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Research article

Advanced psoriasis treatment: Development and optimization of resorcinol-loaded nanoemulgel with lavender oil

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Abstract: Psoriasis, a long-term autoimmune illness, affects 2%–5% of people worldwide. Drugs from BCS class II that are commonly used to treat psoriasis include resorcinol, which presents burning feelings and itchiness as adverse effects. To minimize adverse effects and increase the effectiveness of treatment, a topical nanoemulgel was developed in the current research. A resorcinol-loaded nanoemulgel was developed using the nanoemulsion technique, and the Design Expert® CCD method was used for optimization. Particle size (PS), zeta potential (ZP), and percentage of entrapment efficiency (EE%) served as the foundation for the optimization. The morphology, chemical interactions between excipients, crystallinity, and thermal behavior of the optimized resorcinol-loaded nanoemulgel were examined by TEM, FTIR, and XRD physicochemical studies. The resorcinol-loaded nanoemulgel was successfully loaded and characterized. For the in vitro release, the dialysis bag technique was employed. The ideal PS, PDI, and ZP values for the optimized resorcinol-loaded nanoemulgel were 31.32 ± 3.1 nm, 0.24 ± 0.005, and −10.6 ± 1.0 mV, respectively. The FTIR data revealed that no chemical interactions were observed between the components of resorcinol-loaded nanoemulgel, while the TEM results supported the spherical shape. The in vitro study confirmed a sustained release of resorcinol-loaded nanoemulgel.

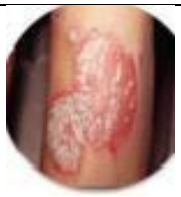
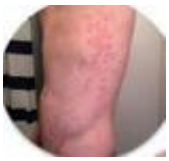
Keywords: psoriasis; anti-inflammatory activity; nanoemultion; nanoemulgel; lavender oil

1. Introduction

Psoriasis is a chronic, non-transmissible condition that causes discomfort, disfigurement, and

frustration, with a major adverse effect on patients' quality of life (QoL) (Table 1). It also has no known cure. Although it can strike at any age, it usually does so before the age of 35. With a reported global frequency of psoriasis ranging from 0.09% to 11.4%, the condition is a severe issue. Although the exact etiology of psoriasis is still unidentified, there are indications of genetic vulnerability. The role of the immune system in the onset of psoriasis is another crucial field of research. Although psoriasis is an autoimmune disorder, there is no known autoantigen to blame. In addition, both internal and external factors, including minor injuries, sunburns, infections, and systemic medications [1].

Table 1. Types of psoriasis.

Types	Site affected	Features	Figure
Plaque	Muscle surfaces(knees or elbows) are the most affected. Scalp, lower back, or fingertips are frequently affected.	Among the most typical forms of psoriasis. Once the hair scales are subjected to extreme friction, hair loss is permanent.	
Flexural (Inverse)	Limbs, trunks, flexures, and perineal and axillary folds are also affected.	It is not scaly or erythematous, containing a variety of skin lesions.	
Guttate	Mostly found on the proximal extremities or trunk.	Unique little papules, cherry pink, and with a thin scale.	
Pustular	Feet and hands.	Also known as Zumbusch's psoriasis. Redness of the skin occurs because of the formation of pustules and scaling.	
Erythroderma	Skin redness and inflammation	The skin is completely affected by aggressive psoriasis. May be caused by infections, low nutrient levels after stopping oral corticosteroids, and some medications, such as lithium, antimalarial drugs, and IL-2.	

Currently, it is widely accepted that psoriasis has a strong association with several psychological problems. Psoriasis can appear or worsen because of stress and other related psychological causes. As a result, psoriasis is more than just a cosmetic discomfort; it causes stress, depression, and other psychological issues that lower the quality of life. Psoriasis patients constantly feel humiliated on a physical, psychological, and socioeconomic level. This shame produces emotional tension, which

worsens an already present illness. Patients with psoriasis often have a lower quality of life, which adversely affects their ability to function. When compared to healthy people, social rejection is typically the cause of a lower quality of life. Because of the prominence of their lesions, these patients also endure increased physical discomfort, emotional swings, negative body and self-image, and limitations on everyday and social activities [2].

Psoriasis can be divided into two groups, Type 1 and Type 2, based on genetic predisposition and familial relationship. Early-onset Type 1 typically manifests in the second and third decades of life. Most patients have positive family histories, indicating a genetic vulnerability, inheritance, and a link to the disease. The course of Type 1 psoriasis is unpredictable and often becomes widespread. In contrast, Type 2 psoriasis typically begins in the sixth decade of life. Most patients display a negative family history due to the absence of genetic linkage [2].

1.1. Etiology

Psoriasis prevalence ranges between 0.2% and 4.8%. Although the actual cause is unclear, T cells are thought to play a role in this inflammatory disorder. Many psoriatic patients show an association with HLA antigens, especially among various racial and ethnic groups. Its familial prevalence suggests hereditary susceptibility. Injury from mechanical, chemical, and radiation sources can result in psoriasis lesions. Certain medications such as lithium, steroids, chloroquine, steroids, NSAIDs, or beta-blockers can aggravate psoriasis. Summer generally improves psoriasis while winter aggravates it. Psoriasis may also be caused by obesity, mental trauma, infections, tobacco use, hypocalcemia, and alcohol consumption [2].

1.2. Introduction of nanoemulsion

1.2.1. Nanoemulsion

A surfactant and, occasionally, a co-surfactant, form an interfacial coating that stabilizes nanoemulsions—dispersions of two immiscible liquids, such as oil and water, that are thermodynamically stable. Because of their special qualities, including transparency, a wide interfacial area, and tiny droplet size, nanoemulsions have received a lot of attention. Research has examined the impact of surfactant and co-surfactant concentration on the formulation and stabilization of lavender oil nanoemulsions. Increasing the concentration of the surfactant and co-surfactant improves the stability of the nanoemulsion and decreases droplet size, thereby improving the bioavailability of neem oil. Reports have shown that the improved nanoemulsion could be employed as a carrier for neem oil–based formulations for a variety of applications, such as insecticide and herbicide compositions [3].

