THE EFFECT OF ADDING AQUADEST ON THE STABILITY OF HAIR SHINE SPRAY PREPARATIONS: A COMPARATIVE STUDY OF TWO FORMULAS

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Abstract

Hair shine spray is generally based on non-aqueous solvents using volatile and non-volatile silicones. The addition of water (distilled water) to the system can affect the homogeneity and stability of the dispersion. This study aims to evaluate the effect of adding distilled water on the physical stability of hair shine spray by comparing two formulas: Formula A (containing distilled water) and Formula B (without distilled water). The experimental results showed that Formula A changed color to milky white when shaken and formed an unstable dispersion, while Formula B remained clear and stable without phase separation. These results indicate that the presence of water in the silicone–ethanol solvent system causes phase incompatibility which reduces physical stability.

Keywords: *Hair Shine, Silicon, Sunflower Oil.*

INTRODUCTION

Hair shine spray is an oil-based cosmetic preparation that provides shine, enhances the visual appearance of hair, reduces frizz, and improves the sensory feel of hair strands. Silicones, such as cyclomethicone, dimethicone, and phenyl trimethicone, are among the main components most commonly used in hair shine product formulations. Silicones are chosen because of their high refractive index, ability to form a thin film on the hair surface, rapid spreadability, and good chemical stability (Sakamoto et al., 2017). These characteristics allow silicones to provide a long-lasting shine without leaving a sticky feeling, making them widely used in sprays, serums, and hair polishes.

In designing a cosmetic preparation, physical stability is a fundamental parameter that determines consumer acceptance and commercial viability of the product. Preparation stability relates to the formulation's ability to maintain its physical, chemical, and organoleptic properties during storage. Silicone-based products are generally more stable because they are non-polar, hydrophobic, not easily oxidized, and do not experience degradation in the presence of water (Mitsui, 2015). However, the polarity mismatch between the silicone oil phase and the water phase will cause a risk of instability if the two components are mixed without an adequate emulsifier.

The addition of distilled water in hair shine spray formulations is often done to reduce production costs, reduce solution density, or produce a light sensation on the hair. However, literature shows that water and silicone cannot mix stably without the help of surfactants or emulsifiers (Tadros, 2013). The high interfacial tension between water and silicone makes it difficult to form a stable dispersion system. As a result, when shaken, the water phase can be temporarily dispersed in the form of small droplets that cause the solution to appear milky white (pseudo-emulsion phenomenon).

Previous research by Kaczmarek (2021) stated that the addition of a polar phase to a volatile silicone system can cause turbidity due to internal dispersion instability. Meanwhile, Pagano (2019) explained that physical instability in silicone-water systems often begins with the formation of water droplets that are not coated with surfactants, resulting in a temporary emulsification phenomenon that quickly disappears during shaking but results in changes in color and clarity. Another study by Nabifar (2020) showed that even a small addition of water (1–5%) to a non-aqueous silicone system can significantly reduce physical stability, especially in spray products that do not contain emulsifiers. Furthermore, research by Lee (2018) suggested that the stability of silicone-based formulations is strongly influenced by interphase compatibility. In systems without surfactants, water particles are unable to form a stable structure in the silicone medium, causing rapid coalescence and a color change to milky white when subjected to mechanical energy such as shaking. A similar phenomenon was also reported by Ghosh (2020) in the evaluation of the stability of oil-based sprays, where the addition of the aqueous phase caused immediate instability.

In the experiments conducted in this study, two formulas were tested: Formula A (with distilled water) and Formula B (without distilled water). Initial observations showed that Formula A experienced a significant color change after shaking, turning milky white and exhibiting turbidity. This is in line with the theory that water that is not stably dispersed in a silicone system will form a temporary, inhomogeneous dispersed phase. In contrast, Formula B, which does not contain distilled water, maintained clarity, homogeneity, and organoleptic stability.

Based on the theoretical background and previous research, it can be concluded that the presence of water in silicone-based systems has the potential to significantly reduce physical stability. Therefore, this study aimed to further evaluate the effect of adding distilled water on the stability of hair shine spray to ensure optimal stability.

METHOD

This study used two hair shine spray formulas designed to evaluate the effect of adding distilled water on the physical stability of silicone-based preparations. The main ingredients used include cyclomethicone and dimethicone as silicone components, 96% ethanol as a volatile solvent and diluent agent, fragrance as an aroma enhancer, and a preservative that functions to prevent the growth of microorganisms. Aquadest was only added to Formula A as a treatment variable, while Formula B was made completely without an aqueous phase to maintain the non-aqueous character of the silicone system.

