Nanoemulsion: A Review on Formulation and Applications

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Abstract—**This review provides a thorough overview of a nanoemulsion technology. The purpose of nanoemulsions is to enhance the delivery of active medicinal substances by creating emulsions at the nanoscale. These are thermodynamically stable isotropic systems where an emulsifying agent, like a surfactant or co-surfactant, is used to mix two immiscible liquids into a single phase. The nanoemulsion's droplet size decreases [1]. Nanoemulsions are thermodynamically stable isotropic systems in which two immiscible liquids (oil and water) are combined to create a single phase using a suitable surfactant or combination of surfactants with droplet diameters roughly between 0.5 and 100 ums. Nanoemulsion droplets have narrow size distributions and are often between 20 and 200 nm in size. This study has covered a number of topics related to nanoemulsion, such as its benefits, drawbacks, and preparation techniques. In order to increase the stability of nanoemulsion formulation, novel techniques for formulation stability, the impact of surfactant kinds and concentrations, process factors, and methodology are also covered.**

I. INTRODUCTION

Two immiscible liquids disperse to form oil-in-water (O/W) and water-in-oil (W/O) nanoemulsions, which are stabilized by an appropriate surfactant. A mean droplet diameter of less than 500 nm is typically attained. Small droplet size gives them a clear or hazy appearance, as opposed to the milky white color associated with coarse emulsions (whose micron-sized droplets participate in recurrent light scattering). Although the terms submicron emulsion and mini emulsion are occasionally used interchangeably, nanoemulsion and microemulsion are not the same thing. Although nanoemulsions and microemulsion have the same droplet size range, they differ greatly in terms of long-term thermodynamic stability and structural features. [2]. They range in size from 10 to 1,000 nm. These carriers are solid spheres with an amorphous, lipophilic, negatively charged surface. It is possible to improve site specificity by using magnetic nanoparticles. As a drug delivery mechanism, they reduce side effects and toxic reactions while increasing the medication's therapeutic efficacy. Treatment of reticuloendothelial system (RES) infections, liver enzyme replacement therapy, cancer treatment, and immunization are major applications.

A biphasic system in which one phase is closely distributed in the other phase as tiny droplets with a diameter of 0.1 to 100 μm is called an emulsion.[3]. Nanoemulsions can be delivered topically, orally, intravenously, intranasally, pulmonary, or ocularly, and in a variety of dose forms, including liquids, creams, sprays, gels, aerosols, and foams. They are used as an aqueous foundation for organic deliverables in the cosmetic and pesticide industries, and they have a better solubilization capacity than simple miceller dispersions and more kinetic stability than coarse emulsions. Their small droplet size, which hinders typical destabilizing processes like creaming, sedimentation, and coalescence, directly affects their long-term physical stability. Brownian motion is frequently powerful enough to counteract kinetic instability caused by gravity or viscosity [4]. Although oil-in-water nanoemulsion formulations have been made for a very long time, K. Landfester has lately studied water-in-oil nanoemulsions. Both of these types of nanoemulsions have a number of benefits in the fields of cosmetics science and pharmaceuticals. In this study, we want to comprehend several features of nanoemulsion manufacturing, emulsifying agent types, and different issues that arise during nanoemulsion delivery system formulation. Because the droplets are so tiny, they offer stability against creaming and sedimentation, with Ostwald ripening serving as the primary mechanism of nanoemulsion breakdown.[5]

