconol crosspolymer
C = trimethylsiloxysilicate/dimethiconol crosspolymer
Uniform films are described as "Pass"

The results show better compatibility in the system when the silicone carbinol fluid is used; the films obtained were uniform and presented the highest value in gloss.

Pigment Wetting and Dispersion

Incorporation of pigment particles into a color cosmetic vehicle occurs in three stages, wetting, grinding and dispersion. The primary purpose of a pigment dispersant is to surround each suspended pigment particle with a barrier envelope that by either ionic repulsion or stearic hindrance prevents random contact with other particles.[20] The pigment wetting stage is accomplished through preferential adsorption, and its efficiency depends on the surface tension properties of the pigment and the vehicle as well as the viscosity of the resultant mix.[21]

Complete wetting and separation of the particles allow them to be homogeneously distributed, avoiding later flocculation. If wetting does not occur or is only partial, the resultant coarse dispersion will not give the proper color and gloss and will not impart the correct flow properties to the dispersion.[5] The wetting and compatibility properties of bis-hydroxyethoxypropyl dimethicone allow it to be used in preparation of pigment dispersions.

To evaluate the performance of the silicone carbinol fluid as a wetting agent in pigment dispersions, three cosmetic pigments were included in this study: yellow #5 aluminum lake, red iron oxide and titanium dioxide. Each was combined with the silicone carbinol fluid and likewise with castor oil, based on the calculated critical pigment volume concentration (CPVC).

The CPVC is the pigment volume content at which there is just sufficient binder or wetting agent in the dry film to give a complete adsorbed layer on the entire pigment surface and fill all the interstices between the particles when they are randomly close-packed. A coating with pigment volume content higher than CPVC will not have sufficient binder, and therefore there will be clusters of pigment particles in the film with no wetting agent between them; that is, there will be holes in the film.[7,22] Further addition of binder leads to a second stage where the pigment particles start to separate from each other. As binder addition continues, the distance between two particles becomes increasingly remote.[7,20]

The resulting dispersion was assessed directly by using instrumentation and visual observations to measure properties such as particle size, type of film being produced, gloss, rheological behavior and stability.

We also conducted a series of tests to determine the equipment power required to suspend pigments in the silicone carbinol fluid compared to castor oil. Figure 1 shows the equipment power requirements to suspend three different untreated pigments (red iron oxide, yellow #5 Al lake and titanium dioxide). The pigments were dispersed in silicone carbinol fluid and castor oil using a Lightnin Mixer (Model TS2010; Rochester, NY USA) at room temperature with a turbine/pitch blade configuration at a constant rpm setting. The silicone fluid dispersions required significantly less power to suspend untreated pigments than did castor oil.[10]

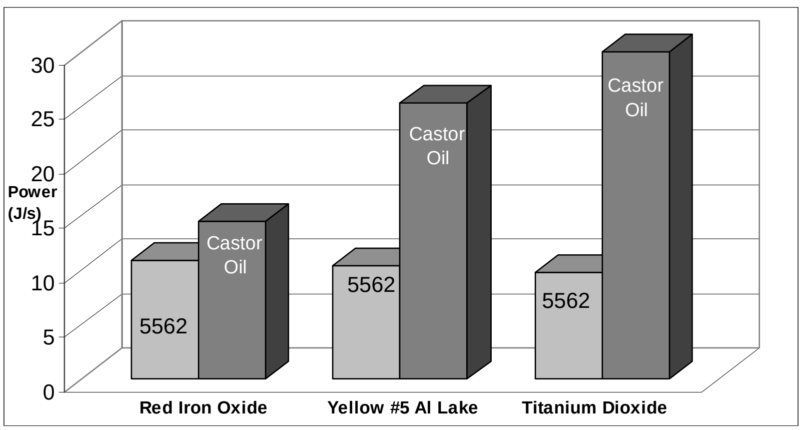

Figure 1. Silicone carbinol fluid requires less equipment power than castor oil to suspend pigments..

