Review Article
CODEN (USA): IJPLCP

ISSN: 0976-7126
Wanjare *et al.*, 12(8):44-53, 2021

International Journal of Pharmacy & Life Sciences
Open Access to Researcher

Nanosuspension: A Promising Approach to Improve Solubility, Dissolution Rate and Bioavailability of Poorly Soluble Drug

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Article info

Received: 11/07/2021

Revised: 26/08/2021

Accepted: 28/08/2021

www.ijplsjournal.com

Abstract

Solubility is a critical element in pharmacological efficacy of drug regardless of the method of administration. The nanosuspension technology can improve the drug's solubility and bioavailability. The fact that many newly discovered drugs are water insoluble and thus show poor absorption and bioavailablity. These low solubility drugs can now be administered using nanosuspension formulation. Commercially available technologies such as high pressure homogenization, media milling, emulsification, and melt emulsification are frequently used to make nanosuspensions. Post-processing techniques such as solidification and surface modification are utilized to provide certain features to advanced therapies. Drugs like Itraconazole, Simvastatin, and Carbamazepine, which are poorly soluble in both aqueous and nonaqueous environments and are categorized as BCS class II make the issue even more complicated. Formulation as a nanosuspension is an appealing and promising solution to these issues. This review article discusses about the advantages, disadvantages, method of preparation, characterization, and applications of nanosuspensions.

Keywords: Nanosuspension, Solubility, Poorly Soluble Drug, Dissolution, Bioavailability, Surfactant

Introduction

Solubility, room temperature stability, solvent compatibility, excipient compatibility, and photostability are all important factors in drug formulation success[1]. More than 40% of new chemical entities discovered through drug development programs are lipophilic or poorly water soluble substances[2]. According to a recent estimate, 2.46% of all New Drug Applications (NDAs) are filed in the United States between 1995 and 2002 were BCS class II and IV, while only 9% were BCS class I drugs, revealing that a majority of the approved new drugs were water insoluble[3]. Because of their weak solubility, it will be more difficult to incorporate them into traditional dosage forms, as it cause lowering of drug's bioavailability[4]. Formulating novel compounds that are weakly water soluble in order to provide acceptable bioavailability has become a critical and difficult scientific, industrial, and medical problem. Poorly soluble drug compounds include "grease ball" and "brick dust" molecules, because there are no interactions with water, grease ball molecules are very lipophilic and have a high log P value.

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The melting point of brick dust molecules is above 200ºC, with a low log P value. The strong intermolecular interaction and high lattice energy in the solid state lead their poor solubility in water.

There are a variety of formulation techniques available to address drug solubility and bioavailability issues[5]. Micronization, the use of fatty solutions, the use of penetration enhancers or cosolvents, the surfactant dispersion method, salt formation, and cyclodextrins are examples of traditional approaches that have shown to be effective as drug delivery systems[1,6]. However, the main drawbacks of these techniques are a lack of universal applicability to all drugs[7]. These methods are ineffective for drug that are insoluble in both aqueous and organic solvents[2]. As a result, there is an increasing demand for a unique method that can address the formulation-related issues connected with the distribution of hydrophobic pharmaceuticals in order to improve clinical efficacy and pharmacoeconomic[8]

Over the last 20 years, a novel method has been developed to boost drug solubility and dissolution rate by reducing drug particle size. Drugs with smaller particle sizes have larger surface areas, which leads to increased dissolution velocity, according to the Noyes–Whitney equation. Bigger dissolution rates, combined with a higher concentration gradient between the gastrointestinal lumen and the systemic circulation, could boost drug bioavailability even further[9]. When compared to a micronized product, the increased surface area and concentration gradient result increase in dissolution velocity[10].

Nanotechnology can be utilized to overcome the drawbacks of traditional approaches to increasing solubility and bioavailability[4]. Atorvastatin, Famotidine, Simvastatin, Revaprazan and Aceclofenac are all hydrophobic medications that are formulated as Nanosuspension[2].

