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REVIEW ARTICLE: SOLID LIPID NANOPARTICLES (SLN) AS A NOVEL DRUG DELIVERY SYSTEM

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ABSTRACT

Solid lipid nanoparticles (SLN) have emerged as a next-generation drug delivery system with potential applications in pharmaceutical field, cosmetics, research, clinical medicine and other allied sciences. Recently, increasing attention has been focused on these SLN as colloidal drug carriers for incorporating hydrophilic or lipophilic drugs. The system consists of spherical solid lipid particles in the Nano-meter ranges, which are dispersed in water or in aqueous surfactant solution. It is identical to an oil-in-water emulsion for parenteral nutrition but the liquid lipid (oil) of the emulsion has been replaced by a solid lipid, i.e., yielding Solid Lipid Nanoparticles. Different production methods which are suitable for large scale production and applications of solid lipid nanoparticles are described. Appropriate analytical techniques for characterization of solid lipid nanoparticles like photon correlation spectroscopy, scanning electron microscopy, differential scanning calorimetry are highlighted. If appropriately investigated, solid lipid nanoparticles may open new vistas in therapy of complex diseases.

KEYWORDS: Solid lipid nanoparticles (SLN), homogenization, Drug released, Preservation, Characterization and Application.

INTRODUCTION

In recent years it has become more and more evident that the development of new drugs alone is not sufficient to ensure progress in drug therapy. Exciting experimental data obtained in vitro are very often followed by disappointing results in vivo. Main reasons for the therapy failure include: size of the carrier depends on the desired route of administration and ranges from few nanometers.

- Insufficient drug concentration due to poor absorption, rapid metabolism and elimination (e.g - peptides, proteins). Drug distribution to tissues combined with high drug toxicity (e.g. cancer drug).
- Poor drug solubility which excludes i.v. injection of aqueous drug solution.
- High fluctuation of plasma levels due to unpredictable bioavailability after peroral administration, including the influence of food on plasma levels (e.g. cyclosporine).

A promising strategy to overcome these problems involves the development of suitable different drug carrier given in fig 1and their different property given in table 1.

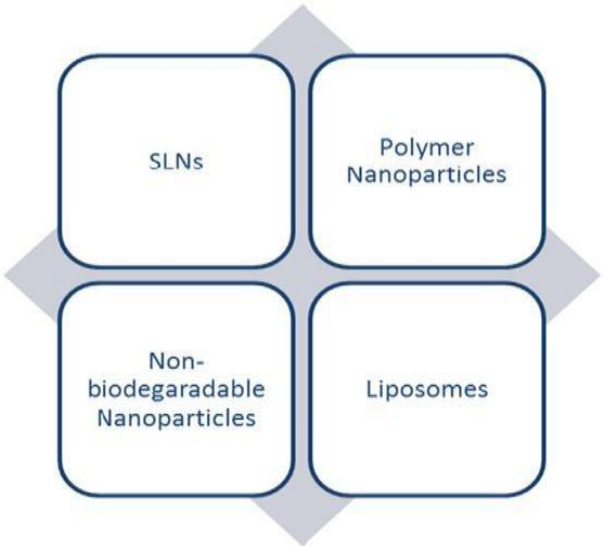


Fig 1: Different Drug Carrier system.

Table 1: Drug carrier system and their properties.

Sr. No.	Property	SLN		Polymer Nanoparticle s	Liposomes	Lipid Emulsions
1	Systemic toxicity	Low		> or = to SLN	Low	Low
2	Cytotoxicity	Low		> = to SLN	Low	Low
3	Residues from organic solvents	No		Yes	May or may not	No
4	Large scale production	Yes		No	Yes	Yes
5	Sterilization by autoclaving	Yes		No	No	Yes
6	Sustained release	Yes		Yes	< or = to SLN	No
7	Avoidance of RES	Depend size coating	On and	No	Yes	Yes

Solid lipid nanoparticles have an edge above the others, as compared to polymer toxicity which is low, inexpensive excipients and organic solvents are not used. SLNs give prolonged drug release and more stable formulations as compared to liposomes with no sterilization problems. Nano emulsion has erratic drug release and nanocrystals were not able to solve the issue of solubility of drug in biological fluids. So that SLNs can provide better profile as a drug delivery system over the other Nano carriers based drug delivery system.

