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Formulation optimization and performance evaluation of a SNEDDS-enabled moisturizing cream containing serum pearls

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Abstract

The Self-Nanoemulsifying Drug Delivery Systems have emerged over the last few years as a modern and effective strategy to improve the apparent solubility, dissolution rate, and bioavailability of poorly water-soluble drugs. SNEDDS consists of isotropic, anhydrous mixtures of oils, surfactants, and co-surfactants that are characterised by a spontaneous formation of fine oil-in-water nano-emulsions after their mild agitation in aqueous media. The resultant nanosized droplets (<200 nm) bring about an increase in surface area for rapid absorption, thus improving therapeutic performance. The review comprehensively discusses the fundamentals on SNEDDS, including formulation components, the mechanism of spontaneous emulsification, preparation methods, characterisation techniques, and evaluation of thermodynamic stability. Besides that, pharmaceutical and cosmetic applications, including the enhancement of bioavailability, mucus permeation, biomolecule delivery, topical and transdermal systems, and incorporation into hydrogel and serum pearls, are highlighted. Despite these advantages, challenges relating to surfactant concentration, cost of formulation, and *In vitro* -in vivo correlation persist. Overall, SNEDDS is a promising, versatile platform for both drug delivery and cosmeceutical development.

Keywords: SNEDDS; Vitamin E; Niacinamide; Nano emulsion; Orange essential oil

1 Introduction

Skin is the largest organ of the body, behaving like a critical barrier against environmental aggressors, microbial invasion, and excess water loss. Adequate hydration of the skin is important in preserving its integrity, elasticity, and health. Conventional moisturizing creams are topical formulations aimed at improving hydration of the skin by preserving or restoring the status of the skin's lipid barrier and reducing trans epidermal water loss1.

Moisturising creams are semisolid emulsions and can be water-in-oil (W/O) or oil-in-water (O/W) formulations. These formulations of creams make them offer greater residence time of the substance at the application site compared to other semisolid formulations. This is because of the nature of the emulsion properties and the oil part of the cream acting as an emollient that forms a barrier against the evaporation of water from the skin. This assists the skin to appear less greasy and feel smooth. Moreover, the creams are nongreasy and penetrable and therefore less irritating and easily washable. Poor penetration through the skin by the lipophilic active ingredients, instability, and consequently diminished bioavailability are common drawbacks of conventional moisturizing creams that might seriously impede their therapeutic and cosmetic efficacies2.

During recent years, the progress of nanotechnology has facilitated the development of new drug and cosmetic delivery systems that are intended to surmount these disadvantages. Among the well-promising approaches, one is called the

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Self Nanoemulsifying Drug Delivery System (SNEDDS). SNEDDS are isotropic mixtures of oils, surfactants, and co-surfactants that form fine oil-in-water nano emulsions spontaneously upon contacting aqueous media under gentle agitation. These systems develop nano-sized droplets, normally less than 100 nm, which enhance the solubility, stability, and delivery of lipophilic compounds enormously3.

In addition, the SNEDDS-based moisturising creams have the advantage of being able to offer a controlled and sustained release of the active components, thus extending the duration of the skin hydrating and protection effects. The technology is well-suited for the delivery of the biologically active components, such as antioxidants, vitamins, plant extracts, and lipids, that contribute to skin hydration4.

1.1 Why Use SNEDDS in a Moisturising Cream?

- Improved Delivery of Active Ingredients

When mixed with lipophilic actives such as vitamins, antioxidants, ceramides, or natural oils, SNEDDS can result in enhanced solubility for these actives that can penetrate the skin layers more effectively than creams5.

- Nano-Scale Emulsion for Better Penetration

The droplet size of nanometres created upon application has an enhanced surface area that helps in better interaction of the skin, thus facilitating the better entry of beneficial ingredients within the epidermis and dermis5.

- Stability & Sensory Feel Enhancers

SNEDDS formulations usually result in a thermodynamically stable system and may produce a smooth, non-greasy, and spreadable texture that could be lighter than a cream formulation rich in oil6.

- Potential for Controlled Release

The structure of the nano emulsion may be useful for time-controlled release mechanisms, which can increase the functional effect of active substances on skin hydration and barrier repair mechanisms6.

1.2 Mechanism of action

- Spontaneous nano emulsion

On application, the water present on the skin surfaces initiates the self-emulsification process of the SNEDDS formulation. In turn, there is the formation of oil droplets of nanometric size.