A range of objectives. Antibiotic therapy, atherosclerosis treatment, transdermal drug delivery, ophthalmic application, cancer therapy, vaccine administration, and more are all areas where nanoemulsion is used. Since it has traditionally been challenging to totally eradicate cancer cells with the least amount of disruption to healthy body cells, it has the potential to significantly transform cancer treatment. This compilation shows the growing potential of nanoemulsions to accurately serve humans with the least amount of harm, as well as the production processes and current research. It is uncommon to find commercial nanoemulsions for intravenous (IV), topical, oral, or ocular drug delivery systems. Intravenous administration of nanoemulsions requires the use of biodegradable surfactants. The creation of nanoemulsions from different drug classes for a variety of applications is currently the subject of extensive investigation. Among the applications of nanoemulsion include antibiotic therapy, atherosclerosis treatment, transdermal drug administration, and ocular use [6]. For instance, vitamins and nutraceuticals have been made more bioavailable by the widespread usage of nanoemulsions. Additionally, they have been utilized to make hydrophobic substances like oil-soluble antioxidants, antimicrobials, pigments, and tastes more water-dispersible and matrix compatible. Because of the tiny size of the particles they contain, nano emulsions have been employed in the cosmetics sector to improve the skin penetration characteristics of active substances. A variety of surfactants and liquid lipids can be used to create nanoemulsions, which offer an inventive platform. This makes it possible to build novel medication delivery systems with a high degree of applicability.[7]

Since the past ten years, a number of nanoemulsion delivery systems have been on the market, such as Restasis®, a non-ionic ophthalmic nanoemulsion of cyclosporine A and Cationorm®, a cationic ophthalmic nanoemulsion that is preservative-free and suggested for the treatment of dry eye syndrome, Neoral®, a non-ionic nanoemulsion of cyclosporine as an oral immunosuppressive agent, and Diprivan. Nanoemulsions are a promising active medication targeting carrier for tumor cells, macrophages, and to cross the blood-brain barrier in addition to improving solubility. Narrow-sized droplet generation via mechanical and spontaneous physicochemical mechanisms is made possible by nanoemulsion's manufacturing process options, which include both high and low energy techniques. Although oil-in-water nanoemulsion formulations have been made for a long time, K. Landfester has recently looked into water-in-oil nanoemulsions. Both of these types of nanoemulsions have a number of benefits in the fields of cosmetics science and pharmaceuticals. We are attempting to comprehend several facets of the production of nanoemulsion in this research, kind of emulsifying agents, as well as a number of issues that arise while creating a nanoemulsion delivery system. Because the droplets are so tiny, they offer stability against creaming and sedimentation, with Ostwald ripening serving as the primary mechanism of nanoemulsion breakdown.

In summary, independent of the preparation technique, nano-emulsions are emulsions (non-equilibrium systems, defined according to with an exceptionally small droplet size (in the nanometer range, e.g., 20200 nm). Figure 1 shows an image of an oil-in-water (O/W) Nano-emulsion along with a schematic representation of the structure. It appears that the range of sizes can differ based on the writers. 500 nm is regarded by several authors as the upper limit. In any event, droplet size does not determine qualitative distinctions, so the size limit is not a major concern.

Numerous articles that are reviewed have proven the creation, characteristics, and stability of nano-emulsions. In terms of applications, nano-emulsions were initially created and employed for a very long time to produce nanoparticles by polymerization, the so-called miniemulsion polymerization method, and more recently, solid lipid nanoparticles. and ceramic particles. Currently, novel uses for nano-emulsions as consumer goods are being developed. This study examines and categorizes recent research on the novel uses of nano-emulsions as consumer goods. This study examines and categorizes recent research on the novel uses of nano-emulsions as consumer goods. To achieve the necessary properties, this direct application of nano-emulsions necessitates optimization with regard to preparation and formulation variables. Three approaches are used to review and categorize recent work on the optimization of nano-emulsion preparation: phase behavior considerations, selective parameter change, and experimental designs.

