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Nanosuspension-An emerging method of drug delivery: A review

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Abstract

Drug nanosuspension emerged as a solution for delivering hydrophobic drugs. Pharmaceutical Nanosuspension is defined as very finely biphasic, colloid, dispersed solid drug particle in a aqueous solution. Two factor that limit the efficacy of pharmaceutical product are solubility and bioavailability. This problem are overcome by using nanosuspensions in place of traditional dosage form. This review describes various methods for preparation of

nanosuspension, characteristics of drugs, application and potential benefits. Techniques such as homogenization, milling precipitation etc found to have a great potential to solve various issues in delivery of API. Nanosuspensions can be used for targeted delivery as their surface properties and in vivo behavior can easily be altered. Thus nanosuspensions help to increase solubility and bioavailability of drugs.

Keywords: Nanosuspension, Drugs, Bioavailability, Solubility

Introduction

As the name suggest Nanosuspension is combination of two words i.e. Nano means very small and suspension means heterogeneous mixture in which solute particles are suspended in the solvent floating freely in the medium. Nanosuspension is biphasic in nature in which solid, colloidal fine particles are dispersed in aqueous vehicle which is stabilized by surfactants ^[1, 2]. Two main factor which play a critical or important role in formation of new Pharmaceutical product is solubility and bioavailability ^[3]. To solve these problems researchers are involved in finding new methods of drug delivery to increase the solubility and bioavailability of drug. Nano sized particle formulation can be made of all drug particle belonging to class II & IV of Biopharmaceutical Classification System (BCS). There are many approaches for increasing the solubility of drugs like micro ionization, precipitation techniques, surfactant dispersion, emulsion, micro emulsion, liposomes ^[4]. But these approaches are only suitable for drugs which are soluble in aqueous and organic solvents whereas Nano suspension technique can be used for drugs which are insoluble in both water and organic solvents. By increasing solubility and bioavailability Nano suspension technology also change the pharmacokinetic property of drug which leads to increased effectiveness and safety profile ^[5].

Characteristics of drug to be selected for Nano suspension:

1. Water insoluble but which are soluble in oil.
2. Insoluble in both water and oils.
3. Drugs which have reduced tendency of the crystal to dissolve.

1. High Pressure Homogenization ^[7]: This is based on Cavitation process. The suspension containing a drug and surfactant is forced under pressure through a Nano sized aperture valve of a high-pressure homogenizer. Homogenization can be used both in aqueous and non-aqueous media. Homogenization in non-aqueous media can be done by Nano pore, Nano edge and Nano Jet technique. Nano edge. It is combination of homogenization and precipitation. Small particle size with better stability can be made in shorter time period. Nano pore- Or as deep freeze homogenization. Water free media or water mixture like PEG 400, PEG 1000 is used for homogenization. Nano jet technique- suspension is divided into more than two parts in a chamber. Molecules get colloid at high pressure with each other. High shear force that produced during the process result in reduction of the particle size.

2. Milling Techniques: Also known as top down approach. In this, mechanical energy is used to break down rough particle into fine particles ^[8]. Nanosuspension are prepared by highshear ball mill or media mill. The size reduction within the chamber charged with drug, stabilizer(s) and wateries carried out by both impact and attrition of particles. Less energy utilization, ease of scale up, variation be minimum from batch to batch and capability to handle large quantities of material and four approved

Food and Drug Administration (FDA) drugs makes top down process more attractive. The quantity of material in the mill is of considered importance because too much feed produces cushioning effect and too little causes loss of efficiency and abrasive wear of the mill parts. The wearing and tearing of milling media may occasionally introduce residues in the finished product. However, this problem has been minimized

by using highly crosslinked polystyrene resin milling medium. Extended or increasing milling process time can introduce more fraction of amorphous into the materials, which may lead to instability. With milling process to manufacture uniform sized nanosuspension using small hard zirconium dioxide beads have been described [54].

