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"A Novel Liquid Crystal Emulsifier: Properties of a Composition Using Glycocare-HA"

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1. Introduction

An emulsion is a system in which fine droplets of one liquid are dispersed in another, where the two liquids are partially or completely immiscible [1]. Liquid crystal emulsions represent a novel type of emulsion in which surfactant and oil molecules are arranged in an ordered structure at the oil-in–water interface. This regular arrangement imparts superior stability and moisturizing properties compared to conventional emulsions [2-4].
Liquid crystals, exhibiting characteristics of both liquids and solids, can typically be formed as oil-in-water (O/W) emulsions using self-assembling surfactants or lipids in aqueous media [5]. The formation of liquid crystalline structures in emulsions is influenced by both the formulation composition and the manufacturing process [6]. Lamellar liquid crystals resemble the lipid structure of the stratum corneum, providing excellent moisturizing effects and reinforcing the skin barrier. Additionally, liquid crystals contribute to the stabilization of emulsions, making liquid crystal emulsions highly stable [5,7,8].
In this study, the formation and differences in liquid crystal structures were investigated using fatty alcohols and acids such as Behenyl Alcohol, Stearic Acid, and Cetearyl Alcohol. Changes over time and temperature were analyzed, and the stability of the liquid crystal emulsion was evaluated using Turbiscan and Rheology Analyzer. Furthermore, the efficacy of the formulation in improving skin absorption and moisturization was assessed.

2. Materials and Methods

To prepare the liquid crystal, Glycocare-HA was formulated according to the composition listed in Table 1. Phase A was first dissolved in a water bath until a clear solution was obtained. Upon complete dissolution of Phase A, Phase B was added and the mixture was homogenized. The resulting mixture was then stirred using an Agi Mixer for 5 minutes. Following emulsification, the mixture was evenly spread onto a plate and allowed to solidify. It was observed that using the Glycocare-HA approximately one day after complete solidification resulted in a more stable formation of the liquid crystal.

Table 1. Composition of Glycocare-HA

Phase	Ingredient Name	(%)
A	Polyglyceryl-3 Distearate	25.00
	Polyglyceryl-10 Stearate	25.00
	Behenyl Alcohol	9.00
	Stearic Acid	9.00
	Cetearyl Alcohol	17.00
B	Hydrogenated Lecithin	15.00

After the preparation of Glycocare-HA, it was used to formulate a liquid crystal emulsion according to the composition shown in Table 2. In this study, the effect of fatty acid content on the formation of liquid crystals was examined. Behenyl Alcohol, Stearic Acid, and Cetearyl Alcohol were selected as the representative fatty acids for analysis.

Table 2. Composition of O/W Emulsion using Glycocare-HA

Phase	Ingredient Name	**1**	**2**	**3**	**4**
A	Behenyl Alcohol	0.60	2.00	-	-
	Cetearyl Alcohol	0.80	-	2.00	-
	Stearic Acid	0.60	-	-	2.00
	Macadamia Ternifolia Seed Oil	5.00	5.00	5.00	5.00
	Cetyl Ethylhexanoate	3.00	3.00	3.00	3.00
	Squalane	3.00	3.00	3.00	3.00
	Dimethicone	0.50	0.50	0.50	0.50
	Glyceryl Stearate	0.50	0.50	0.50	0.50
	Glycocare-HA	4.00	4.00	4.00	4.00
B	Disodium EDTA	0.01	0.01	0.01	0.01
	Water	51.69	51.69	51.69	51.69
	Glycerin	3.00	3.00	3.00	3.00
	Carbopol 940(2.5%Soln)	16.00	16.00	16.00	16.00
	Sodium Hyaluronate 1%	2.00	2.00	2.00	2.00
	PGA-BG5(HD)	3.00	3.00	3.00	3.00
	1,3-Butylene Glycol	3.00	3.00	3.00	3.00
	1,2-Hexanediol	2.00	2.00	2.00	2.00
C	Tromethamin	0.40	0.40	0.40	0.40
	Water	1.00	1.00	1.00	1.00

The Glycocare-HA containing cream was prepared as an oil-in-water (O/W) emulsion. The oil and aqueous phases were weighed separately and then mixed in a glass beaker, followed by heating to 80°C. The oil phase was then added to the aqueous phase, and the mixture was homogenized using a Homo Mixer at 2500 rpm for 5 minutes. After the addition of post-treatment ingredients, the mixture was further homogenized at 3000 rpm for another 5 minutes. Upon completion of mixing, the emulsion was cooled to 30°C.

