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A REVIEW ON "Solid Lipid Nanoparticles" (SLNs)

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Abstract

Solid lipid nanoparticles (SLNs) were recently developed in 1991 having particle size range from 10 to 1000 nm. SLNs used for novel drug delivery system basically it is colloidal carrier of lipids. In this review proposed of ideal characteristics of SLNs, Advantages & disadvantages of SLNs. This review also discussed the preparation methods of SLNs with diagrammatic representation procedure. Appropriate determination of characterization of SLNs like zeta potential and particle size, SEM, differential scanning Calorimetry and powder x-ray diffraction, etc. Route of administration of SLNs are also discussed in this review. Also added the various applications of SLNs in the advance drug delivery with suitable example.

Keywords: SLNs, SEM, TEM, SLS, DLS, HPH, Colloidal drug carriers, Homogenization, Preparation techniques, Nanoparticles.

Introduction

The nano- prefix comes from the Greek word nannos, which means "extremely short man". [1] Fine particles have a diameter of between 100 and 2500 nanometers, while ultrafine particles have a diameter of between 1 and 100 nanometers.[2] Nanoparticles, at the nanoscale, nanotechnology created a variety of materials. Nanoparticles (NPs) are a broad category of materials that include particulate compounds with one dimension less than 100 nm and at least three dimensions less than 100. [3] Bionanoparticles are nanoparticles that are biological in origin or are created by biological systems. Nanoparticles are the most important part of nanotechnology. Carbon, metal, metal oxides, and organic materials are all used to make nanoparticles. [4]

Particulate dispersions or solid particles are defined as nanoparticles. [5] The size, shape, and material qualities of nanoparticles can be used to classify them into several categories. Organic and inorganic nanoparticles are distinguished in several classifications[6].Solid lipid nanoparticles (SLN) were first presented in 1991 as an alternative to traditional colloidal carriers. [7] Nanotechnology is linked with items that are only a few nanometers in size. Cells are the building blocks of living beings. These cell parts, on the other hand, are nanoscale. Nanotechnology is concerned with the design, manufacture, and characterisation of nanoscale particles.

Nanoparticles are small things that act as a single unit terms of transport and characteristics. [8] Because of their huge surface to volume ratio, extremely small size, and size-dependent optical characteristics, these NPs have a unique physical and chemical conduct. [9] Fatty acids, steroids, waxes, monoglycerides, diglycerides, and triglycerides are all examples of SLNs. SLNs can be utilized for both hydrophilic and hydrophobic medicines, depending on the technique of synthesis. [10]

Particulate drug carriers, particularly small particles such as microparticles and colloidal systems in the nanometer range, have been credited with a significant potential for drug delivery. Nanoparticle drug delivery systems may have a number of advantages over traditional dose forms, including better toxicity, improved biodistribution, and increased patient compliance. Nanoparticles are colloidal particles with sizes ranging from 10 to 1000 nanometers. They are made of natural polymers and are well-suited to improving drug delivery and lowering toxicity. [11]

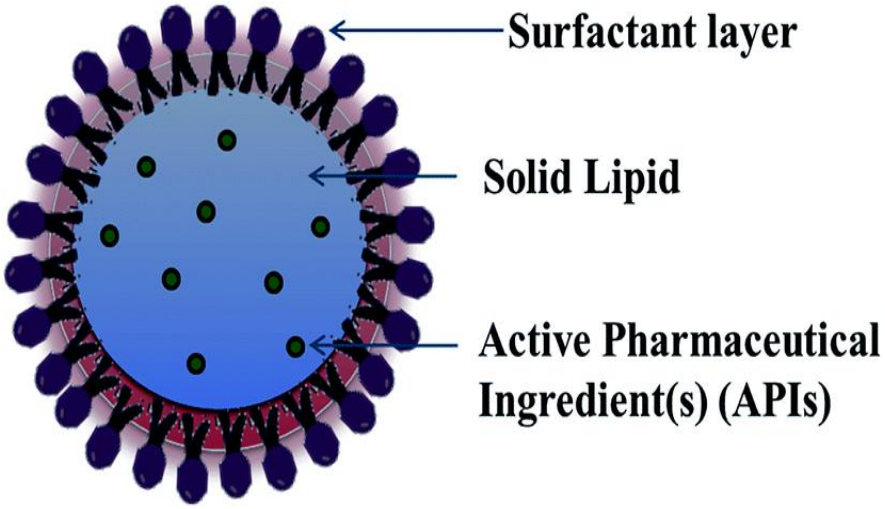

Fig.No.1. Structure of solid lipid nanoparticles

The following features must be included in an ideal nanoparticulate medication delivery system

1) Highest possible drug bioavailability.

2) Tissue selection.

3) Kinetics of release that are controlled.

4) The immune system's response is kept to a bare minimum.

5) The ability to administer medications that are generally difficult to distribute, such as lipophiles, amphiphiles, and biomolecules.

6) Adequate medication loading capability.

7) There is a high level of patient compliance. [12]

Advantages of SLNs

1) Control and target the release of a medication.

