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SYNERGISTIC NANOEMULSION: UNVEILING THE THERAPEUTIC POTENTIAL OF *CAMELLIA SINENSIS* AND *BOMBAX CEIBA*

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Abstract:
Nanoemulsions have emerged as a promising approach to enhance the solubility, stability, and bioavailability of bioactive compounds derived from natural sources. In this study, we aimed to develop a nanoemulsion formulation incorporating extracts from *Camellia sinensis* (green tea) and *Bombax ceiba* (silk cotton tree), two plants known for their diverse pharmacological properties. The nanoemulsion was prepared using high-pressure homogenization techniques, and its physicochemical properties, including particle size, zeta potential, and stability, were characterized. The nanoemulsion was prepared using high-pressure homogenization technique and characterized for its physicochemical properties including particle size, zeta potential, and stability. The optimized nanoemulsion exhibited a uniform particle size distribution with an average diameter in the nanometer range, indicating its suitability for enhanced drug delivery. Moreover, the zeta potential analysis revealed sufficient electrostatic repulsion among the droplets, ensuring physical stability against aggregation and sedimentation. The nanoemulsion demonstrated enhanced solubility and permeability of bioactive components, leading to improved bioavailability compared to conventional formulations. Furthermore, synergistic effects between *Camellia sinensis* and *Bombax ceiba* extracts were observed, suggesting potential multifaceted health benefits. Overall, the developed nanoemulsion holds promise for various applications in pharmaceuticals, cosmeceuticals, and functional foods, offering improved stability, enhanced bioavailability, and potential synergistic effects. Further research is warranted to explore its efficacy in preclinical and clinical studies and to optimize formulation parameters for specific applications.

Index terms: Nanoemulsion, zeta potential, Diffusion study, Skin irritation test

I.Introduction

Nanoscience is the study of atomic- or molecular-scale particles, whose dimensions are measured in nanometers. One billionth of a meter is a nanometer. As a result, nanotechnology can be defined as a collection of strategies for transforming substances at the atomic and molecular level to produce products that differ from typical products in terms of their physicochemical features. In contrast, nanobiotechnology

focuses on the creation of components on the biomolecular nanoscale as well as of tools for studying cellular biology, both at the molecular and cellular levels. (Thakur et, al 2012)

Benefits of nanotechnological carriers over traditional drug delivery methods:

- They encourage the precise delivery of different bioactive compounds without affecting healthy tissues;
- They are highly effective in encapsulating drugs and capable of skin penetration and prolonged drug release.
- These carriers can both encapsulate and lessen the toxicity of both lipophilic and hydrophilic medicines;
- These carriers prolong the drug's residence period in the target organ and shield it from physical and chemical deterioration;
- They preserve the physicochemical characteristics of drug molecules that have been encapsulated. (Savardekar, P et,al 2016)

Significance of Nanotechnology in Topical treatment:

Nanotechnology plays a significant role in topical treatments due to its unique properties and capabilities. Here are some key significances of nanotechnology in this context:

Enhanced drug delivery: Nanoparticles can improve the delivery of drugs to the target site within the skin. They can overcome barriers, such as the stratum corneum, and penetrate deeper layers more effectively than conventional formulations. This enables efficient and targeted delivery of drugs to specific skin compartments, enhancing their therapeutic effects.

Increased drug stability: Nanoparticles can protect drugs from degradation or inactivation, improving their stability. They can encapsulate drugs, shielding them from external factors, such as light, heat, or enzymes, which may degrade or alter their properties. By maintaining drug stability, nanoparticles ensure that the drug remains effective during storage and upon application to the skin.

Controlled and sustained release: Nanoparticles can be engineered to release drugs in a controlled manner. This allows for sustained drug release over an extended period, reducing the frequency of application and enhancing patient compliance. Controlled release also provides a more consistent drug concentration at the target site, optimizing therapeutic outcomes.

Targeted therapy: Nanoparticles can be functionalized with ligands, antibodies, or peptides that specifically target diseased cells or receptors in the skin. This active targeting increases drug accumulation at the desired site while minimizing exposure to healthy tissues. Targeted therapy improves treatment efficacy, reduces side effects, and allows for lower drug doses, which can be particularly beneficial in topical treatments.