1.2.2. Advantages of nanoemulsions

The increased stability of nanoemulsions compared with traditional emulsions is one of its many important benefits. Because of their droplet and interfacial area sizes, nanoemulsions are a thermodynamically stable system. Additionally, the low interfacial tension between the oil and water phases does not allow droplet coalescence or phase separation. Due to their tiny droplet size, which improves the contact area between the drug and the body, nanoemulsions can greatly improve medication bioavailability through improved medication absorption and penetration. Nanoemulsions

are able to absorb both hydrophilic and hydrophobic substances by fitting a significant quantity of the active component in the tiny droplets of the dispersed phase [3].

1.2.3. Nanoemulgel

A brand-new category of semi-solid compositions, called nanoemulgels, combines the qualities of emulsions and gels. These consist of a lipophilic constituent, which is spread throughout the gel network as tiny droplets, and a hydrophilic gel network. Due to its distinctive qualities, such as better stability, controlled release, and better cosmetic penetration, nanoemulgels have drawn a lot of attention from the pharmaceutical and cosmetic sectors. Nanoemulgels are translucent, emollient, easy to spread, greaseless, easy to remove, and non-staining, have a prolonged shelf life, and are far less likely to have major side effects, just to name a few of the many promising qualities they present for dermatological application. Several researchers have started to make nanoemulgel formulations using a variety of active pharmaceutical ingredients, particularly those that are hydrophobic in nature [3].

1.2.4. Advantages of nanoemulsion-based emulgels

a) Increased solubility: Medications that are poorly soluble in water can have their solubility improved by the vast surface area provided by submicron-sized droplets in nanoemulsions. The ability of these nano-sized droplets to solubilize both hydrophilic and hydrophobic medications enhances drug loading and distribution.

b) Increased permeability: Nanoemulsion-based emulgels improve medication penetration into the skin due to their small droplet size—typically 20–200 nm. By quickly penetrating the skin's barrier, these nano-sized droplets increase the bioavailability of the medication at the site of action. The gel base further facilitates prolonged drug release by providing better skin contact and allowing the nanoemulsion to remain in situ for longer [3,4].

c) Increased stability: Nanoemulsion-based emulgels offer enhanced physical stability compared to traditional emulsions and creams. The small droplet size in nanoemulsions prevents phase separation (such as creaming, sedimentation, or coalescence), ensuring that the formulation remains stable over time. The gel structure provides a stabilizing effect, shielding the active ingredients of the nanoemulsion from degradation caused by heat, light, and oxygen.

d) Improved bioavailability and enhanced patient compliance: Patients appreciate the gel-like texture of nanoemulsion-based emulgels, as they do not leave a greasy residue, dissolve quickly, and apply easily over large areas of skin. This makes them particularly appealing for long-term treatment plans, especially for dermatological conditions. The small droplet sizes and enhanced skin penetration of nanoemulsions increase the bioavailability of medications. As a result, the medication can more effectively reach deeper layers or systemic circulation by promoting improved penetration through the stratum corneum of the skin.

e) Less adverse effects and streamlined manufacturing: Localized medication administration via nanoemulsion-based emulgels can minimize systemic side effects by ensuring that the active components primarily act at the point of application, in contrast to oral or systemic delivery methods. The controlled release offered by nanoemulsion-based emulgels further reduces the likelihood of side effects by significantly minimizing drug surges in the bloodstream. Simple production techniques, such as sonication and high-shear mixing, can be employed to create nanoemulsion-based emulgels. This makes the process scalable and cost-effective for large-scale manufacturing [3,4].

2. Materials and methods

2.1. Materials

List of chemicals used for the formation of nanoemulsion (Table 2).

Table 2. List of chemicals used for the formation of nanoemulsion.

Component	Name	Source
Surfactant	Tween 80, PEG 400	CDH-Central Drug House (P) Ltd., New Delhi
Oil	Lavender oil	*Lavandula angustifolia*
Water	Distilled water	

2.2. Methodology

2.2.1 Preparation of nanoemulsion

The aqueous titration approach was utilized to create a nanoemulsion containing resorcinol. A clean, transparent, and stable isotropic system was obtained by vortexing a subset of formulation components over a short period of time, based on a pseudo-ternary phase diagram. Although other methods, e.g., aqueous titration, are supported by the literature [4], applying a high-energy input into the system is also an efficient way to create a nanoemulsion.

2.2.2 Pre-formulation studies

When creating a dosage form, it is important to consider the inherent physicochemical properties of each chemical utilized in the preparation to guarantee that the excipients and the drug are compatible and that their impact on the final formulation is as expected. Pre-formulation studies are considered the initial phase of any medication development process, aiming to produce an effective, stable, potent, and secure dosage form [5].

2.2.3 Organoleptic properties

The organoleptic qualities are assessed according to sensory impressions, such as the physical appearance, color, and odor of the pharmacological ingredient. These properties help estimate the drug's purity and detect any impurities. Essential oils are volatile, aromatic liquids naturally extracted from plants. They are complex mixtures of secondary metabolites, including terpenes, phenolic chemicals, and alcohols [6].

2.2.4 Pseudo-ternary phase diagram

Aqueous titration was used to construct pseudo-ternary phase diagrams that displayed the concentration range of components for the current boundary of the nanoemulsion. Five phase diagrams were prepared with different weight ratios (1:1, 1:2, 4:1, and 5:1) of Tween-80 and propylene glycol 400.

The surfactant mixture and the aqueous phase were then combined at different weight ratios (Table 3). The weight ratios of oil to surfactant/co-surfactant (S/Co) were diluted dropwise with water while being gradually stirred. Following equilibration, the mixtures were evaluated visually [7] (Figure 1).