Key Characteristics [8][9]

- Droplet Size: The minute droplet size (nanoscale) gives them unique properties compared to conventional emulsions, which have droplet sizes ranging from 0.1 to 100 μm.
- Appearance: Due to the small size of the droplets, which are often below the wavelength of visible light, nanoemulsions are typically transparent or have a bluish-white appearance.
- Stability: While technically thermodynamically unstable (meaning they will eventually separate over a very long time), they are kinetically stable and can remain stable for months or even years without creaming, sedimentation, flocculation, or coalescence, which are common instabilities in macroemulsions.
- Composition: They primarily consist of an oil phase, an aqueous (water) phase, and an emulsifying agent (surfactant, often with a co-surfactant).
- Formation: They can be prepared using high-energy methods (e.g., high-pressure homogenization, ultrasonication) or low-energy methods (e.g., phase inversion temperature or composition methods, spontaneous emulsification

Advantage [10-13]

1. It could be utilized in place of vesicles and liposomes (Bouchemal et al. 2004a, b).
2. The smaller droplets in nanoemulsions have a larger surface area, which increases absorption.
3. Enhance bioavailability: A major advantage of nanoemulsions is their ability to dissolve large amounts of hydrophobic (water-insoluble) drugs. The small droplet size and large surface area significantly improve the dissolution rate and subsequent absorption of the drug across biological membranes, thereby increasing bioavailability
4. Improves stability: Nanoemulsions exhibit excellent stability against sedimentation, creaming, flocculation, and coalescence compared to traditional emulsions. The very small droplet size reduces gravitational forces and Brownian motion prevents phase separation, leading to a prolonged shelf life
5. Rapid Onset of Action: Due to the small droplet size, the active ingredients can be absorbed more quickly into the bloodstream, leading to a faster and more efficient therapeutic response
6. Enhanced Skin Penetration (Topical/Cosmetic Use): For topical and cosmetic applications, the small droplet size allows for deeper and faster penetration of active ingredients into the skin layers. They provide a high surface area for drug delivery through the skin barrier
7. High Kinetic Energy for Drug Targeting: The high kinetic energy of the droplets allows for easier diffusion through biological barriers, which can facilitate targeted drug delivery to specific sites in the body and potentially reduce systemic toxicity.
8. Reduced Side Effects and Dosage: By increasing the bioavailability and targeted delivery, nanoemulsions can often allow for a lower effective dose of the active ingredient, which can minimize potential side effects.
9. Ease of Preparation and Versatility: Nanoemulsions can be formulated for various routes of administration, including oral, topical, intravenous, and pulmonary routes. They can often be prepared using low-energy methods or high-energy methods depending on the specific application requirements
10. Transparency/Translucency: The small droplet size (typically 20-200 nm) is often smaller than the wavelength of visible light, which results in nanoemulsions appearing transparent or translucent, a highly desirable quality for cosmetic and food applications.

Disadvantages [14-16]

1. Ostwald Ripening: This is a major challenge for the long-term stability of nanoemulsions. It involves the growth of larger droplets at the expense of smaller ones, leading to potential phase separation over time.
2. Temperature Sensitivity: Nanoemulsions can be sensitive to temperature changes, which can affect droplet size and overall stability, requiring careful storage conditions.
3. High-Energy Methods: Producing nanoemulsions often requires sophisticated, high-energy equipment like high-pressure homogenizers or sonicators, which are expensive to purchase and operate, making large-scale production costly.

4. Scale-Up Challenges: Scaling up production from the laboratory to industrial levels can be complex and difficult to optimize while maintaining consistency in droplet size and stability.
5. High Surfactant Concentration: To achieve and maintain the small droplet size, nanoemulsions typically require a high concentration of surfactants (emulsifiers), often between 5% and 20%.
6. Toxicity: Some surfactants can be toxic, irritating, or cause adverse reactions, particularly in pharmaceutical or cosmetic applications where the product is applied to sensitive areas or ingested. The regulatory limits for surfactant use must be strictly followed.
7. Low Drug Loading Capacity (in some cases): While nanoemulsions improve solubility, they may have a lower capacity for loading certain drugs compared to some other delivery systems, limiting their application for high-dose medications
8. Regulatory Hurdles: The high concentration of surfactants and the complex nature of nanoemulsions can lead to more rigorous regulatory scrutiny compared to conventional emulsions, potentially slowing down product development and approval.
9. Limited Understanding of Long-Term Effects: While current research indicates general safety for many applications, long-term studies on the effects of ingesting or applying nanoparticles and high surfactant concentrations are still somewhat limited.