Combination therapies: Nanoparticles offer the potential to deliver multiple drugs or therapeutic agents simultaneously. This enables combination therapies, where different drugs with complementary mechanisms of action can be administered together. Combination therapies have the advantage of synergistic effects, addressing multiple aspects of a disease or targeting different pathways simultaneously. Nanoparticles facilitate the co-delivery of these drugs, enhancing treatment outcomes. (Lonappan, D et,al 2018, Light, K.,2022)

Diagnostic and imaging capabilities: Nanoparticles can also serve as diagnostic tools in topical treatments. They can be engineered to carry imaging agents, allowing for non- invasive visualization and monitoring of skin conditions. Nanoparticle-based imaging can provide real-time feedback on treatment progress, enabling personalized medicine approaches and optimizing therapeutic strategies.

Overall, nanotechnology offers numerous advantages in topical treatments, including enhanced drug delivery, controlled release, targeted therapy, combination therapies, and diagnostic capabilities. These features contribute to improved treatment efficacy, reduced side effects, and enhanced patient outcomes. However, it's important to continue research and development to ensure the safety and efficacy of nanotechnology-based topical treatments, as well as address any regulatory considerations. (Patel, A.,et,al 2014)

1.Nanoemulsion:

A colloidal dispersion of two immiscible liquids which is thermodynamically unstable is defined as a nanoemulsion. A colloidal dispersion is made up of particles that are solid, liquid, or gas that is distributed in a continuous phase (solid, liquid, or gas). Colloidal particles are defined as having at least one dimension ranging from 1nm to 1µm.)

Nanoemulsions (NEs) are submicron-sized and have generated growing attention as medication carriers for enhancing therapeutic agent delivery. They are powerful nanodroplet delivery methods for systemic, controlled, and targeted drug delivery.

According to Thakur et al., NEs are colloidal dispersions composed of two immiscible liquids (water and oil), in which one liquid is dispersed in the other using an appropriate surfactant combination, generating a system with droplet sizes ranging from 10 to 200 nm.(Jaiswal, M, 2015)

1. Compared to macroemulsions, nanoemulsions have a larger surface area and a more effective transport system. In contrast to microemulsion, nanoemulsion is a metastable and extremely sensitive system by nature. It has a broad variety of formulations and products, including gels, lotions, all kinds of creams, translucent milk, clear gels, and many more with varied rheological behaviours, richness, and aesthetic qualities. The bioavailability of hydrophilic and lipophilic medicines that are poorly soluble in nanoemulsion is increased. It enhances the performance of the skin barrier and transdermal water loss.

2. Because of the encapsulation, it helps prevent the medications from getting oxidised and hydrolyzed. Due to the lack of any thickening agent or colloidal components, nanoemulsion has an obvious fluidity character that improves formulation treatment efficacy. Because nanoemulsions are thermodynamically stable systems, they can self-emulsify.

3. The quantity of surfactant needed for nanoemulsions is lower than for microemulsions. 20–25 percent surfactant is required to make microemulsion, but 5–10 percent surfactant is sufficient to make nanoemulsion. Additionally, the capacity to produce nanoemulsion in a variety of forms, such as spray, foam, liquid, and cream, has market advantages.

4. Fragrances can be delivered using it in personal care products. Nanoemulsion protects chemically unstable chemicals against oxidative and UV damage, which is useful when using them. It offers both a comfortable skin feels and an attractive aesthetic character.

The droplets may also deposit uniformly over substrates due to their modest size.

The weak interfacial tension of the oil in water droplets and the low overall system surface tension may facilitate wetting, spreading, and penetration. (Sisak, M.,et,al, 2017)

1.1 Advantages of Nanoemulsion:

1. Absorption variability is eliminated.
2. Increases the absorption rate.
3. Aids in the solubilization of lipophilic drugs.
4. bioavailability increase.
5. Provides aqueous dosage form for substances that are insoluble in water.
6. The substance can be delivered in many ways such as topical, oral, and intravenous.
7. The use of Nanoemulsion as a medication delivery technology enhances effectiveness by allowing the total dose to be minimized, hence decreasing adverse effects.
8. Fast and effective drug molecule penetration.
9. Lipophilic as well as hydrophilic substances are carried by nanoemulsions.
10. Aids in taste masking
11. Non-toxic and non- irritant in nature

1.2 Disadvantages of Nanoemulsion:

Low capability for solubilizing high melting compounds.

Environmental factors such as temperature and pH affect the stability of nanoemulsions.

A high concentration of surfactant and cosurfactant is required for Nanodroplet stabilization.

For medicinal uses, the surfactant must be harmless. (Halnor,et,al, 2018 Reza,2011)

1.3 Components of Nanoemulsion:

The main components of nanoemulsion are **oil, emulsifying agents, and aqueous phases**

Oils:

Lipids are made up of fatty acid esters or medium-chain, long-chain saturated, partially saturated, or unsaturated hydrocarbon chains such as triglycerides, diglycerides, and monoacylglycerol. Oil selection for the formation of nanoemulsions is based on drug solubility in the oil phase and drug loading capacity.