Table 3. Different concentrations of surfactants.

Concentration	Surfactant (µL)	Distilled water (µL)
5%	50	950
10%	100	900
15%	150	850

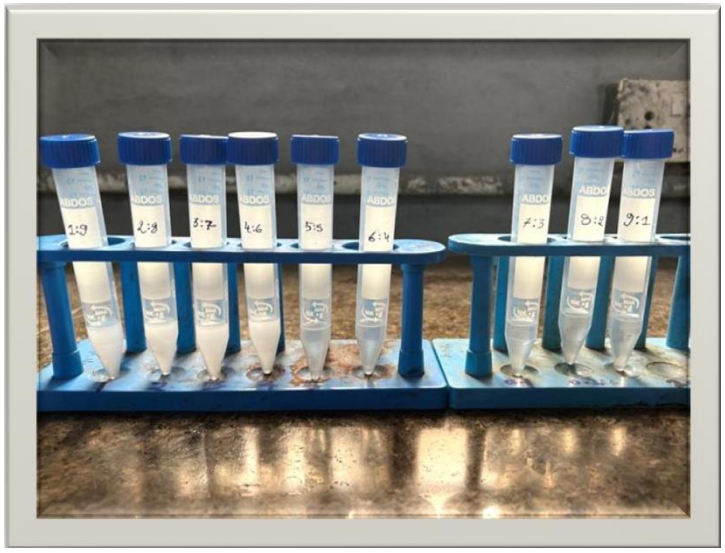


Figure 1. Solutions prepared at different concentrations for turbidity analysis required for the preparation of pseudo-ternary phase diagrams.

2.2.5 Identification using UV spectrophotometer

The absorption maxima (λmax), specific for each compound, was calculated as the maximum wavelength at which the drug shows maximum absorbance. The spectrometer wavelength range was selected to 200–400 nm [8].

2.2.6 Preparation of the calibration curve

The calibration curve shows a linear relationship between concentration and absorbance. By comparing it with the known concentration, it helps determine the concentration of unknown samples. To prepare the calibration curve, 100 mL of distilled water was used to dilute 1 mL of the optimized nanoemulsion, referred to as the stock solution. Various volumes were removed from this stock solution (0.2, 0.4, 0.6, 0.8, and 1 mL) to create different concentrations. Distilled water was added to each solution until the total volume reached 10 mL. A UV spectrometer was used to detect absorbance at 220 nm [9].

2.3. Formulation development

2.3.1. Screening of surfactant/co-surfactant

The surfactants and co-surfactants were selected after a comprehensive review of the literature and solubility tests with essential oils. Solutions composed of 5%, 10%, and 15% surfactants mixed with distilled water were screened at various concentrations of Tween 80, Tween 20, and PEG400, and the results were compared with lavender oil. A vortex mixer was used to combine 5 µL of essential oil for 45–60 s until the mixture became turbid. PEG 400 was chosen as the co-surfactant, while Tween 80 was selected as the surfactant [10].

2.3.2. Optimization of formulation and formulation variables

The nanoemulsion consists of oil, suitable surfactants (S_{mix}: Surfactant to co-surfactant ratio), and distilled water mixed in fixed proportions to obtain a clear oil-in-water nanoemulsion. These fixed proportions were optimized using a pseudo-ternary phase diagram. Various concentrations of the formulation were screened for constructing a pseudo-ternary phase diagram, with the oil phase, surfactant, and co-surfactants selected based on maximum drug solubility [11].

2.3.3. Construction of phase diagram

Vortex mixing was used to create the pseudo-ternary phase diagrams, which illustrate the oil phase, surfactant phase, and aqueous phase. The ratios used to create the optimal S_{mix} (Tween 80: PEG 400) were 1:1, 1:2, 1:3, 1:3.5, 1:4, 2:1, and 3:1. To achieve turbidity, every proportion of S_{mix} was repeatedly titrated with distilled water using a micropipette and a vortex mixer, and minute assessments were taken. Using Tri-plot software, the terminal measurements were represented on triangle coordinates, and a 1:2 ratio—the ratio with the largest area—was chosen based on its phase diagram [12].

2.3.4. Design of the experiment

The optimization was carried out using CCD.

2.4. Characterization of nanoemulsion

2.4.1. Particle size and PDI

The polydispersity index (PDI) evaluates the average uniformity of particles in a liquid and characterizes the range of particle sizes. A higher PDI indicates a broader size distribution of the sample. The Malvern Zeta Sizer Nano ZS evaluated the particle size and PDI for the optimized nanoemulsion at 25 ℃ using dynamic light scattering (DLS) methods. The samples were diluted 50 times with distilled water, transferred into a glass cuvette, placed in the instrument holder, and examined [13].

2.4.2. pH

Using a pH meter, the pH of the created nanoemulsion was measured three times.

2.4.3. Viscosity

The viscosity of the produced nanoemulsion was tested using a Brookfield Viscometer without dilutions, and values were recorded [14].

2.4.4. Turbidity

Turbidity describes a solution's hazy appearance. Turbidity was assessed for the prepared nanoemulsion [15].

2.4.5. Characterization and preparation of nanoemulgel

Preparation of the nanoemulgel: Once 1.5 g of Carbopol was fully dispersed in the water, it was gradually added to 100 mL of purified water while being constantly stirred. The gel was allowed to sit overnight to swell.

Preparation of the nanoemulsion-based nanoemulgel: After overnight swelling, 5 mL of nanoemulsion was applied gradually. Triethanolamine, a cross-linking agent, was added in batches of approximately 2–3 drops each and agitated until it thickened, achieving a gel-like appearance [16].

2.4.6. Visual appearance

The nanoemulsion-based nanoemulgel was visually inspected for color, homogeneity, and consistency.