- Increased solubilization and dispersion of actives

The nano-droplets enhance the surface area, which is beneficial for the dissolution of the drug or active. The solubility and distribution of the lipophilic actives, which always have difficulty being delivered via conventional cream, are improved.

- Enhanced interaction with skin lipids

The nano-emulsion particles are engaged with the lipid matrix within the stratum corneum layer. This makes it possible to increase penetration and accumulation of actives in lower skin layers. This also assists with hydration, repair, and sustained release5.

1.2.1 Components of SNEDDS for Topical Drug Delivery

Topical Self-Nanoemulsifying Drug Delivery Systems (SNEDDS) are the lipid nano systems that create nano-emulsion on their own on interacting with semisolid bases (creams and gels) or upon application on the skin, which are developed for the improved solubility, penetration, and retention of drugs on the skin.

The typical formula for topical SNEDDS consists of the following components: oil phase, surfactant, co-surfactant/co-solvent, and optionally, penetration enhancers/excipients for the skin, which are selected based on5.

- Oil Phase (Lipid Component)

Role:

  - Makes lipophilic drug soluble.
  - Participates in formation of the internal phase (oil) in the nano-emulsion.
  - Can serve as a skin penetration enhancer by interacting with lipids in the stratum corneum.

Examples

  - Labrafil® M 1944 CS - A combination of mono, di, and triglycerides. It is used as the oil phase in the SNEDDS drug astaxanthin.
  - Essential lipids or terpenes (Limonene, geraniol, etc.) – useful for increasing the permeability of the skin, if added to the oil phase.

Topical Delivery Mechanism: Lipophilic oils assist in distributing the drug into the lipophilic layers of the stratum corneum, thus enhancing the driving force to distribute the drug further into the inner layers of the epidermis5.

- Surfactants

Role:

  - Stabilize the nano-emulsion droplets
  - Used as wetting and spreading agent
  - Reduce the interfacial tension

Examples

  - Kolliphor® EL (polyoxyl-35 hydrogenated castor oil) - non-ionic surfactant; of high HLB value; used in
  - Tween 80, Span series, Cremophor® EL – often used due to low irritation and emulsifying properties. The above is well accepted in topical dosage forms (such as creams or gels in the nano-emulsion system).
  - Non-ionic surfactants of high hydrophilic-lipophilic balance (HLB) values can be considered to be much better in topical dosage forms to reduce irritation to the skin. They produce stable fine nanodroplets5.

- Co-Surfactants

Role:

  - Help surfactants further decrease the interfacial tension.
  - Flexible adsorbed interfacial films to help in nano-emulsion formations.
  - As penetration enhancers, they disrupt the skin's lipid components, the stratum corneum

Examples

  - Transcutol P (diethylene glycol monoethyl ether), used as a co-surfactant and a penetration enhancer through the skin because of its capacity to solubilize water and oil phases5.
  - Additionally, PEG 200/400 and alcohols of low molecular weight are used as solubilizers and to enhance percutaneous penetration in topical gels7.

- Penetration Enhancers and Functional Additives
  - Additional ingredients may be added to topical products to assist in penetration beyond a basic nano-emulsion:

Examples & Mechanisms

  - Terpenes (D-Limonene, Geraniol, Farnesol): These can alter the interlamellar packing pattern in the SC lipid layer and aid in the diffusion of drug substances
  - These terpenes may be present as components of the oil phase or as additives to the formulation5.

- Vehicle / Semisolid Base (Cream, Gel)
  - Although not a part of the SNEDDS formula, the actual dosage form becomes important for the intended drug delivery route:
  - Usually, SNEDDS carriers mix in creams or gels (Carbopol, Pemulen TR-1, etc.), to favour their administration in an appropriate dosage.
  - The base may be provided with emollients and/or polymer to modify viscosity and spreadability in a manner that promotes compliance5.