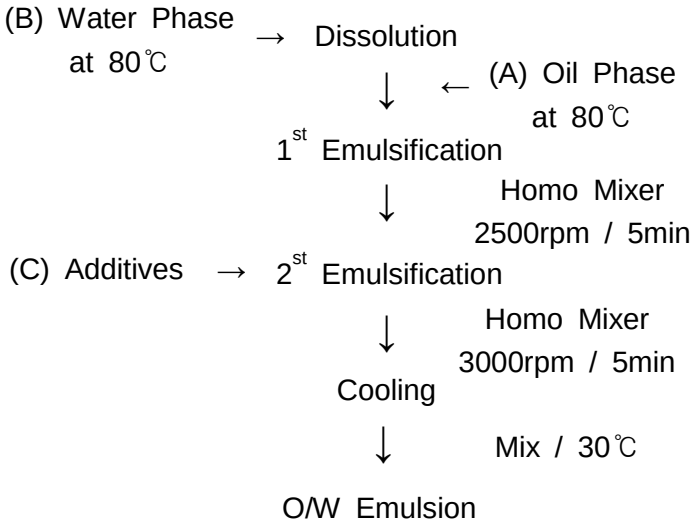

Figure 1. Manufacturing Process of O/W Emulsion using Glycocare-HA

To investigate the formation of liquid crystals in the O/W emulsion, polarized light microscopy (DM2000 LED, Leica Microsystems CMS GmbH, Germany) was employed. The emulsions were observed without dilution using a 10× objective lens.

The dispersion stability of the liquid crystal emulsion was analyzed using a Turbiscan (Turbiscan LAB, Formulaction, France). Since dispersion stability is time-dependent, the entire height of the sample was repeatedly scanned over time to detect changes caused by particle migration (creaming/sedimentation) and particle size variation (flocculation/coalescence). Measurements were conducted at 25°C and at 45 °C over a period of 8 hours to assess the dispersion stability under both ambient and elevated temperature conditions.

In addition, the rheological properties of the liquid crystal emulsion were evaluated using a Rheology Analyzer (Rheolaser Master, Formulaction, France). As with the Turbiscan analysis, measurements were performed at 25°C and at 45 °C over a period of 48 hours. Rheological properties, which significantly influence product characteristics such as flow behavior and stability, were assessed by observing the time-dependent deformation of the sample. This deformation is caused by the continuous Brownian motion of the particles within the viscoelastic emulsion.

3. Results

Under polarized light microscopy, the liquid crystal structures were observed as shown in Figure 2. In formulation 1, the liquid crystals exhibited uniform shape and size. In formulation 2, the crystals appeared aggregated, while in formulation 3, a larger number of crystals were observed but with irregular shapes. In formulation 4, no liquid crystals were detected. These results indicate that formulation 1 produced the most stable liquid crystal emulsion.