The most significant problems with poorly water-soluble drugs:

- Poor bioavailability
- Inability to choose the best lead molecule based on efficacy and safety
- Bioavailability differences between fed and fasting individuals
- Lack of proportionality in dose-response relationships
- Inadequate dosing
- Excessive use of harsh excipients, such as co-solvents and other excipients
- Excessive use of basic or acidic condition to improve solubilization[11].

Nanosuspension

A nanosuspension is a colloidal dispersion of drug particles that is submicron in size. A pharmaceutical nanosuspension is defined as a very finely colloidal, biphasic, dispersed, solid drug particles in an aqueous medium with a size of less than 1μm, stabilized by surfactants and polymers, and manufactured using appropriate procedures for drug delivery applications through various routes of administration like oral, topical, parenteral, ocular & pulmonary routes[12]. A nanosuspension not only overcomes the problem of poor solubility and bioavailability, but it also changes the drug's pharmacokinetics, improving its safety and efficacy[5]. Nanosuspension particles range in size from 200 to 600 nanometers[13].

Criteria for selection of drug for nanosuspensions

Nanosuspension can be made for drugs that have one or more of the following properties:

- Insoluble in water but soluble in oil.
- Drugs that inhibit the crystal's tendency to dissolve, regardless of the solvent,
- API with a very high dose[12,14].

Advantages of nanosuspensions

Nanosuspension has a number of unique characteristics that make it a viable drug delivery option, as mention below.

- Reduced particle size, increased dissolving rate, and absorption rate and extent.
- Physical stability over time.
- To improve bioavailability, drugs with a high log P value can be synthesized as nanosuspensions.
- Compounds that are insoluble in water but soluble in oil can be used to make nanosuspension.
- The pharmaceutical nanosuspension can be administered via oral, topical, parenteral, ophthalmic, pulmonary, and other routes.
- Nanosuspensions can be used in tablet, pellet, hydrogel, and suppositories.

- Drug nanosuspension can be used to provide passive drug targeting.
- Due to high dissolving rate and saturation solubility of the drugs, it can improve *in-vivo* performance.
- Manufacturing and scale-up for large-scale production are simple.
- Surface modification for site-specific drug delivery is a possibility. The amorphous fraction in particles can be increased via nanosuspension technology, which could lead to a change in crystalline structure and solubility[5,15].

Disadvantages for nanosuspensions

- Physical stability, sedimentation, and compaction are all potential issues.
- Because it is bulky, more caution must be exercised when handling and transporting it.
- It is impossible to achieve a consistent and correct dose[5,13,16].

Limitation of nanosuspensions

- An increase in the rate of sedimentation during storage can cause instability.
- Wear and tear can occur during transportation and storage due to their bulkiness.
- Complications in manufacturing[16,17].

Formulation consideration

Stablizer

The main purpose of the stabilizer is to thoroughly wet the drug particles and to prevent Ostwald's ripening and agglomeration of the nanosuspension in order to produce a physically stable formulation by forming steric or ionic barriers. In the formulation, the drug-to-stabilizer ratio might range from 1:20 to 20:1. Poloxamers, polysorbate, cellulosic, povidones, and lecithin stabilisers have been employed in the past. The stabilizer of choice for creating parenterally acceptable and autoclavable nanosuspensions is lecithin[13,18].

Surfactants

Surfactants are used to improve the dispersion by lowering interfacial tension. They can also be used as deflocculating or wetting agents. Tweens and spans are often used as surfactants[13,19,20].

Cosurfactants

When utilising microemulsions to make nanosuspensions, the choice of co-surfactant is crucial[18]. When microemulsions are employed to make nanosuspensions, co-surfactants can have a big impact on phase behaviour. The effect of a co-surfactant on internal phase uptake and drug loading for a specific microemulsion composition should be explored[9]. Although bile salts and di-potassium glycyrrhizinate are described in the literature as co-surfactants, other solubilizers, such as transcutol, glycofurol, ethanol, and isopropanol, can be employed safely as co-surfactants in the formation of nanosuspension[9,13,19,20].