2) Outstanding biocompatibility.

3) Enhance medication stability.

4) Extensive and improved medication content.

5) Scalability and sterilisation are simple.

6) Encapsulated substance release kinetics can be better controlled.

7) Bioavailability of entrapped bioactive substances is improved.

8) Chemical protection of integrated substances that are labile.

9) Biopolymeric nanoparticles are far more difficult to make.

10) There is no need for a specific solvent.

11) Emulsions can be made using traditional procedures.

12) The same raw components are required for emulsions.

13) Extremely strong long-term stability.

14) Commercial sterilisation treatments are possible. [13]

Disadvantages of SLNs

1) It has a low capacity for drug loading.
2) Gelatinization tendency is unknown.
3) Polymeric transition kinetics are uneven.
4) During storage, particle development is noticed.
5) The dispersion has a somewhat higher water content (70-99.9 percent). [14]

Aims of solid lipid nanoparticles

1) Possibility of controlled medication discharge and medicine focused on
2) More moderate.
3) Possibility of incorporating lipophilic and hydrophilic drugs.
4) Natural solvents should be avoided.
5) Issues with significant scale creation and sanitization.
6) Sedate security has been improved.
7) The transporter has little biotoxicity, despite the fact that most lipids are biodegradable.
8) Bioavailability of certain bioactive mixtures is increased.[13]

General preparation methods of Solid Lipid Nanoparticles

Different ways for making SLNs from lipid, emulsifier, and water are discussed below.

1) Homogenization under high pressure
   i. Hot homogenization
   ii. Cold homogenization
2) Ultrasonication method
   i. Probe ultrasonication
   ii. Bath ultrasonication
3) Evaporation of a solvent
4) Method of solvent emulsification-diffusion
5) Method based on microemulsions
6) The method of supercritical fluids
7) The method of precipitation
8) The method of double emulsion

9) Spray drying
10) Solvent injection technique
11) Membrane contactor technique
12) Dispersion of ultrasonography in films.

1) Homogenization under high pressure (HPH)

It's a dependable and strong technology that's being employed for the first time to make SLNs. High-pressure homogenizers force a liquid through a tight gap at high pressure 100–2000 bar. The fluid accelerates from a very low velocity to a very high velocity over 1000 km/h in a very short distance. The particles are disrupted down to the submicron level by extremely high shear stress and cavitation forces. Generally, a lipid percentage of 5-10% is employed however up to 40% lipid content has been studied. Hot homogenization and cold homogenization are the two forms of HPH. In all circumstances, a preliminary step entails dissolving or dispersing the medication in the lipid melt to incorporate it into the bulk lipid. [15]

i) High pressure hot homogenization: It's carried out at temperatures over the lipid melting point and is so referred to as emulsion homogenization. A high-shear mixing device is used to create a pre-emulsion of the drug-loaded lipid melt and the aqueous emulsifier phase at the same temperature. HPH of the pre-emulsion is done at temperatures over the lipid melting point. Higher temperatures cause the inner phase thickness to drop, resulting in smaller particle sizes. High temperatures, on the other hand, hasten the deterioration of both the medicine and the carrier. Due to the high kinetic energy of the particles, increasing the homogenization pressure or the number of cycles frequently results in an increase in particle size. [16]