1.3 Topical Applications of SNEDDS

- Increased Penetration into Human Skin for Lipophilic Ingredients
  - Astaxanthin SNEDDS for Topical Skin delivery
    - The SNEDDS containing astaxanthin was found to significantly facilitate penetration through the stratum corneum, and into the layers of epidermis, dermis, and follicle compared to oil solution and commercial serum.
    - Furthermore, terpenes, such as D-limonene, were also effective5.
- Curcumin SNEDDS for Topical Dosage Forms: Creams and Gels
  - Topical Curcumin SNEDDS for Skin Delivery
    - Curcumin was found to have poor penetration through the skin due to hydrophobicity. Formulation of curcumin with SNEDDS and its incorporation into creams and gels increased the efficacy of the drug by enhancing the drug's release and permeation, and the anti-inflammatory.
    - The gel, which contained SNEDDS, was seen to have faster penetration than conventional products in Franz diffusion studies8.
- Topical Cream of 5-Fluorouracil for Skin Cancer Therapy (SNEDDS)
  - 5-FU SNEDDS Cream for Actinic Keratosis
  - An isopropyl myristate, Tween 80, and Transcutol P combination was incorporated into a cream.
  - Exhibited enhanced spreadability, release of the drug (~88.7%), and cytotoxic activity against carcinoma cells compared to the conventional formulation9.
- Transdermal Curcumin SNEDDS for Anti-inflammatory
  - Curcumin SNEDDS for Transdermal Delivery
    - SNEDDS with incorporated curcuminoids and lipid carriers were found to exhibit adequate skin penetration with considerable in vivo anti-inflammatory activities with reductions of about ~80% for paw edema in animal studies10.
- Azelaic Acid SNEDDS Hydrogel for Atopic Dermatitis
  - Azelaic Acid SNEDDS Hydrogel
    - It was also observed that in the preparation of hydrogel with azelaic acid-loaded SNEDDS, skin permeation was enhanced compared to marketed formulation and offered no irritation to the skin in animal tests11.
- Ocular Topical SNEDDS – Non-Invasive
  - Triamcinolone SNEDDS for Ocular Topical Delivery
    - A SNEDDS of triamcinolone acetonide applied topically to the eyes showed enhanced permeability into the posterior tissues of the eye (retina and sclera) as well as safety12.

1.4 Advantages of SNEDDS for topical delivery

- Increased Skin Permeation

Topical SNEDDS form nano-sized oil-in-water droplets of large interfacial surface area, which enhances permeation through the stratum corneum due to an improvement in drug diffusivity and interaction with skin lipids.10,11

- Enhanced Solubility of Poorly Water-Soluble Drugs

SNEDDS can keep the lipophilic drugs in a solubilized state in the oil phase, thereby increasing the thermodynamic activity and enhancing drug partitioning into the skin. 5,9

- Increased Local Drug Retention with Reduced Systemic Exposure

Topical SNEDDS Favor drug deposition within skin layers, leading to higher local drug concentration while minimizing systemic absorption and associated adverse effects.8,10

- Protection of Drugs from Chemical and Environmental Degradation

Encapsulation of the drug is achieved, where the drug will be protected from degradants like oxidation, exposure to direct or indirect light, as well as environmental conditions on the skin surface.5,8

- Versatile Incorporation into Patient-Friendly Topical Dosage Forms

The incorporation of SNEDDS into gels, creams, ointments, and nanoemulgels can be done effectively to enhance spreadability, aesthetic properties, and patient compliance.9,11

- Use of Skin-Compatible and Less Irritating Excipients

Non-ionic surfactants and other biocompatible oils that make up topical SNEDDS have also cut down irritation to the skin compared to the use of other topical enhancers.5,8

- Enhanced Therapeutic Efficacy in Dermatological Disorders

Topical SNEDDS formulations have also demonstrated superior therapeutic results in skin disorders like inflammation, hyperpigmentation, actinic keratosis, and dermatitis due to their penetration and controlled drug release properties.9,10,11

1.5 Disadvantages of SNEDDS for topical delivery

- Risk of Skin Irritation

The high concentrations of surfactants and co-surfactants, which are often essential for nano emulsification, have been shown to have the potential for disrupting skin barrier integrity. 5,11

- Limited Suitability for Hydrophilic Drugs

SNEDDS are mostly applicable for lipophilic drugs, while the incorporation of a hydrophilic drug might show difficulty in maintaining solubilization in the oil phase, which may be a drawback in formulation. 5

- Stability Issues

Concerns regarding topical SNEDDS involve various physical issues during storage or after the product is entrapped in semisolids.8,9

- Excessive or Uncontrolled Skin Penetration

Increased permeability can sometimes result in unwanted systemic absorption, thus enhancing the chances of systemic side effects. 10,11