Organic solvent

Pharmaceutically acceptable less hazardous water miscible solvents, such as methanol, ethanol, chloroform, isopropanol, and partially water miscible solvents, such as ethyl acetate, butyl lactate, triacetin, propylene carbonate, and benzyl alcohol are preferred in the formulation over traditional hazardous solvents, such as dichloromethane[14,18].

Other additives:

Other substances are chosen according to the physiochemical features of the prospective medicine or the method of administration, however buffers, salts, polyols, and osmogene are commonly utilized[14,20].

Techniques of preparation of nanosuspension

Nanosuspensions have been proven to be cost effective and a very straightforward way of synthesizing poorly water-soluble drugs, as opposed to numerous standard techniques of generating colloidal drug carriers. The preparation of nanosuspensions can be done using a variety of techniques. The ‘Top Down' method and the ‘Bottom-Up' method are two general classifications[21].

Bottom up techniques- The solubility of the drug in the water solvent mixture is low, and it precipitates. The basic challenge is that the growth of the crystals during the precipitation operation must be controlled with the addition of surfactant to avoid the production of microparticles[14,22,23]. The following are examples of traditional precipitation methods, sometimes known as bottom-up process techniques:

- Precipitation technique
- Super critical fluid process
- Emulsification solvent evaporation technique
- Lipid emulsion/micro-emulsion template
- Melt emulsification method

- Solvent evaporation techniques
- Hydrosol technique[24]

Top-down techniques- The breakdown of big particles, microparticles, and nanoparticles occurs in the top- down process. The techniques that are used are as follows:

- High pressure homogenization
- Nanoedge
- Nanopure
- Media milling
- Dry-co-grinding

Top-Down Techniques:

Media-milling

Nanosuspensions are made using mills with high shear or pearl mills. Milling chamber, milling-shaft, and re-circulation chamber are among the components. An aqueous suspension of the drug is then delivered into the mill, which contains microscopic grinding balls/pearls[25]. These balls fly within the grinding container jar and collide on the other grits as they rotate at a high shear rate (under controlled temperature). The combined forces of friction and impact result in a magnified particle size reduction. The milling media or balls are made of ceramic-sintered alumina or zirconia or firmly cross-linked polystyrene resin and have a high abrasion resistance. A planetary ball mill is an example of a kit that will be used for grind sizes of less than 0.1μm using a wet milling method[24]. Using the pearl milling process, a nanosuspension of Naproxen with a mean particle size of 300–600 nm is created[25,26].

High pressure homogenization

Many poorly water-soluble drugs have been nanosuspended using this technology. Homogenization is achieved by driving the suspension under pressure through a narrow-aperture valve. The surfactant and drug are focused under pressure and homogenized using a nanosized aperture value of high-pressure homogenization in this procedure. The principle is based on aqueous phase cavitation's. The need for small sample particles before loading and the fact that numerous cycles of homogenization are necessary are also concerns with this procedure. It is necessary to prepare a pre-suspension of the medicine before undergoing the homogenization process[27]. First, drug powders are dispersed in stabilizer solution to generate pre-suspension, which is then homogenized at low pressure in a high-pressure homogenizer for pre-milling, and then homogenized at high pressure for 10 to 25 cycles to form nanosuspensions of the appropriate size[28].

High pressure homogenization in water (Dissocubes)

Homogenization is accomplished by driving the suspension under pressure through a narrow-aperture valve. Muller et al invented Dissocubes in 1999. The instrument is capable of operating at pressures ranging from 100 to 1500 bars (2800–21300 psi) and up to 2000 bars with a 40ml capacity (for laboratory scale)[28].

Principle-

The cavitation principle is used in piston gap homogenizers to reduce particle size. Particles are also diminished as a result of significant shear forces and particle collisions with one another. The dispersion contained in a 3cm diameter cylinder moves through a 25m gap fairly quickly. The flow volume of liquid in a closed system per cross section is constant according to Bernoulli's Law. When the diameter is reduced from 3cm to 25m, the dynamic pressure rises while the static pressure falls below the boiling point of water at ambient temperature. Water begins to boil at room temperature, forming gas bubbles that collapse when the suspension leaves the gap (cavitation) and normal air pressure is attained. Temperature, the number of homogenization cycles, the power density of the homogenizer, and the homogenization pressure all influence the size of the drug nanocrystals that can be produced[29].

