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A REVIEW ON SOLID LIPID NANOPARTICLES

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ABSTRACT

Solid lipid nanoparticles are stable colloidal carriers made of lipids solid at both room and body temperatures .They are formed of a solid lipid core stabilized by a surfactant and containing the drug dissolved or dispersed. They consist of macromolecular materials in which the active component is dissolved, entrapped, or in which the active component is adsorbed or attached .They have been used as a physical approach to alter and improve the pharmacokinetics and pharmacodynamic properties of a various types of drug molecules. The review highlights the most widely used methods for synthesis of SLNs including Solvent emulsification evaporation, Solvent emulsification diffusion, solvent injection, High pressure homogenization, Phase inversion temperature, High speed stirring and ultra sonification, Membrane contactor, Micro emulsion, Co-acervation, Double emulsion and super critical fluid. Each method offers unique advantages interms of particles size control, surface modification, drug loading efficiency and targeted delivery. The application of SLNs acrossed drug delivery systems for controlled release, targeted delivery, gene therapy. Additionally SLNs have significant potential in treatment of cancer, Tuberculosis, Parasitic diseases like malaria and leishmaniasis, due to their ability to improve therapeutic efficacy with targeted delivery while minimizing side effects. In this review the different techniques for preparation of the SLNs are described and also contains its characterization, route of administration and application.

Nanoparticles

Nanoscience is the study of structures and molecules on the scale of nanometer ranging between 1 and 100 nm and the technology that utilizes it in practical applications such as devices etc., is called Nanotechnology. He laid foundation step of nanotechnology in his

lecture on" There is a plenty of room at the bottom" in 1959 at the California Institute of technology (Caltech). The term nanotechnology was coined by Japanese professor Norio Taniguchi Nanotechnology employes knowledge from the field of physics, chemistry, biology, materials science, health science, engineering.

Nanotechnology defined as the design, characterization, production and applications of structures, devices and systems which involved in controlling shape and size at nanometerscale. The prefix derives from the Greek word vavoc through the Latin word nanus, which means literally "dwarf" and thus "very small". "Technology" is the making, usage, knowledge of tools, machines, techniques, in order to solve a problem or perform a specific action. Nanoparticles are the building blocks of nanotechnology. A nanoparticle is microscopic particle whose size is measured in nanometres nanoparticles.

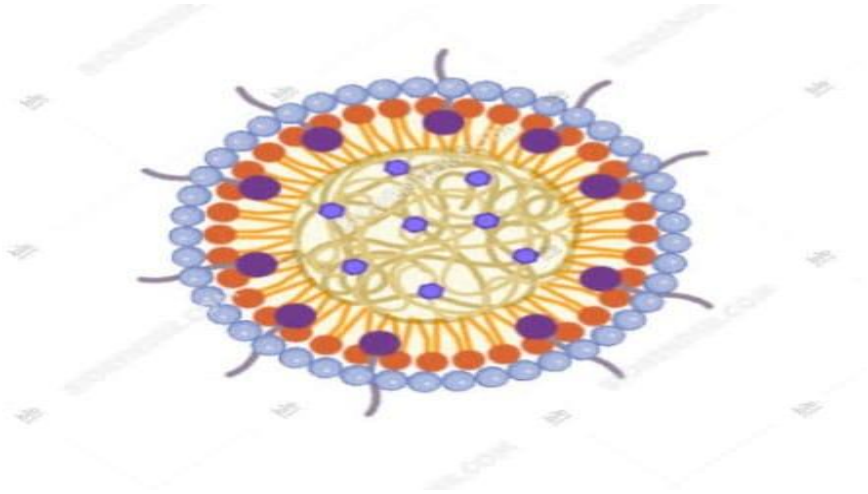
A Nanoparticles are sub-nano sized colloidal structures composed of synthetic or semi-synthetic polymer. These polymers are able to changes the actual activity of drug via, delay or increases the drug release. The drug is dissolved, entrapped, encapsulated or attached to a nanoparticle matrix. They are in different shape, size and structure. It may be spherical, cylindrical, tubular, conical, hollow core, spiral, flat, etc. or irregular. Some nanoparticle may be crystalline, amorphous with single or multiple crystal solids either loose or agglomerated. Drug carriers which are solid, submicron-sized (less than 100 nm in diameter), an either biodegradable or not are referred to as pharmaceuticals.

The structure of nanoparticles. They have two or three layers each.

- A surface layer that has been functionalized by different small molecules, metal ions, surfactants, or polymers.
- The shell layer is chemically distinct from the core and can be intentionally added.
- The fundamental components, the heart of NPs.

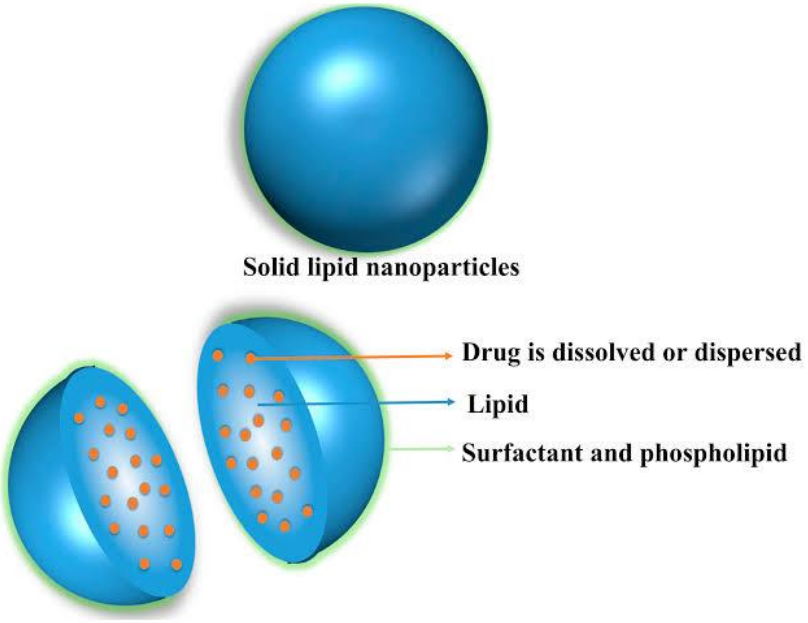
The creation of these environmentally friendly methods for synthesizing nanoparticles, particularly silver nanoparticles, which have numerous applications, is developing into a significant area of nanotechnology. For the synthesis of NPs, there are primarily three different types of approaches, the methods of physical, chemical and biological method. While chemical and biological approaches are collectively referred to as the bottom-up approach, the physical approach is also known as the top & down approach. The biological method is additionally known as the green system of NPs.