2.4.7. pH

Using a pH meter, the pH of nanoemulsion-based nanoemulgel was tested. A sample of 0.5 g of the product was dissolved in 100 mL of distilled water and properly mixed. The results of three samples were averaged [17].

2.4.8. *In vitro* studies

The in vitro drug release was determined by a modified dialysis apparatus method. For the modified assembly, a broken cylinder covered with treated dialysis membrane served as the donor compartment. A beaker containing PBS was used as the receptor compartment, placed on a magnetic stirrer. The temperature was maintained at 37 ℃ throughout the study [18].

2.4.9. Spreadability

The spreadability was measured using spreadability equipment to measure the effectiveness of

the nanoemulsion-based nanoemulgel. A known quantity of formulation was placed on a slide held on a slider, which was attached to a lever. After the equipment was activated, the gel spread a specific distance, and the time taken was measured. Measurements were recorded in triplicate, and the average was computed [19].

2.4.10. Viscosity

The nanoemulgel viscosity was measured using a Brookfield viscometer with a spindle at a speed of 100 rpm. The viscosity often indicated the consistency of nanoemulgel formulations.

2.4.11. Texture analysis

For texture analysis, the test speed, distance, and trigger force were set at 5 mm/s, 10 mm, and 5 g, respectively [20].

3. Results and discussion

3.1. Pre-formulation studies

The physical properties of resorcinol (Table 4) and lavender oil (Table 5).

Table 4. Physical properties of resorcinol.

Parameters	Observations
Appearance	White crystalline powder
Odor	Odorless
Physical state	Solid

Table 5. Physical properties of lavender oil.

Parameters	Observations
Appearance	Colorless liquid
Odor	Characteristic
Physical state	Liquid

3.2. Solubility studies

In order to select the appropriate surfactant and co-surfactant for the creation of the nanoemulsion using a pseudo-ternary phase diagram, solubility tests were carried out to assess the amount of lavender oil that could be dissolved in the surfactants until the mixture became turbid (Table 6). The procedure involved using a variety of co-surfactants (such as ethanol and PEG 400) and surfactants (such as Tween 80 and Span 20). Stock solutions for every surfactant and co-surfactant were prepared independently. If needed, the surfactant could be dissolved in water or another appropriate solvent to create solutions at various concentrations (e.g., 1%, 5%, 10%, and 20% w/w). To determine the

solubility of lavender oil in each surfactant solution, small quantities of lavender oil (about 5–10 µL) were added to individual vials containing the surfactant solutions. The amount of lavender oil was adjusted to determine the solubility range. Initially, a small quantity of lavender oil was added, followed by increments of 5 µL or other suitable amounts, to gradually increase the concentration. The lavender oil and surfactant were mixed using a magnetic stirrer or a vortex until well combined and allowed to cool. For the lavender oil to completely dissolve in the surfactant, it was essential to thoroughly mix it after each addition. If the mixture required heat to achieve solubility, the vial was placed in a water bath at 37 ℃ while stirring. The mixture would turn murky, indicating that the surfactant could no longer dissolve the oil, as excess lavender oil was added. Turbidity signaled that the solubility limit of lavender oil I the surfactant had been exceeded, leading to phase separation or cloudiness. The amount of lavender oil added at the turbidity point was recorded, indicating the maximum solubility of lavender oil in that particular surfactant. This procedure was repeated for each surfactant and co-surfactant to document the dissolution limits for each combination [21].

Table 6. Solubility of lavender essential oil in various concentrations of surfactants.

Surfactant	5% (µL)	10% (µL)	15% (µL)
Tween 80	25	40	50
PEG 400	35	40	25
Span 80	40	35	45

3.3. Pseudo-ternary phase diagram

A trigonal graph displaying the concentrations suitable for creating the nanoemulsion was produced by studying 16 formulations for each S_{mix} ratio and plotting the results using the Tri-plot software. Plots were generated for ratios of 1:0, 3:1, and 4:1. The largest area swept in the graph indicated the optimal choice, leading to the use of a 4:1 S_{mix} ratio [22] (Figure 2).

3.4. Preparation of calibration curve

A UV spectrometer was used to examine the calibration curve at the absorption maximum of 220 nm. Plotting absorbance versus concentration at this wavelength yielded a calibration curve that adhered to Beer-Lambert's law. The results are displayed in the table provided below. Concentrations were determined in µg/mL. The prepared calibration curve produced an R^2 value of 0.9986, with a slope of 0.0201 and an intercept value of 0.00059 [23] (Figure 3).

