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NANOSUSPENSION: A NOVEL DRUG DELIVERY

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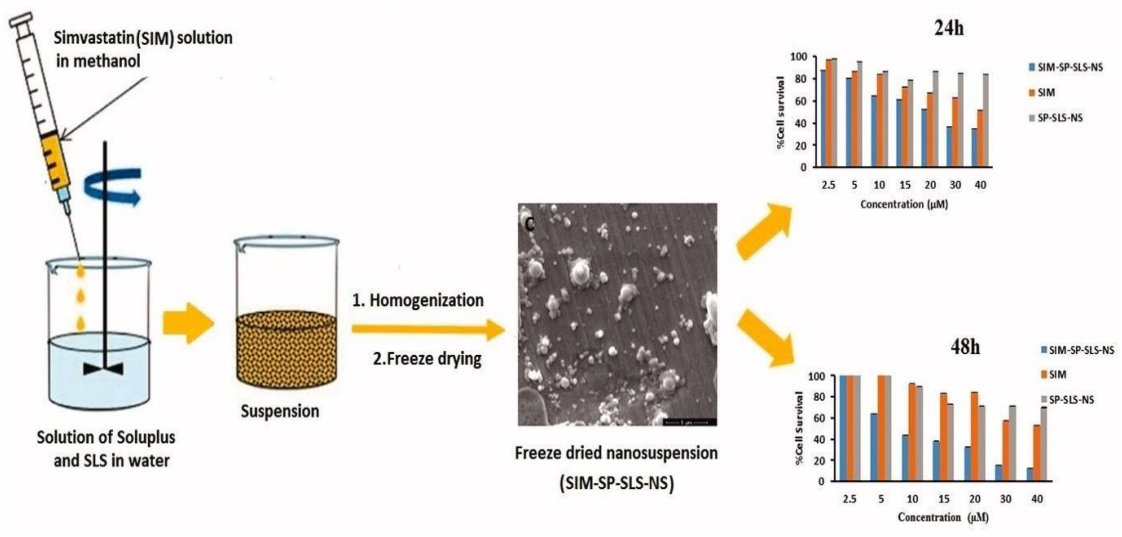
ABSTRACT

Nanosuspension is an attractive and promising choice to break these problems. Nanosuspension consists of the poorly water-soluble medicine without any matrix material suspended in dispersion. Preparation of Nanosuspension is simple and applicable to all medicines that are water insoluble. A Nanosuspension not only solves the problems of poor solubility and bioavailability, but also alters the pharmacokinetics of medicine and therefore improves medicine safety and therapeutic effectiveness. Solubility is the pivotal factor for medicine effectiveness, independence of the route of administration. Large proportions of recently discovered medicines are water insoluble, and thus poorly bioavailable, contributing to vacated development effort. Preparation of Nanosuspension is simple and applicable to all medicines that are waterless and insoluble. Nanosuspensions are prepared by using a wet mill, high pressure homogenizer, emulsion solvent evaporation, melt emulsification method and supercritical fluid techniques. Nanosuspension can be prepared by using stabilizers, organic solvents and other additives similar as buffers, salts, polyols, and cryoprotectant. Nanosuspensions can be delivered by oral, parenteral, pulmonary and optical routes. Nanosuspensions can also be used for targeted drug delivery when incorporated in the optical inserts and mucoadhesive hydrogels.

KEYWORD:- Nanosuspensions, Solubility enhancement, Characterization, Formulation, Surfactants.



INTRODUCTION

1. Nanosuspensions have emerged as a revolutionary approach in pharmaceutical sciences, particularly for enhancing the solubility and bioavailability of poorly water-soluble drugs. With over 40% of new chemical entities exhibiting low solubility, the development of effective formulation strategies has become increasingly critical. Nanosuspensions, which consist of drug particles reduced to the nanometer scale (typically <1 µm) and stabilized by surfactants or polymers, provide a versatile solution to these challenges.

2. Nanosuspensions are colloidal dispersions containing drug particles in a liquid medium. The primary goal of this technology is to improve the

dissolution rate and, consequently, the bioavailability of hydrophobic compounds. By reducing particle size, nanosuspensions significantly increase the surface area available for dissolution, thus enhancing the rate at which the drug can be absorbed in the gastrointestinal tract.