SLNs are the colloidal system of nanoparticles (diameter 50–1000 nm) made up of solid lipid as matrix medium which is stabilized in aqueous media by surfactants (fig. 2) The surfactant system got immobilized on SLNs surface during the solidification of lipid matrix. SLNs have the advantage of controlled release kinetics, target specific delivery, stability, and tolerability, protection of light and acid sensitive drugs. In SLNs solid lipids used are complex glyceride mixtures, highly purified triglycerides, or waxes which do not melt at body temperature. SLNs are prepared by GRAS graded solid lipids and surfactant.

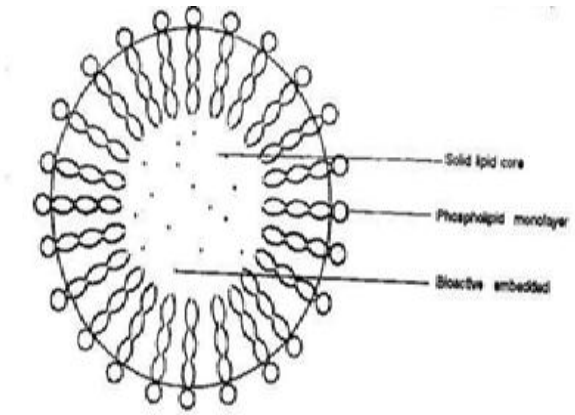


Fig. 2: Proposed structure of SLN.

SLN are most commonly used to incorporate lipophilic drugs which are not easy to administer by commonly used dosage forms. SLNs has used in the delivery of peptides like calcitonin, cyclosporine A, insulin, luteinizing hormone-releasing hormone, somatostatin and proteins like BSA, lysozyme. SLNs are also used as vector for transfection, cationically modified SLN produced by hot homogenization using Compritol ATO888 or paraffin as lipid matrix, tween 80 and span 85 as tenside and cetylpyridinium as charged carrier. The cationic lipids used in liposomal transfection agents were also used to formulate cationic solid lipid nanoparticles (SLN) for gene transfer. It's better to use cationic SLN as transfecting agent as compared to Cationic SLN bind electrostatically to DNA, sreptavidin and biotinylated ligands which can interact with the surface receptors. So SLN acts as targeted non-viral gene delivery vector. liposomal counterpart.

Advantages of SLN

1. SLNs have better stability and ease of upgradability to production scale as compared to liposome.
2. In SLNs the lipid matrix is made from physiological lipid which decreases the danger of acute and chronic toxicity.
3. Very high long-term stability.
4. It is easy to manufacture than polymeric nanoparticles.
5. Better control over release kinetics of encapsulated compound.
6. SLNs can be enhancing the bioavailability of entrapped bioactive.
7. Chemical protection of labile incorporated compound.
8. Raw material which are to be required are same as that of emulsion.
9. Large scale production is possible.
10. High concentration of functional compound can be achieved.
11. Lyophilisation possible.

Disadvantage of SLN

1. Poor drug loading capacity.
2. Drug expulsion after polymeric transition during storage.
3. Relatively high water content of the dispersions (70-99.9%).
4. The low capacity to load hydrophilic drugs due to partitioning effects during the production process.