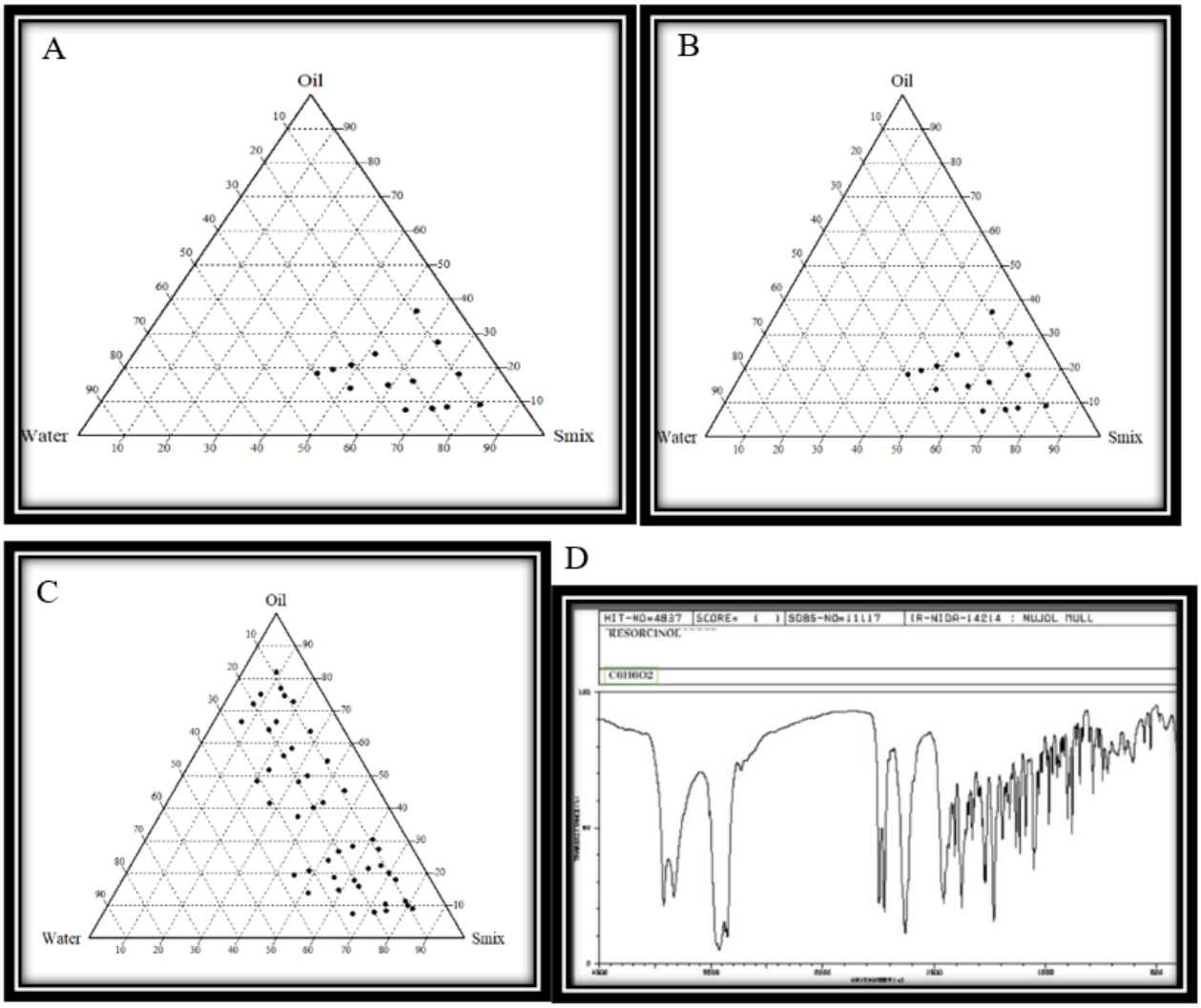


Figure 2. Pseudo-ternary phase diagrams for ratios 1:0 (A), 3:1 (B), and 4:1 (C) and FT-IR spectroscopy of resorcinol (D).

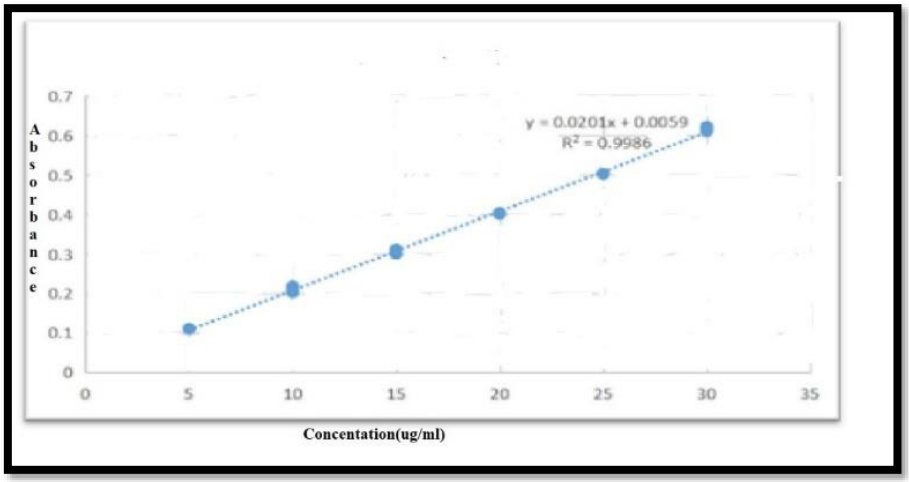


Figure 3. Graph showing the calibration curve.

3.5. Formulation development

3.5.1. Screening of surfactants

The surfactants and co-surfactants were selected based on solubility tests. Lavender oil and Tween 80 were chosen as the surfactant and PEG 400 as the co-surfactant due to their high antibacterial properties and good solubility [24]. 5% Tween 80 and 15% PEG 400 were chosen as surfactant and co-surfactant (Table 7).

Table 7. List of screened surfactants.

Surfactant	5% (µL)	10% (µL)	15% (µL)
Tween 80	25	40	50
PEG 400	35	40	25
Span 80	40	35	45

3.5.2. Optimization of process and formulation variables

The pseudo-ternary phase diagram, created to optimize the ratios of S_{mix}% and oil% for preparing the nanoemulsion, was used to mix the Oil, S_{mix}, and distilled water. According to the readings presented on Tri-plot, a 1:2 (Oil: S_{mix} ratio) is the ideal formulation for creating a nanoemulsion [25].

3.5.3. Experiment design

To further optimize the formulation, Central Composite Design (CCD) was employed, selecting two variables and three outcomes (Tables 8–10) (Figures 4 and 5). The two variables chosen were S_{mix}% and oil%. The three responses measured were particle size, polydispersity index, and viscosity. Nine formulations were created and examined (F1–F9). The optimal nanoemulsion was chosen based on droplet size, polydispersity index, and viscosity [26,27].

Table 8. Independent variables, dependent variables, and constraints for the central composite design.

Independent variable	Low (−1)	High (+1)
X_1 = Oil %	2	10
X_2 = S_{mix}%	2	9

Table 9. Experimental and predicted responses of formulations with their coded factors.

