The Use of Silicones in Hair Colorant Formulations

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Consumer demand for high performance hair colorant products continues to grow. To meet this market need, formulators are challenged to develop products that provide long-lasting, natural-looking color as well as improved hair shine and conditioning effects. Although silicones are often used in colorant products, their expanded use can help meet evolving product requirements in this market segment. This paper summarizes evaluations of several silicone materials in hair colorant formulations, and it illustrates simple methods formulators can use to assess formulation performance.

Hair colorant systems typically provide three types of coloring: permanent, semi-permanent or temporary. Silicones can enhance these products in several ways. They remain stable in the extreme pH and oxidizing environments typical of hair colorants and help protect the hair fibers against oxidative damage. In addition, silicones can be used to increase hair shine and ease of combing, reduce drying time and impart a soft feel to the hair. Silicones also help to increase and maintain the depth of color on the hair.

Table 1. Coloring Composition Used for Prototype Colorants

Ingredient	Wt %
p-Phenylenediamine	0.28
Resorcinol	0.44
p-Aminophenol HCl	0.02
m-Aminophenol HCl	0.05
2,4-Diaminophenetol Sulfate	0.0308

Table 2. Cream Base Used for Prototype Colorants

Ingredient	Wt %
Cetyl Alcohol	2.50
Stearyl Alcohol	2.50
Oleth-30	3.60
Oleic Acid	2.70
Oleocetylic Alcohol 80/85	2.50
Ethylene Glycol Monostearate	1.00
Polyquaternium 7	3.00
DTPA Na5 (40%)	1.80
Sodium Metabisulfite	0.60
Sodium Erythorbate	0.20
Monethanolamine (99%)	0.66
Propylene Glycol	5.00
Carbopol ETD 2020	0.30
Rheology Modifier	1.00
Ammonium Hydroxide (27%)	10.02
Coloring Composition	0.82
Silicone	q.s.
Water	to 100%

Evaluating Prototype Formulations

A trained hair consultant evaluated several silicone fluids and emulsions as part of this study. The choice of materials reflects recent use of these silicones in colorant products. In addition, a new silicone elastomer blend was included because of interest generated by the properties of this material. Among the silicone fluids in the study, the amount used in the prototype formulation was 1.25%. For the silicone emulsions tested, 3.57% was used because these products contain 35% silicone. The following materials were evaluated:

- ***Dow Corning*® 749 Fluid (1.25%)** INCI designation: Cyclomethicone (and) Trimethylsiloxysilicate
- ***Dow Corning*® 949 Cationic Emulsion (3.57%)** INCI designation: Amodimethicone (and) Trideceth-12 (and) Cetrimonium Chloride
- ***Dow Corning*® 7224 Conditioning Agent (3.57%)** INCI designation: Trimethylsilylamodimethicone (and) Octoxynol-40 (and) Isolaureth-6 (and) Propylene Glycol
- ***Dow Corning*® 193 Surfactant (1.25%)** INCI designation: Dimethicone Copolyol
- ***Dow Corning*® 9040 Silicone Elastomer Blend (1.25%)** INCI designation: Cyclomethicone (and) Dimethicone Crosspolymer

Tables 1 and 2 illustrate prototype formulations for the coloring composition and cream base used to evaluate the five silicone materials in this study.

Hair colorants typically are simple emulsions that are prepared by melting the oil phase and adding it to the water phase. For prototype formulations in this study using *Dow Corning* 949 Cationic Emulsion, *Dow Corning* 7224 Conditioning Agent and *Dow Corning* 193 Surfactant, the

silicone materials were combined with 5% water and added after the oil-in-water emulsion was blended. The mixture was cooled, and the ammonium hydroxide was added. For prototype formulations containing *Dow Corning* 749 Fluid and *Dow Corning* 9040 Silicone Elastomer Blend, the silicone materials were added in the oil phase.

Both approaches demonstrate that silicones are easily incorporated into coloring systems. When compared to a reference formulation without silicone, viscosity and pH measurements indicated that with the exception of one material, inclusion of silicone in the system does not significantly affect these two parameters. A decrease in viscosity of the coloring composition was observed with the addition of *Dow Corning* 949 Cationic Emulsion. This parameter could easily be adjusted by increasing the level of thickening agent in the formulation.

The ability of silicone materials to aid spreading is often noted in personal care applications. In an attempt to translate this property to ease of application on the hair, the prototype colorant formulations were evaluated for spread and glide on the hair. Based on their ability to spread easily, the prototype formulations containing each silicone were ranked in the following order by the hair consultant:

(+) 7224 > 749 > 193 = 949 = 9040 > Reference w/o silicone (-)

In other words, the formulation containing *Dow Corning* 7224 Conditioning Agent provided the easiest conditions for application, followed by the formulations containing *Dow Corning* 749 Fluid and *Dow Corning* 193 Surfactant.

