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HERBAL NANOEMULGEL: A NOVEL DRUG DELIVERY SYSTEM

[1]Pramod Radhakisan Dengale , [2]Nikita Dattatraya Gavhane ,
[3]Rutuja Dattatraya Kakad, [4]Sonali Rajendra Harde, [5]Sakshi Sanjay Shelake

[1]Assistant Professor, [2]UG Student, [3]UG Student, [4]UG Student, [5]UG Student
[1]Department of Pharmaceutics,
[1]PRES`S Institute of Pharmacy, Loni Tal.: Sangamner Dist.: Ahilyanagar, Maharashtra, India

Abstract : A new drug delivery technology called nanoemulgel aims to improve the therapeutic profile of lipophilic medications. Among the many drawbacks of lipophilic formulations are their low oral bioavailability, inconsistent absorption, and poor solubility. An amalgamated preparation of many systems called nanoemulgel attempts to address these drawbacks. By adding nanoemulsion to gel, a unique system is created that enhances stability and allows for both immediate and controlled release of the medicine. Because of its safety profile, ease of application, lack of gastrointestinal degradation or first pass metabolism, and capacity for targeted delivery, nanoemulgel has also drawn more attention. The pharmacokinetics, safety profiles, and formulation elements of nanoemulgel for topical drug delivery are the main topics of this review. Topical delivery, permeability, surfactant, bioavailability, and nanoemulgel.

Keyword: *Nanoemulgel, Lipophilic, Topical ,Targeted Delivery*

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1. INTRODUCTION

The goal of the novel drug delivery technique known as nanoemulgel is to enhance the therapeutic profile of lipophilic drugs. Lipophilic formulations have numerous disadvantages, including poor solubility, variable absorption, and limited oral bioavailability. Nanoemulgel is an amalgamated preparation of many systems that aims to overcome these limitations. A special approach that improves stability and permits both immediate and regulated release of the medication is produced by mixing nano-emulsion with gel. Because of its safety profile, ease of application, lack of gastrointestinal degradation or first pass metabolism, and capacity for targeted delivery, nanoemulgel has also drawn more attention. This review focuses on the formulation components, safety characteristics, and pharmacokinetics of nanoemulgel for topical drug administration. Topical administration, nanoemulgel, permeability, surfactant, and bioavailability. [2-4]. Because of their limited bioavailability, which is linked to poor absorption, first-pass metabolism, and chemical and enzymatic degradation, oral delivery of medications is not always practical, even with the use of numerous technologies to increase solubility [5,6]. Additionally, oral drug administration is hampered by clinical issues and low drug concentrations at the site of action

For instance, hepatotoxicity, hematologic toxicity, and carcinogenicity are among the adverse effects linked to the oral administration of disease-modifying anti-rheumatic medications (DMARDs), which are used to treat arthritis [7,8]. By administering the medication topically, these clinical side effects can be minimized [9].The pharmaceutical and cosmeceutical industries have adopted gel formulations based on nanoemulsions as a solution to some of these problems. A promising substitute to enhance drug delivery and solubility is a nanoemulsion, which can be either O/W or W/O in size and behave as a dispersed system. By incorporating a nano-emulsion into the gel matrix, nanoemulgel releases oil droplets from the gel upon application, which pierce the skin's stratum corneum and transport the medication to the desired location. Additionally, compared to creams and ointments, they are less sticky and more spreadable, which improves patient compliance.Additionally, the preparation time and expense of nanoemulsion-based gels are reduced because they don't require any costly, advanced equipment. In order to maintain the drug's release, enhance patient compliance, and prevent repeated administration, the project aims to create a Posaconazole nanoemulsion to boost its solubility and a Posaconazole-loaded nanoemulsion-based gel for topical administration in a single dose. [41,42]