II. TYPES [15]

Types	Size	Solubility	Stability
Oil in water nano-emulsion	20-200nm	Enhance solubility of lipophilic drug	Kinetically stable
Water in oil nano-emulsion	20-200nm	Enhance solubility of hydrophilic drug	Kinetically stable
Bi- continuous nano-emulsion	60-95nm	Enhance solubility and control release of drug	Thermodynamically stable
Multiple nano-emulsion	100-500nm	Enhance solubility of both hydrophilic and lipophilic drug	Centrifugation, thermal and freez-thaw

(Table 1.1)

1.Oil-in-Water (O/W) Nanoemulsions:
In an O/W nanoemulsion, oil droplets are dispersed in a continuous aqueous (water) phase.
Characteristics: These systems are often transparent or translucent and have low viscosity. They are highly conductive to electricity.
Applications: They are commonly used for delivering lipophilic (oil-soluble) drugs or supplements by oral, intravenous, or topical routes, as the aqueous continuous phase allows for easy dispersion in the body or on the skin surface.
Example Reference: Formulations using Tween 80 and PEG 400 were found to create a clear, stable O/W nanoemulsion with a droplet size of approximately 14.56 nm.

2. Water-in-Oil (W/O) Nanoemulsions
In a W/O nanoemulsion, water droplets are dispersed in a continuous oil phase.
Characteristics: These typically have a higher viscosity and low electrical conductivity, as oil is the external phase. They may appear white and milky in concentrated form.
Applications: These are often used for topical applications, where the oil phase can enhance skin penetration of active ingredients.
Example Reference: W/O nanoemulsions can be prepared using surfactants with low HLB values, such as Span 80 or Span 85, combined with an oil phase like mineral oil or peanut oil.

3. Bi-continuous Nanoemulsions:
In a bi-continuous system, microdomains of both oil and water are interspersed within the system, with neither phase being solely continuous.
Characteristics: These can form during the phase inversion process, where the curvature of the surfactant changes from favoring one phase to favoring the other.
Applications: These structures are important intermediates in the formation of other nanoemulsion

types and have unique properties that are still being explored in drug delivery and other fields.

4. Multiple Nanoemulsions
These are more complex, such as a water-in-oil-in-water (W/O/W) or oil-in-water-in-oil (O/W/O) structure.
Characteristics: They involve droplets of one type of nanoemulsion dispersed within another immiscible phase. They require a combination of hydrophilic and hydrophobic surfactants for stabilization
Applications: They have potential for advanced drug delivery systems, such as sustained drug release or protecting a drug from environmental degradation
Example Reference: Acyclovir-loaded multiple W/O/W nanoemulsions have been formulated, showing good physicochemical stability.

III. APPLICATION [20-30]

Nanoemulsions containing pharmaceutically active ingredients can be used to create pharmacological formulations. If necessary, the combination might be given a distinctive galenic form. Solutions, especially oral liquids, ocular drops, and nasal drops that may contain different auxiliary chemicals; ampoules, especially sterile injection and infusion solutions; aerosols without a metering mechanism and dosing aerosis; which can include the nanoemulsion along with stabilizers and propellant gas; hydrophilic and hydrophobic gels and ointments containing the nanoemulsion; o/w or w/o creams containing the nanoemulsion; and commercially available lotions and pastes.
Despite the many clear benefits of NEs, there are a few issues that should be taken into consideration. First, the stability of NE may be impacted by the duration of storage at various temperatures. In Mitri's investigation, obvious, large-sized particle aggregations were observed at 40 °C after a month, despite the NE product remaining stable at both 4 °C and room temperature [8]. Maintaining stability in a NE formulation requires an adequate amount of stabilizer. Second, the size and stabilization of the EM droplets are influenced by the amount of surfactant. However, a 5% surfactant concentration is insufficient to produce a NE, according to Bernardi et al.
The lowest surfactant concentration that preserves centrifugal stability, thermal stability, and small droplet size is thought to be the optimal NE formulation. Thirdly, a NE formulation with the same surfactant content will undoubtedly exhibit different stability. Two NEs with the lowest surfactant (10%) in Bernardi's study exhibited varying degrees of stability; for example, the NE with 10% oil and 70% water showed hints of instability at high temperatures (70 °C), whereas the NE with 10% oil and 80% water was quite stable [10]. Finally, the capacity of the medication to sufficiently permeate the skin to reach a therapeutic level determines how well transdermal drug delivery works.