3. The stability of the patches attained in the nanosuspension is attributed to their invariant flyspeck size which is created by colourful manufacturing processes. The absence of patches with large differences in their size in nanosuspensions prevents the actuality of different achromatism solubilities and attention slants, accordingly precluding the Oswald ripening effect.[1]

4. A pharmaceutical nanosuspension is defined as veritably finely dispersed solid medicine patches in an waterless vehicle for either oral and topical use or parenteral and pulmonary administration. The flyspeck size distribution of the solid patches in nanosuspensions is between 200 and 600nm. Nanosuspensions differ from nanoparticles. Nanoparticles are generally polymeric colloidal carriers of medicines whereas solid lipid nanoparticles are lipidic carriers of medicines. Nanosuspensions differ from nanoparticles. Nanoparticles are generally polymeric colloidal carrier of medicines whereas solid lipid nanoparticles are lipidic carriers of medicines. In nanosuspension technology, the medicine is maintained in the liquid state with reduced flyspeck size, leading to increase dissolution rate & thus bettered bioavailability. medicines reprised within nanosuspensions live in pharmaceutically accepted crystalline or unformed state. Nanosuspensions can successfully formulate the slipup dust motes for bettered dissolution & good immersion.[2]

5. There are numerous conventional styles similar as micronation, solubilization using co-solvents, surfactant dissipation and rush fashion has been developed for perfecting solubility of inadequately water answerable medicines.[3] But these ways show limitations to the medicines which aren't answerable in both waterless and organic detergents. Nanosuspension technology can be used to break the problems associated with colourful approaches described before. Nanosuspension is colloidal dissipation of NATO- sized medicine patches stabilized by surfactants. They can also define as a aphasic system conforming of pure medicine patches dispersed in a waterless vehicle. The periphery of suspended flyspeck is lower than 1µm in size.[3][4]

Advantages of nanosuspensions in pharmaceutical drug delivery systems: Nanosuspensions represent a significant advancement in pharmaceutical technology, offering innovative solutions for drug delivery challenges. These colloidal dispersions of pure drug particles, typically measuring between 1 and 100 nanometers, provide numerous benefits that address persistent issues in drug formulation and delivery.

The following comprehensive analysis explores the multifaceted advantages of nanosuspensions, particularly their ability to enhance drug efficacy, improve patient outcomes, and overcome limitations associated with conventional formulations:

- Enhanced Solubility and Bioavailability
- Improved Dissolution Rate and Saturation Solubility
- Overcoming solubility limitations
- Extended contact with absorption surfaces
- Advanced drug delivery capabilities
- Enhanced penetration across biological barriers
- Targeted Delivery to Specific Tissues and Cells
- Interaction with physiological structures
- Versatile administration routes
- Multiple delivery options
- Oral administration benefits
- Enhanced Stability and Safety Profiles
- Improved Physical and Chemical Stability
- Preservation of drug properties
- Reduced Toxicity and Side Effects
- Reduced volume requirements

Disadvantages of nanosuspensions in pharmaceutical formulations

Nanosuspensions have emerged as a promising approach for addressing solubility and bioavailability challenges of poorly water-soluble drugs. However, despite their advantages, nanosuspensions present several significant disadvantages that must be carefully considered during formulation development and clinical application.

This report examines the key Limitations and Challenges associated with nanosuspension technology

- **Physical stability challenges**

Sedimentation and compaction represent significant physical stability challenges for nanosuspensions during storage.

- **Physical instability**

Agglomeration: Over time, nanoparticles often cluster together, resulting in alterations in particle size and diminished effectiveness.

Crystal growth: Ostwald ripening can take place, where smaller particles dissolve and reattach to larger ones, causing instability.

- **Manufacturing challenges**

High energy input: The preparation process frequently demands expensive and energy- consuming methods such as high-pressure homogenization or media milling.

Scalability issues: Certain techniques are challenging to scale up for industrial production without compromising quality.

- **Restricted drug capacity**

Nanosuspensions generally consist solely of the active pharmaceutical ingredient, but the overall amount that can be delivered may be restricted due to limitations in volume or concerns regarding stability.

- **Requirement for stabilizers**

To ensure stability, surfactants or polymers are necessary, which can potentially lead to toxicity or compatibility problems

- **Challenges in sterilization**

Conventional sterilization techniques, such as heat, may not be appropriate, and alternative methods like filtration might not be effective for all particle sizes.