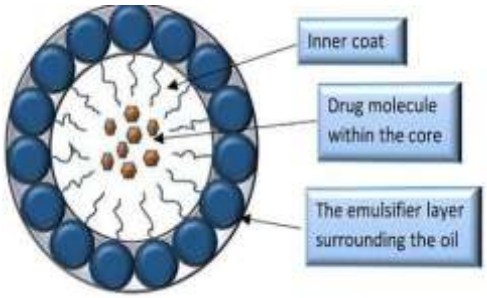

Fig 1. Diagram of nanoemulsion

Fungal skin infections are the most frequent cause of skin illness across the majority of age groups. Invasive candidiasis, ringworms, Mucor mycosis, oral thrush, and other fungal infections can be mild or severe in humans. One These infections can range from minor rashes on the skin, nails, or mucosa to systemic infections, where the fungus spreads through the blood and can colonize any major internal organ. Candida species are among the more relevant etiological agent's causative of superficial and invasive fungal infections. C. albicans is an opportunistic pathogen that lives in the gut, genitourinary tract, and skin as a harmless commensal. However, it can turn into an opportunistic pathogen in a variety of host conditions, typically involving an imbalance of the competing bacterial microflora or decreased immune competence. Despite the fact that Candida is the primary cause of surface opportunistic infections, antifungal treatment is not widely available. [43]Because herbal remedies are widely used, have therapeutic benefits, and have less side effects than contemporary medications, there is a global shift away from synthetic drugs. However, because of their low oral absorption, instability, poor solubility, poor bioavailability, and unpredictable toxicity, herbal medications are not widely used. Nanotechnology has been used in the development of several drugs to address these problems with traditional remedies. Incorporating herbal medications into nano-carriers enhances their useful and efficient effects. Using a drug in a carrier system or altering the drug's molecular structure are two ways to implement nanotechnology [42]

By breaking down the lipid bilayer, as demonstrated by the noticeable void and empty spaces in the skin samples treated with nanoemulsion, the literature has shown that nanosized topical formulations increase the permeability of the active moiety, increase drug retention at the site of action [05], and help get around problems with the current crystallization processes [06]. According to research, nanoemulsions have a greater capacity for drug solubilization and are superior to emulsions and suspensions due to their thermodynamic stability. Low viscosity and spreadability are the primary disadvantages of topical nanoemulsion formulations, despite their many advantages [43]. The literature has demonstrated that nanosized topical formulations increase the permeability of the active moiety, increase drug retention at the site of action [05], and help circumvent issues with the current crystallization processes [06] by breaking down the lipid bilayer, as evidenced by the noticeable void and empty spaces in the skin samples treated with nanoemulsion. Research indicates that because of their thermodynamic stability, nanoemulsions are better than emulsions and suspensions and have a higher capacity for drug solubilization. Although topical nanoemulsion formulations have several benefits, their main drawbacks are low viscosity and spreadability [43].

2. History:

Emulgel was first conceptualized as a hybrid dosage form that combined the qualities of gels and emulsions in the late 20th century. Because they offered superior spreadability, viscosity, and patient compliance over ointments and creams, conventional emulgels became more and more popular in dermatology and topical drug delivery. Their primary flaw, though, was their restricted capacity to administer lipophilic medications, which frequently exhibited poor solubility and little skin penetration. The nano-emulgel system was created in the early 2010s as a result of researchers integrating nanoemulsions into a gel matrix to get around these restrictions. This innovative hybrid solution combines the thickening and spreadability of gels with the penetration-enhancing properties of nanoemulsions, making it appropriate for targeted, controlled, and prolonged topical distribution. Nanoemulgels were identified as a unique and promising drug delivery method in early reviews published in the International Journal of Pharmaceutics and Nanomedicine. Since then, nanoemulgels have developed into a much studied delivery technology with uses in dermatology, cosmeceuticals, and pharmaceuticals, particularly for anti- inflammatory medications, antifungals, analgesics, and herbal actives. [37]

➢ **Advantages** [38,39]

- Enhanced Solubility and Bioavailability.
- Improved Skin Penetration.
- Controlled and Sustained Release.
- Better Stability.
- Ease of Application and Patient Compliance.
- Bypass of First-Pass Metabolism.
- Versatility

➢ **Disadvantages** [40]

- High Production Cost.
- Formulation Complexity.

- Regulatory Challenges.
- Limited Drug Loading.
- Skin Irritation Potential.
- Stability Issues.

3. Nanoemulgel Drug Delivery System:

Despite their numerous benefits, nano-emulsions lack spreadability due to their low viscosity, which results in poor formulation retention on the skin [22]. This constraint limits nanoemulsions' clinical applications [23]. This issue has been addressed by including a gelling agent into the nanoemulsion, yielding a nanoemulgel [24]. Gels are formed by combining significant volumes of aqueous or hydroalcoholic bases in a colloidal particle structure [25]. Nanoemulgel is formed by inserting a nano-emulsion into a hydrogel matrix, which reduces the emulsion's thermodynamic instability. The increased consistency of the external medium reduces the mobility of the non- aqueous phase, resulting in improved thermodynamic stability.The formulation's improved retention duration and thermodynamic stability allow the medication to be released over time, changing nanoemulgel into a controlled release dosage form for topical administration, which advantages medicines with a short half-life [19,26]The integration of nano-emulsion to a gelling process helps to overcome the limitations of both independent technologies. The combination nanoemulgel combines the advantages of a gel and the precise properties of a nano-emulsion. Table 2 shows the advantages of nanoemulgel over traditional emulgel in terms of particle size and thermodynamic stability. Nanoemulgels offer numerous advantages, including enhanced skin penetration, higher loading of an active moiety, less irritation, and increased spreadability. This is seen when compared to other nano-carriers such liposomes and solid lipid nanoparticles.The nano-emulsion's enhanced viscosity makes it suitable for topical use. To accomplish this, numerous skin-friendly gelling agents, including xanthan gum, carbomer 980, Pluronic's, carrageenan, and carbomer 934, are applied topically [27]. Nanoemulsions offer adequate localization and drug dispersion by allowing for proper percutaneous absorption throughout the skin. This helps to increase efficacy both locally and systematically via the skin. This approach can also be used to deliver drugs to the central nervous system (CNS) because it can cross the blood-brain barrier when administered by the nose [28,29].