Results show a significant reduction of equipment power to disperse the three pigments when bis-hydroxyethoxypropyl dimethicone was used as wetting agent.

The resulting pigment dispersions were milled in a three-roll mill (Model 2 1/2 x 5 T.R.M., Charles Ross and Son Company, Hauppauge, NY). Periodic samples were taken after each mill process to make Hegman gauge readings to determine the particle size of the pigment dispersion. The viscosity was also measured after each mill pass. The silicone carbinol fluid and castor oil reduced the particle size of pigments equally when dispersed.

Table 4 shows the particle size after the dispersing process and one milling pass for each pigment with silicone carbinol fluid and castor oil at its CPVC.

Table 4. Evaluation of Particle Size

Critical Pigment Volume Concentration (CPVC)			Dispersion Process Measurements Silicone Carbinol Fluid vs Castor Oil	
Pigment	**Wetting Agent**	**CPVC %**	**Particle Size (Hegman gauge, after dispersing)**	**Particle Size (Hegman gauge, after mill pass 1)**
Red iron oxide	Carbinol fluid	46.06	> 50 microns	< 3 microns
Red iron oxide	Castor oil	43.83	> 50 microns	< 3 microns
TiO_2 cosmetic white	Carbinol fluid	42.63	> 50 microns	< 5 microns
TiO_2 cosmetic white	Castor oil	41.46	> 50 microns	< 5 microns
FD&C yellow 5 Al lake	Carbinol fluid	34.54	> 50 microns	< 10 microns
FD&C yellow 5 Al lake	Castor oil	37.19	> 50 microns	< 10 microns

Pigment Dispersion Assessment

Viscosity measurement is possibly the most common technique for assessing the effectiveness of pigment dispersants when preparing a pigment dispersion. This is because the tremendous viscosity reduction provided by a dispersant (wetting agent) affords a very practical indication of its depressive powers.[20]

We measured the final viscosity of three pigment dispersions (red iron oxide, yellow #5 Al lake and titanium dioxide) in either castor oil, silicone carbinol fluid, or capryl caprylic triglyceride after mixing for two hours with the Lightnin Mixer. The final viscosities (cPs) of the pigment mixtures, as shown in Table 5, were lower for the bis-hydroxyethoxypropyl dimethicone compared to castor oil or capryl caprylic triglyceride, which indicates that the silicone carbinol fluid is a better pigment-wetting agent than either castor oil or capryl caprylic triglyceride. We also saw similar results when a dispersator (Series 2000, Model 90, Premier Mill Corporation, Reading, PA) or the Ross three-roll mill were used to create pigment/fluid dispersions.

Table 5. Viscosities (in cPs) of Pigment Mixtures, Castor Oil Vs. Silicone Carbinol Fluid vs Capryl Caprylic Triglyceride

Pigment	Castor Oil	Silicone Carbinol Fluid	Capryl Caprylic Triglyceride
TiO_2	19500	4477	211000
Yellow #5 aluminum lake	7913	710	Not measured
Red iron oxide	12413	4180	Not measured

Dispersion Stability

Settling refers to the degree of sedimentation from the dispersed pigments, and it determines if a dispersion is of good quality. Qualitative and quantitative measurements have been used to assess pigment dispersion stability. The ASTM qualitative method D869-48 (1974) specifies dispersion quality by the degree of settling. The test is carried out manually with a flexible steel spatula probing that the sediment that has collected at the bottom of the container over a

6-month undisturbed storage period can or cannot be reincorporated into the system.[20] The silicone carbinol fluid dispersions had some soft sediment in the bottom of the containers. This dispersion contained a loose and weak network structure that readily redisperses with simple mixing to yield a uniform composition. We did not observe sediment in our castor oil dispersions or our capryl caprylic triglyceride dispersions. However, these dispersions were extremely viscous.