Techniques for preparing Nano suspension [6]

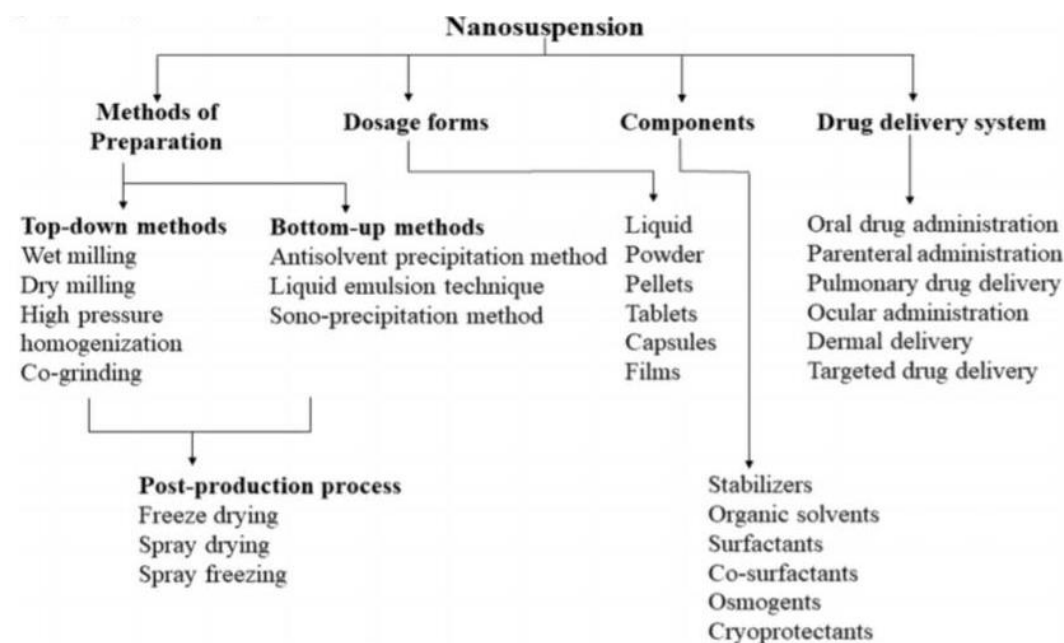


Fig 1

The x-ray diffraction analysis showed that the initial crystal nature as well as crystallinity of the active remained same even after the wet -milling process.

3. Emulsification Solvent: In this emulsification of drug in non-solvent liquid is done after preparing solution of drug. High speed stirrer is used for creating shear force to control crystal growth and particle aggregation.

4. Precipitation: Or solvent-antisolvent method. It is used for poorly soluble drug. In this technique, drug is mixed with organic solvent and then it is mixed with miscible antisolvent in presence of surfactant [9]. Firstly drug is dissolved in a suitable solvent. Then this solution is mixed with a miscible anti-solvent system in the presence of surfactants. Rapid addition of drug solution in to the antisolvent leads to the sudden super saturation of drug in the mixed solution forms ultrafine drug solids. This method involves two phase's nuclei formation and crystal growth. When preparing a stable suspension with the minimum particle size, one must keep in mind that a nucleation rate should be high and growth rate be low and it is necessary. Both the rates are depended on temperature. In this technique the drug needs to be soluble in at least one solvent which should be miscible with non-solvent [55].

5. Superficial Fluid Process: It is used for preparation of nanoparticles from drug solution. In this process, supercritical fluid is used in which drug is poorly soluble and a solvent is miscible with the supercritical fluid. It forms particle and size range from 5-2000 nm in diameter.

6. Lipid Emulsion/Micro Emulsion Template: In this technique, mixture solvent or organic solvent is loaded with the drug which is dispersed in aqueous phase containing suitable surfactant to form an emulsion. The organic phase is evaporate under reduced pressure to make drug particles.

Applications of Nanosuspension

Oral Drug Delivery: Because of lot of advantages oral route is the most preferable route for many drugs especially in the case of orally administering antibiotics such as atovaquone and bupravaquone. By making it in Nano size, due to which it's solubility and bioavailability will increase.