- Scale-Up and Regulatory Challenges

The optimization of excipients and the lack of standardized regulations for topical SNEDDS may pose challenges in their manufacture and approval.8

2 Methodology

- Preparation of the SNEDDS Preconcentrate

Accurately weigh the ingredients in the pre-optimised ratio (e.g., MCT oil 30% w/w, Tween 80 60% w/w, propylene glycol 30% w/w, vitamin E 0.5% w/w; Type IIIA system). Mix all components in a glass vial or beaker using a magnetic stirrer at ~500 rpm with mild heating (40 ± 2 °C) for 10–20 minutes until an isotropic solution forms. Allow the mixture to cool to room temperature (25 °C) and store undisturbed13.

- Preparation of hydrogel base.

Carbopol 940 (0.75% w/v) is slowly dispersed into distilled water containing glycerin (5–10% w/v) and preservative under high-speed stirring (800–1000 rpm) to prevent lump formation. The dispersion is stirred for 20–30 minutes and allowed to swell for 1–2 hours or overnight at 4 °C. The hydrated dispersion is then neutralized by dropwise addition of triethanolamine (≈0.5–0.8% w/v) under stirring, with continuous pH monitoring until pH 6.0–6.5 is reached, forming a clear, smooth hydrogel10.

- Preparation of Serum Pearls by gelation.

Sodium alginate (2.0 g) is dissolved in ~80 mL of water under stirring for 10–15 minutes. Niacinamide (1.0 g) is dissolved separately in 10 mL of water and then added to the alginate solution with continuous stirring. Mica powder (0.5 g) is dispersed in glycerine (2.0 g) and incorporated into the mixture. An oil phase consisting of orange essential oil (0.5 g) and Tween 80 (0.5 mL) is prepared and slowly added to form a uniform oil-in-water system. The alginate mixture is loaded into a syringe and extruded dropwise into a gently stirred $CaCl_2$ solution (3.0 g in 100 mL water) from a height of 5–10 cm to form gel beads. The beads are cured for 20–30 minutes, then transferred into a chitosan solution (0.25 g in 100 mL of 1% acetic acid) and gently stirred for 10–20 minutes. Finally, the beads are rinsed with distilled water, lightly dried, and stored in an airtight amber container 15.

- Final composite formulation.

Alginate serum pearls are removed from their storage medium and gently blotted with lint-free or filter paper to prevent dilution of the hydrogel base. A measured pearl (e.g., 3.5% w/w, within the 2–5% range) is slowly incorporated into the SNEDDShydrogel using low-shear mixing with an overhead stirrer or spatula at 50–150 rpm for 5–10 minutes, ensuring uniform distribution without damaging the pearls.

2.1 Evaluation of Cream

The moisturising cream was assessed based on the specified parameters, following the standard evaluation procedure meticulously.

- Organoleptic evaluation

The cream obtained underwent scrutiny for its organoleptic characteristics, including colour, odour, and consistency through visual observation and touch.

- Determination of pH

The pH of the cream is measured by a digital pH meter at room temperature, which was calibrated with standardized buffer solutions of pH 4,7 and 9 before each usage. About 0.5 g of the cream was measured and transferred to a beaker, and mixed with 50 ml of distilled water.

- Determination of Viscosity

An approximate amount of sample of each formulation is transferred to a beaker, where the viscosity of the formulation is evaluated using a Brookfield Viscometer with spindle number S64 at 10 rpm.

- Homogeneity

The examination was conducted through tactile exploration using hands.

- Washability

The removal of the cream applied on the skin was done by washing under tap water with minimal force to remove the cream.

- Irritancy test

Mark an area (1sq.cm) on the left-hand dorsal surface. The cream was applied to the specified area and time was noted. Irritancy, erythema, oedema, was checked if any for regular intervals up to 24 hrs and reported.

- Determination of emulsion type

Dilution test: To determine the oil in water emulsion, the dilution method involved mixing the emulsion with an aqueous solvent, while for identifying the water in oil emulsion, it entailed diluting the emulsion with an oily liquid 16.

- Spreadability test

Spreadability of semi-solid formulation, that is, the ability of a cream or gel to evenly spread on the skin, plays an important role in the administration of a standard dose of a medicated formulation to the skin and the efficacy of a topical therapy. The most common method for measuring the spreadability is the parallel-plate method, which has many variations. During the measurement using the parallel- plate method, 0.2 g of the sample prepared for the test is placed between twoglass slides of uniform length. A weight of 100g is placed on top for 1 minute. Then the diameter of the sample between the plates is measured.