Various Examples of oils used for the preparation of Nanoemulsion are as follows:

Oleic acid Castor oil Cinnamon oil, Clove oil, Canola oil, Isopropyl Myristate IPM, Sesame oil, Sunflower oil, Corn oil, Coconut oil, Paraffin oil, Eucalyptus oil, labrafac PG.

Surfactants:

Surfactants are classified as Non-ionic, cationic, anionic, and zwitterionic surfactants.

Surfactants adsorb at the interface of oil and water, lowering surface tension. Emulsifiers cover droplets inside an emulsion, preventing them from aggregating or coalescing. An emulsifier is a surfactant that helps to keep emulsions stable.

Non-ionic surfactants: Because of their low toxicity and minimal interference with Nanoemulsions, non-ionic surfactants are the most often employed form of surfactant in transdermal NEs.

Anionic surfactants: Anionic surfactants, in particular, improve target molecule skin penetration by interacting more powerfully with keratin and lipids.

Cationic surfactants: They alter the electrical characteristics of the SC by interacting with the anionic components there, hence improving the absorption of anionic medicines through the skin. They also affect cornified cells by reacting with keratin fibrils and disturbing the cell-lipid matrix. (Sisak,et,al,2017, Gurpreet, K,2018)

Table.1: Example of surfactants

Sr No.	Surfactant	Examples
1	Non-ionic Surfactant	Polysorbate 80, polyoxyl 40, Sorbitan monooleate.
2	Anionic surfactant	Sulfonates, Divalent ion, Carboxylate groups
3	Cationic Surfactant	Quaternary ammonium compounds, Amines.

Co-Surfactants:

In the manufacture of nanoemulsions, the cosurfactant is usually combined with the surfactant, which reduces the interfacial tension between the two immiscible liquids. According to the Research work of Muhammad Asriabdsisak *et al.* 2017, a medium-chain-length surfactant is the best co-surfactant to use in conjunction with a single-chain surfactant. The chain length of a co-surfactant determines whether or not it is acceptable for emulsion production. In his work, he employed PEG400 (long chain), Transcutol (mid-chain), and propylene glycol (short chain) to analyze the influence of co-surfactant on the manufacture of the microemulsion. (Gurpreet, K.,2018, Kumar,et,al 2019)

II. Material and Methods:

Solubility of *Camellia sinensis* extract:

The solubility of ***Camellia sinensis*** extract in various oils (Isopropyl myristate, Captex 35, Oleic acid, and Capmul 708G, Corn oil), surfactants (Tween 20, Brij 35 and Tween 80), and cosurfactants (Propylene glycol, Transcutol HP) was determined by dissolving a 100 mg extract in 1 gm of each of the selected oils, surfactants, and cosurfactants in stoppered vials. The mixtures were continuously stirred using a vortex mixer for 10 min. solubility was determined visually.

Solubility of *Bombax ceiba* **extract:**

The solubility of *Bombax ceiba* extract in various oils (Isopropyl myristate, Captex 35, Oleic acid, and Capmul 708G, Corn oil), surfactants (Tween 20, Brij 35 and Tween 80), and cosurfactants (Propylene glycol, Transcutol HP) was determined by dissolving a 100 mg extract in 1 gm of each of the selected oils, surfactants, and cosurfactants in stoppered vials. The mixtures were continuously stirred using a vortex mixer for 10 min. solubility was determined visually.

2.1Ternary phase diagrams:

Corn oil was chosen as the oil phase on the results of the solubility tests. Brij 35 and Transcutol HP were chosen as the surfactants and co-surfactants, respectively. Distilled water was used as an aqueous phase. Different mass ratios of surfactant and co-surfactant (Smix) were combined (1:1, 1:2, 1:3, 2:1, 3:1). For a thorough examination of the phase diagrams, these ratios were chosen in increasing concentrations of surfactant concerning co-surfactant and co-surfactant concerning surfactant. Oil and Smix were mixed completely in various glass vials at various mass ratios ranging from 1:9 to 9:1 for each phase diagram. Using the aqueous titration approach, pseudo-ternary phase diagrams of the oil, Smix, and aqueous phases were created. (Safaya,2020)

The following tables show the amount of water added to the point of phase inversion of the

Formulation.