The oral administration of naproxen nanoparticles leads to an area under the curve (AUC) (0-24) of 97.5 mg/h/l compared with naproxen Nano suspension and Naproxen tablets. In the case of danazole (gonadotrophin inhibitor) Nano suspension has absolute bioavailability of 82.3 and the conventional dispersion only 5.3% [10].

Parental Drug Delivery: The drug clofazimine is given as iv, for most of the mycobacterium avium strains, the concentration in the liver, spleen and lungs reached a high level i.e.; Greater than minimum inhibitory concentration. Tarazepide is formulated as nanosuspension in order to overcome the use of surfactants and cyclodextrins to improve the bioavailsecretion [11].

Pulmonary Drug Delivery: It is used for nano preparations for the drugs which have poor solubility in pulmonary secretions. For the lung delivery it is nebulized by mechanical or ultrasonic nebulizer. E.g. budesonide [12].

Ocular Drug Delivery: It is applied for hydrophobic drugs. It increases the residence time include sac. The best example of nanosuspension is ibuprofen. The anti-inflammatory activity of ibuprofen increased compared with the aqueous preparation [13].

When to go for Nano Suspension Approach

- Preparation for Nano suspension is preferred for the compound that are insoluble in water (but are soluble in oil) with high log P value.
- Conventionally the drugs that are insoluble in water but soluble in oil phase are formulated in liposome, emulsion systems but these lipidic formulation approaches are not applicable to all drugs. In such cases nano suspensions are preferred.
- Nanosuspensions are being used as a formulation purposes In case of drugs that are insoluble in both water and in organic media instead of using lipidic systems.
- Nanosuspension formulation approach is most suitable for the compounds with high log P value, high melting point and high dose [14, 15].

Potential Benefits of Nanosuspension Technology for Poorly soluble Drugs

1. Reduced particle size, increase drug dissolution rate, increased rate and extent of absorption bioavailability of drug, onset time, peak drugs level, reduced variability, fasted effects.
2. Nanosuspensions may be used for compounds that are insoluble in water but soluble in oil. On the other hand, Nanosuspensions can be used in contrast with lipidic systems, successfully formulate compounds that are insoluble in both water and oils.
3. Nanoparticles can adhere to the gastrointestinal mucosa, prolonging the contact time of the drugs and thereby enhancing its absorption.
4. A noticeable advantage of nano suspension is the area of many administration routes for nanosuspension, such as oral, pulmonary, dermal and ocular.
5. Nanosuspension of nanoparticles (NPs) offers various advantages over conventional ocular dosage forms, including reduction in the amount of dose, maintenance of drug release over a prolonged period of time, decrease in systemic toxicity of drug, increased drug absorption due to longer residence time of nanoparticles on the corneal surface, greater drug concentrations in the tissue that are infected, suitability for poorly water – soluble drugs and smaller particles are superior tolerated by patients than larger particles, therefore nanoparticle may represent auspicious drug carriers for ophthalmic application.
6. Nanosuspension has low incidence of side effects by the excipients.
7. Nanosuspensions overcome issues of delivery for the compounds by obviating the need to dissolve them, and by maintaining the drug in a preferred state of crystalline of size sufficiently small for pharmaceutical acceptability.
8. Increased resistance to hydrolysis and oxidation, increased physical stability for settling.
9. Reduced administration volumes; essential for intramuscular, subcutaneous, ophthalmic use.
10. Finally, Nanosuspension can provide the passive targeting [16-19].

Need of Nanosuspension for bioavailability enhancement

Nevertheless, pharmacokinetic studies of BCS class-II drugs showed that they have a low oral bioavailability, which may be due to poor water solubility of drugs. There are many classical pharmaceutical ways to improve drug dissolution rate such as dissolution in aqueous mixtures with an organic solvent, formation of B-cyclodextrin complexes, solid dispersions and drug salt form. During last 20 years a new technology, reducing drug particle size, has been developed to increase drug dissolution rate [20]. According to Noyes Whitney equation, drugs with smaller particle size have enlarged surface areas which lead to increase dissolution velocity. Greater the dissolution rate together with the resulting higher gradient of concentration between gastrointestinal lumen and systemic circulation could further (more) increase oral bioavailability of drugs. A nanosuspension is a submicron colloidal dispersion of drug particles which are stabilized by surfactants [21]. A Pharmaceutical nanosuspension is defined as very finely dispersed solid drug particles in an aqueous vehicle for oral, topical, parenteral or pulmonary administration. The particle size distribution of the solid particles in nanosuspensions is usually less than one micron with an average particle size between 200 and 600 nm. In nanosuspension technology, the drug is maintained in the required crystalline state with reduced particle size, leading to an increased dissolution rate and therefore improving bioavailability [22].