Homogenization in non-aqueous media (Nanopure)

This is a different type of nanosuspension preparation method that involves homogenization in water or water-free media and is used to make thermolabile chemicals. Nanopure is also known as deep freezing because drug suspensions are homogenized in non-aqueous medium at 0°C temperature, or even below the freezing point using deep freeze homogenization[30]. Suspensions homogenized in nanopure without the use of water media or water blends. PEG 400, PEG 500, and PEG 1000 are examples of blends[31].

Homogenization– high-pressure homogenization (Nanoedge)

Nanoedge is a process that combines microprecipitation with high-pressure

homogenization. In this method, friable materials are precipitated, then fragmented under high shear and/or thermal energy[32]. In this method, the drug is dissolved in an organic solvent and then combined with a miscible antisolvent for precipitation. The precipitated suspension is homogenized further in this method to reduce particle size and prevent crystal formation. In a short amount of time, it produces nanosized stable dispersion[27].

Nanojet technology

Nanojet is a commonly utilized technology in which a high pressure of force is applied to pass a suspension that has been divided into at least two sections and that collide with one other due to high shear forces produced during the operation, resulting in particle size reduction[30]. The M110L and M110S microfluidizers are examples of equipment that use this technique (Microfluidics). The high number of passes through the microfluidizer and the fact that the product obtained contains a significantly higher fraction of microparticles are the two key drawbacks of this technology[29].

Dry-co-grinding

Many nanosuspensions are now made using the dry milling process. Dry-co grinding is simple and cost-effective, and it does not require the use of organic solvents. Because of an improvement in the surface polarity and transformation from a crystalline to an amorphous drug, co-grinding improves the physicochemical properties and dissolving of poorly water soluble pharmaceuticals[26,33].

Bottom Up Techniques:

Precipitation technique

Precipitation has been employed to prepare submicron particles for many years, particularly for poorly soluble drugs[20]. First, the drug is dissolved in a solvent. In the presence of surfactant, this solution is combined with miscible antisolvent[25]. When drug solution is added to antisolvents, the drug becomes supersaturated in the mixed solution, resulting in the formation of crystals or amorphous drug solids. There are two steps to this process: nuclei creation and crystal development[26].

Supercritical fluid method

Solvent evaporation, solvent diffusion, and organic phase separation are some of the procedures utilized to prepare diverse formulations, but these technologies are hazardous to both human health and the environment. As a result of this difficulty, experts looked towards eco-friendly supercritical technology[30]. Rapid expansion of supercritical solution process (RESS), supercritical anti-solvent process, and precipitation with compressed anti-solvent process are some of the ways that have been tried. The RESS involves expanding a drug solution in supercritical fluid through a nozzle, which causes the supercritical fluid's solvent power to be lost, resulting in the drug precipitating as small particles[29]. The drug solution is atomized into a container containing pressurized CO_2 in the PCA procedure. As the solvent is withdrawn, the solution becomes supersaturated, and fine crystals form. The supercritical anti-solvent process employs a supercritical fluid in which a weakly soluble drug is present, as well as a drug solvent that is miscible with the supercritical fluid and the drug solution is introduced into the supercritical fluid, and the supercritical fluid extracts the solvent[20].

Emulsification-solvent evaporation techniques

This method entails making a drug solution and then emulsifying it in a liquid that is not a non-solvent for the drug. Evaporation of the solvent causes the drug to precipitate[22]. A high-speed stirrer can be used to control crystal formation and particle aggregation by providing high shear forces[26].