Water-based nanoemulsions are used across various industries due to their ability to enhance the solubility and bioavailability of active ingredients:

1. Pharmaceuticals: Used for drug delivery systems (oral, topical, intravenous, ocular) to improve the absorption and efficacy of poorly water-soluble drugs and protect them from degradation.
2. Cosmetics and Personal Care: Incorporated into creams, lotions, and sunscreens because of their enhanced skin penetration, moisturizing activity, and pleasant feel.
3. Food and Beverages: Used to incorporate lipophilic (oil-soluble) nutrients, flavors, antioxidants, and antimicrobial agents into aqueous food systems and clear beverages, improving product quality, stability, and shelf life.
4. Agriculture: Employed in pesticide and fertilizer delivery systems to enhance their efficacy and reduce environmental impact.

Organoleptic By employing the five senses to observe the dosage's color, odor, and form, organoleptic testing can be performed.

IV. DRUG SELECTION CRITERIA [31-32]

The choice of drug for a nanoemulsion is based on its solubility in the selected oil phase as well as its physicochemical characteristics, which are particularly crucial for transdermal delivery and include the molecular weight and melting point. Crucial factors also include the drug's stability in the finished formulation, its ability to stay soluble in the oil, and its appropriateness for the planned administration route (topical, oral, etc.).
Solubility: The drug must be soluble in the oil phase chosen for the nanoemulsion, particularly for oral

formulations where this solubility is key to maintaining the drug in a dissolved state.

Physicochemical properties:

Molecular weight: For transdermal applications, a molecular weight under 500 Da is preferred.

Melting point: A low melting point is a desirable characteristic for transdermal delivery

Affinity: For transdermal delivery, the drug should have an affinity for both hydrophobic and hydrophilic phases.

Formulation stability: The drug should be stable in the final nanoemulsion formulation, and the formulation should protect it from degradation such as hydrolysis and oxidation.

Route of administration: The drug's properties must be suitable for the intended delivery route. For example, it must be appropriate for topical, oral, or other routes like ocular or parenteral.

Bioavailability: Nanoemulsions are often used to enhance the bioavailability of poorly soluble drugs or those with high first-pass metabolism. The drug should be one that would benefit from this enhancement.

V. COMPOSITION [33-38]

Oils, lipids, surfactants, water-soluble co-solvents, and water are all parts of nanoemulsion systems. Triglycerides such as tri-, di-, or mono-acylglycerols, vegetable oils, mineral oils, free fatty acids, etc. can be included in the oil phase of nanoemulsion formulations (Gonçalves et al., 2018). Drug solubility is typically the basis for oil selection. For the creation of nanoemulsion, oil phases with a high drug loading are typically utilized (Qadir et al., 2016). Spans (sorbitan fatty acid esters), tweens (polyoxymethylene (POE) derivatives of sorbitan fatty acid esters), Cremophor® EL (polyoxyl-35 castor oil), lauroyl macro-golglycerides (Gelucire® 44/14), polysaccharides (gum and starch derivatives), phospholipids (egg, soy, or dairy lecithin), and amphiphilic proteins (whey protein isolate and caseinate).