Criteria for selection of drug for Nanosuspensions

Nanosuspension can be prepared for the API that is having either of the following characteristics:

1. Water insoluble but which are soluble in oil or API are insoluble in both water and oils.
2. Drugs with reduced tendency of the crystal to dissolve, regardless of the solvent.
3. API with large dose [23].

Advantages of Nanosuspension Drug Delivery System

1. It can be applied for poorly water soluble drugs.
2. Physically more stable than liposomes.
3. Most cost effective.
4. Reduction in tissue irritation.
5. Improved dose proportionality [24].

Formulation of Nanosuspension

1. Stabilizers: Wet the drug particles thoroughly; prevent Ostwald's ripening and agglomeration of nanosuspensions, providing steric or ionic barriers. Eg: Lecithins, poloxamers, Cellulosics, Povidones.
2. Cosurfactants: Influence phase behavior when micro emulsions are used to formulate nanosuspensions, eg: Bile salts, Dipotassium Glycerrhizinate, Transcutol, Isopropanol.
3. Organic solvent: Pharmaceutically acceptable less hazardous solvent for preparation of formulation eg: Methanol, Ethanol, Chloroform, Isopropanol, Ethyl formate, Butyl lactate, Triacetin, Propylene carbonate, Benzyl alcohol [25].

Recent Trends in Nanosuspension

In recent years, nanosuspension technology has been successfully applied to tackle the formulation issue of poorly soluble drugs [26]. Recently, nanopowders are used for

delivery system for oral administration to increase the dissolution rates of poorly soluble drugs. Tween 80/poloxamer 188 stabilised nanosuspension of a hydrophobic antiretroviral drug; loviride was prepared on a laboratory scale by media milling, and sucrose cofreeze-dried nanopowders were obtained [27]. Pulmonary products are essentially feasible. Nanosuspensions are aerosolized through commercial nebulizers, even though no products have been created. May be due to commercial reason but not technical. It makes little sense to replace a well – shelling products with a nanosuspension simply because pulmonary deposition might be superior. The cost for introducing nanosuspension in market is too high. Even with a new molecule, and established routine delivery technology is preferable [28].

Additionally, nanosuspension of poorly water soluble injection is rapidly growing field that has seek increasing attention due to its advantages in reducing toxicity and increasing drug efficacy through elimination of co solvent in the formulation [29]. The current approaches for parenteral delivery include salt formation, solubilization using cosolvents, micellar solutions, complexation with cyclodextrins and recently liposomes. However, there are limitations on their use these approaches because of the limitations on their solubilization capacity and parenteral acceptability. In this regards, liposomes are much more tolerable and versatile in terms of parental delivery. However, they often suffer from problem such as physical instability, high manufacturing Cost, and difficulties in scale-up. Nanosuspension would be able to solve the problems mentioned above [30].

Some recent studies based on stability have proved that nanosuspension could significantly improve the chemical and photo stability of quercetin compared with the solution stored in the same conditions. Nanosuspension technology would be an beneficial route for improving the stabilization of the chemical labile drugs [31]. Tam *et al.* [32, 33]. Have recently attempted to achieve stable nanosuspension via a novel design of flocs structure called "open flocs". Thin flim freezing was used to produce BSA nanorods with aspect ratio of approximately 24. These BSA nanorods were found to be highly stable when dispersed into hydroflouroalkane (HFA) propellant, with no apparent sedimentation observed for 1 year. Due to the high accept ratio of BSA nanorods and relatively strong attractive van der Waals (vdW) forces at the contact sites between the particles, primary nanorods where locked together rapidly as an open structure upon addition of HFA inhibiting collapse of the flocs [34].