Several important visual observations were recorded when evaluating the sample tresses. Those treated with colorants containing silicone showed better deepness of color than tresses treated with the reference formulation. In addition, tresses treated with formulations containing *Dow Corning* 193 Surfactant or *Dow Corning* 9040 Silicone Elastomer Blend showed more consistent color from root end to tip of the hair. The best coverage for grey hair was found with formulations containing *Dow Corning* 193 Surfactant or *Dow Corning* 7224 Conditioning Agent.

Confirming the Results by Test Panel

To confirm the evaluations of the hair consultant, a group of panelists was asked to evaluate a second series of sample tresses using a tone index scale. A set of sample tresses was prepared, using two tresses for each of the five silicones and the reference, for a total of twelve. Each of the six conditions was evaluated twenty times, and the tone index for the tress was compared to the scale. Observations were recorded and entered into a statistical program.

A summary of the results shows that all the dyes containing silicone caused a slight deviation of the tone index toward a darker or deep color, that is, a lower color index. Although this deviation is easily perceived visually, it is not significant, but rather translates to a known effect that can be referred to as "improvement in color depth." This effect corresponds to the observations of the color consultant described in the first portion of the study.

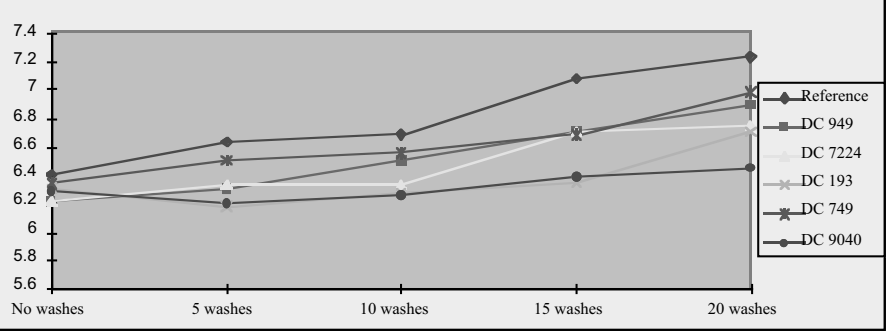
In the case of the prototype formulations containing *Dow Corning* 7224 Conditioning Agent and *Dow Corning* 949 Cationic Emulsion, the increase in color depth was significant. If necessary, colorants based on these materials might be reformulated with a lower level of coloring agent.

Durability of Color

Evaluations also were conducted to determine color retention after tresses had been washed five, ten, fifteen and twenty times. Tests were conducted for formulations containing each of the five silicones and for a control formulation without silicone. In addition, one reference group of tresses was left unwashed.

Figure 1 summarizes the effects of repeated washing on the sample tresses. Although all the silicone-containing formulations aided in color retention, tresses treated with the formulations containing *Dow Corning* 193 Surfactant, *Dow Corning* 7224 Conditioning Agent and *Dow Corning* 9040 Silicone Elastomer Blend demonstrated the highest degree of color retention of the five silicones tested. There was no significant difference in color retention between the unwashed reference tresses and the

Figure 1. Color Loss After Washes



in color retention between the unwashed reference tresses and the tresses that were washed twenty times. These results suggest that the silicone acts as a color protectant on the hair.

The more deeply into the hair shaft that a coloring agent can penetrate, the more depth of shade will be apparent. Silicones are typically used in personal care products to aid in spreading, and one explanation for the color retention associated with these silicones is that they may facilitate contact with the coloring agents on the hair. Photographs taken with the aid of electron microscopy show that after twenty washes there is no silicone left to protect the hair from loss of color. However, when coloring agents penetrate more deeply into the hair shaft, both the coloring agent and the silicone are retained through a greater number of wash cycles.

Conclusions

In summary, this study confirms the usefulness of silicones in hair colorant formulations and suggests how they might be screened for even broader utility. Silicones are easy to incorporate, and they do not affect critical formulation parameters such as pH and viscosity. In addition, silicones can improve ease of application by helping to spread the colorant formulation in the hair. Of the silicone materials tested, *Dow Corning* 7224 Conditioning Agent, *Dow Corning* 749 Fluid and *Dow Corning* 193 Surfactant were the most effective aids to spreading.

Silicones can improve the initial color in hair and act to protect color durability, even after twenty washings. Silicones also improve homogeneity of hair color from tip to root and improve coverage for gray hair. In this study, *Dow Corning* 9040 Silicone Elastomer Blend and *Dow Corning* 193 Surfactant were related to the best homogeneity of color from root to tip of the hair shaft. *Dow Corning* 193 Surfactant, *Dow Corning* 7224 Conditioning Agent and *Dow Corning* 9040 Silicone Elastomer Blend were responsible for the greatest degree of color retention. Formulations containing *Dow Corning* 193 Surfactant or *Dow Corning* 7224 Conditioning Agent were the most adept at covering grey hair.

Several other aspects of hair coloring will be investigated through future studies. These include the effect of UV radiation on hair as well as approaches for increasing color coverage of grey hair.

Printed in USA AGP5464 Form No. 27-055-01