We also evaluated our pigment dispersions with a sonic concentration analyzer. This is a quantitative method recommended for measuring the sedimentation of solid particles in a suspension. With this method, an ultrasonic wave (high frequency pressure fluctuation) travels through the material and changes in ways (amplitude, energy frequency distribution and travel time) that are representative of the properties of the material being evaluated. Hence, pigment settling can be detected by a buildup of solids at the bottom of the sample over time.[23] The data that we obtained with this technique was consistent with that acquired with ASTM method D869-48 (1974).

Formulation 1 is an example of a prototype colored lip-gloss formulation using pigment dispersions prepared with the silicone carbinol fluid.

FORMULATION 1
Lip-Gloss

Ingredient	% w/w
A (Pigment master batch)	
Titanium dioxide/bis-hydroxyethoxypropyl dimethicone	22.9
Red iron oxide/bis-hydroxyethoxypropyl dimethicone	49.5
FD&C yellow #5 Al lake/bis-hydroxyethoxypropyl dimethicone	22.9
FC&C blue #1 Al lake/bis-hydroxyethoxypropyl dimethicone	4.7
B	
White beeswax	1.2
Carnauba wax	0.7
Candelilla wax	1.7
Ozokerite wax	2.4
Ceresin wax	0.9
Isopropyl palmitate	5.7
Octyldocecanol	8.0
Myristyl lactate	5.7
Lanolin alcohol	5.7
Lanolin oil	4.3
Propylparaben	0.2
Polybutene	11.4
Bis-hydroxyethoxypropyl dimethicone	28.6
Pigment master batch	11.4
Polyisobutene (and) polybutene	6.0
Isopropyl lanolate	6.1

Procedure: Make a pigment master batch by combining the following previously milled pigment dispersions: (42.6% titanium dioxide/57.4% silicone carbinol fluid, 42.3% red iron oxide/57.8% silicone carbinol fluid, 35.4% FD&C yellow #5 Al lake/64.6% silicone carbinol fluid, and 30.0% FD&C blue #1 Al lake/70.0% silicone carbinol fluid). Combine B ingredients and heat to 80°C until completely melted. Add A to B and continue mixing until homogeneous. Pour into lipstick molds or other suitable container. Agitate the batch occasionally during this operation.

Color Powder

Bis-hydroxyethoxypropyl dimethicone can be used as a binder in color powder cosmetics. The binders used in compact powders are blends of esters, oils and other emollients. Their main function is to improve compressibility, especially in formulations that include pearlescent materials at high levels and that are difficult to compact. The binder components may also contribute additional benefits to the formulations (e.g., moisturization, soft feel).

Our tests were made using the silicone carbinol fluid as a binder at up to10% by weight (the amount depended on the amount of filler used) in a color powder formulation. Results revealed that at the same conditions of compression (2000 psi), the resulting color compact had the same mechanical properties in penetration and breaking as a premium commercial brand formulation used for comparison. The compact prepared with the silicone carbinol fluid also showed smooth application on the skin, with a uniform color film and a silky afterfeel.

Formulations 2 and 3 illustrate pressed eyeshadows that incorporate the silicone carbinol fluid. (Formulations 2 and 3 courtesy of S. Black Ltd.)

FORMULATION 2
Monochromatic Eyeshadow

Ingredient	INCI Name	Supplier	% w/w
J-68 BC	Talc	US Cosmetics Corp	60.80
Micronasphere M	Mica, silica	Rona	1.00
Vestosint 2158	Nylon-12	Creanova Inc	1.00
Excel Mica JP2	Mica, Aluminum hydroxide	US Cosmetics Corp	5.00
Sericite S—152	Sericite	US Cosmetics Corp	20.00
C47-7756	CI 77891	LCW/Sun Chemical	2.00
C43-7718	CI 77742	LCW/Sun Chemical	2.00
Nipasol M	Propylparaben	Clariant Corp	0.10
Nipagin M	Methylparaben	Clariant Corp	0.10
Dow Corning® 5562 Carbinol Fluid	Bis-hydroxyethoxypropyl dimethicone	Dow Corning Corp	8.00