A nanosuspension of indinavir has been loaded into bone marrow derived macrophages and injected into HIV -1 – Challenged humanized mice. The targeted delivery system significantly reduced numbers of virus – infected cells in plasma, lymph nodes, spleen, liver, and lung and led to CD4 (+) T-cell protection [35]. Sipronolactone (SP) is a mineralocorticoid widely prescribed in pediatric population. It is a poor water -soluble drug characterized by incomplete oral bioavailability, bitter taste, and tendency to destabilize in aqueous media. Regarding the good solubility of Spironolactone in lipid materials, lipid nanoparticles seemed to be an excellent way to overcome these issues [36]. To overcome the problems associated with oral absorption and bioavailability issues, various strategies have been utilized [37]. And nanosuspensions is emerged as a promising strategy for the efficient delivery of hydrophobic drugs nowadays [38].

Nanosuspension of Herbal Extract

Herbal medicines are used all over the world for decades. The efficacy of several species of therapeutics plants relies on the release of biologically active compounds. The majority of the active components of extracts are unable to pass the lipid membrane of the cells because either they have a markedly high molecular size or poor water stability, there suffers from low absorption and bioavailability [39]. Various phytomedicines thereby due to their poor absorption, exhibit the least or no considerable *in vivo* activities despite their amazing *in vitro* potential. Due to this obstacle, some extracts are not used clinically, it has been extensively suggested to incorporate herbal drugs with nanotechnology, as nanostructured systems might be capable to strengthen the action of herbal extracts decreasing the necessary dosage and side effects, and improving bioactivity [40]. Numerous nano-oriented approaches are been projected with the aim of optimizing the technology features of drugs [41, 42]. Nanosuspension technologies were introduced as a result of countless efforts made by formulation scientists and have been developed as a potent candidate for the delivery of poorly soluble drugs in a better efficient and pronounced manner [43]. Because by considering the limitations of previously used technology of particle size reduction Pharmaceutical scientists have been waiting for search a universal approach that would be able to address the formulation -related problems and barriers of poorly soluble drugs up to their desired label [44].

Silybum marianum commonly known as milk thistle is a member of Asteraceae family and genus silybum. Silymarin is the major bioactive compound isolated form its seed which has innumerable applications. Silymarin is employed for the oral therapy of chronic liver disorder but it has poor aqueous solubility there by poor bioavailability. Pharmacokinetics studies have revealed that after oral administration just 23 % to 47% of silymarin enters the systemic circulation.[45] Elettaria cardamomum generally known as cardamom has well known culinary value. Seeds of this plant are used in folk medicines for the treatment of cardiac and gastrointestinal disorders [46]. Coriandrum sativum commonly known as coriander has various pharmacological properties. Coriander is used as anti- inflammatory, antihypertensive, antiseptics, antidiabetic, myorelaxant [47]. this project had been designed to prepare the nanosuspension of three poor aqueous soluble plant extract to enhance their bioactivities. Nanosuspensions of S. Marianum. E. Cardamomum and C. Sativum were prepared by the nanoprecipitation method. Prepared nanosuspension were characterized for their particle size and morphology by scanning electronic microscopy (SEM).

Evaluation of the modified surface of particles

Surface Hydrophilicity [48]. For intravenously administer nanosuspensions additional parameters need to be determined which influence the *in vivo* fate of the drug nanoparticles. Surface hydrophilicity is considered one of the valuable parameters influencing the *in vivo* organ distribution after *i.v.* injection. The surface hydrophobicity determines the interaction with cells before phagocytosis and in addition, it is an applicable parameter for the adsorption of plasma proteins the main factor for organ distribution. To avoid artefacts, the surface hydrophobicity requires to be determined in the actual environment of the drug

nanoparticles, which means in the aqueous dispersion medium. An acceptable technique is hydrophilic interaction chromatography, previously employed to determine the surface hydrophobicity of bacteria, and then transferred to the characterization of nanoparticulate drug carriers.