Nanoparticle formulation is more convenient formulation when compared to tablet, pellets, capsule. They have nano size so they can be used in parenteral formulation and also have 100% bioavailability. Nanoparticle is formulated for BCS class II and IV because these classes of drugs have solubility problems. So by converting this type of molecules into nanoparticles we can remove this problem. The major goals in designing nanoparticles as a delivery system are to control the particle size, surface properties and release of pharmacologically active agents on the affected area to produce specific action at a therapeutically optimal rate. On the other hand, polymeric nanoparticles offer some specific advantages of increasing the stability of drugs/proteins and possess useful controlled release properties. Other features of nanoparticles include low number of excipients used in their formulations, simple procedure for preparation, high physical stability, and the possibility of sustained drug release that may be suitable in the treatment of chronic diseases.



Solid lipid Nanoparticles (SLNs)

- Solid lipid nanoparticles (N1, Ns) are sub-micron colloidal carriers ranging from 50-1000 am, which are composed of a physiological lipid dispersed in water or in aqueous surfactant solution.
- They consist of macromolecular materials in which the active component is dissolved, entrapped, or in which the active component is adsorbed or attached.
- SLNs are generally spherical in shape and diameter range from 10-1000 nm.
- Solid lipid nanoparticles were initially designed to overcome the disadvantages associated with the liquid state of the oil droplets. Solid lipid nanoparticles were discovered by Gasco and Muller in 1991.



Solid lipid nanoparticles are stable colloidal carriers made of lipids solid at both room and body temperatures. They are formed of a solid lipid core stabilized by a surfactant and containing the drug dissolved or dispersed. The rigidity of the lipid core is an important parameter which determines the rate of drug release. Despite the diversity of compounds involved in the preparation of solid lipid nanoparticles, they are well tolerated by the lungs and are considered carriers of low toxicity. Compared to liposomes, solid lipid nanoparticles present the advantage of being more stable physically (e.g., during nebulization).

Solid lipid nanoparticles have been shown to sustain the release of different drugs in the lungs. Prepared microparticles containing thymopentin-loaded solid lipid nanoparticles for pulmonary delivery. The microparticles showed similar sustained release of the systemically acting as free solid lipid nanoparticles**.**

Ideal properties

1) High drug bioavailability.
2) Minimum immune response.
3) Controlled release kinetic.
4) Tissue targeting.
5) Good patient compliance.
6) High capacity for drug loading.
7) Capability of deliver traditionally difficult drugs such as biomolecules.

Advantages of SLNs

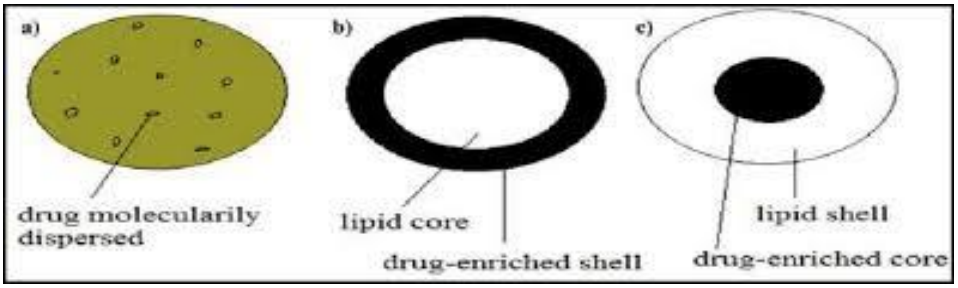
- ✓ The use of biodegradable lipids reduces the possibilities of severe and prolonged toxicity.
- ✓ Enhancing the bioavailability of low water-soluble active constituents.
- ✓ Enhancing the stability of chemically labile drugs through protection from the external environment.
- ✓ SLNs have improved stability in comparison with other drug carriers as liposomes.
- ✓ The high entrapment efficiency of the active constituents.
- ✓ The possibility of lyophilisation.

Disadvantages of SLN

- ✓ The drug loading ability is poor.
- ✓ Water content in the dispersions is comparatively high (70-99.9%).
- ✓ The unpredictable tendency to gelation.
- ✓ The unpredicted dynamics of polymeric changes.
- ✓ Drug expulsion during storage after a polymeric transition.
- ✓ Possibility of particle growth.

TYPES OF SLNs

1. Homogenous matrix model or SLN Type I
2. Drug enhanced shell model or SLN Type II
3. Drug enhanced core model or SLN Type III



SLN Type I

Type 1 is generated from a solid solution of lipid and active constituent. The solid solution is obtained when SLNs are prepared by a cold homogenization technique without using a surfactant. A lipid mixture can be made with the active constituent in a molecularly dispersed form. Upon solidifying the lipid mixture, it is crushed in its solid form to reduce the accumulation of the drug in various parts of SLNs.