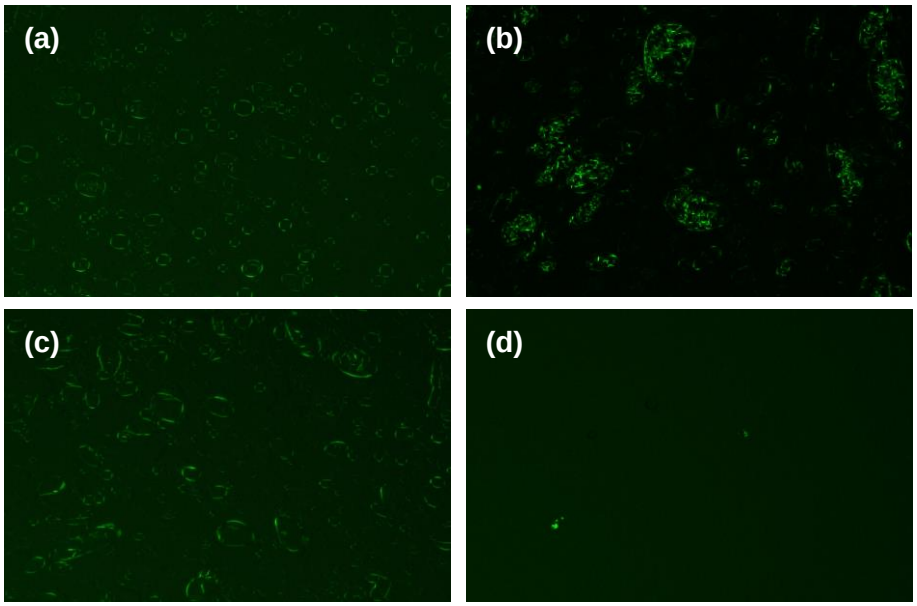

Figure 2. Liquid Crystal Structures of Emulsions Containing Glycocare-HA; (a) formulation 1; (b) formulation 2; (c) formulation 3; (d) formulation 4

The Turbiscan graph illustrating the dispersion stability of the liquid crystal emulsions at 25°C is shown in Figure 3. Among the graphs, graph b exhibited the most uniform profile, indicating a stable formulation. In contrast, graph c showed the greatest variation and fluctuation, suggesting that this graph was the least stable. A general decrease in the graph over time indicates changes in particle size, likely due to flocculation or coalescence. Based on the uniformity of the graph profiles, graphs a and b were identified as homogeneous and relatively stable emulsions, as their graphs displayed minimal fluctuations over time.

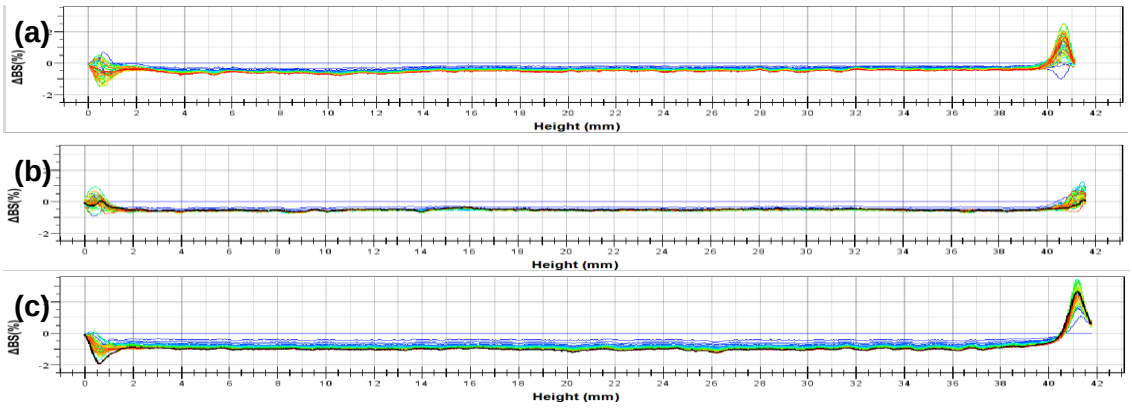

Figure 3. Turbiscan Data(25°C); formulation 1; (b) formulation 2; (c) formulation 3

The Turbiscan results at 45 °C are shown in Figure 4. Similar to Figure 3, graphs a and b exhibited more uniform and stable profiles compared to graph c, indicating better homogeneity. However, in comparison to Figure 3, the graphs in Figure 4 showed more pronounced variations in the Turbiscan profiles. These findings suggest that storing the liquid crystal emulsion at 25°C is more favorable for maintaining the stability of the liquid crystal structure than storage at 45 °C.