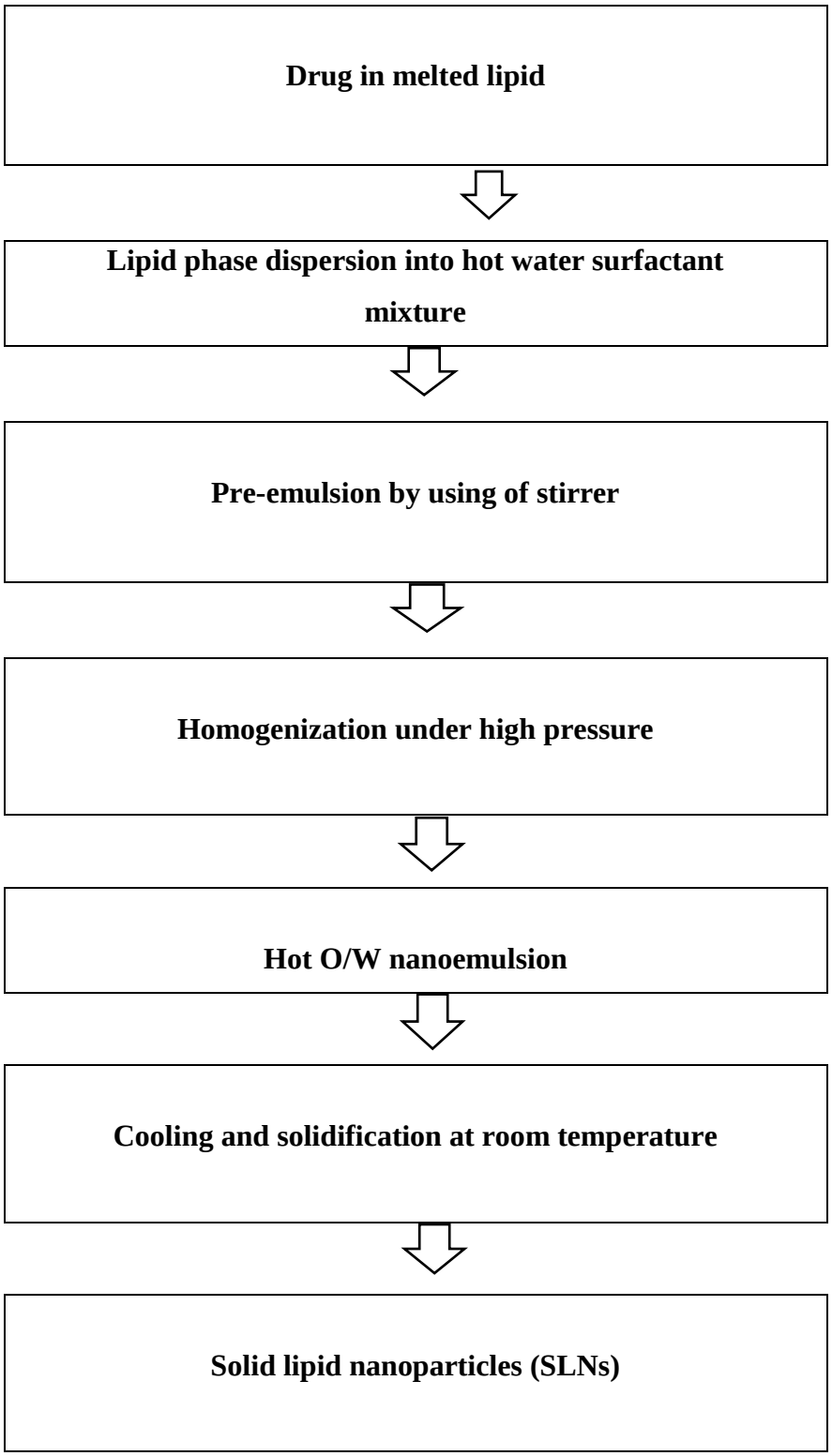

Fig. No. 2: Hot homogenization method

ii) High pressure Cold Homogenization

Cold homogenization is performed with solid lipid containing drugs and is referred to as milling of a partitioning of hydrophilic drugs from the lipid phase to the aqueous nanoemulsion, resulting in numerous modifications and super cooled melts. The initial step in the preparation is heat homogenization which

involves dispersing, dissolving, solubilizing the medication in melted lipid. The drug lipid combination is then quickly chilled using liquid nitrogen or dry ice. Cold homogenization was designed to prevent temperature induced drug degradation. Lipids are creased to micron size 50-100 micron in a ball mill then dispersed in cooled emulsifier solution to produce a pre-suspension. Pre-suspension is then homogenized at high pressure at room temperature, where the cavitation force is strong enough to break the microparticles into SLNs. This method avoids lipid melt resulting in loss of hydrophilic medication to the aqueous phase. Another way to reduce the loss of hydrophilic drugs to the aqueous phase is to additional water with a low-solubility media such as PEG 600. Cold homogenization has a higher particle size and polydispersity index larger size distribution than hot homogenization. Due to the melting of the lipid mixture in the initial step of preparation, cold homogenization only reduces the drug thermal exposure to a certain extent.

Advantages

1) Low initial investment.
2) Demonstrated on a small scale in the lab.

Disadvantages

1) This is a high-energy process.
2) Demonstrated on a small scale in the lab Damage to biomolecules.
3) Distributions that are polydisperse.
4) Scalability has yet to be shown. [17]