4. EXCIPIENTS IN NANOEMULGEL:

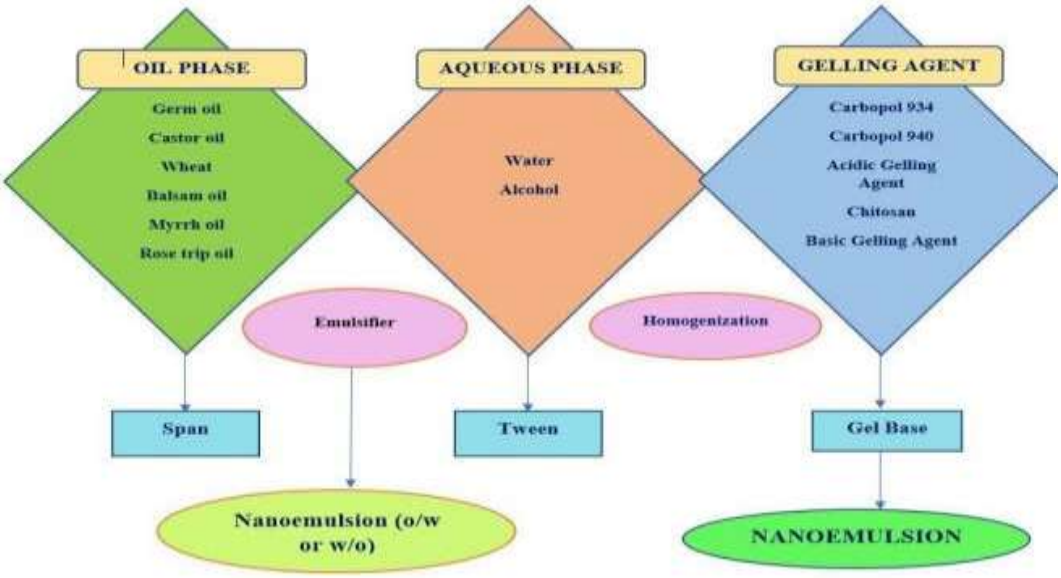

Fig 2: Types of Excipients

4.1 Oil Phase: The oil phase in a nanoemulgel is an important component that dissolves lipophilic medicines, forms nanosized droplets, and improves drug stability and skin penetration. It serves as a medium for incorporating poorly water-soluble medicines, increases bioavailability, and can control drug release for rapid or sustained administration. Natural oils such as coconut, olive, and almond oil; synthetic oils such as isopropyl myristate and medium-chain triglycerides; and essential oils such as tea tree or peppermint, which may also have therapeutic properties. The selection of the oil phase is determined by medication solubility, safety, stability, and compatibility with other formulation components. [45]

4.2 Aqueous Phase : The oil phase in a nanoemulgel is a key component that dissolves lipophilic medications, creates nanosized droplets, and increases drug stability and skin penetration. It acts as a carrier for poorly water-soluble drugs, improves bioavailability, and can modulate drug release for quick or prolonged administration. Natural oils include coconut, olive, and almond oil; synthetic oils like isopropyl myristate and medium-chain triglycerides; and essential oils like tea tree or peppermint, which may have therapeutic effects. The oil phase is chosen based on the medication's solubility, safety, stability, and compatibility with other formulation components. [45]

4.3 Gelling Agent: Gelling agents are critical components of nanoemulgels, providing viscosity, consistency, and mechanical stability to the formulation. They convert the liquid nanoemulsion into a semi-solid gel, which improves spreadability, simplicity of application, and patient compliance. Carbomers (Carbopol), hydroxypropyl methylcellulose (HPMC), xanthan gum, and tragacanth are among the most often used gelling agents. The gelling agent's composition and concentration have an impact on the gel's rheological properties, drug release profile, and skin retention. A suitable gelling mechanism also aids in the stabilization of dispersed nanoemulsion [46].