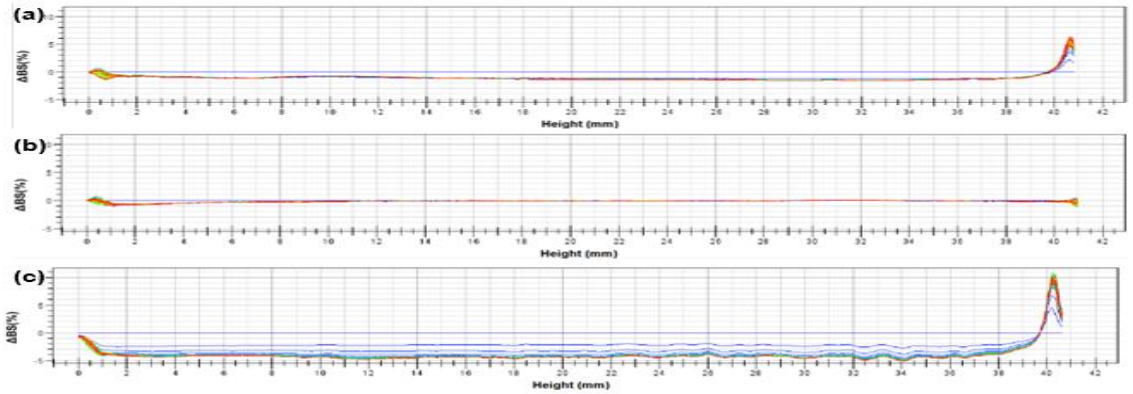

Figure 4. Turbiscan Data(45°C); (a) formulation 1; (b) formulation 2; (c) formulation 3

The TSI (Turbiscan Stability Index) can also be used to assess dispersion stability. A lower TSI value indicates greater stability. As shown in Figure 5, the TSI values for each formulation suggest that Formulation 1 exhibits the highest stability. A TSI value of 1 or less is generally considered stable, and based on the TSI evaluation, Formulation 1 demonstrates the lowest TSI value, indicating superior stability.

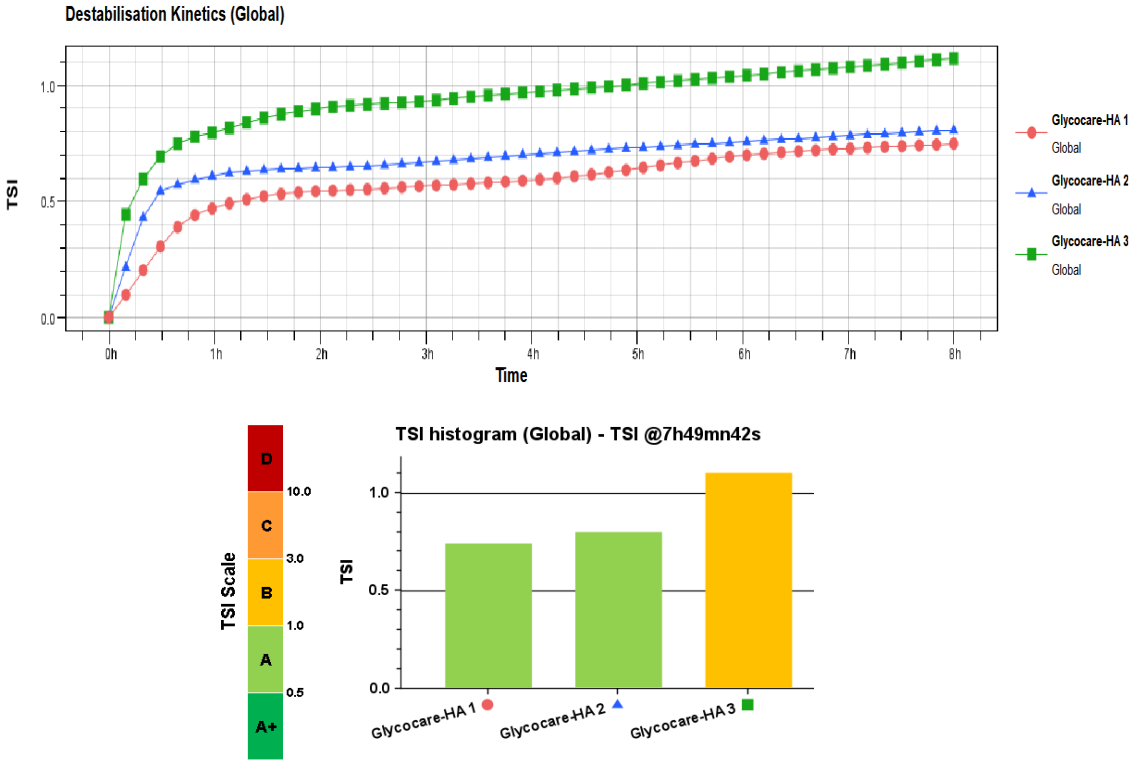

Figure 5. TSI Data(25°C)

The flow and deformation behavior of the liquid crystal emulsion formulations were analyzed using a Rheology Analyzer. The results are shown in Figure 6. In (a), the MSD (Mean Square Displacement) graph shifts downward and to the right, indicating an increase in both elasticity and viscosity. In contrast, the MSD graph in (b) shifts upward and to the right, suggesting a decrease in elasticity but an increase in viscosity. Additionally, the graph in (a) appears more stable compared to (b), indicating that the rheological characteristics of the emulsion in (a) are more stable.