The generation of nanoemulsions requires extremely low negative interfacial tension. Co-surfactants or co-solvents are employed in conjunction with a surfactant for this purpose. When creating nanoemulsion systems, co-surfactants or co-solvents including polyethylene glycol, propylene glycol, ethanol, transcutol-P (diethylene glycol monoethyl ether), ethylene glycol, glycerin, and propanol are frequently utilized.

Oil

For the drug candidate to dissolve as much as possible in the nanoemulsion formulation, the oil is necessary. This is often the most crucial tactic due to its high drug loading capability. Long chain fatty acids are found in triglycerides, a mixture of oils and fats that can be produced artificially or naturally. Lipids are classified as short chain triglycerides. Triglycerides (12 carbons) are necessary to lower the degree of unsaturation and stop oxidative damage. The oil phase to be employed depends on how well the solubilized medications work, and nanoemulsion is crucial. Drugs must be moved into intracellular compartments by increased friction in order to make less water-soluble medications more soluble.

For example, when fatty oil and medium chain triglycerides are mixed, a good balance between the drug's loading capability and emulsification or nanoemulsification is needed. When creating SMEDDS, it is essential to use long chain and medium chain triglyceride oils at different saturation levels. Triglycerides are highly lipophilic oily molecules, and their solvent capacity is a common function of their effective concentration in ester groups. Compared to long chain triglycerides, medium chain triglycerides (MCT) molecules have a higher solvent capacity and greater resistance to oxidation.

These days, fats and oils, whether digestible or not, such as olive oil, palm oil, corn oil, oleic acid, sesame oil, soybean oil, and hydrogenated oil, are added to oil phases to improve their solubility. In order to affect the water solubility of poorly soluble pharmaceuticals, innovative semi-synthetic MCT is used in place of MCT.

Surfactant

1.Non-ionic Surfactants

Non-ionic surfactants are widely preferred due to their low toxicity, high compatibility, and stability across different pH and ionic strengths.

Polysorbates (Tweens): Polyoxymethylene sorbitan monolaurate (Tween 20), monostearate (Tween 60), and monooleate (Tween 80) are some of the most common due to their high HLB values, which are suitable for oil-in-water (O/W) nanoemulsions.

Sorbitan Esters (Spans): Sorbitan monolaurate (Span 20) and monooleate (Span 80) are often used as co-surfactants, particularly in combination with Tweens, to achieve an optimal Hydrophilic-Lipophilic Balance (HLB).
Cremophors: Polyoxyl-35 castor oil (Cremophor EL or Cremophor RH40) is a widely used emulsifier in commercial products.
Other Non-ionics: Lauroyl macrogol glycerides (Labrasol®), polyglycerol esters of fatty acids, and the poloxamer family (e.g., Pluronic L44 or Poloxamer 188) are also frequently used.

2.Anionic Surfactants
Anionic surfactants are used to provide electrostatic repulsion and can enhance skin penetration, though they may cause irritation at high concentrations.
Sodium Lauryl Sulfate (SLS) or Sodium Dodecyl Sulfate (SDS), Sodium Deoxycholate (bile salt), Zwitterionic Surfactants
These surfactants possess both positive and negative charges, offering good surface activity and low toxicity.
Lecithin (phosphatidylcholine, often from egg or soy), which has a GRAS status and high biodegradability.

Co-surfactant
polyethylene glycol, propylene glycol, ethanol, and Transcutol-P, which help to stabilize the emulsion by lowering interfacial tension and preventing droplet coalescence. They work alongside surfactants to facilitate the spontaneous formation of a thermodynamically stable nanoemulsion with a very small droplet size.