Table.2.1: Amount of water added to the formulations with S-mix ratio 1:1

Ratio (Oil: S-mix)	Oil(g)	Smix(g)	Water(ml)
1:9	0.2	1.8	9
2:8	0.4	1.6	8
3:7	0.6	1.4	3
4:6	0.8	1.2	2.5
5:5	1	1	2
6:4	1.2	0.8	1.2
7:3	1.4	0.6	1
8:2	1.6	0.4	0.2
9:1	1.8	0.2	0.1

Ratio (Oil: S-mix)	Oil(g)	Smix(g)	Water(ml)
1:9	0.2	1.8	8
2:8	0.4	1.6	5.5
3:7	0.6	1.4	6.5
4:6	0.8	1.2	4.5
5:5	1	1	2.4
6:4	1.2	0.8	1
7:3	1.4	0.6	0.6
8:2	1.6	0.4	0.1
9:1	1.8	0.2	0.1

Table.2.2 : Amount of water added to the formulations with S-mix ratio 1:2

Table.2.3: Amount of water added to the formulations with S-mix ratio 1:3

Ratio (Oil: S-mix)	Oil(g)	Smix(g)	Water(ml)
1:9	0.2	1.8	4
2:8	0.4	1.6	2.4
3:7	0.6	1.4	2.5
4:6	0.8	1.2	2
5:5	1	1	1.9
6:4	1.2	0.8	1
7:3	1.4	0.6	1.1
8:2	1.6	0.4	0.8
9:1	1.8	0.2	0.1

Table.2.4 : Amount of water added to the formulations with S-mix ratio 2:1

Ratio (Oil: S-mix)	Oil(g)	Smix(g)	Water(ml)
1:9	0.2	1.8	5
2:8	0.4	1.6	5
3:7	0.6	1.4	2
4:6	0.8	1.2	1.8
5:5	1	1	1.9
6:4	1.2	0.8	1.8
7:3	1.4	0.6	0.4
8:2	1.6	0.4	0.2
9:1	1.8	0.2	0.2

Table 2.5: Amount of water added to the formulations with S-mix ratio 3:1

Ratio (Oil: S-mix)	Oil(g)	Smix(g)	Water(ml)
1:9	0.2	1.8	6
2:8	0.4	1.6	4
3:7	0.6	1.4	2.2
4:6	0.8	1.2	3
5:5	1	1	2.4
6:4	1.2	0.8	1.9
7:3	1.4	0.6	1.4
8:2	1.6	0.4	0.4
9:1	1.8	0.2	0.3

Used Software: Chemix school:

Procedure:

1. Open the Chemix school software. Click on the **ternary plot**.

2. After opening the window of the ternary plot, you can **add the title** of your diagram (i.e., Ratio 1:1).

3. Below the title you can add names of ternary phases **(i.e., Oil, Smix, Water)**.

4. Copy your 1st data set from the Excel sheet (i.e., your results of Aqueous titrations) and paste it into the box.

5. Click on **Normalize** option then on interpolate select the option **Natural cube spline**.

6. Then select **spline/poly mode** which is below the calculate. Connect all the points which are shown in the plot.

7. Then select **fill mode** instead of **spline/ poly mode** to fill the clear emulsion region of the plot. You can use different colours to fill the phase. The same procedure was followed for further different Smix ratios. (Jadhav,et,al,2020)