In these cases, spreadability is determined by the formula

$$Si = d2 \times \pi/4$$

Si-spreading area (mm2) depending on mass

D-spreading area diameter (mm).

- *In vitro* drug release

This study was carried out using the modified diffusion cell. Samples, each 1 gm of the different formulations, were spread on egg membrane previously soaked overnight in the diffusion medium. The loaded membrane was firmly stretched over the edge of glass tube of 3.10 cm diameter. The tube was then immersed in the receptor medium, which contained 200 ml of the diffusion medium (phosphate buffer 7.4) previously warmed and maintained at 37 ± 1 C and stirred at 100 rpm using magnetic stirrer. Aliquots of 10 ml was withdrawn from the receptor medium at different time intervals. Withdrawn samples were replaced by equal volume of fresh medium. The samples were analyzed at 260 nm against blank using UV-spectrophotometer. Experiments were carried out in triplicates.17

- Moisture Content determination

Dishes were washed and dried overnight in a hot air oven at 105˚C. These dishes were placed in desiccator, cooled, and weighed. About 1.0g of test sample was weighed and placed into an oven at 105±2°C for 16-18hours to constant weight. Dishes were removed, covered on the top and placed in desiccators and cooled. Removed from desiccator and weighed as quickly as possible.

$$\text{Moisture content (\%)} = \{Ws - (W2-W1)/ Ws\} \times 100$$

W1-Weight of dish; Ws-Weight of sample; W2- Weight of dish after drying

- *In vitro* Antioxidant Study
  - DPPH ASSAY

Determination Of 1,1-Diphenyl-2-Picrylhydrazyl (DPPH) Free Radical Scavenging Activity

The DPPH is a stable free radical, widely used to assess the radical scavenging activity of antioxidant compounds. This method is based on the reduction of DPPH in methanol/ethanol solution in the presence of a hydrogen-donating antioxidant due to the formation of the non-radical form DPPH-H. This transformation results in a colour change from purple to yellow, which is measured spectrophotometrically at 517 nm.

  - Sample Preparation

Weighed about 0.01 ml of cream formulations and dissolved in ethanol. Prepared face cream sample solution was filtered by the Whatman filter paper, and the volume was made up to 10 ml in a volumetric flask.

Procedure:

Ethanol-DPPH solution (0.1mM DPPH in ethanol) was prepared fresh. The DPPH solution (2.9 mL) was placed in a glass cuvette and the absorbance at 515 nm in time t = 0 min (t0) was measured. 0.1mL of sample extract was added and the mixture was shaken vigorously and kept in the dark at room temperature for 30 min (t30). The absorbance at 515 nm was then measured using a Spectro quant Pharo 100 spectrophotometer (Merck, United States). A standard curve using Trolox was prepared and percentage reduction of DPPH was calculated as

$$\% \text{ DPPH reduction} = 100\ [\text{Absorbance}(t30) / \text{Absorbance}(t0)]\ 100$$

2.2 Evaluation of SNEDDS

2.2.1 Emulsification Time Method

The emulsification time can be measured by the following visual assessment technique in a specific environment:

A known volume of the SNEDDS preconcentrate (usually a volume of around 0.5 to 1 mL) is slowly added to a volume of distilled water or a phosphate buffer (pH from5.5 to 7.4) ranging from 100 to 500 mL.The medium is gently agitated using a magnetic stirrer or a paddle stirrer set to 50-100 rpm.The time for complete emulsification is measured by the help of a stop- watch. The achievement of complete emulsification is observed when the system shows the presence of a clear or even slightly bluish color of the formed nano emulsion with no phaseseparation, and the absence of oil globules.18

2.2.2 Interpretation

- Emulsification time < 1 min suggests efficient SNEDDS self-nano emulsification, desirable for topical SNEDDS formulations
- Rapid emulsification facilitates enhanced drug release, skin spreading, and skin penetration, especially in a semisolid dosage form after the SNEDDS contains a vehicle.18