Method of Preparation of SLN

1. High shear homogenization (HSH)

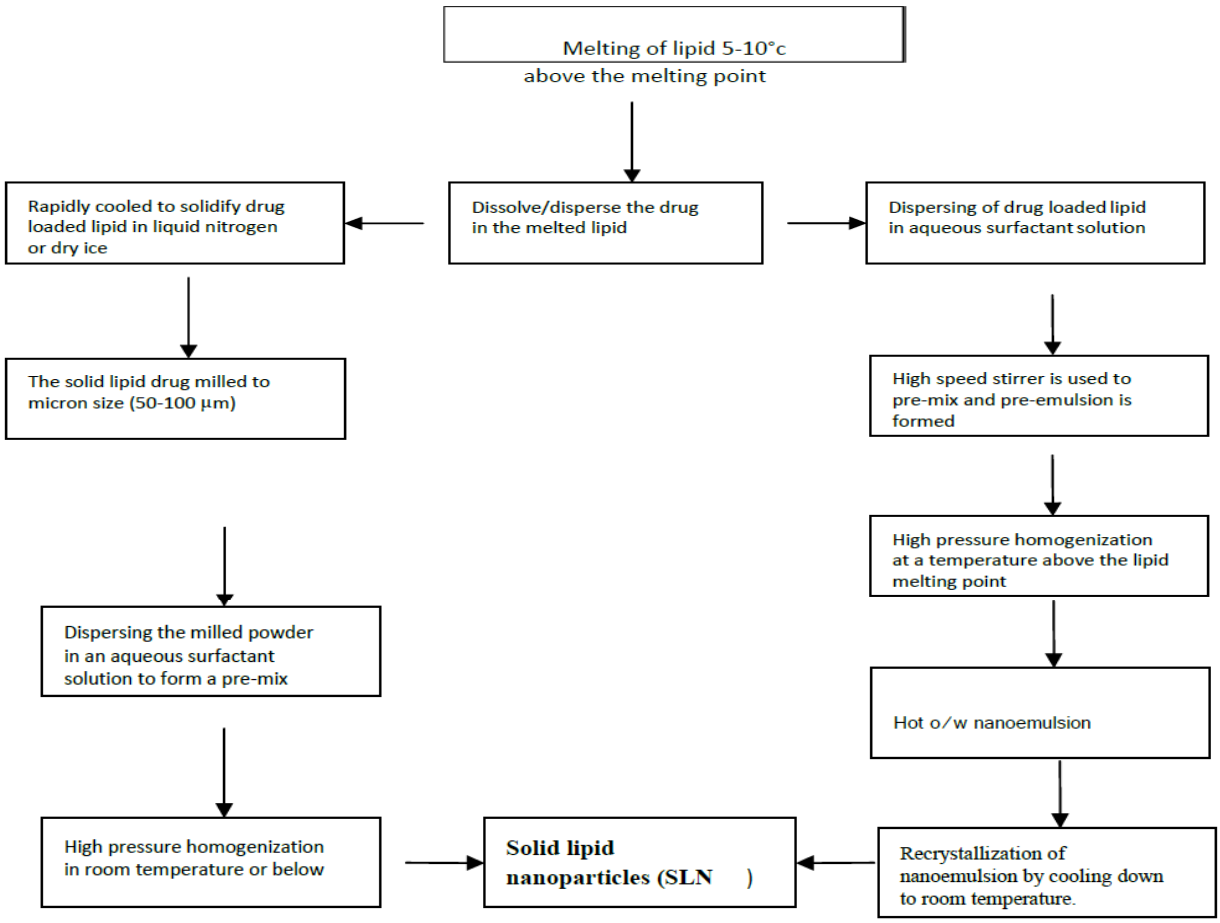
Initially used for the production of solid lipid Nano emulsions, this method is reliable. It involves high

pressure homogenization which pushes the liquid with high pressure (100- 2000 bar) through a narrow gap ranging a few microns. The fluid accelerates to a very short distance at very high viscosity of over 1000 km/h. Very high shear stress and cavitation forces disrupt the particles down to submicron range. As low as 5% to as high as of 40% lipid content has been investigated.