5. APPLICATION:

Table 1. Applications of Nanoemulgel DDS

Therapeutic Use	Specific Examples (Drugs/Herbals)	Marketed/Investigational Products
Dermatology (Acne, Psoriasis, Fungal Infections, Wound healing)	Clindamycin, Benzoyl peroxide, Ketoconazole, Terbinafine, Curcumin, Aloe vera	Nizoral® cream (Ketoconazole); Lamisil® gel (Terbinafine); Curcumin nanoemulgel (investigational)
Musculoskeletal Disorders (Pain & Inflammation, Arthritis)	Diclofenac, Ketoprofen, Ibuprofen, Indomethacin	Voltaren® Emulgel (Diclofenac); Fastum® gel (Ketoprofen); Dolgit® cream (Ibuprofen)
Cardiovascular Disorders (Hypertension, Angina, Hyperlipidemia)	Nifedipine, Propranolol, Nitroglycerin, Silymarin, Curcumin	Nitro-Bid® ointment (Nitroglycerin); Procardia® patches (Nifedipine, experimental); Herbal nanoemulgels (research phase)
Neurological Disorders (Migraine, Epilepsy, Parkinson's)	Sumatriptan, Dopamine agonists (experimental)	No approved marketed nano- emulgel yet (research formulations under study)
Infectious Diseases (Bacterial, Fungal, Viral)	Ciprofloxacin, Mupirocin, Clotrimazole, Acyclovir	Zovirax® topical (Acyclovir); Canesten® cream (Clotrimazole); Nanoemulgel prototypes (research
Ophthalmic Disorders (Glaucoma, Inflammation, Keratitis)	Timolol, Ketorolac, Natamycin	Timoptic® (Timolol eye drops); Acular® (Ketorolac); investigational nanoemulgels for ocular delivery
Oral/Buccal Delivery	Curcumin, Silymarin, Diclofenac, Lidocaine	Curcumin nanoemulgel (investigational); Xylocaine® gel (Lidocaine)
Vaginal/Rectal Delivery (Antifungal, Antiviral, Microbicidal)	Clotrimazole, Miconazole, Tenofovir (ARVs)	Gyno-Daktarin® (Miconazole cream); Tenofovir nanoemulgel (clinical trials for HIV prevention)
Anticancer Applications	Paclitaxel, Doxorubicin, Resveratrol, Curcumin	Abraxane® (Paclitaxel nanoemulsion, IV); Resveratrol nanoemulgels (investigational)
Cosmetic & Cosmeceutical Uses (Anti-aging, Sunscreen, Skin whitening)	Retinoids, Vitamin E, Coenzyme Q10, Arbutin, Kojic acid	Retin-A® gel (Tretinoin); Olay® anti-aging creams (CoQ10, Vit E); Herbal nanoemulgel cosmetics (investigational)

6. KEY CRITERIA FOR DRUG SELECTION

6.1 Lipophilicity

Lipophilic medicines (those that are weakly water soluble) are especially well suited to nanoemulgels because they dissolve easily in the nanoemulsion's oil phase. Lipophilic medicines benefit from increased solubility, bioavailability, and skin penetration when administered by nanoemulgel. [44]

6.2 Molecular Size

The molecular weight of the medicine influences its capacity to permeate the skin. Drugs with a molecular weight of less than 500 Da are ideal candidates for effective diffusion across the stratum corneum. Drugs with high molecular weight may require penetration enhancers or different delivery mechanisms. [45]

6.3 Stability

The medicine must be chemically and physically stable in both oil and water, as well as compatible with surfactants, cosurfactants, and gelling agents. Drugs that are susceptible to hydrolysis, oxidation, or photodegradation require antioxidants or encapsulation techniques to remain stable. [46]

6.4 Therapeutic Activity

The medicine should have strong pharmacological efficacy at low doses since nanoemulgels can give controlled or prolonged release, lowering the frequency of application. Drugs with narrow therapeutic windows must be carefully examined to avoid toxicity. [47]

6.5 Skin Permeation Potential

For topical and transdermal distribution, the medication must have acceptable penetration qualities. Depending on the therapeutic goal, drugs with moderate lipophilicity and good partition coefficients (log P 1-3) provide effective skin penetration while reducing systemic absorption. [47]

6.6 Safety and Irritation Potential

Drugs designed for topical use must pose little risk of local irritation or sensitization. In addition, formulation components should be non-toxic, non-irritant, and drug-compatible. [45]

7. COMPOSITION

Table 2. Composition of Nanoemulgel

Component	Importance	Examples
Oil phase	Solubilizes herbal active, enhances bioavailability, aids skin penetration	Neem oil, Clove oil, MCTs
Surfactants	Reduces interfacial tension, stabilizes nanoemulsion droplets	Tween 80, Cremophor RH40
Co-surfactants	Improves stability, prevents droplet coalescence	PEG-400, Propylene glycol
Gelling agents	Provides viscosity, spreadability, and retention on skin	Carbopol, HPMC
Aqueous phase	Disperses system, supports hydration, forms continuous phase	Purified water
Additives	Enhances stability, provides hydration, preserves formulation	Preservatives, Glycerin