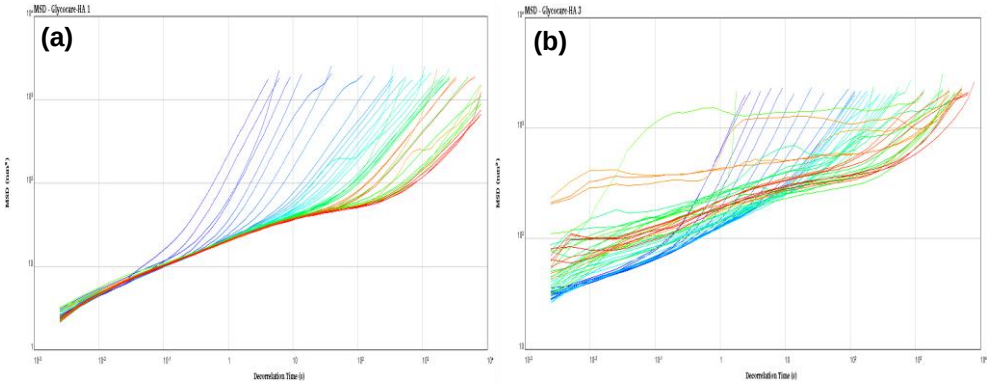

Figure 6. Rheology Analyzer Data(25°C); (a) formulation 1; (b) formulation 3

The comparative graphs of the Elasticity Index (EI) and Macroscopic Viscosity Index (MVI) for each sample are presented in Figure 7. In the EI graph (a), formulation 2 showed the highest elasticity, followed by formulation 1 and formulation 3. In the MVI graph (b), formulation 1 exhibited the highest viscosity, followed by formulation 2 and formulation 3. These results suggest that formulations 1 and 2 are capable of maintaining the emulsion structure and exhibiting liquid crystals over an extended period of time.

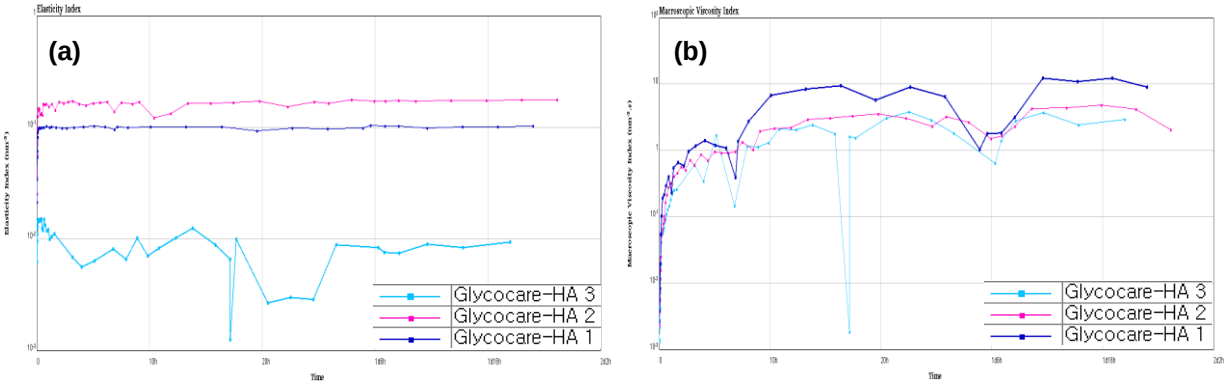

Figure 7. Rheology Analyzer Data(25°C); (a) EI Data; (b) MVI Data

Based on the Turbiscan and Rheology Analyzer analyses, the liquid crystal emulsion prepared with formulation 1 maintained its initial viscosity and elasticity, demonstrating stable dispersion over time.