Lipid emulsions as templates

Drugs that are soluble in volatile organic solvents or partially water miscible solvents can benefit from these approaches. This method involves dispersing a drug-loaded organic solvent or combination solvent in an aqueous phase containing appropriate surfactants to generate an emulsion. The organic phase is then evaporated at a low pressure, causing drug particles to precipitate instantly, forming a nanosuspension that is stabilized by surfactants. Another approach for making nanosuspensions is to employ an emulsion, which is made by utilizing a partly water miscible solvent as the dispersed phase in the traditional procedure. Simply diluting the emulsion yields nanosuspensions. In addition, nanosuspensions can be made using microemulsions as templates. The drug can be

injected into the internal phase or intimately mixed into the pre-formed microemulsion. The drug nanosuspension is created by diluting the microemulsion appropriately[34]. This strategy is demonstrated by the Griseofulvin nanosuspension, which is created by utilizing the microemulsion technique with water, butyl lactate, lecithin, and the sodium salt of taurodeoxycholate. The advantages of using lipid emulsions as nanosuspension templates are that they are simple to make by adjusting the emulsion droplet size and that they are straightforward to scale up. Organic solvents, on the other hand, have a negative impact on the environment, and huge volumes of surfactant or stabilizer are necessary[35].

Melt emulsification method

This process involves dispersing the drug in an aqueous solution of stabilizer, heating it over the drug's melting point, and homogenizing it to produce an emulsion. The sample holder is wrapped in a heating tape with a temperature controller during this operation, and the temperature of the emulsion was kept above the drug's melting point. The emulsion is then carefully cooled to room temperature or placed in an ice bath[2].

Hydrosol technique

It works in the same way that emulsification solvent evaporation does. The distinction is that the drug anti-solvent is completely miscible with the drug solvent. Challenges such as Ostwald ripening and crystal development can be met with high shear forces. It guarantees that the residual precipitate is smaller in size[31].

Solvent evaporation technique

This method entails making a drug solution and then emulsifying it in a liquid that is not a nonsolvent for the drug. Evaporation of the solvent causes the drug to precipitate. A high-speed stirrer can be used to control crystal formation and particle aggregation by providing high shear forces. Successful nanosuspension drug formulations for Griseofulvin, Diclofenac, Acyclovir, and Mitotane have been reported[36].

Post-Production Processing:

When a drug candidate is very vulnerable to hydrolytic cleavage or chemical degradation, post-production processing of nanosuspensions becomes critical. Processing may be necessary if the best feasible stabilizer is unable to keep the nanosuspension stable for an extended period of time or if the targeted route has unacceptable constraints. Techniques such as lyophillization or spray drying may be used to produce a dry powder of nano-sized drug particles when these factors are taken into account[2]. In these unit procedures, rational selection must be made based on drug attributes and cost considerations. Spray drying is generally more cost-effective and convenient than lyophillization. It is crucial to think about how post-production processing affects the particle size of nanosuspension drug and the moisture content of dried nano-sized parmaceuticals[8].

Characterization of nanosuspension

***In-vitro* Evaluations:**

Color, odor, and taste

These properties are especially essential in formulations that are taken orally. Variations in particle size, crystal habit, and subsequent particle dissolution can all be blamed for changes in taste, especially of active components. Chemical instability can also be indicated by changes in colour, odour, and taste[2].

Mean particle size and size distribution

Polydispersity index (PI) refers to the mean particle size and the width of the particle size distribution. The saturation solubility, dissolving velocity, and biological performance are all governed by particle size and PI. Photon correlation spectroscopy can be used to determine the PI and particle size distribution (PCS). If the PI value is 0.1-0.25, the size distribution is reasonably tight; if the PI value is larger than 0.5, the size distribution is very broad. Laser diffraction (LD) and the coulter-counter multisizer can also be used to assess particle size distribution. The coulter-counter, which is more efficient and accurate, yields the absolute number of particles per volume unit for the various size classes. In addition to PCS and LD measurement, particle size analysis using the coulter-counter technique is required for nanosuspensions intended for intravenous injection. Because the coulter-counter calculates the absolute number of particles per volume unit for various particle sizes. To explain the correlations between particle sizes and saturation solubility, the Noyes–Whitney

equation, Ostwald–Freundlich equation, and Kelvin equation could be employed[19].