Samples pressed at 75 or 100 bar

FORMULATION 3
Monochromatic Pearlescent Eyeshadow

Ingredient	INCI Name	Supplier	% w/w	% w/w
J-68 BC	Talc	US Cosmetics Corp	47.80	47.70
C37-7740	CI 16035	Kingfisher Colors Ltd	2.00	2.00
Nipasol M	Propylparaben	Clariant Corp	0.10	0.10
Nipagin M	Methyparaben	Clariant Corp	0.10	0.10
Dow Corning® 5562 Carbinol Fluid	Bis-hydroxyethoxypropyl dimethicone	Dow Corning Corp	10.00	10.00
Timiron MP45	Mica, CI 77891	Rona	40.00	/
Timiron MP99	Mica, CI 77891	Rona	/	40.00

Both samples double-pressed at 50 bar followed by 150 bar

Moisturization

Besides color beauty and good performance, it is also necessary that color cosmetics provide additional benefits to the consumer. The skin requires proper hydration to prevent dryness. In general, formulators include topical moisturizers such as glycerin in their products to balance the humectancy of the skin and rehydrate it.

Because the silicone carbinol fluid has an ABA (EO_1) substitution, the ethylene oxide moiety is hydrophilic and has the capacity to bind water from the environment. As part of our evaluations, studies were conducted through corneometry to determine the effect of bis-hydroxyethoxypropyl dimethicone as moisturizer on the skin.

Based on corneometer readings, Figure 2 shows that the silicone carbinol fluid improves the hydration level of skin by 10 to 20% over in a period of five hours. This benefit may allow formulators to create color cosmetics with long-lasting moisturization effects.[10]

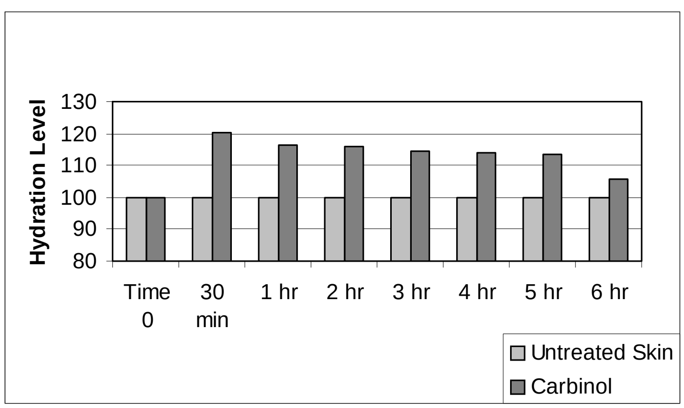

Figure 2. Moisturization benefits of the silicone carbinol fluid compared to untreated skin.

Fragrance Retention

Due to its compatibility, the silicone carbinol fluid improves fragrance retention. Studies were conducted through gas chromatography analysis. Results show that the material has sustained fragrance capabilities, maintaining fragrances longer than polydimethylsiloxane (PDMS) fluids of similar viscosity (50 cSt) and cyclopentasiloxane. Figure 3 illustrates the comparative evaporation of a complex fragrance, Aloe Lily (Firmenich), over 24 hours in dimethicone (50 cSt) and bis-hydroxyethoxypropyl dimethicone. The fragrance notes are numbered from most volatile to least volatile. The silicone carbinol fluid demonstrates greater fragrance retention, particularly with the most volatile components (high notes).[19]