- **Regulatory and Quality assurance issues**

Maintaining consistent particle size, distribution, and drug release characteristics can be complicated, necessitating stringent quality control measures.

- **Potential toxicity**

Nanoparticles could exhibit unforeseen biological interactions or harmful effects, especially when administered systemically or over extended periods.

Manufacturing process limitations

❖ **Bottom-Up technology limitations:** The bottom-up approach to nanosuspension preparation faces several constraints:

- The drug must exhibit solubility in at least one solvent, which immediately excludes new drugs with poor solubility in both aqueous and organic media
- At least one non-solvent must be miscible with the solvent being utilized, limiting formulation options
- Removal of residual solvents increases production costs significantly
- Preserving particle characteristics, particularly size and the amorphous fraction, presents significant challenges during manufacturing

❖ **Microemulsion template method:** When using the microemulsion template method for nanosuspension preparation:

- Drugs that show low solubility in both organic and aqueous media are not suitable candidates for this technique
- The purification process through ultrafiltration may substantially increase overall process costs
- Relatively larger amounts of surfactant/stabilizer are needed compared to other production techniques

Other Process-Related Disadvantages

Certain nanosuspension preparation methods involve

1. Use of toxic solvents, raising safety and environmental concerns.
2. Larger quantities of stabilizers and surfactants compared to other pharmaceutical formulation approaches
3. Potential particle nucleation overgrowth due to temporary high supersaturation, which may lead to the creation of unwanted forms or polymorphs, affecting drug stability and efficacy

❖ **Preparation techniques of nanosuspension**

Substantially There are two styles for the preparation of nanosuspension. The conventional system of rush is called 'BOTTOM-UP TECHNOLOGY'.[5] In bottom-up technology the medicine is dissolved in a detergent, which is also added to a nonsolvent to precipitate the chargers. This fashion is that during the rush procedure the growing of the medicine chargers needs to be controlled by addition of surfactant to avoid conformation of microparticles. The other method to prepare nanosuspension is the 'TOP -DOWN TECHNOLOGY'. The Top- down technologies are the decomposition styles and are preferred over the rush styles.[6] The top-down technologies include media milling, high pressure homogenization in water, high pressure homogenization in non-waterless media and combination of precipitation and high pressure homogenization.[7]

➢ **Two methods**

1. Bottom-up technology
2. Top-up technology

1. Bottom-up technology

An approach known as" bottom-up technology" begins at the molecular position and develops through molecular association to produce solid patches. This system uses conventional precipitation approaches, similar as changing the temperature or adding a nonsolvent to change the detergent's quality. In pharmaceutical chemistry and technology, precipitation is a well-known process.[8][9]

The time period of "Bottom-up technology" way that one begins from the molecular degree, and goes by way of molecular association to the arrangement of a strong patch. That we are talking about established precipitation approaches by lowering the detergent, excellent, for illustration, through pouring the solvent right into a nonsolvent or altering the temperature or a quintet of each. Precipitation is a classical process in pharmaceutical chemistry and technology.[10]

❖ **Nanoprecipitation method (Solvent-antisolvent method)[11]**

It is substantially used for inadequately answerable medicines. The first medicine is dissolved in a suitable detergent. This result is also mixed with a miscible antisolvent system in the presence of surfactants, Rapid addition of medicine result into the antisolvent leads to the unforeseen supersaturation of medicine in the mixed result forms ultrafine medicine solids. The precipitation method involves two phases – nuclei formation and crystal growth. When preparing a stable suspension with the minimal particle size, a high nucleation rate and a low growth rate are necessary. Both rates are depending on temperature. In this fashion, the medicine needs to be

answerable in at least one detergent that is compatible with a nonsolvent.

➢ **Advantages**

1) Use of simple and low-cost equipment.
2) Higher saturation solubility is the advantage for precipitation compared to other methods of Nanosuspension preparation

➢ Disadvantages

1) The drug needs to be soluble in at least one solvent (thus excluding all new drugs that are simultaneously poorly soluble in aqueous and in organic media).
2) The solvent needs to be miscible with at least one nonsolvent.
3) Solvent residues need to be removed, thus increasing production costs.
4) It is an little bit tricky to preserve the particle character (i.e. size, especially the amorphous fraction). In general, it is recommended that a second consecutive process has to be performed for particle preservation that is spray drying or lyophilization.[12-14]

2. Top-up technology

Top-down methods involve the breakdown of larger drug particles into smaller nanoparticles through mechanical forces. These methods include media milling, high-pressure homogenization, and micro fluidization.