Adhesion properties [49]:

In vivo bioadhesive study is accomplished where Male Wistar rats can be used. In general, each animal receives a single oral dose of 1ml aqueous suspension containing 10 mg of the nanoparticles loaded with the drug (approximately 45 mg particles/kg body Weight). The animal is sacrificed by cervical dislocation at 1 and 3 h post-administration. The abdominal cavity is opened and the stomach, small intestine and cecum are eliminated, opened lengthwise along the mesentery and wash out with phosphate saline buffer (pH 7.4). Further, the stomach, small intestine and cecum is cut into segments of 2 cm length and digested in suitable alkali for 24 h. Drug is extracted from the digested samples by addition of 2ml methanol, vortexed for 1 min and centrifuged. An aliquot (1ml) of the supernatants is to be assayed for the drug by spectrofluorimetry to calculate the fraction of adhered nanoparticles to the mucosa. For calculations, standard curves of the drug can be prepared.

Interaction with body proteins [49]

In vitro interaction between nanoparticles and mucin can be studied by incubation of mucin and nanoparticles (1.4 weight ratio) either in acidic or in neutral medium. The incubation is carried out under mixing at a temperature of 37 degrees Celsius. The dispersions are then be centrifuged and 150µl of each supernatant is placed on a test plate. Micro BCA Protein Assay Reagent Kit (150µl) was then added to the supernatants and the plate, in a test plate. Micro BCA Protein Assay Reagent Kit (15µl) then added to the supernatants and the plate is incubated for 2 h at 37° C. According to this protocol, the absorbance of mucin can be measured by calorimetry at a max of the drug at λmax of the drug.

The amount of mucin absorbed into the nanoparticles can be determined as the difference between its initial concentration and the concentration found in the dispersion after incubation and centrifugation. The calculations can be prepared based on mucin standard curves.

Properties of Nanosuspensions

- Physical Long-term stability [50]: Another special feature of nanosuspensions is the absence of Ostwald ripening, which is suggestive of their long-term physical stability. Ostwald ripening is responsible for crystal growth and subsequently formation of microparticles. Ostwald ripening is caused by the differences in dissolution pressure/saturation solubility between small and large particles. Molecules diffuse from the higher the potent area around small particles (higher saturation solubility) to areas around larger particles containing a lower drug concentration. This leads to the formation of a supersaturated solution around the large particles and consequently to drug crystallization and development of the large particles. The diffusion process of the drug from the small particles to the large particles leaves an area around the small particles that is not saturated anymore, accordingly leading to the dissolution of the drug from the small particles and finally completes the disappearance of the small particles.

- Internal structure of Nanosuspensions [51]: The high-energy input during disintegration process causes structural changes inside the drug particles. When the drug particles are exposed to high-pressure homogenization, particles are transformed from crystalline state to amorphous state. The change in the state depends upon the hardness of the drug, number of homogenization cycles chemical behaviour of the drug and power density pertained by a homogenizer.
- Adhesiveness [51]: There is a distinct increase in adhesiveness of ultra-fine powders compared to coarse powders. This adhesiveness of small drug nanoparticles can be exploited for improved oral delivery of poorly soluble drugs. A drastically remarkable report is that of the increase in bioavailability for danazol from 5 % (as macrosuspension) to 82% (as nanosuspension).
- Crystalline state and morphology [51]: A potential change in the crystalline structure of nanosuspensions saying increasing the amorphous fraction in the particle or even creating completely amorphous particles is a characteristic of consideration. The application of increased pressures during the production of nanosuspensions was established to promote the amorphous state.
- Increase in Saturation Solubility and Dissolution Velocity of drug [52]: Dissolution of drug is increased due to increase in the surface area of the drug particles from micrometres to the nanometer size. According to Noyes-Whitney equation (Equation no.1), dissolution velocity increases due to increase in the surface area from micron size to particles of nanometer size.

$$dx/dt = [(D \times A) / h] [Cs - X/V] \text{ -----Equation (1)}$$

Where D is diffusion coefficient, A is surface area of particle, dx/dt is the dissolution velocity, V is volume of dissolution medium and, h is the thickness of the diffusion layer is the concentration in the surrounding liquid.