2.3 Evaluation of serum pearls

2.3.1 Drug entrapment efficiency (%)

100 mg of beads were taken and crushed using pestle and mortar. The crushed powders of drug-containing beads were placed in a very 250 ml volumetric flask and volume was made up to 250 ml by phosphate buffer, pH 7.4, and kept for 24 h with infrequently shaking at 37 ± 0.50 C. After the specified time mixture was stirred at 500 rpm for 20 min using a magnetic stirrer (Remi Motors, India). The polymer debris fashioned after the disintegration of the bead was removed by filtering through Whatman® filter paper (No. 40). The drug content within the filtrate was determined using a UV–vis spectrophotometer (Shimadzu, Japan) at 233 nm against an acceptable blank. The DEE (%) of these prepared beads was calculated by the subsequent formula.20

$$\text{DEE (\%)} = \text{actual drug content in beads} / \text{Theoretical drug content in beads} \times 100.$$

3 Results and discussion

3.1 Organoleptic Evaluation

All four formulations of moisturizing cream were evaluated for physical evaluation, and the results are shown in Table No. 1.

Table 1 Organoleptic Evaluation

SI. NO	Evaluation Parameters	F1	F2	F3	F4
1.	Visual appearance	White	White	White	White
2.	Texture	Smooth	Smooth	Smooth	Smooth
3.	Odour	Pleasant citrus aroma	Pleasant citrus aroma	Pleasant citrus aroma	Pleasant citrus aroma

The pH of all four formulations was recorded by a digital pH meter, and the results of pH were shown in Table no: 2.

Table 2 Evaluation of pH

Sl.No.	Formulations	pH
1.	F1	5.2
2.	F2	5.5
3.	F3	5.6
4.	F4	5.8

The pH of the formulations was found to be in the range of 5.2-5.8, which is the acceptable range of pH of the skin.

3.2 Viscosity

A Brookfield viscometer was used to measure the viscosity of each of the four moisturizing cream formulations. The result of viscosities is shown in Table No. 3.

Table 3 Evaluation Of Viscosity

Sl. No.	Formulations	Viscosity(cps)
1.	F1	8434
2.	F2	9622
3.	F3	12832
4.	F4	14558

Viscosities of all the formulations were noted and found in the range of 8434 to 14558 cps at 10 rpm, as shown in Table 3. All the formulations had having acceptable range of viscosities.

3.3 Homogeneity

All the formulations were found to be homogeneous and free from grittiness. This was confirmed by visual examination and by touch.

3.4 Washability

All the formulated creams were found to be non-greasy after application to the skin and were easily removable by washing with tap water.

3.5 Irritancy test

The skin irritancy test demonstrated that all SNEDDS-based cream formulations were non-irritant to the skin. No signs of redness, swelling, or inflammation were observed throughout the study period Determination of emulsion type

3.6 Dilution test

All the formulations remain stable after dilution with water; hence, the dilution test confirms that all the formulations were o/w type emulsion cream.

3.7 Spreadability

Table 4 Spreadability studies

Formulation	Diameter (cm)	Time (sec)	Spreadability (mm^2)
F1	4	300	1256
F2	4.5	300	1589.6
F3	3.4	300	907.46
F4	3.2	300	803.84

Spreadability of the formulations is shown in Table 4. Formulations are spreadable, and F2 has higher spreadability.

3.8 *Invit*ro drug release (Cumulative % Drug Released)

Table 5 Percent cumulative drug release

Time (h)	F1 (%)	F2 (%)	F3 (%)	F4 (%)
0.5	18 ± 1.2	22 ± 1.0	15 ± 1.5	12 ± 1.3
1	30 ± 1.5	36 ± 1.3	25 ± 1.8	20 ± 1.6
2	48 ± 2.0	55 ± 1.7	42 ± 2.3	35 ± 2.0
4	65 ± 2.5	75 ± 2.1	60 ± 2.8	50 ± 2.4
6	78 ± 2.8	88 ± 2.4	72 ± 3.0	63 ± 2.7
8	85 ± 3.0	94 ± 2.6	80 ± 3.2	70 ± 3.0
12	92 ± 3.5	98 ± 2.9	88 ± 3.6	78 ± 3.3

Percent cumulative drug release of formulations is shown in table 5.F2 has higher percent Cumulative drug release.

3.9 Moisture content determination

Table 6 Determination of moisture content

Sample	Ws (g)	W1 (g)	W2 (g)	Ws-(W1-W2)/Ws	Moisture Content
F1	1	45.620	45.790	0.830	83
F2	1	45.779	45.922	0.857	85.7
F3	1	45.510	45.690	0.820	82.0
F4	1	45.880	45.080	0.800	80

Determination of moisture content was carried out for all 4 formulations, and the result F2 formulation showed a higher moisture content.