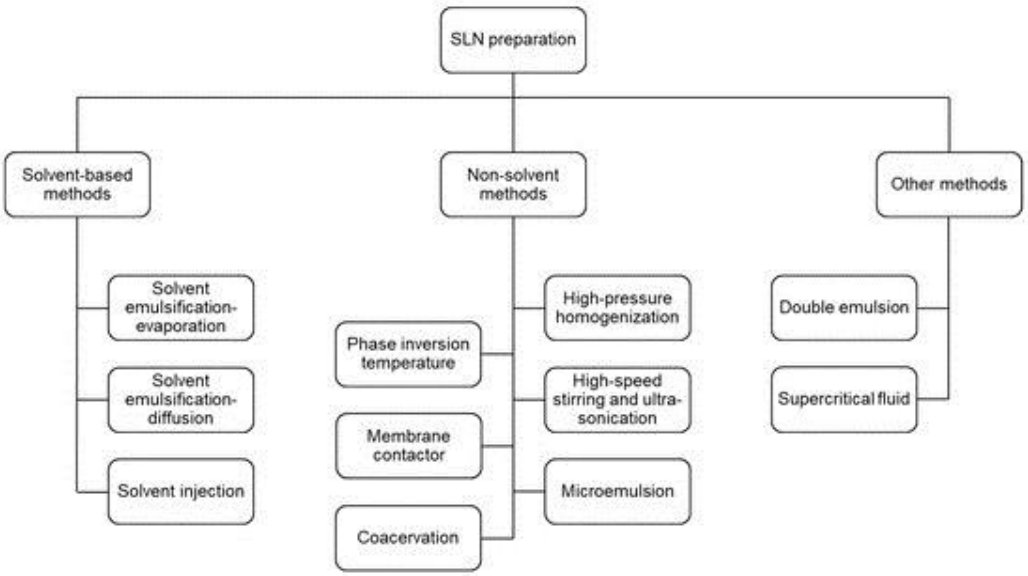
SLN Type II

SLN type II is produced using the hot high-pressure homogenization technique and applying a small concentration of the active ingredient in the lipid matrix. In the process of cooling the hot O/W nano-emulsion, the lipid is precipitated first. As a result, there is an increase in the concentration of the drug molecules, which remained in the melt. Then, the outer shell is solidified containing both lipid and drug. The active constituent percentage contained in the outermost shell can be altered in a regulated shell design when the coenzyme is incorporated.

SLN Type III

When the concentration of the active ingredient in the lipid melt is high and comparatively near saturation, the core model is developed. In this method, cooling Nano-emulsion leads to the precipitation of the drug due to super saturation at low temperatures. Further cooling leads to the precipitation of the melted lipid and surrounding the precipitated drug particles and the development of drug enriched.

METHOD OF PREPARATION SLNs



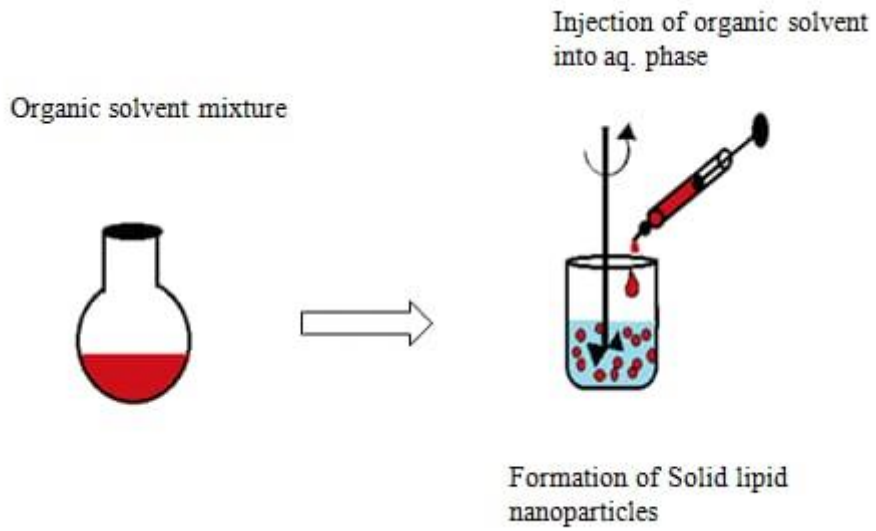
1. SOLVENT BASED METHODS
2. NON SOLVENT BASED METHODS
3. OTHER METHODS

SOLVENT BASED METHODS

Solvent-based methods are widely used for the preparation of solid lipid nanoparticles (SLNs) due to their simplicity, scalability, and ability to avoid high temperatures that could degrade heat-sensitive drugs. Several solvent-based techniques have been established:

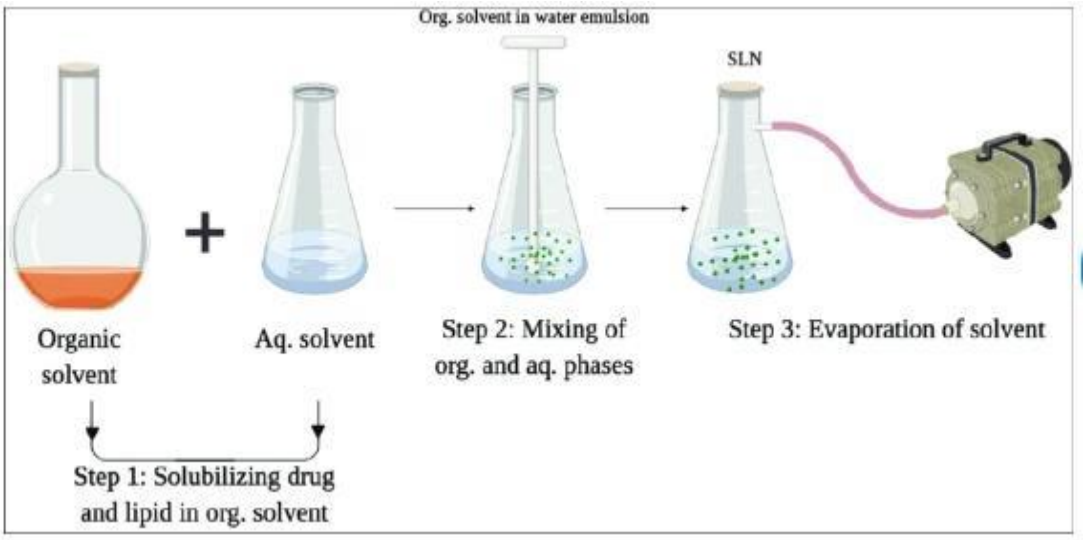
Solvent Injection Method

Lipids and drugs are dissolved in a water-miscible organic solvent (e.g., ethanol, acetone, methanol, or isopropanol). This solution is rapidly injected into an aqueous phase containing a surfactant or stabilizer under continuous stirring. The rapid diffusion of the organic solvent into water causes the lipid to precipitate, forming SLNs. The process is simple, fast, and suitable for lab-scale and large-scale production. However, complete removal of residual solvent is necessary for safe use.



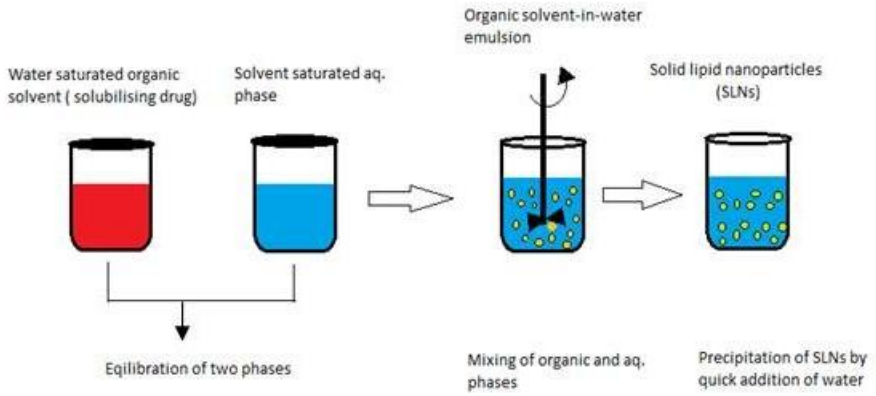
Solvent Emulsification–Evaporation Method

Lipids and drugs are dissolved in a water-immiscible organic solvent (e.g., chloroform, dichloromethane, or toluene). The organic phase is emulsified into an aqueous phase with a surfactant, typically using high-speed homogenization or ultrasonication. The organic solvent is then evaporated under reduced pressure, leading to lipid precipitation and SLN formation. This method avoids heat but may result in dilute suspensions and requires careful solvent removal.



Solvent Emulsification–Diffusion Method

Partially water-soluble solvents (e.g., benzyl alcohol, butyl lactate) are used. The lipid solution is emulsified in water, and upon dilution, the solvent diffuses into the aqueous phase, precipitating the lipid as nanoparticles.



NON SOLVENT BASED METHODS

Non-solvent based methods for the preparation of solid lipid nanoparticles (SLNs) have gained attention due to their advantages in avoiding toxic organic solvents, which is especially important for pharmaceutical applications. Among these, high-pressure homogenization (HPH) is a widely used technique. In this process, the lipid is melted and dispersed in an aqueous phase containing surfactants, and the mixture is then passed through a high-pressure homogenizer. The resulting emulsion is cooled, causing the lipid to solidify and form nanoparticles. This method is scalable and does not require organic solvents, making it suitable for industrial production.

Another solvent-free approach involves high-shear processing. Here, the lipid and aqueous phases are subjected to intense shear forces, which emulsify the lipid without the need for organic solvents. The process can be tightly controlled for temperature, allowing for the encapsulation of temperature-sensitive drugs.

Additionally, novel organic solvent-free methods have been developed using natural biopolymers such as sodium caseinate and pectin as emulsifiers and stabilizers. In these methods, melted stearic acid is emulsified directly into an aqueous phase containing the biopolymers. The mixture is then subjected to pH adjustment and thermal treatment, resulting in stable SLNs with improved physicochemical properties and enhanced stability.

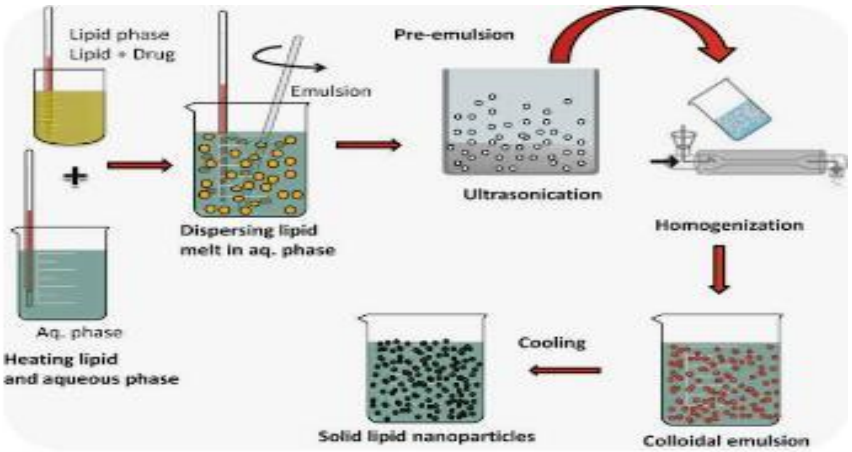
Several methods are available for the preparation of solid lipid nanoparticles (SLNs), each with distinct advantages and limitations:

High-Pressure Homogenization (HPH)

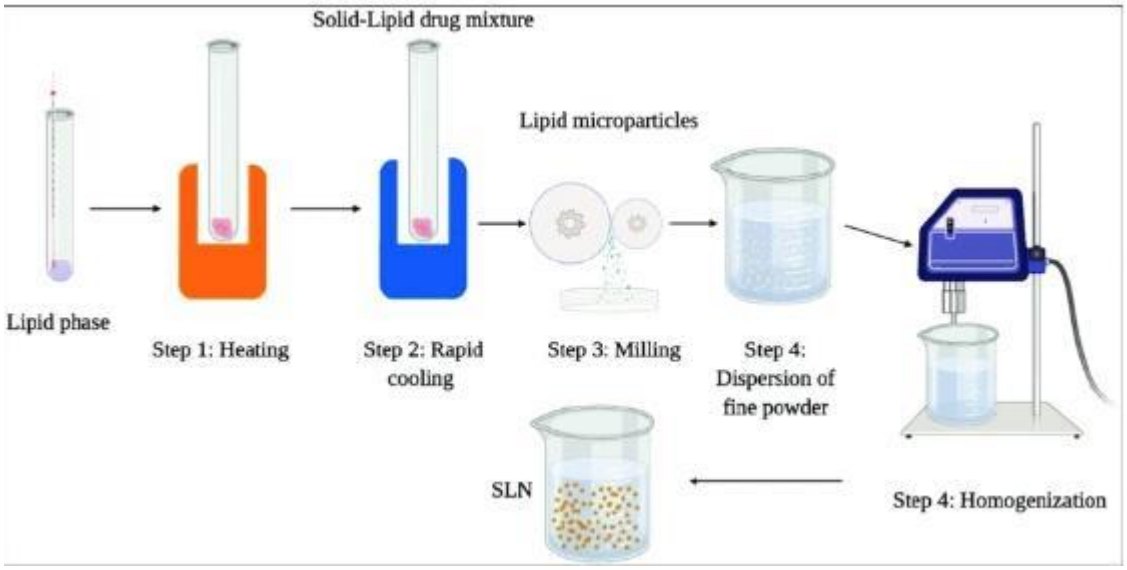
This is the most widely used and scalable method. Coarse lipid particles are forced through a narrow gap at high pressure (typically 100–2000 bar), generating shear gravitation forces that reduce particle size to the nanoscale. The process is repeated until desired size and uniformity are achieved. It is suitable for large-scale production and is organic solvent-free.

Hot and Cold Homogenization

Both variants use HPH. In hot homogenization, lipids are melted and mixed with a hot aqueous surfactant solution, homogenized, and then cooled to form SLNs. Cold homogenization involves grinding solid lipids with liquid nitrogen and then homogenizing the resulting microparticles.



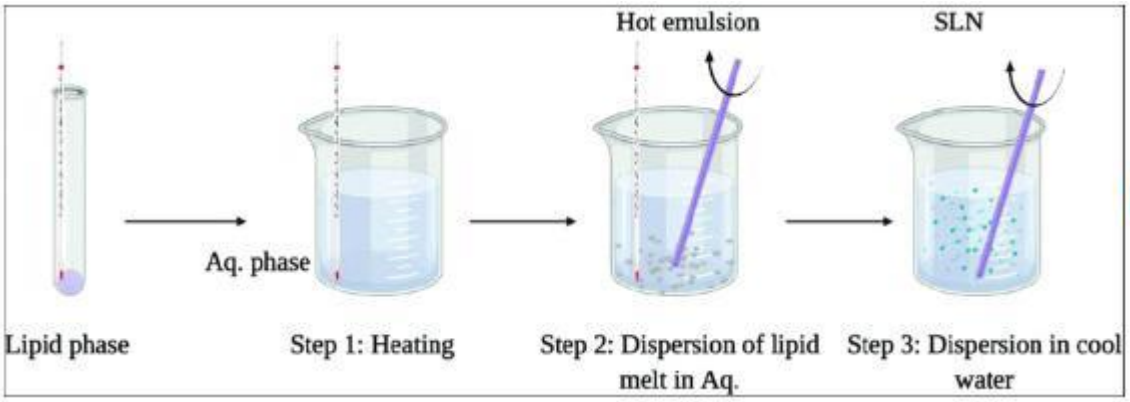
Cold homogenization



Hot homogenization

Microemulsion Method

Lipids are melted and mixed with aqueous surfactant solution to form a microemulsion, which is then dispersed in cold water to precipitate SLNs.