Zeta potential measurement

The zeta potential of a nanosuspension must be determined since it provides information about the nanosuspension's physical stability. Both the stabilizer and the drug control the zeta potential of a nanosuspension[33]. The zeta potential is used to investigate the surface charge characteristics of nanosuspensions. The macroscopic stability of nanosuspensions is determined by the value of particle surface charge. For electrostatically stable nanosuspensions, a minimum zeta potential of ±30 mV is required, and a minimum of ±20 mV is required for steric stabilisation.

Crystalline state and particle morphology

The crystalline constitution and particle morphology of the drug will alter as it is nanosized. X-ray diffraction analysis is primarily utilized to determine the particle's solid state, and scanning electron microscopy is employed to supplement it[32].

Dissolution velocity and saturation solubility

Nanosuspensions have a significant advantage over other approaches in that they can boost both dissolving velocity and saturation solubility[34]. In diverse physiological solutions, these two parameters should be determined. The evaluation of saturation solubility and dissolution velocity aids in determining the formulation's *in-vitro* behaviour. With a drop in particle size to the nanoscale range, Böhm et al showed an increase in dissolve pressure as well as dissolution velocity. The dissolving pressure rises as the size of the particle decreases[2].

Density

The formulation's specific gravity or density is a significant quantity. The existence of entrapped air inside the formulation's structure is generally indicated by a drop in density[5]. Density measurements at a specific temperature should be performed with a well-mixed, homogenous formulation; a precision hydrometer can help with this[11].

pH Value

To reduce "pH drift" and surface coating with suspended particles, the pH value of an aqueous formulation should be obtained at a certain temperature and only after settling equilibrium has been attained[14]. To keep the pH stable, no electrolyte should be introduced to the exterior phase of the formulation[2].

Viscosity measurement

Using a Brookfield type rotating viscometer, the viscosity of lipid-based formulations of various compositions can be evaluated at various shear rates and temperatures. The thermal bath in the instrument's sample chamber must be kept at required temperature, and the samples for measurement must be immersed in it[2].

Nanosuspension stability

Drug crystals agglomerate as a result of excited nanosized particles with high surface energy. The primary goal of the stabilizer is to thoroughly wet the drug particles in order to prevent Ostwald ripening and/or agglomeration in the nanosuspension, resulting in a chemically stable preparation by providing a steric and/or ionic barrier[14]. Nanosuspensions are often stabilized using cellulosic, polysorbates, and lecithin. Parenteral nanosuspension is made in this way[24].

***In-Vivo* Biological Performance:**

The launch of an *in-vitro/in-vivo* correlation and monitoring of the drug's *in-vivo* output, regardless of the route and thus the delivery mechanism utilized, is an important aspect of the analysis. It is critical in the case of nanosuspension that is injected intravenously. Because the drug's *in-vivo* behaviour is influenced by the organ's distribution, which is influenced by drug surface[24]. Effective methodologies must be employed to quantify surface attributes and protein interactions in order to promote an understanding of *in-vivo* behaviour. Surface hydrophobicity may be determined using techniques like hydrophobic interaction chromatography, while protein adsorption following intravenous injection can be measured quantitatively and qualitatively using intravenous injection of drug nanosuspensions in animals[2].

Application of nanosuspension in drug delivery system

Bioavailability Enhancement

Poor oral bioavailability is caused by drugs with low solubility, permeability, or solubility in the gastrointestinal tract. Nanosuspension improves bioavailability by addressing the challenges of poor solubility and permeability across membranes. When Diclofenac was synthesized as a nanosuspension, the rate of dissolution was

enhanced. A nanosuspension formulation enhanced the bioavailability of Celecoxib, a poorly soluble COX2 inhibitor. When compared to micronized Celecoxib, crystalline nanosized celecoxib alone or in tablet demonstrated a considerable increase in dissolving rate and extent. Spironolactone and Budesonide are drugs that are difficult to dissolve[37].