8. PREPARATION OF NANOEMULGEL:

Nanoemulgel is a non-equilibrium formulation of structured liquids that requires energy, surfactant, or both to prepare. They are formed spontaneously by combining the components. This is accomplished by either infusing energy into the biphasic system or reducing the interfacial tension between the two immiscible phase surfaces [30]. Various nanoemulgel preparation methods have been reported, depending the sequence in which depending aqueous phases are mixed [31]. Lupi et al. (2014), as shown in Figure 3A, dissolved the medication in the oil phase and the gelling agent in the water phase separately. To make an emulsion, the oil phase is stirred into the aqueous gel phase and then homogenized.The sol form of the gelling agent in the emulsion is transformed to gel via a variety of methods, such as the addition of a complexing agent or the adjustment to the necessary pH [32]. Dong et al. (2015), as shown in Figure 3B, divided the total amount of water required for the preparation into two sections. One portion of the divided quantity is used to make the preemulsion, while the other is used to make the gel. Later, these two components are combined together while stirring [33]. Jeengar et al. (2016) produced the emulsion and gel separately, then combined them in a 1:1 w/w ratio [34].
This method is most commonly used for phase transitions during phase inversion. Cooling with constant stirring causes the emulsion to reverse after being formed at inversion temperature. Reducing the phase inversion temperature makes it easier to include thermolabile components using this strategy [36]. In this case, the formulation's shear thinning tendency creates a thin layer on the skin's surface, increasing permeability, whereas a thicker formulation reduces permeation. As a result, rheological behavior is a critical aspect in nanoemulgel formation, and various different types of viscometers can be employed to determine it [16].