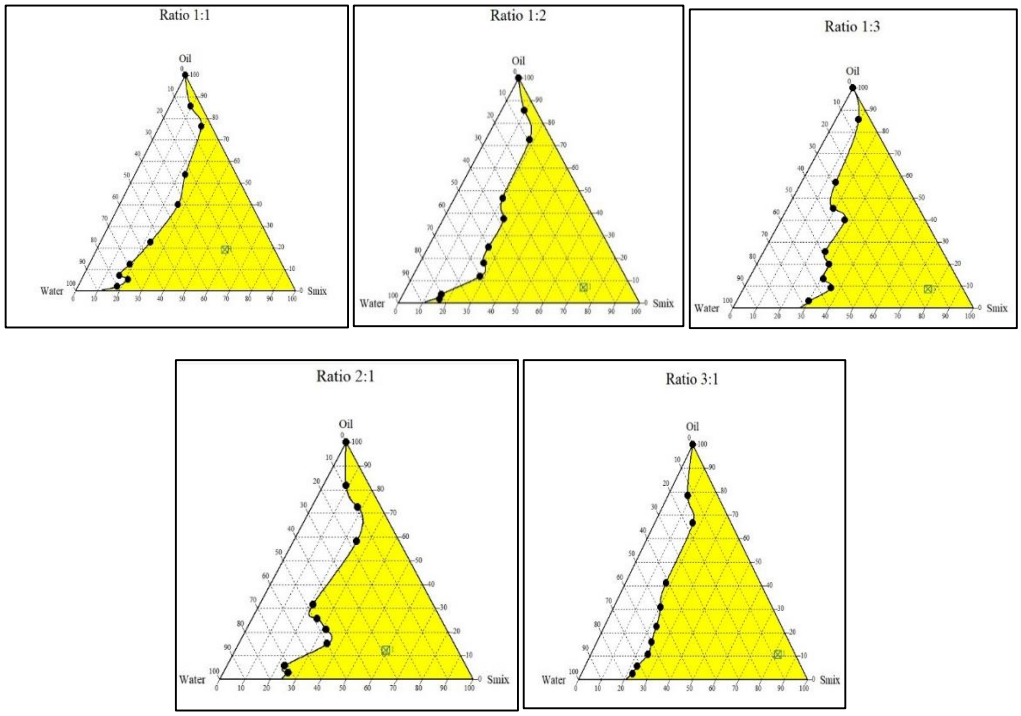

Fig. 2.1: Ternary phase diagram with different ration of oil, water and S mix

As surfactant concentration was increased in the Smix ratio, a higher nanoemulsion area was observed. The smix ratio (3:1) shows a greater nanoemulsion area hence it was selected for the formulation of nanoemulsion.

Table .2.6: Batch of 9 Runs combination mixtures of Nanoemulsion

Runs	Oil (%)	Smix (%)	Water (%)	*Camellia sinensis* Extract(mg)	*Bombax ceiba* Extract(mg)
1	30	30	40	30	7.5
2	30	50	20	30	12.5
3	20	50	30	20	12.5
4	30	40	30	30	10
5	10	30	60	10	7.5
6	20	40	40	20	10
7	10	40	50	10	10
8	10	50	40	10	12.5
9	20	30	50	20	7.5

2.2 Fomulation of CS and BC-loaded Nanoemulsion system:

For the preparation of extracts-loaded NE, aqueous titration was used. Firstly, ***Camellia sinensis*** extract was dissolved in the oil phase. i.e., corn oil (10mg extract /1gm oil) and *Bombax ceiba* extract was dissolved in cosolvent. i.e., Transcutol HP (10mg extract / 1gm cosolvent). According to Ternary phase diagrams (3:1), the Smix ratio was used. According to 9 runs which are given by DoE, oil and Smix were weighed in different glass vials in which extracts were dissolved and then mixtures were vortexed for 5 minutes with a vortex mixer. After that stirred by using a magnetic stirrer at 300 RPM for 30 mins. After that Dropwise, distilled water was added to the mixture while it was being stirred continuously then by using a Probe sonicator (Sonic VibraCell) ultrasonication of the emulsion was done. In brief, NE was prepared with optimized parameters, i.e., ultrasonication intensity of 20.0%, ultrasonication time of 25 min, and temperature of 37 °C which formed clear and homogenous NE. Ultrasonic emulsification uses a probe that emits ultrasonic waves to break up macroemulsions through cavitation forces.

2.3 Characterization of the developed NE

Physical Appearance:

The appearance of NE was checked visually.

Globule Size and Polydispersity Index Analysis:

The sample formulation, which included about 1 ml, was further diluted with 4 ml of distilled water, and the Zetasizer (Nano-ZS90, Malvern Instruments, Worcestershire, UK) was used to measure globule size and PDI. Three replicates of the average droplet size were measured for 9 Samples

Zeta Potential:

The sample formulation, which included about 1 ml, was further diluted with 4 ml of distilled water, and the Zetasizer (Nano-ZS90, Malvern Instruments, Worcestershire, UK) was used to measure Zeta Potential. (Safaya,2020, Jadhav,et,al,2020]

Refractive Index and Viscosity:

Abbe's refractometer was used to measure the refractive Index of optimized NE. The viscosity of the optimized NE formulation was measured using a brook field viscometer.The refractive index of O/W optimized NE was found to be **1.392** which is closer to water RI (RI of water = 1.333), which indicates NE is **more uniform** and **transparent.**The Viscosity of O/W optimized NE was found to be **26.9 cPS** at 100 RPM.

pH:

The pH of optimized NE was measured by using calibrated pH meter

Conductance:

The conductivity of optimized NE was measured by using calibrated conductometer.