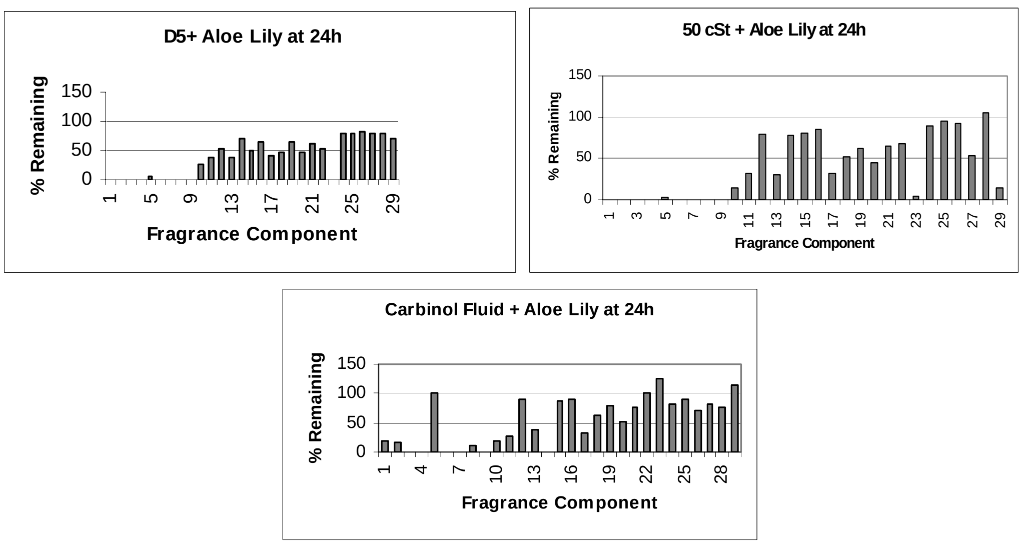

Figure 3. Fragrance retention benefits obtained with silicone carbinol fluid after 24 hr.

Sensory Evaluation

Due to the nature of the base dimethylsiloxane structure, the silicone carbinol fluid provides smoothness and emolliency to the skin. Sensory evaluations were conducted with a trained panel using paired-comparison tests and skin feel scoring. The silicone carbinol fluid was tested neat and in formulations. It was compared with baby oil as a benchmark and with other silicone fluids such as PEG/PPG-18/18 dimethicone and dimethicone (50 cSt).

Results show:

1. PEG/PPG-18/18 dimethicone is more tacky than the silicone carbinol fluid.

2. There were no perceivable differences between dimethicone (50 cSt) and the silicone carbinol fluid when evaluated for smoothness and slipperiness.

3. The silicone carbinol fluid had a higher smoothness and slightly higher oiliness score compared to baby oil after 5 minutes.

Summary and Conclusions

Based on analysis of its physicochemical properties and behavior in laboratory studies, the silicone carbinol fluid possesses characteristics that can be useful in the formulation of color cosmetics.

- With its low surface tension and compatibility profile, bis-hydroxyethoxypropyl dimethicone promotes spreadability on surfaces, enhancing color film leveling.
- Due to its wetting properties, the silicone carbinol fluid disperses pigments more easily than castor oil.
- The use of bis-hydroxyethoxypropyl dimethicone in the grinding process results in the same pigment particle size as obtained with castor oil.
- The viscosity of the final pigment dispersion in the silicone carbinol fluid is significantly lower compared to dispersions in castor oil, which indicates its dispersive benefits.
- The stability of pigment dispersions in the silicone carbinol fluid after 25 days is acceptable for color cosmetic applications.
- The silicone carbinol fluid enables stable, glossy films with silicone resins that provide formulation durability.
- The wetting properties of the silicone carbinol fluid make it a good binder for color powder cosmetics.
- The silicone carbinol fluid provides the aesthetics of a smooth and lubricious silicone polymer.
- The silicone carbinol fluid has good compatibility with many cosmetic ingredients.
- Bis-hydroxyethoxypropyl dimethicone moisturizes the skin for at least 6 hours after application.
- The carbinol-functional silicone maintains fragrances longer than dimethicone fluids of similar viscosity (50 cSt) and cyclopentasiloxane for at least 24 hours.