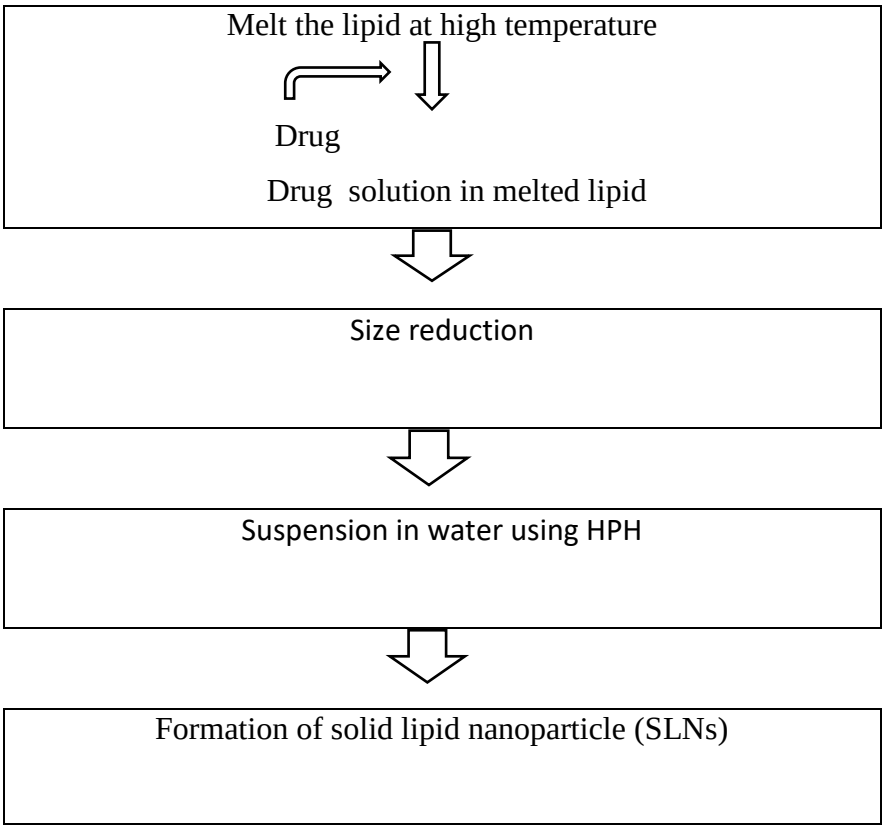

Fig. No. 3: Cold homogenization method

2) **Ultrasonication method**

Ultrasonication or high-speed homogenization procedures are also used to make SLNs. A combination of ultrasonication and high-speed homogenization is necessary to achieve lower particle sizes.

Advantages

1) Shear stress is reduced.

Disadvantages

1) Metal pollution is a potential.
2) Structural instability, such as particle development during storage. [16]

3) Evaporation of a solvent

The lipophilic substance is dissolved in a water-insoluble organic solvent cyclohexane that is emulsified in an aqueous phase to produce nanoparticle dispersions by precipitation in o/w emulsions. When the solvent evaporates, the lipid in the aqueous media precipitates, forming a nanoparticle dispersion. With cholesterol acetate as the model medication and a loci-thin/sodium glycocholate blend as the emulsifier, the average diameter of the produced particles was 25 nm. Siemen and Wests (1996) proved the repeatability of the result by producing cholesterol acetate nanoparticles with a mean size of 29 nm.

Advantages

1) It's an endless process.
2) It's adaptable.
3) Advanced technology.
4) Commercially validated.

Disadvantage

1) For starts, a polydisperse distribution.
2) Biomolecules are harmed. [18]

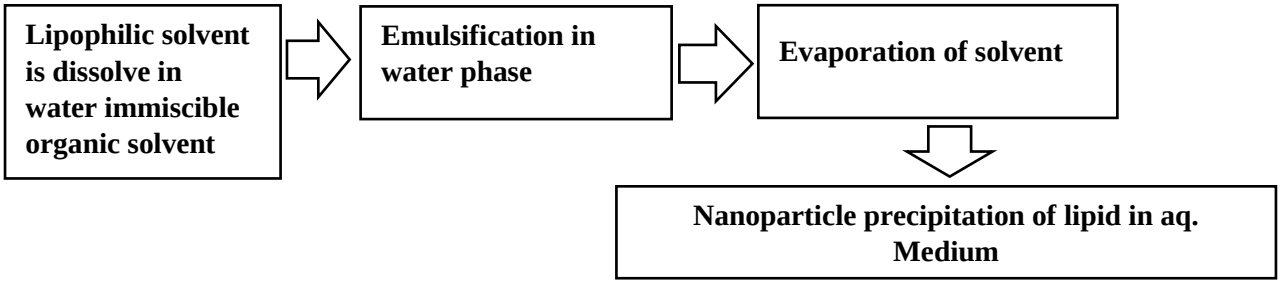

Fig. No. 4: Solvent evaporation

4) Solvent emulsification diffusion method

Solvent emulsification diffusion is for producing solid lipid nanoparticles that has been proposed. The average particle size is determined by the amount of lipid in the organic phase and the emulsifier used. This approach can produce particles with average sizes of 30 - 100 nm. The most major benefit of this technique is the avoidance of heat during the preparation. [19]