The top-down technologies include

a) Media milling
b) High pressure homogenization

a) Media milling

Nanosuspensions are produced by using high-hear media mills or pearl mills. The mill consists of a milling chamber, mulling shaft and a recirculation chamber. An aqueous suspension of the medicine is also fed into the mill containing small grinding balls plums. As these balls rotate at a veritably high shear rate under controlled temperature, they fly through the grinding jar interiors and impact against the sample on the contrary grinding jar wall. The combined forces of friction and impact produce a high degree of particle size reduction. The milling media or balls are made of ceramic-sintered aluminium oxide or zirconium oxide or largely cross-linked polystyrene resin with high bruise resistance. Planetary ball mills (PM100 and PM200; Retsch GmbH and Co., KG, Haan, Germany) is one illustration of an outfit that can be used to achieve a grind size below 0.1 µm. A nanosuspension of Zn- Insulin with a mean flyspeck size of 150 nm was prepared using the wet milling fashion. The major downsides of this technology include the corrosion of balls plums that can leave remainders as pollutants in the final product, declination of the thermolabile medicines due to heat generated during the process and presence of fairly high proportions of patches ≥ 5 µm.[15-18]

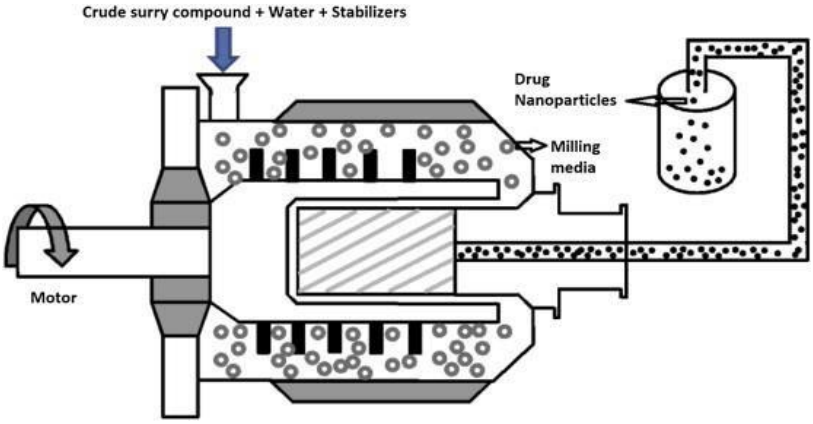


Figure 1: Media milling equipment.

➢ **Advantages**

➢ **Disadvantages**

- Simple technology
- Low-cost process regarding the milling itself
- Large-scale product possible to some extent by batch process).
- Implicit corrosion from the milling material leading to product impurity.
- Duration of the process not being veritably product friendly.
- Implicit growth of origins in the water phase when milling for a long time.
- Time and costs associated with the separation procedure of the milling material from the medicine nanoparticle suspense, especially when producing parenteral sterile products.[15-18]

b) High pressure homogenizer

Disco Cubes technology was developed by R. H. Muller (Muller et al1998). The patent rights of Disco cells were originally possessed by DDS (Drug Delivery Services) GmbH, but presently they are possessed by Skye Pharma plc. Disco cells are finagled using piston-gap-type high-pressure homogenizers. A generally used homogenizer is the APV Micron LAB 40(APV Deutschland GmbH, Lübeck, Germany). Still, other piston gap homogenizers from Austin (Avestin Inc., Ottawa, Canada) and Stansted