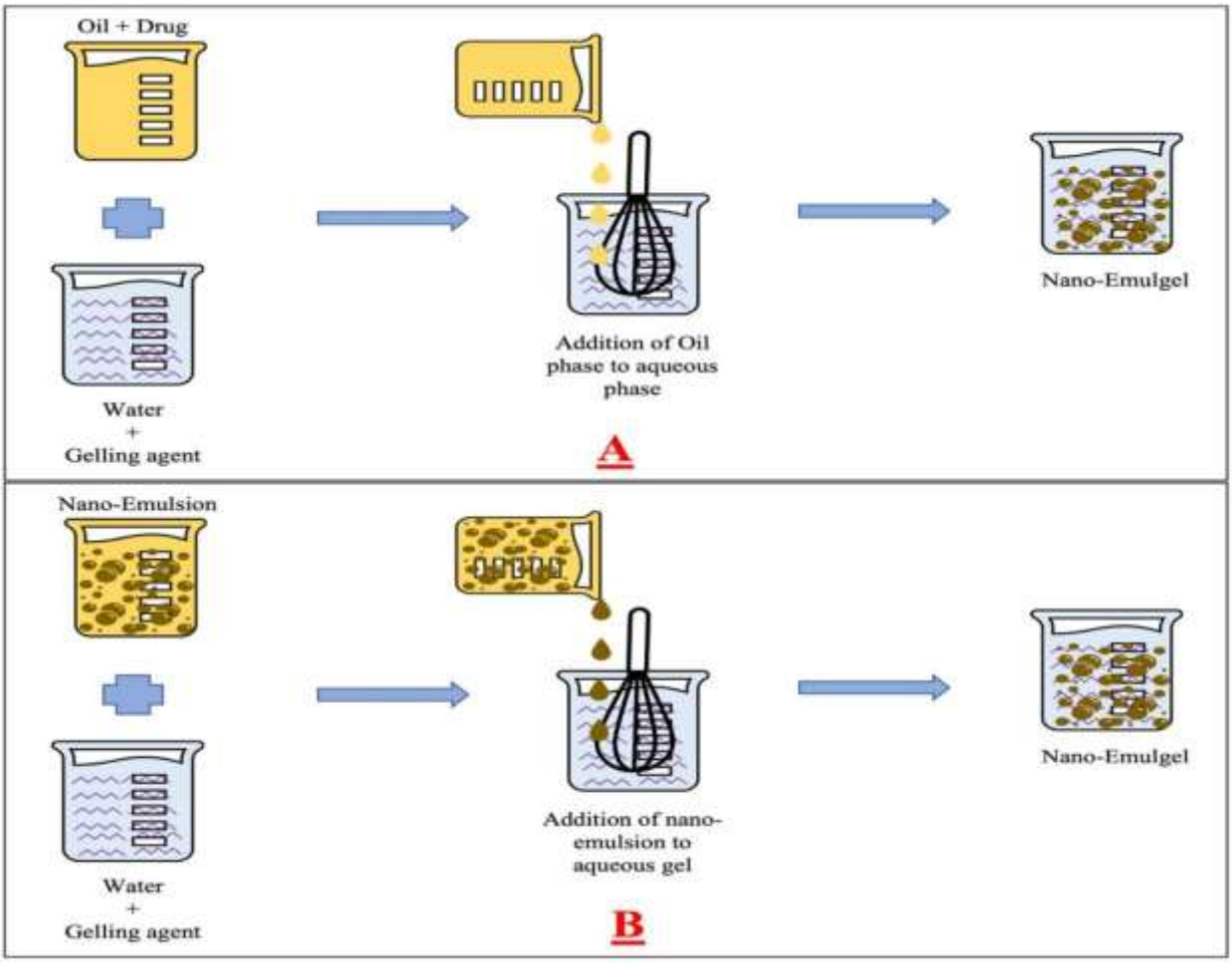

Fig 3. Schematic representation for the preparation of nano-emulgel by (3A) adding Oil (oil + drug) phase to aqueous (water + gelling agent) phase (3B) adding nano-emulsion to aqueous (water + gelling agent) phase.

Nanoemulgel formulation preparation is further classified into two categories based on the use of high- and low- energy emulsification processes. The high energy approach employs mechanical devices to provide a highly disruptive force, resulting in size decrease in both phases. As a result, this approach may cause components in the formulation to heat up, resulting in thermodynamic instability and rendering the formulation unsuitable for thermolabile medications. High-energy methods for creating a nanosized emulsion include microfluidizers, high- pressure homogenizers, and ultrasonication. This approach is used to create nano-formulations with diameters of around 1 nm. Low energy approach approaches include phase inversion, self-emulsification, temperature control, and phase transition. These procedures ensure the nano-emulsion's thermodynamic stability.

The spontaneous approach, which involves combining oil, surfactant, and water in the greatest possible ratio, is particularly suitable for thermolabile chemicals. The surfactant and co-surfactant properties, as well as the order in which they are added, determine the emulsifying process. Temperature-dependent changes in HLB are used for non-ionic surfactants such as Tween 20, Tween 60, Tween 80, and Labrasol [35]. This method is most commonly used for phase transitions during phase inversion. Cooling with constant stirring causes the emulsion to reverse after being formed at inversion temperature. Reducing the phase inversion temperature makes it easier to include thermolabile components using this strategy [36]. The second stage involves adding a gelling agent to the nano-emulsion, which converts the liquid state to a gel. The thixotropic characteristic of the gelling ingredient facilitates the gel solution. conversion when shear stress is applied to the preparation keeping the volume constant. This leads to thickening in o/w nano-emulsion because of the creation of a gelled structure.

9. MANUFACTURING OF NANOEMUGEL

9.1 Development of Ternary Phase Diagram

The existence of nanoemulsion regions was determined by using pseudo ternary phase diagram. Oleic acid as oil phase, Tween 80 as surfactant and Transcutol-P as co-surfactant were selected from the solubility studies. Pseudo ternary phase diagrams were constructed by titrating the blend of oil and surfactant: co-surfactant mixture (Smix) without drug by incremental amounts of water. Mixture of surfactant and cosurfactant were prepared in different weight ratios (1:1, 2:1, 3:1, 3:2, 4:1). Each Smix was mixed with oil in different weight ratios (oil: Smix) 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1. Each mixture of oil and Smix was subjected to vortex mixing to form homogenous mixture before titration with water. During titration the aqueous phase was added in drop wise until turbidity is formed. These values of oil, surfactant and cosurfactant were used to determine the boundaries of nanoemulsion region identified in the region of the phase diagram which showed the maximum and minimum levels of mixtures for the formulation of NE. The visual appearance of the homogenous mixture was noted down for clear and easily flowable o/w nanoemulsions.[47,48]