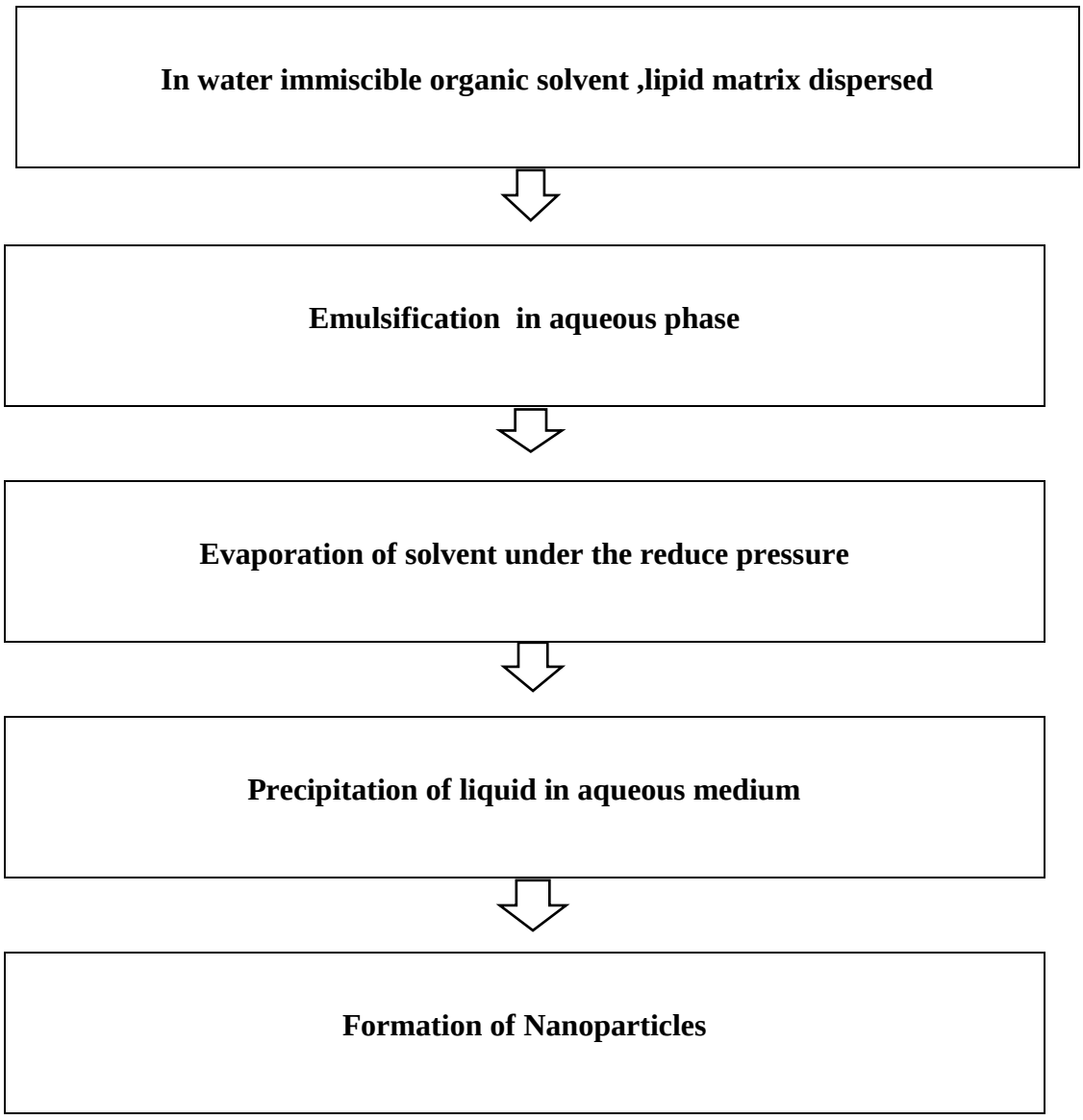

Fig. No. 5: Solvent emulsification diffusion method

5) Method based on microemulsions

At 65-70°C, a microemulsion is an optically clear mixture or a slightly bluish solution made up of a low melting lipid, an emulsifier, co-emulsifier, and water. The lipid phase precipitates when the heated microemulsion is disseminated in cold water (2-3°C) with continual stirring, generating fine particles smaller than 300nm.

The hot microemulsion to cold water volume ratio is normally in the range of 1:25 to 1:50. To improve particle concentration and eliminate surplus emulsifier residue, ultra-filtration is used to remove excess water. In the case of microemulsions, the temperature gradient and pH value, as well as the microemulsion's composition, determine the product quality.

Advantages

1) Input of mechanical energy is minimal.
2) Theoretical consistency.

Disadvantages

1) Extremely change-sensitive.
2) Formulation work that requires a lot of time and effort.
3) Nanoparticle concentrations are low. [17]

6) The method of supercritical fluid

This is a relatively novel method for producing SLN that has the advantage of not requiring the use of solvents. This platform technology for powder and nanoparticle manufacturing comes in a variety of flavours. The rapid expansion of supercritical carbon dioxide solutions (RESS) method can be used to make SLN. As a solvent, carbon dioxide (99.99 percent) was an excellent choice. [20]

7) Method of precipitation

A precipitation that does not require solvents can also be used to make SLNs. The glycerides will be dissolve in an organic solvent such as chloroform and emulsified in an aq. phase. The lipid will precipitate when the organic solvent has evaporated and producing nanoparticles. Due to the limited solubility of the lipids in the organic solvents utilised the suspensions produced by solvent emulsification evaporation are slightly dilute. Solvent cause toxicological effects if the solvent is evaporated further. [19]

8) The method of double emulsion

A novel approach based on solvent emulsificationevaporation was employed to prepare hydrophilic loaded SLN. The medication is encapsulated with a stabiliser in this case to avoid drug partitioning to the external water phase during solvent evaporation in the w/o/w double emulsion's external water phase. [21]

9) Spray drying

It is a more cost-effective alternative to lyophilization. This advises that lipids having a melting point above 70^0C be used. The best results were obtained with a concentration of 1% SLN in a trehalose in water solution or a 20% trehalose in ethanol-water mixture. The presence of carbohydrates and a low fat content aids in the retention of colloidal particle size during spray drying. The melting of the lipid can be avoided by using ethanol–water mixes instead of pure water since cooling causes small and heterogeneous crystals. [12]