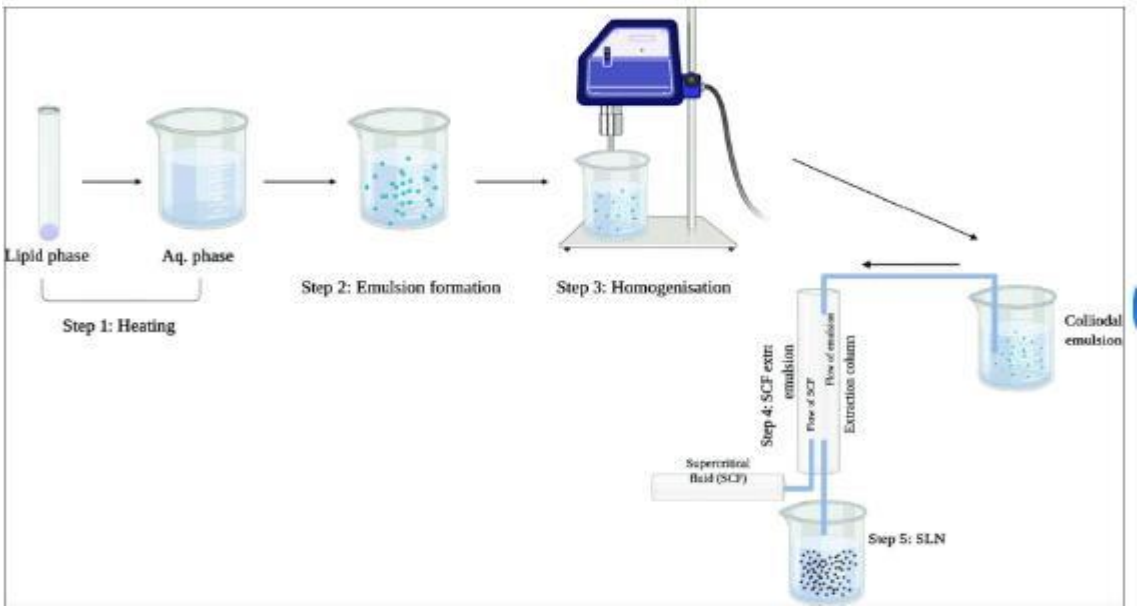


Solvent Diffusion/Emulsification

Lipids are dissolved in a water-miscible organic solvent, which is then mixed with an aqueous phase containing surfactant. The solvent diffuses out, leading to particle precipitation.

Supercritical Fluid Techniques

Methods like rapid expansion of supercritical carbon dioxide solutions (RESS) and particles from gas-saturated solutions (PGSS) are used for solvent-free, dry powder SLN production.



Spray Drying and Spray Congealing

Involve atomizing a lipid melt or solution into a drying chamber, resulting in dry SLN powders. These methods offer flexibility for different applications and scale-up requirements.

OTHER METHODS

Double emulsion (water-in-oil-in-water, W/O/W) method is widely used for the preparation (PPN: likely refers to "preparation" or "production") of solid lipid nanoparticles (SLNs), especially when encapsulating hydrophilic drugs or compounds. Here's how the process typically works:

Double Emulsion Process for SLN Production

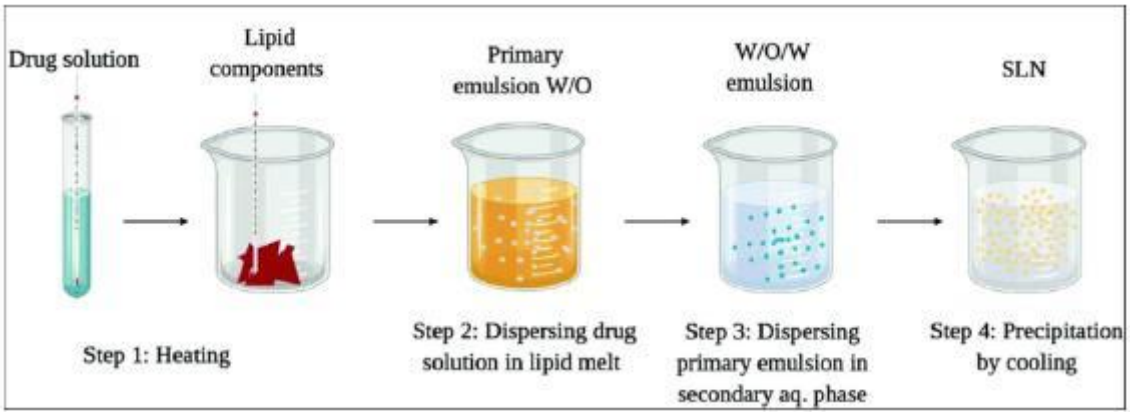
1] Primary Emulsion (W/O)

The hydrophilic drug is dissolved in water. This aqueous phase is emulsified into a lipid phase (containing the lipid and a suitable surfactant), often using high-speed homogenization or ultrasonication, forming a water-in-oil (W/O) emulsion.

2] Secondary Emulsion (W/O/W)

- Surfactant (like Tween 80).
- This mixture is The primary W/O emulsion is then added to an external aqueous phase containing a homogenized and/or sonicated to create a double emulsion (W/O/W).
- Solidification and Purification:

- The double emulsion is poured into cold water under gentle stirring to induce solidification of the lipid nanoparticles.
- The organic solvent (if used) is evaporated or removed by dialysis or lyophilization.
- The resulting SLNs are collected, washed, and sometimes lyophilized for storage.



Supercritical fluid methods

This methods is for the production (ppn) of solid lipid nanoparticles (SLNs) offer several advantages over traditional techniques. The most commonly used supercritical processes include supercritical fluid extraction of emulsions (SFEE) and supercritical anti-solvent (SAS) precipitation. In SFEE, a supercritical fluid—typically carbon dioxide (CO_2)—is used to extract the organic solvent from an oil-in-water (o/w) emulsion, leading to the formation of SLNs. This method avoids high temperatures and organic solvent residues, resulting in nanoparticles with small particle sizes, smooth surfaces, and improved stability. However, CO_2 has limited solvent strength for many drugs, which can restrict its use for certain formulations.