	Independent variables			Dependent variables	
	X_1 = Oil% (v/v%)	X_2 = S_{mix}% (v/v%)	Y_1 = Droplet size	Y_2 = PDI	Y_3 = Viscosity
Constraints	In range	Minimized	Minimized	Minimized	In range
Importance	+++	+++	++++	++++	++++

Table 10. Summary of model fitting statistics and analysis of variance (ANOVA) for the responses.

Std	Run	Factor 1	Factor 2	Response 1	Response 2
		A; oil	B; S_{mix}	Particle size	PDI
		µL	µL	nm	Mw/Mn
12	1	55	95	161.4	0.266
1	2	20	30	126.6	0.581
9	3	55	95	161.4	0.266
7	4	55	3.07612	264	0.751
11	5	55	95	161.4	0.266
10	6	55	95	161.4	0.266
13	7	55	95	161.4	0.266
8	8	55	186.924	108	0.252
3	9	20	160	70.9	0.205
5	10	5.50253	95	108	0.278
2	11	90	30	258.8	0.581
6	12	104.497	95	268	0.261
4	13	90	160	140.9	0.185

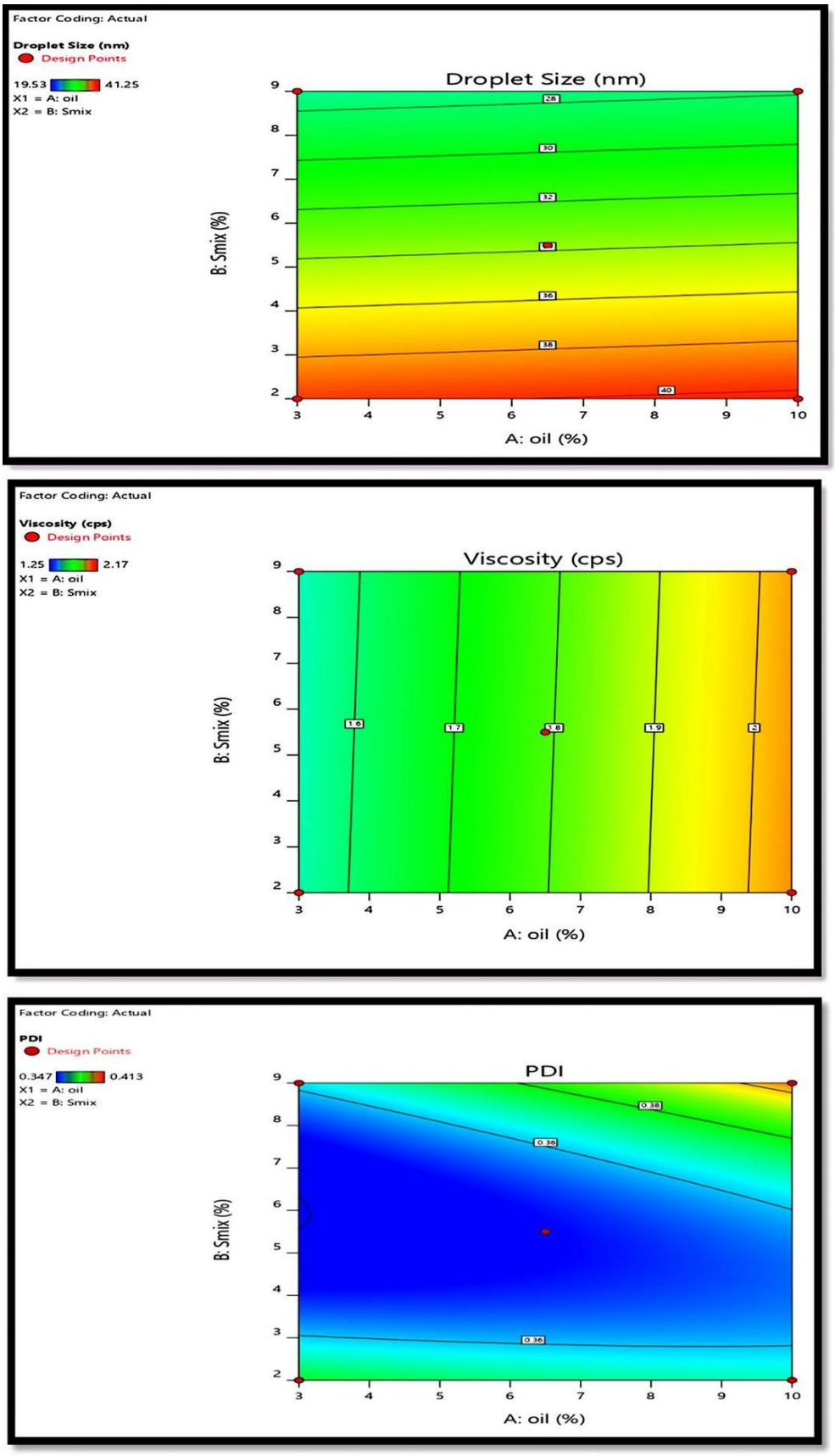


Figure 4. Contour plots illustrating the effect of independent variables for three responses.