Changes in the liquid crystal structure over time are shown in Figure 8. As observed in Figure 8a, the emulsion maintained its original appearance and liquid crystal structure even after two weeks, indicating good stability. Temperature-dependent changes were also examined. As shown in Figures 8b and 8c, the emulsions stored at 25 °C and 4 °C retained both the original shape and quantity of liquid crystals. In contrast, as shown in Figure 8d, the emulsion stored at 45 °C exhibited a reduction in the amount of liquid crystals over time, along with increasingly irregular crystal shapes. These results suggest that when stored at 4 °C or 25 °C, the liquid crystal emulsion maintains its structural integrity without phase separation or visible changes. The quantity, shape, and size of the liquid crystals remained consistent over time. Therefore, the liquid crystal emulsion can be stably maintained when stored at 4 °C or 25 °C.

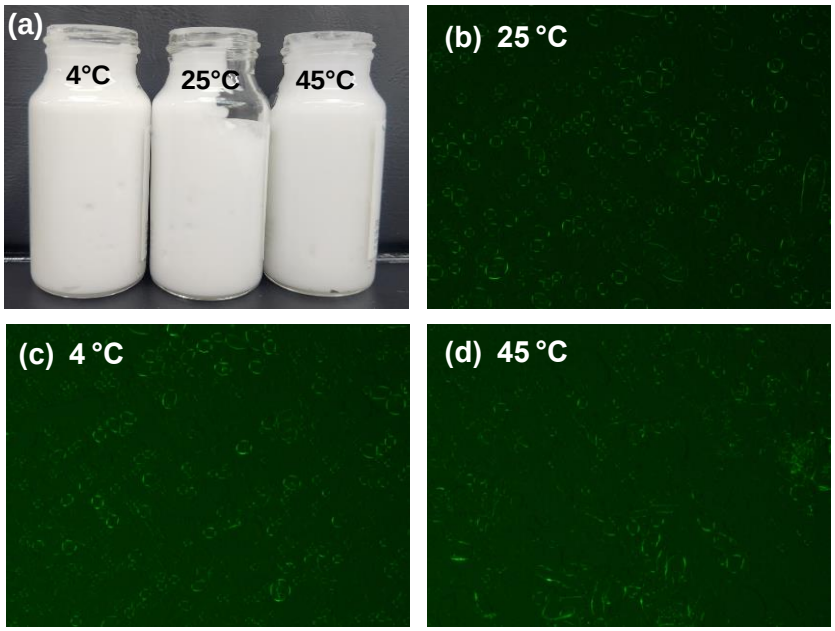

Figure 8. Changes in Liquid Crystal Emulsions Over Time and Temperature;
(a) Appearance of the emulsion after 2 weeks;
(b)~(d) Liquid crystal structure after 2 weeks of storage at 25,4,45 °C

4. Discussion

This study demonstrated the effectiveness of Glycocare-HA in forming stable liquid crystal (LC) emulsions. Among the formulations tested, formulation 1, composed of Behenyl Alcohol : Cetearyl Alcohol : Stearic Acid in a 3:4:3 ratio, exhibited the most uniform and stable LC structures under polarized light microscopy. In contrast, formulations 2 and 3 showed aggregated or irregular LC morphologies. Turbiscan analysis supported these findings. At 25 °C, formulations 1 and 2 maintained stable dispersion over time, with formulation 1 showing the lowest Turbiscan Stability Index (TSI), indicating superior stability. At 45 °C, all samples exhibited reduced stability, confirming that lower storage temperatures (4 °C or 25 °C) are more suitable for maintaining LC structure. Rheological measurements further revealed that formulations 1 and 2 had superior viscoelastic properties. Notably, formulation 1 retained high viscosity and consistent elasticity over time, contributing to structural integrity and product

stability. Overall, Glycocare-HA was shown to enhance both the formation and long-term stability of LC emulsions. Proper selection of fatty alcohol and acid ratios, along with appropriate storage conditions, is critical to maintaining the structural and functional properties of these systems.

5. Conclusion

This study demonstrated that Glycocare-HA is an effective emulsifier for forming stable liquid crystal O/W emulsions. Among the tested formulations, formulation 1 showed the most uniform liquid crystal structures, as well as excellent dispersion stability and rheological properties. Analysis confirmed that the emulsion maintained its viscosity, elasticity, and structure over time, particularly when stored at 4 °C or 25 °C. In contrast, higher temperatures (45 °C) led to reduced stability and irregular crystal formation. These results highlight the importance of optimized formulation in developing high-performance liquid crystal emulsions for cosmetic applications.

6. References

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