Examples of co-surfactants
Polyols: Polyethylene glycol (PEG), propylene glycol, glycerin
Alcohols: Ethanol, propanol
Other solvents: Transcutol-P (diethylene glycol monoethyl ether), propylene carbonate
Lipid-based: Capryol 90, Span 80, Capmul, Lauroyl glycol

Role of co-surfactants in nanoemulsions
Stabilization: Co-surfactants and surfactants work together to form a stable emulsion interface.
Low interfacial tension: They help lower the tension between the oil and water phases, which allows for the spontaneous formation of a stable nanoemulsion without high-energy mixing.
Increases interfacial fluidity: They get incorporated between the primary surfactant molecules, making the interfacial film more flexible and allowing for various film curvatures needed for nanoemulsion formation.
Reduces surfactant requirement: Adding a co-surfactant can decrease the total amount of surfactant needed in the formulation
Enhances stability: The combination of surfactant and co-surfactant provides a robust interfacial film that prevents droplet coalescence.

Water
nanoemulsion water (more accurately, a water-based nanoemulsion or oil-in-water (O/W) nanoemulsion) is a colloidal dispersion system in which tiny droplets of oil (the dispersed phase) are uniformly dispersed in a continuous aqueous (water) phase, stabilized by an interfacial film of surfactants. These systems are characterized by their extremely small droplet size, typically ranging from 20 to 200 nm, and appear transparent or translucent due to their minimal light scattering.

VI. EVALUATION [39]

1. Droplet Size and Polydispersity Index (PDI): Assessed through Dynamic Light Scattering (DLS) or Photon Correlation Spectroscopy (PCS) to evaluate the average droplet size and size distribution uniformity. A PDI value under 0.25 typically signifies a consistent size distribution.
2. Zeta Potential: Assesses the surface charge of the droplets, indicating the electrostatic stability of the nanoemulsion. A zeta potential of ±30 mV or greater is typically regarded as adequate for physical stability because repulsive forces inhibit coalescence.
3. pH and Osmolarity: Assessed with a pH meter and a micro-osmometer, respectively, to confirm suitability for the proposed administration route (e.g., ophthalmic, oral).
4. Viscosity: Measured with a viscometer (such as a Brookfield rotary viscometer) to evaluate the flow properties (rheology) and aid in identifying the emulsion type (O/W or W/O).

VII. MARKETED PRODUCT

Drug	Brand name	Company	Strength	Cost
Alprostadil palmitate	Liple	Mitsubishi pharmaceutical	200-300mcg of alprostadil per100 mg of cream	5650rs.
Dexamethasone	Limethason	Mitsubishi pharmaceutical	1.00mg/ml	750rs.
Propofol	Diprivan, troypofol	Astra zeneca, troika	10mg/ml	180rs
Flurbiprofen axtil	Ropion	Kaken pharmaceutical	50mg/5ml	200rs.
Vitamin A, D, E and K	Vitalipid	Fresenius kabi	60k IU/5ml	600rs.
Etomidate	Etomidat-lipuro	B.Braun melsungen	2mg/ml	500rs.
Cyclosporine	Restasis, gengraf	Allergen, abott	0.5mg/ml	300rs.

(Table:2.1)

VIII. CONCLUSION [40-41]

In conclusion, nanoemulsions are highly beneficial due to their ultra-small droplet size, which leads to enhanced physical stability against sedimentation and creaming, improved bioavailability, increased drug loading capacity for lipophilic compounds, and unique optical clarity. These properties make them superior to conventional emulsions in numerous applications, such as efficient drug delivery, targeted therapy, and the encapsulation of sensitive bioactive compounds.

However, despite their advantages, the successful implementation of nanoemulsions is constrained by certain limitations. The primary challenges include high production costs, the need for potentially high concentrations of surfactants, and issues with long-term thermodynamic stability (specifically Ostwald ripening). Ongoing research is focused on developing more efficient and cost-effective production methods and identifying novel, non-toxic surfactants to mitigate these drawbacks. The future prospects of nanoemulsions are bright, particularly with advancements in formulation strategies and the growing demand for improved therapeutic efficacy and natural product delivery systems.

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