In Vitro Diffusion Study:

The Franz diffusion cell was used for Nanoemulsion in vitro diffusion experiment. The diffusion cell apparatus is a cylindrical, open-ended tube. 1 ml of the NE was placed onto the *0.45 µm* nylon membrane filter and was immersed slightly in 7 ml of receptor medium (phosphate buffer pH 5.5) which was continuously stirred at 300 RPM and the temperature was maintained at 37±1°C. Aliquots of 1ml were withdrawn from the system at time intervals of 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 and 330 minutes and were analyzed for drug content using an ultraviolet spectrophotometer at 260 and 274 nm. To maintain the sink conditions in the receptor compartment, the same volume of fresh buffer solution was added. (Choradiya,2021, Hussain, et,al, 2016)

Stability testing of NE:

The sample was kept at refrigerator temperature (4°C) and room temperature for stability tests on optimized Nanoemulsion. These studies were carried out for three months. After 3 months, the particle size, viscosity, and refractive index were measured. Accelerated stability studies on optimized Nanoemulsion were also carried out by the International Conference on Harmonization (ICH) standards.Three samples of optimized formulation were stored in glass vials at accelerated temperatures of 40±°C at ambient humidity. The samples were collected After 3-month periods. The drug content of these samples was determined using HPTLC.

Skin irritation test:

Albino Wistar rats weighing 200–300 g was obtained from AISSMS College of Pharmacy. Pune, India. All animals received standard food and water, and they were subjected to 12-hour cycles of light and darkness. Relative humidity was kept at 45% and the temperature was kept at 25°C. AISSMS College of Pharmacy in Pune's Institutional Animal Ethical Community gave its approval for all animal care and handling procedures.

The institutional animal ethics committee at AISSMS College of Pharmacy approved the protocol with permission number **CPCSEA/IAEC/PT-13/01-2K23**. The albino Wistar rats were kept in cages made of polypropylene.

After the dorsum was removed, albino rats were subjected to a skin irritation test. A small region (6 cm^2) is treated with a test substance (0.5 ml Nanoemulsion), and the treated site is covered with a patch. After 4 hours, the patch is removed, and indications of erythema and edema are assessed, as well as responses at 1, 24, 48, and 72 hours. The initial test is performed on one animal, and the test site is examined shortly after the patch is removed. If the test substance is not corrosive, a confirmatory test with an extra two animals is performed. Depending on the intensity, erythema and oedema are graded from 0 to 4. (Sadeq, Z. A. (2020), Patel, 2012)

Table.2.7: Grades for erythema and oedema

No erythema	0
Very slight erythema	1
Well defined erythema	2
Moderate to severe erythema	3
Severe erythema (beef redness) to eschar formation preventing grading of erythema	4

Referred: OECD guideline for testing of chemicals Acute Dermal Irritation/Corrosion

III. Result and discussion:

3.1 Globule Size and Polydispersity Index Analysis

The nanoemulsion's smaller droplet size denotes enhanced drug bioavailability and faster absorption. Results showed that the mean droplet size diminishes as Smix concentration rises. The optimised formula displayed a droplet size of 17.55 nm and a polydispersity value of 0.534.

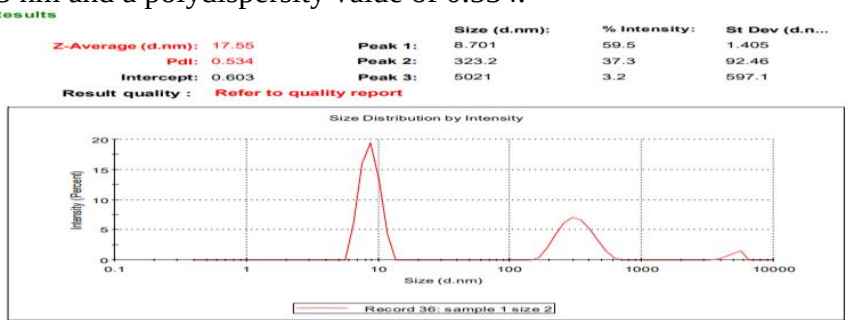

Fig.3.1 : Globule size

3.2 Zeta potential:

The optimised formula found a Zeta Potential of -4.17. It shows that NE is moderately stable.

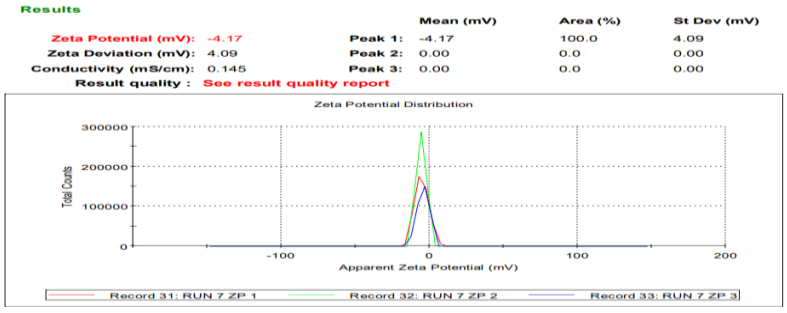

Fig.3.2 : Zeta potential

In Vitro Diffusion Study:

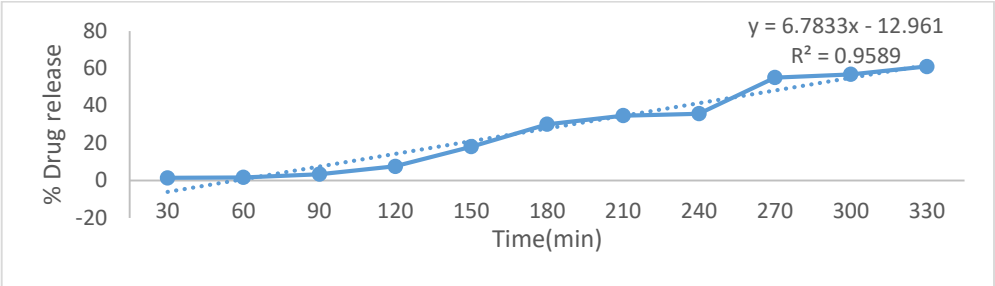

Fig.3.3 % drug release of EGCG from Nanoemulsion

Nanoemulsion releases up to 60.92 % of EGCG within 330 minutes which shows that Nanoemulsion shows better release.

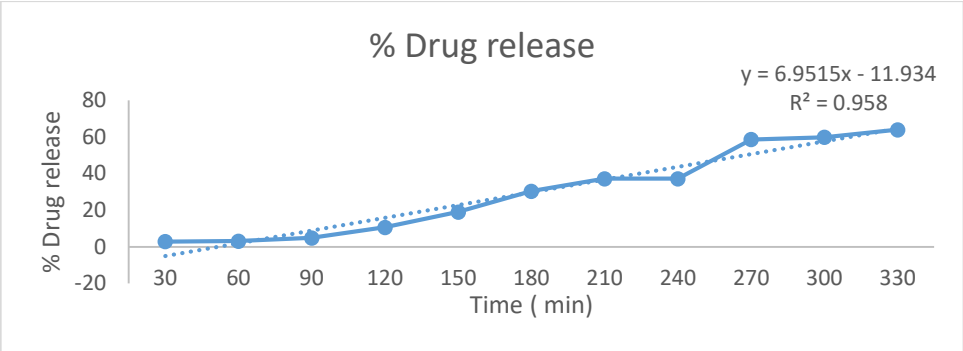

Fig.3.4 % drug release of Gallic acid from Nanoemulsion

Nanoemulsion releases up to 63.90 % of Gallic acid within 330 minutes which shows that Nanoemulsion shows better release.