(Stansted Fluid Power Ltd, Stansted, UK) can also be used. A high-pressure homogenizer consists of a high-pressure plunger pump with a posterior relief valve (homogenizing valve). The task of the plunger pump is to give the energy position needed for the relief. The relief stopcock consists of a fixed stopcock seat and a malleable stopcock. These corridors form a malleable radial perfection gap. The gap conditions, the resistance and therefore the homogenizing pressure vary as a function of the force acting on the stopcock. An external impact ring forms a defined out let sampling and prevents the stopcock containing from being damaged due to the inflow (Jahnke 1998). The instrument is available in spastic and nonstop performances. The nonstop interpretation is suitable for optimizing the colourful parameters of the homogenization process. Use of the spastic interpretation is sensible if the medicine is veritably expensive or of limited vacuity. The instrument can be operated at pressures varying from 100 to 1500 bars. In some instruments, a maximum pressure of 2000 bars can be reached. High-pressure homogenizers are available with different capacities ranging from 40mL (for laboratory purposes) to a many thousand litres (for large-scale product).[19-21]

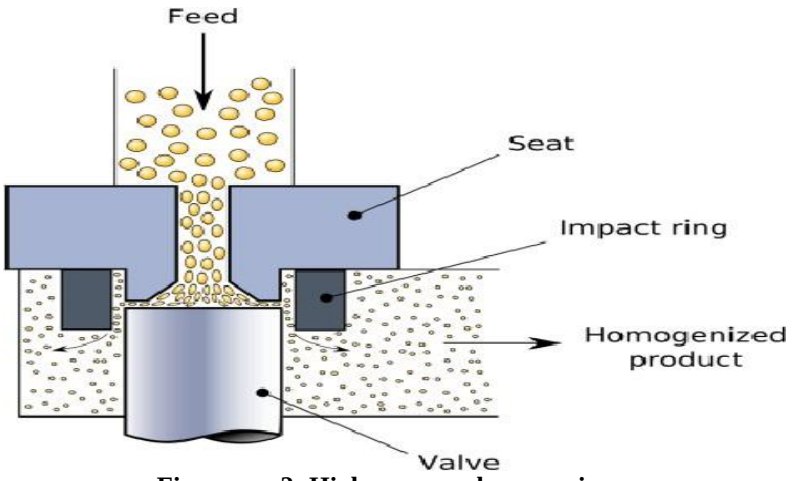


Figure no. 2: High pressure homogenizer.

➢ Advantages

1. High Homogenization Efficiency
2. Control Precision
3. Product Quality Enhancements
4. Environmental and Cost Benefits

➢ **Disadvantages**

1. Technical limitations

- **Equipment wear:** High pressures cause significant wear on equipment components, increasing maintenance costs.
- **Viscosity limitations**: May struggle with extremely viscous materials, limiting its application in certain formulations.

2. Practical challenges

- **Size and Portability:** Equipment is often large and heavy, requiring dedicated space and limiting portability.
- **High initial costs:** Substantial upfront investment required, making it less accessible to smaller operations.
- **Cleaning requirements:** Labor-intensive cleaning between uses due to complex internal components.

3. Operational considerations

- **Output capacity:** May have lower output rates compared to other technologies, impacting production timelines.
- **Heat generation:** While generally less than ultrasonic methods, heat generation can still be a concern for temperature-sensitive samples.

Characterization techniques

➢ **Viscosity**

Procedure

1. Sample preparation

Make sure the nanosuspension is uniform by gently stirring or shaking it. Eliminate any trapped air by letting it sit or by degassing if necessary.

Check for the presence of solid clumps or undispersed particles.

2. Instrument preparation

Power on the viscometer and let it stabilize.

If needed, calibrate the viscometer with a standard viscosity fluid. Choose and attach the correct spindle based on the anticipated viscosity range.

Set the desired temperature, typically 25°C or 37°C, using a temperature control unit or water bath.

3. Sample loading

Pour the nanosuspension into the sample container without overfilling it. Be careful not to create bubbles during the transfer.

Insert the spindle into the sample until it reaches the immersion mark.

4. Measurement

Begin by setting the viscometer to a chosen rotational

speed (for instance, 30 rpm).
Wait for the reading to stabilize, which typically takes 30 to 60 seconds. Note the viscosity value shown (in cP or mPa·s).
Optionally, repeat the measurement at various rotational speeds to analyze flow behavior.

5. Cleaning
Once measurements are complete, thoroughly clean the spindle and container using an appropriate solvent or distilled water.
Ensure the equipment is dried and stored correctly.