10) Solvent injection technique

Lipids are dissolved in a water-miscible solvent and injected by an injection needle into a swirling aqueous solution with or without surfactant in this approach. The nature of the injected solvent, lipid concentration, injected amount of lipid solution, viscosity, and the diffusion of the lipid solvent phase into the aqueous phase are all parameters in this approach for synthesis of nanoparticles. [22]

11) Membrane contactor technique

The SLN is prepared using a unique process. In the membrane contactor technique, the liquid phase was squeezed through the membrane pore at a temperature above the melting point of the lipid, resulting in the creation of tiny droplets. The aqueous phase was constantly agitated and circulated tangentially inside the membrane module, sweeping away the droplets that were forming at the pore outlets. The formation of SLNs was achieved by cooling the preparation to room temperature. Both phases were placed in a thermo stated bath to maintain the desired temperature, and nitrogen was utilised to provide the liquid phase's pressure.

Several process factors (aqueous phase cross flow velocity, lipid phase pressure, aqueous and lipid phase temperature, lipid phase quantity, and membrane pore size) were investigated. Methods employing a polymerization of dispersed monomers (interfacial polymerization method) or a dispersion of premade polymers are also utilised to create polymeric nanoparticles using the membrane contact or method (Nano precipitation method). The ease of use, control of SLN size through appropriate process parameter selection, and scaling up ability of this SLN synthesis process using a membrane contactor have all been demonstrated. [20]

12) Dispersion of ultrasonography in films

The lipid and the medication were placed in suitable organic solutions, and a lipid film was created after decompression, rotation, and evaporation of the organic solutions, followed by the aqueous solution. The emulsions were also added. Finally, the ultrasound was used with the probe to diffuser. The SLN is created with a small and homogenous particle size. [23]

Methods of Secondary Production

1) Freeze-drying

Water can be removed from these systems to improve their physical and chemical stability. The most widely used method in the pharmaceutical industry for converting liquids or suspensions into stable solids for distribution and storage is freeze-drying. Freeze-drying, also known as lyophilization, is an industrially scalable technique that involves sublimation of frozen water and vacuum desorption. [24]

2) Sterilization

For parenteral administration and autoclaving, sterilisation of the nanoparticles is desirable, which is applicable to formulations including heat-resistant medicines. The effects of sterilisation on particle size have been studied, and it has been discovered that sterilisation causes a significant increase in particle size. [25]

3) Sanitization

Sterilization of nanoparticles is desirable for parenteral administration and autoclaving, which is applicable to formulations comprising heat-resistant pharmaceuticals. The effects of sterilising on particle size have been investigated, and it has been discovered that sterilisation increases particle size significantly. Schwarz investigated the impact of several sterilisation techniques on SLN characteristics steam sterilisation at 121°C (15 min) and 110°C (15 min), as well as g-sterilization. Particle aggregation may emerge as a result of the treatment, according to the research. [26]

Characterization of Solid Lipid Nanoparticles

For quality control, adequate and correct characterization of the SLNs is required. However, due to the colloidal size of the particles and the intricacy and dynamic nature of the delivery system, characterisation of SLN is a significant problem. Particle size, size distribution kinetics, degree of crystallinitity and lipid modification, coexistence of additional colloidal structures (miscelles, liposomes, super cooled melts, drug nanoparticles), time scale of distribution processes, drug content, in-vitro drug release, and surface morphology are some of the important parameters evaluated for SLNs.

1) Zeta potential and particle size

The particle size of SLNs determines their physical stability. The most potent approaches for determining particle size are photon correlation spectroscopy (PCS) and laser diffraction (LD). The fluctuation of the intensity of scattered light produced by particle mobility is measured by PCS. Particle size determination via photon correlation spectroscopy (PCS) detects sizes ranging from 3nm to 3m, and laser diffraction detects sizes ranging from 100 nm to 180 m. Although PCS is an excellent method for characterising nanoparticles, it can also identify bigger microparticles. The smaller methods are compared to the LD approach.

A zeta potential analyzer or a zetameter can be used to test zeta potential. For size determination and zeta potential measurement, SLN dispersions are diluted 50 times using the original dispersion preparation media. In the absence of other complicating factors such as steric stabilisers or hydrophilic surface appendages, a higher zeta potential may lead to particle deaggregation. The storage stability of colloidal dispersions can be predicted using zeta potential measurements. [18]

2) Scanning electron microscopy (SEM)

SEM can also be used to explain the microscopic structure of treatment models loaded on S LN, and SEM analysis can be performed using the JSM-5610LV (JEOL Ltd, Tokyo, Japan). Specimens can be stuck to seed

samples and then zoomed in to observe acceleration. In a scanning electron microscope (SEM) research, electrons flow freely on the sample's exterior surfaces. The image was taken while the electron microscope was turned off. [27]

3) Infrared spectroscopy (FT-IR)