3.10 *In vitro* Antioxidant Activity

3.10.1 DDPH ASSAY

Table 7 DDPH Scavenging activity of formulation

Formulation	Absorbance	Percentage inhibition (%)
F1	0.330	71.38
F2	0.240	78.81
F3	0.290	67.66
F4	0.360	64.66

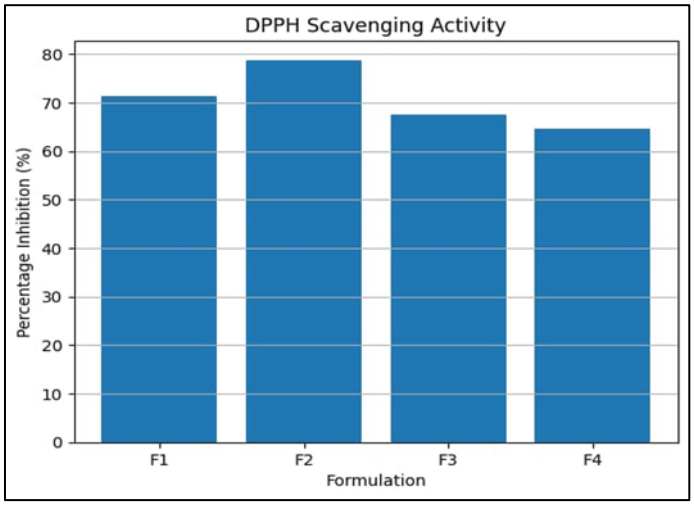

Figure 1 DPPH radical scavenging activity of formulations

Antioxidant assay by DPPH radical scavenging activity was carried out for all 4 formulations. Percentage inhibition was calculated, and the result F2 formulation showed a higher antioxidant assay.

3.11 Evaluation of SNEDDS

3.11.1 Emulsification time

Table 8 Determination Of Emulsification Time

GRADE	DESCRPTION
GRADE A	Rapid nano emulsion (<1min)
GRADE B	Rapid emulsion (<2min)
GRADE C	Milky emulsin (>2 min)
GRADE D	Slow emulsification
GRADE E	Poor emulsification

The SNEDDS moisturizing cream showed an emulsification time of less than minute, indicating Grade A (rapid nano-emulsion). This reflects efficient and rapid formation of a stable nano-emulsion.

3.12 Evaluation of serum pearls

3.12.1 Drug entrapment efficiency

Table 9 Percent drug entrapment

Formulation	Entrapped drug(mg)	%EE
F1	84.2	84.2%
F2	88.5	88.5%
F3	86.7	86.7%
F4	83.9	83.9

Drug entrapment efficiency was carried out for all 4 formulations, and the result F2 formulation showed a higher percent dug entrapment.

4 Conclusion

The present study was undertaken to develop and evaluate an SNEDDS-based moisturizing cream incorporated with serum pearls, aiming to enhance skin hydration and improve the delivery of active ingredients. Four formulations (F1–F4) were prepared using optimized concentrations of oil, surfactant, and co-surfactant to obtain a stable Self-Nano Emulsifying Drug Delivery System (SNEDDS), which was further incorporated into a suitable cream base. All formulations were evaluated for various physicochemical and performance parameters, including organoleptic properties, pH, viscosity, spreadability, homogeneity, type of emulsion, antioxidant activity (DPPH method), and stability studies. The prepared creams were found to be smooth, homogeneous, non-greasy, easily spreadable, and washable, with all formulations exhibiting oil-in-water (o/w) emulsion characteristics. The pH of the formulations ranged from 5.2 to 5.8, indicating good compatibility with normal skin pH, while viscosity values ranged between 8434 and 14558 cps, suggesting adequate consistency and stability. In-vitro antioxidant activity showed percentage inhibition between 64% and 78%, with formulation F2 demonstrating the highest inhibition (around 85%) along with optimal pH, viscosity, spreadability, and stability. Based on the overall evaluation, F2 was identified as the optimized formulation. The study concludes that the incorporation of SNEDDS significantly enhances the solubility and penetration of active ingredients, while serum pearls improve the aesthetic appeal and functional performance of the product, making the for effective topical application with improved skin hydration and antioxidant benefits.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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