The formula design consisted of two variations. Formula A contained silicone, ethanol, fragrance, preservative, and additional distilled water within 10% of the total formula. The presence of distilled water was intended to observe how the aqueous phase affected the stability of the silicone system. Meanwhile, Formula B was designed without distilled water, so it only consisted of silicone, ethanol, fragrance, and preservative. This main difference aimed to compare the physical stability between the water-based and non-aqueous silicone formulations.

Tabel 1. Formula Design

Material	**Formula 1**	**Formula 2**
Main Active Material(%)	*Cyclomethicone 40% Dimethicone 5%*	*Cyclomethicone 50% Dimethicone 3%*
Water Phase (%)	*Ethanol (96%) 15% Aquadest 10%*	*Ethanol (96%) 20%*
Oil Phase (%)	*Sunflowers oil 23%*	*Sunflowers oil 20%*
Emulsifier/ Surfaktan (%)	*Polysorbate 80 5%*	*Polysorbate 80 5%*
Preservative (%)	*Phenoxyethanol 1%*	*Phenoxyethanol 1%*
Additional Material	*Fragrance 1%*	*Fragrance 1%*

The manufacturing process involves first mixing the silicone material with ethanol until a homogeneous mixture is obtained. Next, fragrance and preservative are added with light stirring to ensure even distribution. In Formula A, distilled water is added last, then the mixture is slowly homogenized to avoid the formation of excessive water droplets. Once all the ingredients are mixed, each formula is poured into a clean spray bottle and tightly closed.

Stability testing was conducted through organoleptic observations, including assessment of clarity, color, homogeneity, and other visual changes. A specific evaluation was also conducted on changes that occur when the preparation is shaken, including the possibility of the formation of a milky white color, turbidity, phase separation, or sediment. Furthermore, the preparation was periodically observed during the 7-14-day storage period at room temperature to identify potential instability that may arise during the storage process. All observation results were used to determine the effect of the presence of distilled water in the formulation on the physical stability of silicone-based hair shine spray

RESULT AND DISCUSSION

1. Visual Observation Result

Visual observation results showed that there was a clear difference in physical stability between Formula A (with distilled water) and Formula B (without distilled water). At initial observation, Formula A appeared clear but slightly cloudy, indicating separation between phases from the initial stage of mixing. In contrast, Formula B appeared clear, homogeneous, and showed no indication of instability. When the shake test was conducted, Formula A experienced a significant color change, turning milky white within a few seconds of shaking. This phenomenon was not seen in Formula B, which remained clear and did not experience any physical changes.

After two minutes of standing, Formula A again showed more pronounced turbidity with the appearance of small grains on the surface and bottom of the container, indicating the occurrence of increasingly pronounced microphase separation. Formula B remained stable without changes in color, clarity, or homogeneity. On the seventh day of storage at room temperature, Formula A showed further instability in the form of increased turbidity, increasingly visible phase separation, and an inhomogeneous dispersion structure. This indicates that the aqueous system is experiencing a progressive degradation in stability. In contrast, Formula

B remained stable, clear, and homogeneous throughout the storage period, reinforcing the characteristics of silicone systems that are naturally non-aqueous and compatible with each other.

Organoleptically, the aroma of both formulas remained stable and unchanged, indicating that the instability was primarily physical, not chemical. Overall, the observations support the hypothesis that adding distilled water to silicone systems can cause significant physical instability.

The phenomenon of color change to milky white in Formula A is an indication of the formation of a temporary emulsion or temporary emulsion between the silicone, ethanol, and water phases. When the mixture is shaken, mechanical energy causes the water to break into small droplets that are dispersed in the silicone-ethanol phase. These water droplets are very unstable because there is no emulsifier that can reduce the interfacial tension between the silicone (non-polar) and water (polar). According to the interfacial tension theory (Tadros, 2013), the extreme difference in polarity between water and silicone causes the water droplets to be unable to maintain their shape in the silicone medium, so only a temporary dispersion is formed that quickly coalesces.

The milky white color seen is the result of light scattering reflected by micrometer-sized water droplets. When light hits the temporarily suspended droplets, it is randomly reflected, resulting in a white or cloudy appearance. This aligns with the findings of Kaczmarek (2021), who explained that the aqueous phase in volatile silicon systems tends to produce cloudiness because the water droplets act like optical particles, disrupting the path of light.

When Formula A was allowed to stand after shaking, the water droplets began to coalesce and eventually fell or rose to form layers, causing further turbidity and increasingly pronounced phase separation. This is very consistent with the results for Formula A, which showed a return from milky white to cloudy with fine droplets reflecting an unstable dispersed phase.

In contrast, Formula B did not experience this phenomenon because it does not contain an aqueous phase, so there are no polar droplets that can cause light scattering. The silicone-ethanol system in Formula B remains homogeneous, indicating that the two components are physically and chemically compatible. The stability of Formula B during shaking and storage tests supports previous literature (Lee, 2018) which states that non-aqueous silicone-based formulations exhibit much better physical stability than multiphase systems involving water.