6. Documentation
Make sure to record the following
- Sample name and batch number
- Type of spindle and speed used
- Temperature
- Viscosity readings
- Observations regarding flow behavior (such as shear thinning)

➢ **PH**
Procedure for pH Testing of Nanosuspensions
1. Required Equipment and Materials
- A calibrated pH meter
- Buffer solutions for calibration (pH 4.0, 7.0, and 10.0)
- A beaker or sample container
- A glass electrode suitable for suspensions or thick fluids
- A magnetic stirrer (Optional for achieving uniformity)
- Distilled water for rinsing

2. Sample preparation
Gently mix or shake the nanosuspension to ensure it is uniform. Allow any trapped air to escape. Transfer an adequate amount (for example, 25–50 mL) into a clean beaker.

3. pH Meter Calibration
Power on the pH meter and let it stabilize.
Rinse the electrode with distilled water and gently dry it with a tissue.
Calibrate the meter using standard buffer solutions, typically at pH levels of 4.0, 7.0, and 10.0.
Confirm that the calibration is correct before moving on.

4. Measurement process
Rinse the electrode once more with distilled water and gently dry it. Submerge the electrode into the nanosuspension sample.
Gently swirl or stir the sample, avoiding any vigorous mixing or bubble creation. Wait for the pH reading to stabilize, which usually takes between 30 to 60 seconds. Record the pH measurement.

5. Cleaning
After use, promptly rinse the electrode with distilled water.
Keep the electrode in the suitable storage solution, typically KCl solution.

6. Documentation
Make sure to note the following details
- Sample name and batch number
- Date and time of the test
- pH value
- Temperature (if relevant)
- Any observations (such as foaming or sedimentation)

➢ **Zeta potential**
Zeta potential testing procedure for nanosuspensions
1. Equipment and Materials
- Zeta potential analyzer (Such as Malvern Zetasizer)
- Disposable or reusable cuvettes/cells that are compatible with your device
- Pipettes and micro-centrifuge tubes
- Distilled or deionized water
- Ultrasonicator (If necessary for dispersing clumps)

2. Sample preparation
- Gently mix the nanosuspension to achieve uniformity.
- Dilute the sample with deionized water (Usually at a ratio of 1:10 or 1:100), based on the requirements of the instrument, to minimize multiple scattering effects.
- If clumping is detected, use sonication briefly to separate the clusters.
- Ensure that there are no visible air bubbles in the sample.

3. Instrument configuration
Power on the zeta potential analyzer and let it complete its initialization process. In the software, select the mode for measuring zeta potential.

Adjust the settings as necessary, including
- Medium: Water or another dispersion medium
- Temperature: Typically set to 25°C
- Viscosity and refractive index of the medium (input as required)

4. Sample preparation
Using a pipette, fill the cuvette or cell with the prepared sample. Make sure to avoid introducing any bubbles.
Gently place the cuvette into the instrument.

5. Measurement
Begin the measurement through the software interface. The analyzer will generate an electric field and track particle movement to determine the zeta potential. Allow the process to finish, which usually takes between 1 to 3 minutes. Note the zeta potential value (in millivolts, mV) and any size data if available.

6. Cleaning and Maintenance
Take out and empty the cuvette. Rinse it with deionized

water and dry it, or discard it if using a single-use cell. Clean the electrodes following the manufacturer's guidelines.

➢ **SEM Analysis [Scanning Electron Microscopy]**

Procedure

1. Sample preparation dry the nanosuspension

Apply a small amount (5–10 µL) of the nanosuspension onto a clean surface (such as a silicon wafer or glass slide) by drop-casting.

Allow it to air-dry, use a low-temperature oven, or lyophilize to eliminate all liquid. Make sure the final sample is completely dry and free of aggregation for optimal imaging clarity.

2. Mounting

Attach carbon tape to the SEM sample stub.

Using tweezers or by gently pressing the substrate onto the tape, place a portion of the dried sample onto the tape.

3. Sputter COATING (If necessary)

If the sample is non-conductive, apply a thin layer (5–10 nm) of gold, platinum, or carbon using a sputter coater.

This step helps prevent charging and enhances image quality.

4. SEM Procedure

Insert the sample stub into the SEM chamber. Pump out the air to establish a high vacuum. Configure the imaging settings:

Voltage: Generally between 5–20 kV

Magnification: Modify according to the size of the particles

Focus and scan the sample to capture images at various magnifications.

5. Image evaluation

Take and store high-resolution images.