Another approach, the Supercritical Assisted Injection in a Liquid Anti-solvent (SAILA), involves solubilising CO_2 in a lipid solution and then atomizing the expanded liquid into an aqueous anti-solvent, directly producing stabilized SLN suspensions under mild conditions. This method provides excellent control over particle size distribution and avoids thermal degradation of sensitive compounds.

Supercritical methods are considered promising for scale-up, as they yield SLNs with narrow size distributions, high encapsulation efficiency, and low cytotoxicity. The main drawbacks include the cost of high-purity CO_2 and the need for specialized equipment. Overall,

supercritical techniques are efficient, solvent-free, and suitable for producing high-quality SLNs for drug delivery applications.

APPLICATIONS

1. Cancer treatment

In recent years, various anticancer agents were compressed to SLNs and their in vitro, and in vivo efficiency were estimated.

A) Targeting of anticancer drugs

The extended-release of tamoxifen (an anticancer drug) is attained by preparing it as SLNs for intravenous administration in breast cancer. Also, the target effect of methotrexate and camptothecin to tumor tissue was accomplished with SLN loaded with the drug. Tupal et al. Prepared Doxorubicin-loaded SLNs for the treatment of skin cancer.

B) SLN in breast cancer and lymph node metastases

Mitoxantrone SLNs local injections were produced to decrease the toxicity and increase the safety and bioavailability of the drug. The efficacy of doxorubicin in the reduction of breast cancer cells was reported to be enhanced when prepared as SLNs. Wang et al. Studied the anticancer effects of resveratrol-loaded SLNs on human Breast cancer cells.

2. Antitubercular chemotherapy

The preparation of anti-tubercular drugs such as rifampicin and Isoniazid as SLNs leads to the reduction of the dosage regimen and the improvement of patient compliance. Bhandari et al. Succeeded in preparing isoniazid-SLNs to improve bioavailability and prolong the therapeutic effect and therefore reduce pulsatile plasma concentrations.

3. SLN as a carrier for vaccines

Adjuvants are used to improve immune response during vaccination. The safer novel subunit vaccines are less efficient in Immunization, and for this reason, efficient adjuvants are needed. Emulsion systems of SLNs have been recently employed to use the adjuvant. This is O/W emulsions that are degraded in the body after administration.

4. SLN for topical application

SLNs are suitable colloidal transport systems for skin applications. Due to their numerous desirable effects on the skin. Recently, studies were carried out on SLNs with compounds such as ascorbyl Palmitate, Vitamin E, retinol, clotrimazole, triptolide, nonsteroidal

Antiandrogen, tocopherol acetate and podophyllotoxin for topical application. Kelidari et al. prepared spironolactone loaded SLNs for skin application.

5. SLN for potential agriculture application

Based on the previous study, it was found that when the volatile oil extracted from Artemisia arborescent L is incorporated into SLNS, it Decreases the rapid evaporation compared to its incorporation into Emulsions. This system is used in agriculture as an appropriate Transporter of ecologically safe pesticides.

6. Stealth nanoparticles

This is a new system for drug-transport. It avoids the rapid clearance of the drug by the immune system. By using antibody-labeled stealth lipobodies, previous researches approved the improved delivery to the unreachable sites of target tissue.

7. SLNs for cosmetics

SLNs have been used in the production of sunscreens and they act as an important carrier for molecular sunscreen and ultraviolet (UV) Blocker. The in vivo study revealed that skin moisturization would be improved by 31% after four weeks when 4% of SLN is added to the conventional cream. SLNs have shown to be a controlled ,Innovative, occlusive, and topical release. Wissing and Müller found that the efficacy of hydrating cream and sunscreen cream Improved when prepared in the form of SLNs.

8. Targeted brain drug delivery

The extremely small particle size of solid lipid nanoparticles, less than 50 nm, might be beneficial with respect to drug targeting. Drug targeting might also be possible by surface modification of solid lipid nanoparticles. SLNs can improve the ability of the drug to penetrate through the blood-brain barrier and is a promising drug targeting system for the treatment of central nervous system disorders.

9. Parasitic diseases

Parasitic diseases (like malaria, leishmaniasis, tryanosomiasis) are one of the major problems around the globe. Antiparasitic chemotherapy is the only choice of treatment for these parasitic infections, the reason for this is that these infections do not elicit pronounced immune response hence effective vaccination may not be possible.

Solid lipid nanoparticles (SLNs) and nano structured lipid carriers (NLCs) represent a second generation of colloidal carriers and have emerged as an effective alternative to liposomes mainly due to their better stability profile, ease of scalability and commercialization and relative cost efficacy.

10. For lymphatic targeting

The solid lipid nanoparticles (SLN) were developed and evaluated for the lymphatic uptake after intraduodenal administration to rats.

11. Transfection agent

Cationic SLNs for gene transfer are formulated using the same cationic lipid as for liposomal transfection agents. Combination of cationic SLN with the nuclear localization signal TAT2 increased transfection efficiency hundredfold

CHARACTERISTICS

The use of advance microscopic microscopic method including Transmission electron Microspy (TEM) Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) has made it possible to characterize nanoparticles according to their morphology, surface charge, and size. In vivo distribution, the nanopartides and physical stability are influenced by the distribution of their size and the mean particle diameter and charge.

Particle size analysis and zeta potential

The physical stability of SLNs is determined by the size of the particle. The most common techniques for particle size determination are the Laser Diffraction (DL) and Photon correlation spectroscopy (PCS). The PCS, also called dynamic light scattering, is employed to determine the intensity of the scattered light resulting from the random motion of the particles. The PCS is employed to determine particle size within the range of 3nm to 3um and laser diffraction is used to determine the particle size for the range of 100nm to 180um. Although the PCS is a good instrument for nanoparticle characterization, it can also be used for larger size determination of the micro-particles. The LD techniques is based on the effect of the particle size on the diffraction. Smaller particles, compared to the larger ones, produce stronger scattering with light diffraction angle.