Discussion

The addition of distilled water to hair shine spray formulations has been shown to be a major cause of physical instability, primarily due to the significant polarity difference between the components. Silicones used in formulations, such as cyclomethicone and dimethicone, are highly hydrophobic. Silicone emulsions are inherently unstable when mixed with polar solvents like water, unless a special silicone surfactant is used that significantly reduces interfacial tension (Huynh et al., 2021). Meanwhile, distilled water is a highly polar component, making it thermodynamically incapable of integrating with the non-polar silicone system. This polarity difference creates strong repulsive forces between the two phases, leading to significant physical instability.

While ethanol in the formula acts as a co-solvent, reducing the interfacial tension between the silicone and water, it is not strong enough to accommodate 10% water without forming a separate phase. At this concentration, ethanol is unable to act as a full solubilizer, leading to phase separation after mixing. This condition is in line with literature reports showing that the silicon–ethanol system can still be stable at water content <5%, but becomes very sensitive to turbidity and large droplet formation when the water content increases.

The milky white phenomenon observed when Formula A is shaken indicates the formation of a temporary emulsion, or coarse emulsion. This type of emulsion forms due to a temporary mechanical dispersion process caused by shaking, in which water droplets are broken down into specific sizes in a silicone-ethanol medium. Emulsions with particles/droplets > ~0.5-50 µm (macro-/coarse-emulsions) exhibit opacity/a white or cloudy appearance—because the droplets are large enough to scatter light, making them appear milky/opaque. This phenomenon is very common in polarity-incompatible systems (Sarkar et al., 2021).

After a few minutes of standing, the unstable water droplets begin to coalesce (flocculation, coalescence), causing the system to become cloudy again and, at some point, may result in phase separation. Visual observations during storage showed that Formula A experienced increasing turbidity day by day, indicating progressive instability. This instability was further evident with the appearance of a fine precipitate or layer of varying density on day 7, indicating that the components were no longer homogeneous. In contrast, Formula B, which was completely water-free, exhibited excellent physical stability. The absence of polar components allowed the silicone and ethanol system to remain in a clear, single phase. Silicones readily dissolve in ethanol and maintain their homogeneity during storage. This is consistent with the theory that hair shine spray formulations should ideally be anhydrous (water-free) systems, as their primary goal is to provide shine, a light sensation, and high volatility without leaving residue. Water, on the other hand, can act as a polar contaminant, disrupting the system and reducing clarity, which are essential characteristics of a high-quality shine spray.

Based on preliminary research results and theoretical support, it can be concluded that the addition of distilled water to hair shine spray formulas increases the risk of physical instability, including turbidity, temporary emulsions, and phase separation. Meanwhile, waterless formulas are able to provide clarity, stability, and more consistent visual performance during storage. These findings reinforce that silicone-based shine sprays are more effective when formulated without the presence of polar components, resulting in a product that is stable, visually elegant, and in accordance with the characteristics of modern hair cosmetics.

Conclusion

Experimental results showed that the addition of distilled water to the hair shine spray formulation significantly affected the physical stability of the preparation. The water-containing formula experienced a clear visual change, characterized by the appearance of a milky white color when shaken and increased turbidity during storage. This phenomenon reflects the formation of a temporary, unstable emulsion due to a polarity mismatch between the water and silicone phases. Because silicone is highly hydrophobic, the presence of water in a system without an emulsifier causes the water droplets to disperse unstably and easily re-aggregate, resulting in turbidity, fine sediment, and phase separation after several days of storage.

Formula B, which did not contain distilled water, demonstrated significantly better physical stability. The preparation remained clear, homogeneous, and exhibited no visual changes even after several days of storage. This indicates that the silicone-ethanol system is more stable when there are no polar components interfering with the interphase interaction. Ethanol is able to dissolve silicone and maintain the clear appearance that is the main characteristic of commercial hair shine spray products. The maintained clarity of Formula B also confirms that an anhydrous (water-free) system is more suitable for silicone-based cosmetic products that prioritize volatility and an elegant appearance. Formulatically, these results indicate that water is not recommended in shine spray formulations due to the incompatibility of water and silicone.

Suggestion

It is recommended that similar product formulations be developed without the addition of water components to maintain clarity, homogeneity, and stability during storage. Formula development in future research can consider variations in different types and concentrations of silicone to optimize the light sensation, shine, and volatility of the preparation. Furthermore, a more in-depth study is needed regarding the possibility of using other co-solvents or cosmetically safe stabilizers. Long-term stability testing, packaging compatibility testing, and sensory performance evaluation are also recommended to obtain a more comprehensive picture of the final product quality. Thus, further research can produce a more optimal and stable hair shine spray formulation that meets the needs of the modern cosmetics industry.

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