Nanosuspension of Some Infectious Diseases [53]

HIV/AIDS

AIDS is a deadly infectious disease caused by a lentivirus called the human immunodeficiency virus. Presently two types of HIV viruses are known, HIV-1 (most prevalent) and HIV-2 (less prevalent and has only 40 % genetic identity with HIV-1). HIV is best known for infecting the T cell and macrophages of the immune system.

Advantages of Nanosuspension

- Nanosuspension (50-1,000 nm) are easily engulfed by the host cell, where they can release the drug to kill the virus by interrupting various intracellular infections.
- Nanocrystals can easily avoid bioelimination processes if arranged wisely. They can be produced in variable sizes depending on the target cell e.g. for macrophages (300-600nm), or intracellular delivery (100-200nm).

Malaria

Malaria infections are commonly accompanied by coma, multi-organ failure, and see anaemia malaria treatment. Plasmodium falciparum majorly causes 95 % of malaria deaths with a high mortality rate of 1-3%, due to the nanosized drug resistance by strain. In humans, maa larval the infectiochloroquineith a bite of Anopheles mosquitoes

contaminating sporozoites (*P. falciparum* and *P. vivax*). Lumefantrine (Pka=9), is a drug of choice in micro-suspension malaria and cerebral malaria treatment however due to low solubility it has severe bio ability problems.

Advantages of Nanosuspension

- The dose for canonized lumefantrine was 42 times lower than that of a standard used i.e. chloroquine at 4.2 ng/ml concentrations
- The DHA nanosuspensions showed higher in vitro antimalarial activity against *Plasmodium falciparum* than micro-suspension.

Chagas Disease

Chagas disease is caused by a hemoflagellate flagellate protozoan *Trypanosoma cruzi* (*T. cruzi*) which is transmitted by various Hematophagous Reduviidae bugs to humans either by contamination of faeces of bugs, during organ or blood transplant operations, genetic transmission and ingestion of contaminated food. It also causes an opportunistic infection among immune-compromised patients e.g. HIV infected people. Nifurtimox is the drug of choice for chagas.

Advantages of Nanosuspension

- The nano suspensions considerably increased trypanocidal activity compared with a standard solution of nifurtimox.
- The drug loaded nanoparticles showed increased trypanocidal activity on intracellular amastigotes with an IC50 of 13 times less than that of free drug.

Tuberculosis

It is induced by two species of *Mycobacterium* i.e. tuberculosis and bovis. Clofazimine, a riminophenazine compound is mainly used for treating *Mycobacterium avium* infection. However, the insufficient use of clofazimine is due to its low solubility and low bioavailability. Nanosuspensions can solve solubility and targeting attributed issues, thereby, improving drug pharmacokinetics and lung deposition. For inhalation targeting, nanosuspensions can be directly converted to nanopowder using spray dryer or lyophilization and directly filled in inhalator without affecting their particle sizes (100–800 nm). This will permit the deposition of nanocrystals in deeper layers of the lung.

Advantage of Nanosuspension: • Nanocrystals showed comparable concentration profile to that of clofazimine encapsulated marketed liposomes.

Summary

Nanosuspension is an ingenious drug delivery method and emerged as a new Approach to overcome the limitations of conventional drug delivery. Methods such as High pressure homogenization, superficial fluid process, precipitation, emulsification solvent, lipid emulsion are used for preparation of nanosuspension. Drugs get delivered through oral drug administration, parental, ocular, pulmonary, dermal and targeted drug delivery. Components used for formulation of nanosuspension are stabilizers, osmogents, cosurfactants and other additives. They are more stable than liposomes. It increases or improved dose proportionality and it solved issues of poorly soluble drugs.

The efficacy of herbal medicines of therapeutic plants relies on the release of biologically active compounds. To overcome the problems associated with oral absorption and bioavailability issues, various strategies have been utilized for that and nanosuspension emerged as a strategy for efficient delivery of hydrophobic drugs at present.

Nanosuspensions can be used for targeted delivery as their surface properties and in vivo behavior can easily be altered.

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