The interaction between lipid and CA was studied using FTIR spectroscopy. There is no interaction between CA, lipid, and SLN formulations, according to FTIR spectra. There was no chemical shift or new peak found. If there is no chemical peak, there is no interaction between the medicine and other components, according to the literature. [28]

4) Acoustic techniques

Acoustic spectroscopy, another ensemble approach, examines the attenuation of sound waves as a means of measuring size by fitting physically relevant equations. Furthermore, the oscillating electric field generated by charged particle movement under the influence of acoustic energy can be measured to offer information on surface charge. [14]

5) Atomic Force Microscopy (AFM)

It is a cutting-edge microscopic approach that is utilised as a novel tool to photograph the particles' original shape and surface features. When the probe is held close to the sample, AFM measures the force acting between the surface of the sample and the tip of the probe, resulting in a convincing resolution of up to 0.01nm for imaging. [29]

6) Analysis using electron microscopy

To study the piroxicam-loaded SLNs directly, scanning electron microscopy (SEM) and transmission electron microscopy (TEM) were used. Particle specifics such as surface topography and exterior morphology of the samples are provided by these approaches.

In comparison to SEM, TEM has a smaller detection size limit. For TEM, samples were transferred to the North Eastern Hill University in Shillong, India, while SEM examination was performed at Oil India Limited in Duliajan, Assam, India.

7) Differential Scanning Calorimetry and Powder X-ray Diffraction (DSC)

The geometric scattering of radiation from crystal planes within a solid can be used to identify the presence or absence of the latter, and hence the degree of crystallinity. Through the measurement of glass and melting point temperature, DSC can be used to assess the type and speciation of crystallinity inside nanoparticles. Due to the rise, thermodynamic stability, lipid packing density, and measurement are all becoming more difficult, whereas drug incorporation rates are decreasing in the following order: 9-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-modification-

modification-modification-modification- Lipid crystallisation modification alterations may be much slowed due to the tiny size of the particles and the presence of emulsifiers. [22]

8) Light Scattering in a Dynamic Environment (DLS)

On a microsecond time frame, DLS, also known as PCS, records the variation in the intensity of dispersed light.

9) Static light scattering (SLS)

SLS is an ensemble method that collects and fits the scattered light from a solution of particles into a fundamental main variable.

10) Electron microscopy

The direct methods of measuring nanoparticles, physical characterisation of nanoparticles, and morphological evaluation are scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The detection limit of TEM is smaller. [13]

Routes of Administration

The following factors will have a significant impact on the SLN particles' in vivo behaviour: Interactions of the SLN with the biological environment, including dispersion and enzymatic reactions, are part of the administration route. There are various administration routes available.

1) Administration via the topical route

Because of their biocompatibility, they're frequently employed in topical applications. Due to enhanced exclusivity and hydration of the stratum corneum, lipophilic drugs loaded with SLN had greater skin penetration than free drugs. SLNs progressively change into the stable polymorph after application, allowing for long-term release. Regulated drug release from SLNs can be detected if such polymorphic transitions are controlled by the addition of a surface-active chemical.

2) Parenteral administration

SLN has been given to animals intravenously. After i.v. injection in rats, pharmacokinetic investigations of doxorubicin integrated into SLN revealed higher blood levels than a commercial drug solution. In terms of distribution, SLN had larger drug concentrations in the lungs, spleen, and brain, whereas the solution had more dispersion into the liver and kidneys. The pharmacokinetics and body distribution of camptothecin following i.v. administration in mice were studied by Yang et al. In compared to a drug solution, SLN was found to have significantly greater AUC/dose and mean residence times (MRT), particularly in organs containing reticuloendothelial cells. The brain had the greatest AUC ratio of SLN to drug solution of all the organs studied. [21]

3) Rectal administration

In some cases, parenteral or rectal administration is desirable when a quick pharmacological impact is desired. Because of its simplicity, this method is preferred by pediatric patients.

4) Nasal administration

Nasal administration is preferable because it allows for rapid absorption and initiation of therapeutic action while also avoiding labile drug breakdown in the GI tract and insufficient transport through epithelial cell layers.

5) Respiratory delivery

Nebulization of solid lipid particles containing antitubercular, antiasthmatic, and anticancer medications was found to improve drug bioavailability and reduce dose frequency, allowing for better pulmonary action management.

6) Ocular administration

The biocompatibility and mucoadhesive qualities of SLN enhance their contact with the ocular mucosa and extend the drug's corneal residence duration, allowing for ocular medication targeting.

7) Topical administration

SLN are extremely appealing colloidal carrier systems for skin applications because they provide a variety of favourable skin effects in addition to colloidal carrier system properties. Because they are based on nonirritant and non-toxic lipids, they are ideal for use on injured or inflamed skin. [30]

Applications of Solid Lipid Nanoparticles

1) Cosmeceuticals using SLNS

Since these carriers' critical purpose for application, cosmetics have grown in popularity. Carrier systems like SLNs and NLCs were created to suit industrial requirements including scale-up, certification and authentication, clear technology, and cheap cost. The SLNs were used as an active carrier agent for molecular sunscreens and UV blockers, as well as in the manufacture of sunscreen.