Pulmonary Drug Delivery System

Nanosuspensions could be an excellent way to deliver drugs that are poorly soluble in pulmonary secretions. For lung delivery, aqueous nanosuspensions can be nebulized utilizing mechanical or ultrasonic nebulizers. Because of their small size, each aerosol droplet is expected to contain at least one drug particle, resulting in a more equal distribution of the drug in the lungs. The drugs nanoparticulate structure enables for fast drug diffusion and disintegration at the site of action. At the same time, the drug's improved adhesion to mucosal surfaces allows for a longer drug residence duration at the absorption site[38]. The capacity of nanosuspensions to provide a rapid onset of action and then controlled release of the active moiety is extremely useful and is required by most lung disorders. An ultrasonic nebulizer was used to successfully nebulize Budesonide drug nanoparticles[34].

Oral Drug Delivery

Because of its numerous well-known advantages, the oral route is the preferred method for drug delivery. Antibiotics taken orally, such as Atovaquone and Buparvaquone, accurately represent this condition. The nanosizing of such drugs can result in a significant increase in oral absorption and, as a result, bioavailability.

The area under the curve (AUC) (0-24 h) for Naproxen nanoparticles was 97.5 mg/h/l, compared to just 44.7 mg/h/l for Naproxen suspensions and 32.7 mg/h/l for Naproxen tablets. The gonadotropin inhibitor Danazol, when administered as a nanosuspension, has an absolute bioavailability of 82.3%, while the traditional dispersion (Danocrine) has just 5.2 percent. In comparison to the conventional commercial formulation, a nanosuspension of Amphotericin B was produced with a considerable increase in oral absorption[39].

Parenteral Drug Delivery

For most mycobacterium avium strains, the drug Clofazimine is given intravenously, and the concentration in the liver, spleen, and lungs reached a high level, i.e., larger than the minimal inhibitory concentration. To boost absorption, Tarazepide is manufactured as a nanosuspension to avoid the use of surfactants and cyclodextrins[9].

Ocular Administration

As ocular drug delivery systems, nanosuspensions provide a number of advantages:

- The use of a bio erodible polymer to modify the surface of nanoparticles results in a longer residual duration, which is necessary for effective treatment. Poly (alkyl cyanoacrylates), polycaprolactone, and poly(lactic acid)/poly (lactic-co-glycolic acid). The use of polymers in ocular drug delivery extends drug ocular residence time and improves treatment efficacy.
- Positively charged nanoparticles cling to negatively charged mucin, allowing for longer drug release. For example, the polymer Eudragit RS 100 was utilised in Ibuprofen nanosuspensions to improve corneal adherence by increasing drug residence duration by producing a positively charged surface.
- Due to the intrinsic adhesiveness of drug nanoparticles, drug loss is reduced.
- Increased rate and extent of drug absorption: nanosuspensions of Hydrocortisone, Prednisolone, and Dexamethasone were generated by high pressure homogenisation in a study by Kassem et al. The absorption rate and therapeutic efficiency of glucocorticoid drugs in the form of nanosuspensions, as opposed to standard dose forms, were dramatically increased in normotensive Albino rabbits with measured intraocular pressure[40].

Conclusion

Poor bioavailability is linked to the administration of hydrophobic drugs, particularly those that are poorly soluble in both aqueous and organic media. Nanosuspensions appear to offer a unique and commercially viable approach of overcoming this problem. Nanosuspensions are colloidal dispersions that contain nanoscale drug particles stabilized by submicron-sized surfactants.

Nanosuspensions can be taken orally, parenterally, pulmonary, ocularly, or topically. Finally, some of the 'nanosuspensions' current flaws were discussed, as well as the 'nanosuspensions' future prospects.

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Cite this article as:
Wanjare M., Sharma P.K., Koka S.K., Gupta A., Sharma R. and Darwhekar G.N. (2021). S Nanosuspension: A Promising Approach to Improve Solubility, Dissolution Rate and Bioavailability of Poorly Soluble Drug, *Int. J. of Pharm. & Life Sci.*, 12(8):44-53.

Source of Support: Nil
Conflict of Interest: Not declared
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