Zeta meter or zeta potential analyzer can be used for the determination of zeta potential. For the size determination and zeta potential determination, the dispersion of SLNs is first diluted

50 fold with the primary dispersion preparation medium. The increased value of zeta potential could give rise to the disaggregation of the particles. Zeta potential determination makes it possible to predict the storage stability of colloidal dispersion.

X-ray diffraction and the differential scanning calorimeter (DSC)

The geometric scattering of radiation from crystal planes within a solid allows the determination of the presence or absence of the former and thus permits the measurement of the degree of crystallinity. DSC can be applied to evaluate the properties and the degree of crystallinity of drugs in nanoparticles.

Elecron microscopy

For direct observation, TEM and SEM are employed. The SEM is used for better morphological examination, and it has a small size limit of detection.

Atomic force microscopy(AFM)

By using this approach, a probe tip with the atomic-scale sharpness is re-established across a sample to create a topological map, which is based on the forces between the tip and the surface. The atomic force microscopy is a useful tool to obtain in ultrahigh-resolution of the particles.

Dynamic light scattering(DLS)

The most common and the fastest methods for determining the particles size are the DLS and PCS. The DLS is commonly used for the size determination of Browninan nanoparticles is colloidal dispersion in the Nano and submicron range. Shining monochromatic light(laser) onto a solution of spherical particles (in case of random Browninan motion) leads to Doppler shift when the light hits the moving particles. As a results, the wavelength of the coming light is scared and it was revealed that this charge is related to the size of the particles. The DLS is also useful for the determination of size distribution, the particle, and the use of the autocorrelation function. The PCS is the commonly applied method for the accurate determination of size based on DLS.

Nuclear magnetic resonance (NMR)

NMR can be used for both the qualitative nature and the size of nanoparticles measurement. The selection of the technique depends on the chemical shifting balances and the sensitivity

to molecular flexibility to provide data about the physiochemical state constitutent inside the nanoparticles

Acoustic methods

Acoustic spectroscopy is a technique that determines the particle size by measuring the attenuation of the sound waves and applying the physical equation. The oscillating electrical field created by the charged particle movement under the control of acoustic energy can be identified to provide information on the surface charge.

Surface charge

The interaction of Nanoparticles with their biological environment and electrostatic interaction with bioactive compound are determined by the intensity and nature of the surface charge. The zeta potential is used to analyze the colloidal stability of the nanoparticle. The zeta potential is an indirect measurement of the surface charge. The determination of zeta potential makes it possible to predict the stability of the colloidal dispersion during storage. The high value of zeta potential, whether positive or negative values, ensures the stability of the colloidal particles and also ensure the absence of aggregations. The degree of surface hydrophobicity then can be estimated from the value of zeta potential. The zeta potential can also give information on the nature of the drug to be encapsulated within the nanocapsule or absorbed on the surface.

ROUTE OF ADMINISTATION

The dispersion of SLNs, which is prepared with low lipid content up to 5%, was reported to have a very small particle size. The direct application of the dispersion of SLNs to the skin is difficult due to the low lipid concentration and low viscosity of the dispersion to facilitate the application of SLNs to the skin, it is preferred to be incorporated into the base of cream, ointment, or gel. For direct application of the dispersion of SLNs, the concentration of lipids should be increased to produce a semisolid system suitable for the application the skin Gönüllu al prepared SLNs of fornoxicam for transdermal delivery.

Topical administration

SLNs are very attractive colloidal carrier systems for skin application due to the numerous desirable effects on the skin. Since they are made up of non-irritant and nontoxic lipids, this makes them appropriate for use on damaged irritated skin. Jain et of designed SLNs for the topical delivery of an anti-fungal drug.

Ophthalmic administration

The preparation of ophthalmic drugs as SLNs increases their efficacy due to the mucoadhesive characteristics of SLNs, which increase the ocular retention time and hence increase the bioavailability. Gowda et al studied the effect of SLNs on enhancing the ocular availability of ophthalmic drugs.

Respiratory application

The nebulization of SLNs carrying anti-tubercular drugs, anti-asthmatic drugs, and anti-cancer was found be effective in increasing drug bioavailability and decreasing the dosing rate for improving the pulmonary action. Rosière et al prepared paclitaxel loaded SLNs with improved efficacy in the treatment of lung tumors when used as inhaler.

CONCLUSION

The review of solid lipid nanoparticles (SLNs) highlights their significance potential across various application. SLNs offers unique advantages such as controlled drug release, targeted delivery and enhanced bioavailability. The diverse method of preparation based on solvent and non solvent method which includes micro emulsions technique, phase inversion method, Solvent injection method, solvent emulsification - evaporation method, solvent emulsification diffusion method, high - pressure homogenization, solvent diffusion/emulsification, super critical fluid techniques, spray drying and spray congealing and double emulsion. It also contains characterizations of SLNs and their applications such as cancer treatment, anti tubercular chemotherapy, carrier for vaccines, in topical application, potential agriculture application, stealth nanoparticles, in cosmetics, targeted brain drug delivery, lymphatic targeting and transfection agent. It includes route of administration such as parental, oral, rectal, nasal, respiratory, ocular and topical. Solid lipid nanoparticles hold great promise for revaluationizing healthcare and other sectors, providing the way for more effective therapies and include patient outcomes.

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