SLN and NLCs have shown to be revolutionary occlusive topicals with controlled release. In comparison to standard formulations, glyceryl behenate SLNs have improved vitamin A localisation in the higher layers of skin. The first two beautifying manufacturing goods with lipid nanoparticles hit the market in early 2005. [27]

2) Administration via parenteral nutrition

Animals were given SLN by intravenous injection. After I. v. injection in rats, pharmacokinetic investigations of doxorubicin integrated into SLN revealed higher blood levels than a commercial drug solution. In terms of distribution, SLN had larger drug concentrations in the lungs, spleen, and brain, whereas the solution had

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3) SLN for possible use in agriculture

According to a prior study, when the volatile oil derived from Artemisia arborescent L is mixed into SLNS, it reduces rapid evaporation when compared to when it is incorporated into emulsions. This technique is utilised in agriculture as a means of transporting environmentally friendly herbicides. [32]

4) Antitubercular chemotherapy with oral SLNs

Antitubercular medications such rifampicin, isonizide, and pyrazinamide-loaded SLN systems have been shown to reduce dose frequency and increase patient compliance. The emulsion solvent is used. Technique of Diffusion Antitubercular drugs are loaded into solid lipid nanoparticles. The nebulization of the aforesaid substance in SLN was also observed to improve the performance of an animal the drug's bioavailability. [31]

5) Stealth Nanoparticles

These provide a novel and unique drug-delivery method that avoids immune system clearance. These nanoparticles were evaluated with marker molecules and medicines in animal models. Stealth Lipobodies labelled with antibodies have shown enhanced delivery to the target tissue in an accessible location. [7]

6) SLN uses for better antiretroviral medication delivery to the brain

Antiretroviral medications (ARVs) are frequently ineffective in reducing HIV viral load in the brain. This is owing in part to the poor transport of many ARVs, particularly protease inhibitors, over the BBB and blood-cerebrospinal fluid barrier. Nano carriers such as polymeric nanoparticles, liposomes, SLNs and micelles have been shown to increase local drug concentration gradients, facilitate drug transport into the brain via endocytotic pathways, and inhibit the ATP-binding cassette transporters expressed at barrier sites, according to studies. The use of nano carriers to carry ARVs to the brain is predicted to result in a significant increase in medication bioavailability in the brain. [33]

7) SLN for Peptide and Protein Delivery

Proteins and antigens that are being considered for therapeutic treatments could be integrated or adsorbed onto SLN. The SLN formulation improves protein stability, prevents proteolysis degradation, and allows for long-term release of the integrated molecules. Peptides including cyclosporine A, insulin, calcitonin, and somtostatin have been integrated into solid lipid particles and are now being studied. There are a variety of local and systemic treatments available. [34]

8) SLNs for use in the respiratory system

By minimising first pass effects, the lungs provide a large surface area for medication absorption. Because the walls of alveoli in the deep lung are exceedingly thin, rapid medication absorption by aerosolization of medicines occurs. The uptake of particles in the respiratory system is greatly aided by lymphatic drainage. SLNs could be used as carriers for anti-cancer medicines or peptide therapies to increase their bioavailability in lung cancer treatment. The data demonstrated an important and significant uptake of radiolabelled SLN into the lymphatic following inhalation, according to the assessment of inhaled radiolabelled SLN bio distribution. Antitubercular medicines (rifampicin, isoniazid, and pyrazinamide) were mixed into various formulations of solid lipid particles ranging from 1.1–2.1 m and nebulized to guinea pigs for direct pulmonary delivery in a recent study. Nebulization of solid lipid particles containing antitubercular medicines was found to improve drug bioavailability and reduce dosage frequency, resulting in better pulmonary tuberculosis therapy. [35]

10) Nasal SLNs application

Due to fast absorption and rapid commencement of drug action, nasal administration was a viable alternative noninvasive method of drug administration, avoiding degradation of labile drugs (such as peptides and proteins) in the GI tract and insufficient transport across epithelial cell layers. Approaches including formulation development and prodrug derivatization have been used to increase drug absorption through the nasal mucosa. SLN has been offered by many research groups as an alternate transmucosal delivery route for macromolecular therapeutics and diagnostics. Coating polymeric nanoparticles with PEG yielded promising results as vaccine carriers, according to a recent study. The role of PEG coating on polylactic acid nanoparticles in increasing transmucosal transport of encapsulated bioactive molecules has been documented. Solid lipid nanoparticles could benefit from this notion. [36]

10) SLNs for use in the eyes

SLN delivery of ocular drugs has been recorded on multiple occasions. With the goal of ocular medication targeting, SLN's biocompatibility and mucoadhesive qualities boost its contact with the ocular mucosa and extend the drug's corneal residence time. In rabbit eyes, SLN was tested as a carrier for ocular administration of Tobramycin. As a result, SLN increased medication bioavailability in the aqueous humour substantially. Pilocarpine administration via SLNs, which is routinely utilised in glaucoma treatment, was also explored previously. They observed remarkably comparable findings in order to improve the drug's ocular bioavailability. [35]

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