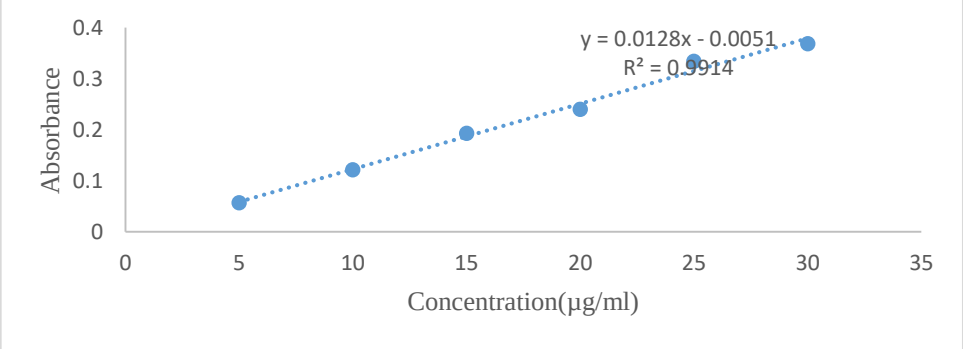

Fig.3.5 Calibration curve of EGCG in Phosphate buffer 5.5 pH

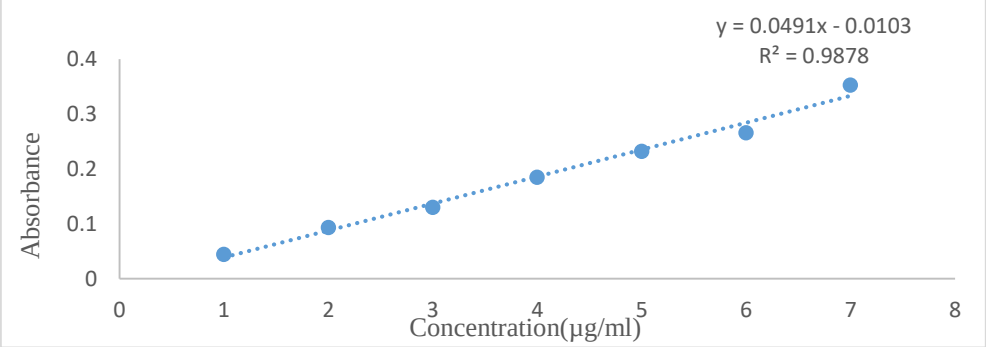

Fig.3.6 Calibration curve of Gallic acid in Phosphate buffer 5.5 pH

Table 3.1: Stability testing of NE:

Stability Parameters	Observations
Room Temperature	**Stable**
4°C	**Stable**
40°C and 75 % RH	**Stable**

Skin irritation test:

There is no sign of erythema or oedema formation in the entire period of 72 h.

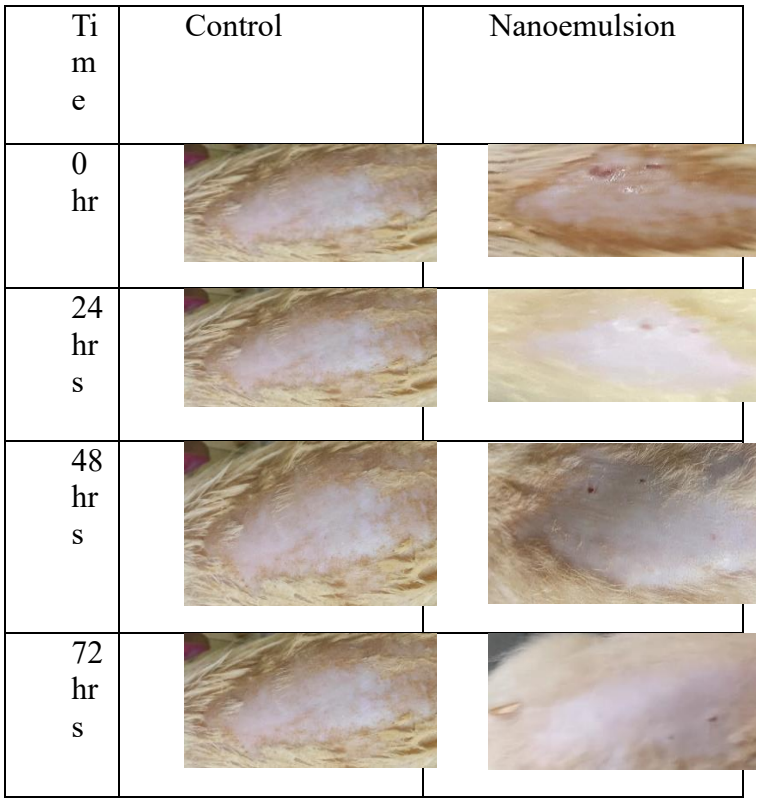

Fig.3.7 Skin irritation test

Based on the solubility study, Brij 35 was selected as a surfactant and Transcutol HP was selected as a co-surfactant and Corn oil was selected as an oil. Using the aqueous titration approach, pseudo-ternary phase diagrams of the oil, Smix, and aqueous phases were created by using chemix school software. The Smix ratio of 3:1 was finalized for the final formulation. Nano-emulsion is evaluated for physical appearance, globule Size and polydispersity index analysis, zeta potential, refractive index and viscosity, pH, conductance, In-vitro antioxidant activity, In vitro diffusion Study, and skin irritation test. Nanoemulsion was found to be clear and transparent. The optimised formula displayed a droplet size of 17.55 nm and a polydispersity value of 0.534. The optimised formula found a Zeta Potential of -4.17. It shows that NE is moderately stable. The refractive index and Viscosity of O/W optimized NE were found to be 1.392 and 26.9 cPS respectively. The pH of optimized NE was found to be 5.45 which is near skin pH. Nanoemulsion releases up to 60.92 % of EGCG and 63.90 % of Gallic acid within 330 minutes which shows that Nanoemulsion shows better release. Skin irritation test shows no sign of erythema or oedema formation in the entire period of 72 h.

Conclusion:

In conclusion, the development of a nanoemulsion incorporating Camellia sinensis and Bombax ceiba represents a promising advancement in pharmaceutical and cosmetic sciences. This innovative formulation offers improved stability, enhanced bioavailability, potential synergistic effects, and diverse applications, paving the way for the development of novel therapeutic and skincare products.

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