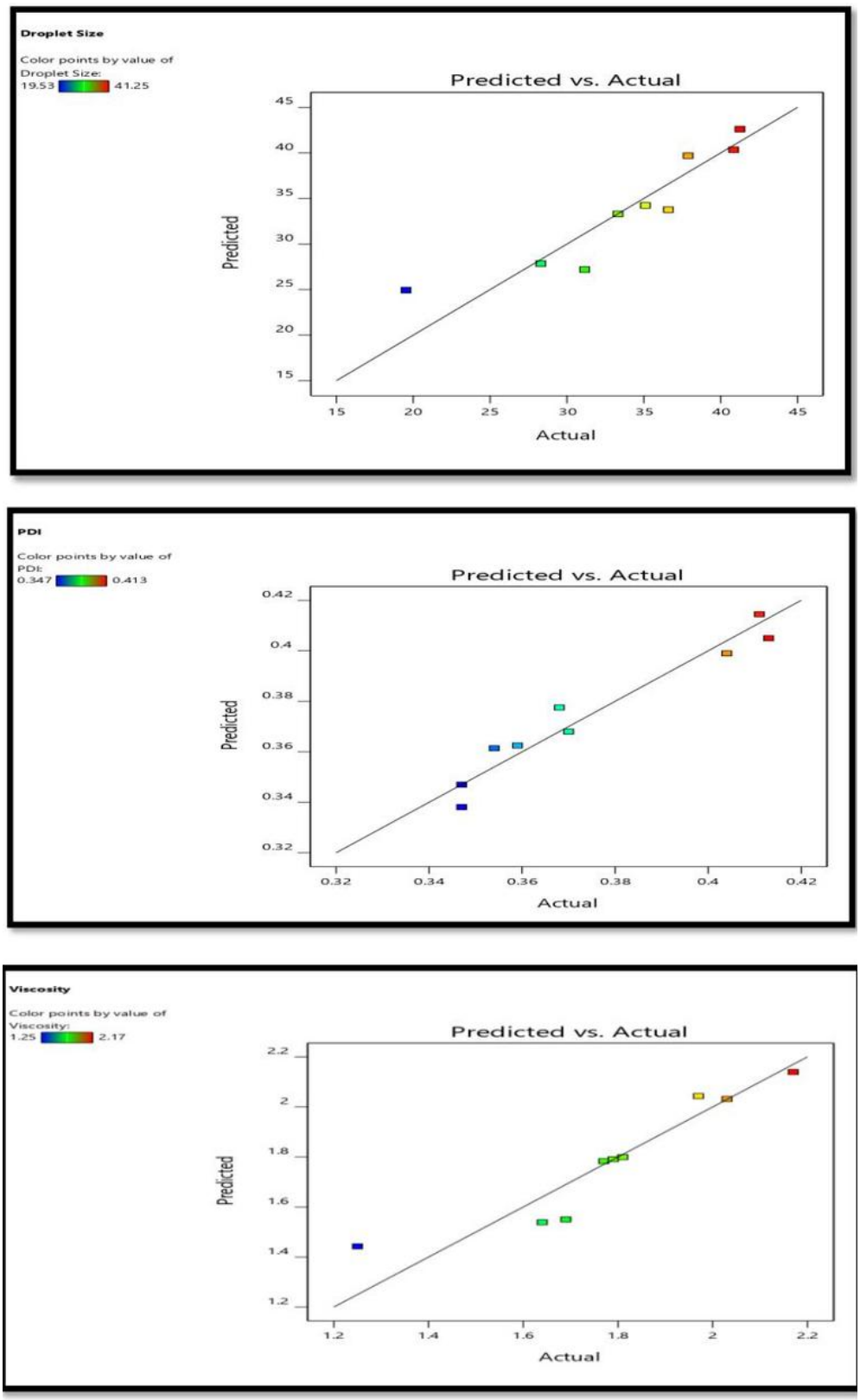


Figure 5. Predicted versus actual plots illustrating the effect of independent variables for three responses.

After careful examination, F8 was chosen as the ideal run for nanoemulsion formulation.

3.5.4. Selection of gelling agent and its concentration optimization

Carbopol 934 at 1.2% was chosen as the gelling agent.

3.5.5. Development of the final formulation

A microemulsion was prepared using 6.5% lavender oil, 5.5% S_{mix}, and distilled water. Finally, 1.5% Carbopol was added to complete the formulation of the nanoemulgel, along with a few drops of triethanolamine [28,29].

3.6. Characterization of the nanoemulsion

3.6.1. Droplet size and PDI

The droplet size and PDI were determined for all nine formulations (F1–F9) (Table 11). The F8 showed comparatively better results (Figures 6 and 7). The optimized formulation was oil 6.5% and S_{mix} 5.5% [30,31].

Table 11. Droplet size and PDI of various formulations.

Formulation	Droplet size	PDI
F1	161.4	0.266
F2	126.6	0.581
F3	264	0.751
F4	108	0.252
F5	70.9	0.205
F6	108	0.278
F7	258.8	0.581
F8	268	0.261
F9	140.9	0.185

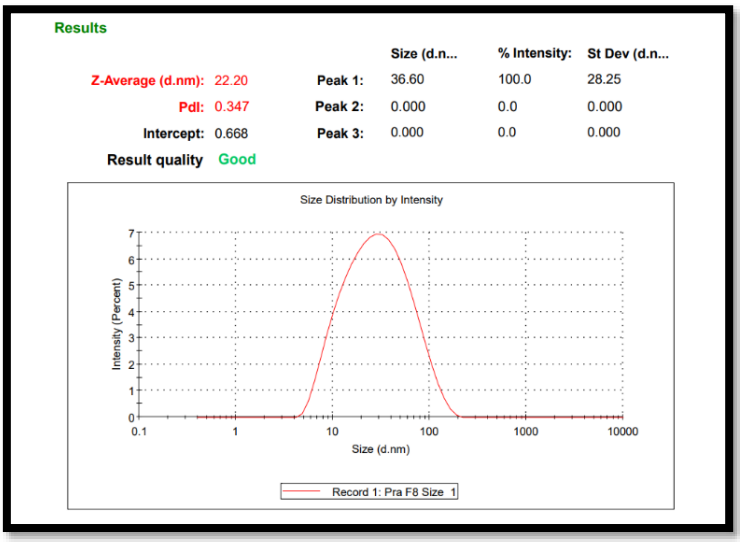


Figure 6. Particle size and PDI for F8.