Examine:

Particle morphology (spherical, rod-like, etc.) Surface characteristics

Estimated particle size (qualitative; for quantitative analysis, utilize image analysis software)

➢ **TEM [transmission Electron Microscopy]**

Procedure

1. Sample preparation dry the nanosuspension

Apply a small amount (5–10 µL) of the nanosuspension onto a clean surface, such as a silicon wafer or glass slide.

Allow it to air dry, use a low-temperature oven, or lyophilize to eliminate all liquid. Make sure the final sample is completely dry and free of aggregation for optimal imaging.

2. Mounting

Attach carbon tape to the SEM sample stub.

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Particle morphology (spherical, rod-like, etc.) Surface characteristics

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Applications

1. **Topical formulations:** objectification of Nanosuspensions into topical formulation-supersaturated structures expanded saturation solubility) bettered diffusion pressure of medicine.

2. **Oral-cavity formulations (Paste, Gel, Patches)**

a. For medicines that didn't have sufficiently inordinate bioavailability in traditional oral phrasings small patches bettered adhesion and extended hearthstone.

b. Reduction in inter-issue interpretation progressed cure proportionality and increased vacuity due to growth in bioadhesion.

3. **Parental drug delivery:** Nanotechnology is also used in the parenteral medicine delivery system. The advantage of this fashion is it need simplest a lot much less volume of poisonous cosolvent for inadequately answerable medicines. This may hoist the remedial impact of the medicine compared with the conventional oral expression and targeting the medicine to the macrophages. The medicine clofarabine is given as iv the attention within the liver, spleen, and lungs reached an inordinate degree i.e.; advancer than minimum inhibitory mindfulness, for utmost of the mycobacterium album lines. Tarazed is formulated as nanosuspension to triumph over using surfactants and cyclodextrins to enhance the bioavailability.

4. **Optical delivery:** Nanosuspension can show to be a boon for medicines that expose bad solubility in lachrymal fluids. Nanosuspensions constitute a unique system for optical delivery of hydrophobic medicines due to their essential capability to

acclimate saturation solubility of medicines. Kassem et, have advanced Nanosuspension delivery system for positive glucocorticoid medicines.

5. **Pulmonary:** Nanosuspensions can be profitable for delivering medicines that show poor solubility in pulmonary secretion. Presently to be had approaches for pulmonary delivery similar as aerosols or dry greasepaint inhalers have sure disadvantages which include subdued prolixity at needed point, much lower hearthstone time and numerous others, which be conquered through means of Nanosuspensions. Fluticasone and budesonide had been successfully formulated as Nanosuspension for pulmonary Delivery.

6. **Dermal:** The non crystalline form possesses increased achromatic solubility ensuring in bettered diffusion of the medicine into the pores and skin. Monocrystals also parade colorful parcels together with increased penetration into a membrane, enhanced saturation.

7. **Mucoadhesion of nanoparticle:** It is the liquid medium and adheres to the mucosal surface before absorption. It improves the bioavailability and concentrated on to the sponger persisting the git. e.g.; buparvaquone in opposition Cryptosporidium parvum.

8. **Targeted medicine delivery** Nanosuspensions can be used for targeted delivery as their face the stabilizer or the terrain. Their versatility and ease of scale-up and parcels and in- Vito get can pain altered by means of changing both the marketable product allows the enhancement of commercially doable nanosuspensions for targeted delivery.[5,6,7]

CONCLUSION

The comprehensive review of nanosuspension formulations represents a significant advancement in addressing the poor aqueous solubility and limited bioavailability challenges associated with this widely prescribed statin medication. The findings consistently indicate that nanosuspension technology effectively transforms the physicochemical properties of simvastatin, resulting in remarkable enhancements in its dissolution profile and potential therapeutic efficacy.