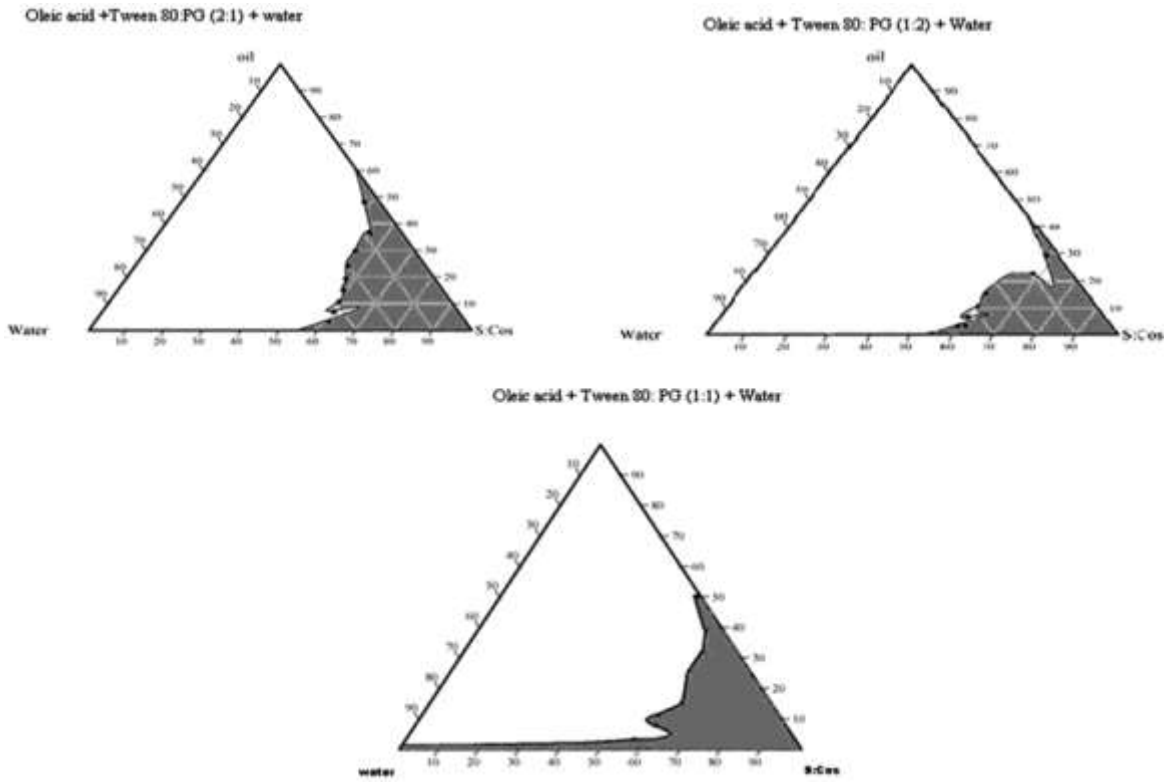

Fig 4 : Pseudo ternary plot for Smix ratio A(3:1), B(3:2), C(1:1)

10. EVALUATION

10.1 Zeta Potential

The particles in a solution typically have a layer of ions on their surface known as the stern layer. Adjacent to the stern layer is a diffuse layer of loosely bound ions, known as an electrical double layer. There is a distinction between ions in the diffuse layer that travel with the particle and those that stay with the bulk dispersion. The zeta potential is the electrostatic potential at the "slipping plane" border [10]. Zeta potential measurements provide an indirect estimate of net charge and are used to assess batch-to-batch consistency. The higher the zeta potential, the greater the repulsion, which improves the formulation's stability. For example, emulsion globules' high zeta potential prohibits them from combining. A surface charge modulator can also be used to adjust the surface charge. For example, applying a negatively charged surface modification reduces the zeta-potential value, and vice versa. [11,12].

10.2 Droplet Size Measurement and Polydispersity Index (PDI)

The size of a globule in nanoemulgel is known as its hydrodynamic diameter, which is the diameter of an equivalent hard sphere that diffuses at the same rate as the active moiety [13]. The PDI defines the distribution of droplet size as the standard deviation divided by the mean droplet size. Droplet size and polydispersity index are directly related to drug stability and release, as well as the dosage form's ex-vivo and in-vivo performance. Furthermore, it is critical to assess consistency across multiple batches.The formulation's globule size and PDI can be determined using a zeta sizer or master sizer. The emulsion's globule size can be assessed using the dynamic light scattering concept, in which the transitional diffusion coefficient is estimated by monitoring the interaction between the laser beam and the dispersion, as well as the polydispersity index [14,15].

10.3 Rheological Characterizations

A zeta or master sizer can be used to determine the globule size and PDI of a formulation. The emulsion's globule size can be determined using the dynamic light scattering concept, which estimates the transitional diffusion coefficient by monitoring the interaction between the laser beam and the dispersion, as well as the polydispersity index [14,15].

10.4 Spreadability Testing

The topical dosage form's spreadability feature ensures that it spreads evenly, resulting in a stranded dose that affects efficacy. The nanoemulgel's viscosity has a significant impact on its spreadability [17]. The instrumental setup consists of two glass slides of equal length, one of which is fixed to the wooden block and the other of which is moveable and connected to a pulley at one end to measure spreadability. The 'Slip' and 'Drag properties of the emulgel govern its spreadability. The nanoemulgel dosage form will be placed on a fixed glass slide and squeezed between stationary and mobile glass slides. The mixture is firmly pushed to evenly divide it between two slides and remove any air bubbles. The known weights are added to the pulley until the upper slide separates from the lower slide. The time necessary for slipping off is recorded and used to calculate spreadability using the equation below [18].

$S = M * L/T$

where, S, M, L and T respectively represent the spreadability, weight bounded to the upper slide, Length of the slide, and Time taken to detach the slides.