References

1. T.C. Sa Dias, I. Van Reeth, G. Gacic, A. Urrutia and S. Postiaux, High Performance Silicones Offer New Solutions for Color Cosmetics, *Eurocosmetics* 7/8 (2003).
2. *Euromonitor Cosmetics and Toiletries* (2004).
3. Cosmetic Research International, USA News and Fiches France, (2002).
4. Coatings Glossary Site: www.coatings.de/glossary.cfm#C
5. M.E. Schrader and G. Loeb, *Modern Approach to Wettability: Theory and Applications*, Plenum Press:New York (1992); pp 377, 385, 391.
6. J.C. Berg, *Wettability*, Marcel Dekker Inc NY (1993); p 2.
7. J.H. Braun, *Introduction to Pigments,* Federation of Societies for Coatings Technology, Blue Bell, PA (1993); pp 8-9.
8. Manoel Carames de B.L., Larance Perfumes Ltda, Rio de Janeiro, Brazil. *Cosmetics & Toiletries*, (January 1978),Vol. 93.
9. Color Selection–Regulations, http://www.sunpigments.com/cosmetics/media/Regulations.pdf

10. H.M. Van Dort, A.Urrutia, G. Brissette, P. Pretzer, R. Haller, I. Van Reeth, V. Caprasse, Silicone Carbinol Fluid: *A Versatile Material for Color Cosmetics*, Dow Corning Corporation (2004); pp 3-7.
11. A.W. Neumann and R.J. Good, *Surface and Colloid Science*, vol. II, R.J. Good and R.R. Stromberg eds., Plenum Press: New York (1979).
12. L.E. Murr, *Intefacial Phenomena in Metals and Alloys*, Addison Wesley: New York (1974).
13. T. Young, *Phil Trans. Roy. Soc*., (1805), **95**, 65-82.
14. A.W. Adamson, *Physical Chemistry of Surfaces*, fifth ed., Wiley-Interscience: New York (1990).
15. W.A. Zisman, in *Advances in Chemistry Series 43* (R.F. Gould, ed.), American Chemical Society: Washington, D.C., (1964); p 1.
16. Good, R.J., *Contact angle, Wetting, and Adhesion, a Critical Review.* In: Contact angle, Wettability, and Adhesion. K.L. Mittal, V.S.P. Utrecht, eds., VSP: The Netherlands (1993); pp 3-36.
17. R.M. Hill, Silicone Surfactants, Marcel Dekker Inc. NY (1999); pp18-19.
18. Owen, M.J. The surface activity of silicones: A short review, *Ind. Eng. Chem. Pro. Res. Dev.* (1980), **19**, 67-103.
19. H.M. Van Dort, R. Haller, P. Pretzer, A. Urrutia, G. Brissette, I. Van Reeth *New Formulation Opportunities with Carbinol-Functional Silicones*, Dow Corning Corporation (2004); pp 2-3.
20. T.C. Paton, *Paint Flow and Pigment Dispersion: A Rheological Approach to Coating and Ink Technology*, Second Edition, John Wiley & Sons: New York (1979); pp 127, 290-97, 544-476.
21. S. Nicolas, *Pigment Dispersions: A Value Added Way of Using Pigment to Formulate Cosmetic Products*, Sun Chemical Colors Group; p 6.
22. Z.W. Wicks, Jr. *Film Formation*. Federation of Societies for Coatings Technology Philadelphia PA.(1986); p 16.
23. Applied Sonics Incorporated, Ultrasonic Sensing of Concentration and Stability in Mixtures, www.appliedsonics.com, (2002); p 1.

LIMITED WARRANTY INFORMATION – PLEASE READ CAREFULLY
The information contained herein is offered in good faith and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information should not be used in substitution for customer's tests to ensure that Dow Corning's products are safe, effective, and fully satisfactory for the intended end use. Suggestions of use shall not be taken as inducements to infringe any patent.

Dow Corning's sole warranty is that the product will meet the Dow Corning sales specifications in effect at the time of shipment. Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than as warranted.

DOW CORNING SPECIFICALLY DISCLAIMS ANY OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY. DOW CORNING DISCLAIMS LIABILITY FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

DOW CORNING

We help you invent the future.™

www.dowcorning.com

Printed in USA Sci0312 27-1253A-01