REFERENCES

1. VB Patravale, AA Date and RM Kulkarni. Nanosuspension: a promising drug delivery strategy. J. Pharm. Pharmacol, 2004; 56: 827-40.
2. Pandya, V. M., Patel, J. K., "Effect of different stabilizer on the formulation of simvastatin nanosuspension prepared by nanoprecipitation technique. "Res. J. Pharm. Biol. Chem. Sci, 2010.; 1(4-5): 910-917.
3. Praveen Kumar G, Krishna KG; Nanosuspensions: The Solution to Deliver Hydrophobic Drugs. International Journal of Drug Delivery, 2011; 3: 546-557.
4. Pattnaik S, Swain K, Rao JV; Nanosuspensions: a strategy for improved bioavailability. International Journal of Pharmacy and Biological Sciences, 2013; 3: 324-327.
5. Muller RH, Jacobs C, Kayer O; Nanosuspensions for the formulation of poorly soluble drugs. In: F Nielloud, G Marti-Mesters (ed). Pharmaceutical emulsion and suspension. New York, Marcel Dekker, 2000; 383-407.
6. Muller RH, Grau MJ, Hildebrand GE; Increase of solubility of poorly soluble drugs by transfer to dissocubes using high pressure homogenization. Proc Int Symp Control Rel Bioact Mater, 1999; 26: 112-115.
7. Radtkem M; Nanopure: pure drug nanoparticles for the formulation of poorly soluble drugs. New drugs, 2001; 3: 62-68.
8. Toshi C. A Review on Nanosuspensions promising Drug Delivery Strategy. Current Pharma Research, 2012; 3(1): 764–76.
9. Pandey S. Nanosuspension: Formulation, Charcterization and Evaluation. Int J Pharma Bio Sci, 2010; 1(2): 1–10.
10. Adenovirus dodecahedron, a new vector for human gene transfer, van den Berg A and Dowdy SF. Protein transduction domain delivery of therapeutic macromolecules, CurrOpinBiotechnol, 2011; 22: 888-93.
11. Chen Y, Liu J, Yang X, H. Oleanolic acid Nanosuspensions: Formulation, In-vitro Characterization and Enhanced Hepato-protective Effect. Journal of Pharmacy and Pharmacology, 2005; 57: 259-264.
12. Prasanta D, Nanotechnology for the Delivery of Poorly Water Soluble Drugs, the Global Journal of Pharmaceutical Research, 2012; 1(3): 225-250.
13. Patel M, Nanosuspension: A Novel Approach for Drug Delivery System, JPSBR, 2011; 1: 1-10.
14. Shelke PV, A Review on Formulation and Evaluation of Nanosuspension, International Journal of Universal Pharmacy and Life Sciences, 2012; 2(3): 516-524.
15. Venkatesh T, Nanosuspensions: Ideal Approach for the Drug Delivery of Poorly Water Soluble Drugs, Der Pharmacia Lettre, 2011; 3(2): 203-213.
16. Yadav GV, Nanosuspension: A Promising Drug Delivery System, Pharmacophore, 2012; 3(5): 217-243.
17. Pandey S, Nanosuspension: Formulation, Charcterization and Evaluation, International Journal of Pharma and Bio Sciences, 2010; 1(2): 1-10.
18. Toshi C, A Review on Nanosuspensions promising Drug Delivery Strategy, Current Pharma Research, 2012; 3(1): 764-776.
19. Muller RH, Gohla S, Dingler A, Schneppe T, Large-scale production of solid-lipid nanoparticles and nanosuspension, Handbook of pharmaceutical controlled release technology, 2000; 359-375.

20. Muller RH, Peters K, Nanosuspensions for the formulation of poorly soluble drugs I: Preparation by a size-reduction technique, Int. J. Pharm, 1998; 160: 229–237.
21. Jahnke S, The theory of high-pressure homogenization. In: Muller RH, Benita S, Bohm BHL, Emulsions and nano suspensions for the formulation of poorly soluble drugs, Medpharm Scientific Publishers, Stuttgart, 1998; 177– 200.
22. Kumari K, P.V, Rao S, Y. Nanosuspensions: A Review. International Journal of Pharmacy [Internet], 2017, [2021; 20]; 7(2): 77–89. Available from: https://www.pharmascholars.com/abstract/nanosuspensions-a-review- 51162.html
23. Hussain MS, Baquee A, Debnath J. Nanosuspension: A promising drug delivery system for poorly water soluble drug and enhanced bioavailability. Int J Pharm Sci Res [Internet], 2020. Available from: https://ijpsr.com/action=download_pdf&postid=67351
24. Nanosuspension: A promising drug delivery system for poorly water soluble drug and enhanced bioavailability [Internet]. International Journal of Pharmaceutical Sciences and Research.