10.5 In-Vitro Release Test (IVRT)

The efficacy and safety of the API are dependent on drug release from the dosage form. The IVRT is used to examine the quality of pharmacological products [19]. According to the FDA, IVRT studies for semi-solid dosage forms are carried out using either a vertical diffusion cell or an immersion cell. The vertical diffusion cell is made up of receptor and donor chambers separated by a receptor membrane. The donor chamber contains a dose form sample, whereas the receptor chamber contains receptor media. The receptor media can be a buffer or a hydroalcoholic solution, depending on the API's solubility, sink state, and stability.The skin-like receptor membrane is chosen based on its effective pore size, high permeability, and predicted inertness to the API. If necessary, the receptor membrane should be saturated with release medium. Maintain medium temperature at 32 ◦C ± 1 ◦C for topical administration and 37 ◦C ± 1 ◦C for mucosal membrane products. A Teflon-coated magnetic stirrer is used to agitate the receptor media. While the immersion cell model includes a cell body that serves as a reservoir [20].

10.6 Bio-Adhesive Property

Bio-adhesive strength is used to calculate the force necessary to remove the drug carrier system from a biological surface. This characteristic is critical for a topical dose form when extended contact is required [21]. This test is typically performed on rat or pig skin, with the latter preferable due to its similarity to human skin. There are several approaches for measuring this attribute, but none of them have been authorized by the FDA. The texture analyzer is one such technology in which the upper mobile probe and stationary lower base plate are coated in skin. The dose form is applied to the skin of the base plate.The upper probe is lowered until it makes contact with the lower base plate, which is held for at least a minute. Slowly elevate the upper probe to separate the skin sheets. The equipment will measure the force required to separate the two skin sheets and report the result as the area under the force-distance curve[22].

11. MARKETED EXAMPLES:

Table 3. Marketed examples of Nanoemulgel

Brand Name	**Company**	**Strength**	**Approx. Cost (INR)**
Voltaren® Emulgel	Novartis	Diclofenac 1% w/w	150–200 (50g tube)
Fastum® Gel	Pharma Swiss	Ketoprofen 2.5% w/w	120–180 (30g tube)
Lamisil® Gel	Novartis	Terbinafine 1% w/w	220–250 (15g tube)
Nizoral® Cream	Janssen	Ketoconazole 2% w/w	180–220 (15g tube)
Dolgit® Cream	Mankind Pharma	Ibuprofen 5% w/w	90–120 (30g tube)
Gyno-Daktarin® Cream	Janssen	Miconazole 2% w/w	150–180 (20g tube)
Xylocaine® Gel	AstraZeneca	Lidocaine 2% w/w	120–150 (30g tube)

12. RECENT RESEARCH/ADVANCES

12.1 Development of Opuntia ficus-indica Seed Oil Nanoemulgel

A 2025 study explored the formulation of nanoemulgel using Opuntia ficus-indica seed oil, incorporating rheological agents like Laponite, Pangel S9, Cimsil G30, and Montmorillonite. This approach aimed to enhance the stability and therapeutic efficacy of the emulgel for topical applications.

12.2 Vitis vinifera Oil Nanoemulgel: Antimicrobial and Anticancer Properties

A 2025 study investigated the formulation of Vitis vinifera oil nanoemulgel, evaluating its antimicrobial and anticancer properties. The results indicated that the nanoemulgel exhibited enhanced activity against various microbial strains and showed potential in inhibiting cancer cell growth, highlighting its therapeutic potential.

12.3 Minoxidil Nanoemulgel for Enhanced Topical Delivery

In 2025, a study developed a nanoemulgel formulation of minoxidil to enhance its topical delivery. The optimized formulation demonstrated improved permeation and prolonged contact time, suggesting its potential for more effective treatment in hair regrowth therapies.

14. CONCLUSION

The qualities of a nanoemulgel are heavily influenced by the ingredients chosen and the suitable ratios used. Deviation from this may have an impact on the conversion of a nano-emulsion to a nanoemulgel, as well as its thermal stability. The nanoemulgel is more stable than a nano-emulsion, owing to its less mobile dispersion phase and lower interfacial tension. Thus, the former is a preferable option for delivering lipophilic moieties, owing to increased penetration and pharmacokinetics, which enhances the

pharmacological action. Patient compliance is also increased as a result of its non-greasy and enhanced spreading qualities when administered topically.Despite its benefits, nanoemulgel is still in its infancy in terms of the pharmaceutical sector. However, many emulgels are being commercialized, such as Voltron emulgel, which gives optimism for the commercialization of nanoemulgel in the near future. As a result, its safety, efficacy, and user-friendliness for topical medication delivery make it a prospective center of attention. Despite several drawbacks, nanoemulgel is a technology for the future that could be an alternative to standard formulations.

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