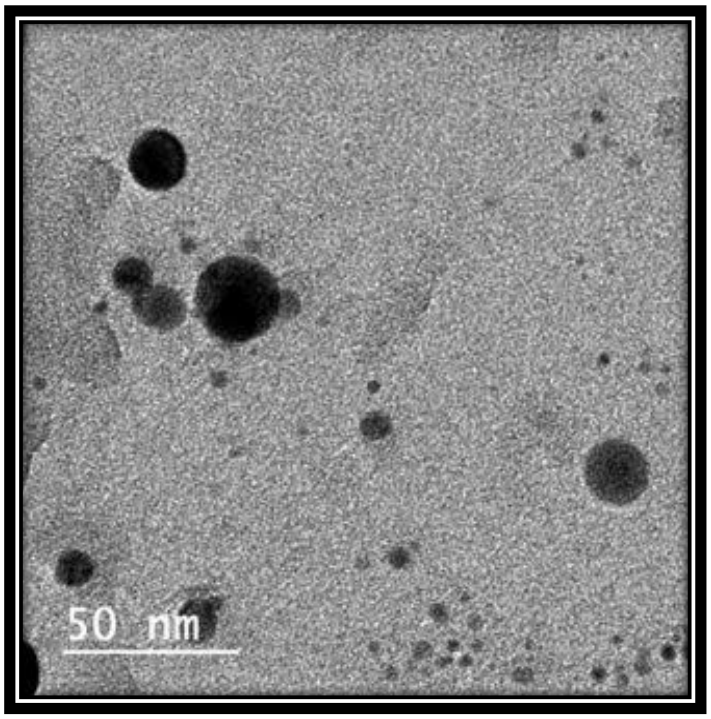


Figure 7. TEM photomicrograph of resorcinol-loaded nanoemulgel.

3.6.2. Viscosity

The Brookfield viscometer measured the viscosity of the prepared nanoemulsion without any dilutions and the readings were noted at 100 rpm; the following values were obtained [32,33] (Tables 12 and 13).

Table 12. Viscosity of various formulations.

Formulation	Viscosity (Cp)
F1	1.87
F2	1.67
F3	1.54
F4	1.69
F5	1.43
F6	1.31
F7	1.59
F8	1.69
F9	1.51

Table 13. pH readings of various formulations.

Formulation	Average pH
F1	6.48
F2	6.52
F3	6.58
F4	6.51
F5	6.62
F6	6.56
F7	6.50
F8	6.53
F9	6.55

3.7. Characterization of nanoemulgel

3.7.1. Physical appearance

The nanoemulsion-based nanoemulgel was visually inspected for color, consistency, homogeneity, grittiness, and phase separation. A white appearance was observed, with no grittiness or phase separation. Resorcinol is a hydrophilic substance, meaning it dissolves in water. This property may affect the distribution of resorcinol between the aqueous and oil phases in a nanoemulgel system. To guarantee that resorcinol is evenly distributed throughout the gel matrix, careful consideration must be given to the hydrophobic lavender oil when adjusting the solubility balance. If solubility is not maximized, phase separation may impact the stability and homogeneity of the nanoemulgel.

3.7.2. pH determination

One gram of prepared hydrogel was dissolved in 100 mL of distilled water. After letting it stay still for some time, pH was measured using a digital pH meter and found to be 6.53 (Tables 14 and 15).

3.7.3. Drug content

The drug content was determined using the slope and intercept values of the standard calibration curve. Drug content was found to be 99.75% ± 0.1%.

3.7.4. Spreadability analysis

The prepared nanoemulgel was subjected to spreadability analysis, obtaining a value of 5.789 g/cm^2.

3.7.5. Viscosity determination

The viscosity of the prepared hydrogel, determined using a Brookfield viscometer at 100 rpm and maintaining the required temperature, was 1.59 cP.

Table 14. Stability studies at room temperature.

Month	Drug content	pH	Viscosity (cP)
1	99.97%	6.52	1.69
2	99.97%	6.51	1.69
3	99.97%	6.52	1.69

Table 15. Stability studies at fridge conditions.

Month	Drug content	pH	Viscosity (cP)
1	98.88%	6.52	1.69
2	98.88%	6.51	1.69
3	98.88%	6.52	1.69

4. Conclusion

Lavender oil and resorcinol underwent pre-formulation studies, demonstrating acceptable ranges and compatibility in their pure forms for this study. The nanoemulsion was successfully prepared using lavender oil as the oil phase, with S_{mix} comprising Tween 80 as the surfactant, polyethylene glycol as the co-surfactant, and distilled water as the water phase, as indicated by the pseudo-ternary phase diagram. A 1:2 ratio was selected for the maximum area swept in the plots obtained using Tri-Plot software. Subsequently, the formulation was optimized using Design Expert Software through Central Composite Design, leading to a total of eight formulations evaluated for droplet size, polydispersity index, and viscosity. The optimized final formulation comprised 6.5% oil and 5.5% S_{mix}, which was then incorporated into Carbopol 934 as a gelling agent to form hydrogels using triethanolamine (TEA).

The characterization parameters for the prepared emulgel were visual appearance, pH, drug content, spreadability analysis, viscosity determination, texture analysis, in vitro studies, and stability studies, as per ICH guidelines. The results suggest that the lavender oil-based emulgel could serve as an alternative for psoriasis treatment. Due to its anti-inflammatory, antibacterial, and antioxidant

properties, lavender oil has the potential to treat skin diseases; however, further pre-clinical and clinical research is required to fully establish its therapeutic potential for the treatment of psoriasis.

In order to assess the effectiveness, safety, and mechanisms of action of the lavender oil-based nanoemulgel, these studies will be conducted using animal models (*in vivo*) or cell lines *(in vitro*). They will also evaluate the antioxidant and anti-inflammatory properties of lavender oil in psoriasis models, evaluate the skin penetration and release profile of the nanoemulgel formulation, and investigate any potential toxic effects or skin irritations.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the preparation of this article.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

Indu Singh; writing—original draft preparation, all authors; writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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