Two general approaches to achieve HSH are hot homogenization and cold homogenization. Fig 3 show the Schematic representation of SLN preparation by hot and cold homogenization.

a **Hot homogenization** is generally carried out at temperatures above the melting point of the lipid. A pre-emulsion of the drug loaded lipid melt and the aqueous emulsifier phase (same temperature) is obtained by high shear mixing device. The resultant product is hot o/w emulsion and the cooling of this emulsion leads to crystallization of the lipid and the formation of SLNs. Smaller particle sizes are obtained at higher processing temperatures because of lowered viscosity of the lipid phase. However, high temperature leads to the degradation rate of the drug and the carrier. Increasing the homogenization temperature or the number of cycles often results in an increase of the particle size due to high kinetic energy of the particles. Generally, 3-5 homogenization cycles at a pressure of 500-1500 bar are used.

b **Cold homogenization** has been developed to overcome the temperature related degradation problems, loss of drug into the aqueous phase and partitioning associated with hot homogenization method. Unpredictable polymeric transitions of the lipid due to complexity of the crystallization step of the nanoemulsion resulting in several modifications and/or super cooled melts. Here, drug is incorporated into melted lipid and the lipid melt is cooled rapidly using dry ice or liquid nitrogen. The solid material is ground by a mortar mill. The prepared lipid microparticles are then dispersed in a cold emulsifier solution at or below room temperature. The temperature should be regulated effectively to ensure the solid state of the lipid during homogenization. However, compared to hot homogenization, larger particle sizes and a broader size distribution are typical of cold homogenization samples.



2. Ultrasonication

Ultrasonication or high speed homogenization is another method for the production of SLNs. The advantage of this method is that the equipment used is commonly available at lab scale. However, this method suffers from problems such as broader size distribution ranging into

micrometer range. Potential metal contaminations, physical instability like particle growth upon storage are other drawbacks associated with this technique.

3. Microemulsion technique

Gasco and coworkers (1997) developed SLNs based on the dilution of microemulsions. These are made stirring an optically transparent mixture at 65-70°C which is typically composed of a low melting fatty acid like stearic acid, an emulsifier (e.g. polysorbate 20, polysorbate 60, soyaphosphatydylcholine and taurodeoxycholic acid sodium salt), co-emulsifiers (e.g. butanol, sodium monooctylphosphate) and water. The hot microemulsion is dispersed in cold water (2-3°C) under stirring. Typical volume ratios of the hot microemulsion to cold water are in the range of 1:25 to 1:50. The dilution process is critically determined by the composition of the microemulsion. The SLN dispersion can be used as granulation fluid for transferring in to solid product like tablets and pellets by granulation process, but in case of low particle content too much of water need to be removed. The nanoparticles were produced only with solvents which distribute very rapidly into the aqueous phase (acetone), while larger particle sizes were obtained withmore lipophilic solvents.

Advantages

- Low mechanical energy input.
- Theoretical stability.

Disadvantages

- Extremely sensitive to change.
- Labour intensive formulation work.
- Low nanoparticle concentrations

4. Supercritical Fluid technology

This is a novel technique recently applied for the production of SLNs. A fluid is termed supercritical when its pressure and temperature exceed their respective critical value. The ability of the fluid to dissolve compounds increases. This technology comprises of several processes for nanoparticle production such as rapid expansion of supercritical solution (RESS), particles from gas saturated solution (PGSS), aerosol solvent extraction solvent (ASES), supercritical fluid extraction of emulsions (SFEE). The advantages of this technique includes avoidance of the use of solvents, particles obtained as a dry powder, instead of suspensions, requires mild pressure and temperature conditions. Carbon dioxide solution is the good choice as a solvent for this method.

5. Solvent emulsification/evaporation

For the production of nanoparticle dispersions by precipitation in o/w emulsions, the lipophilic material is dissolved in water-immiscible organic solvent (cyclohexane) that is emulsified in an aqueous phase. Upon evaporation of the solvent nanoparticle dispersion is formed by precipitation of the lipid in the aqueous medium. The mean diameter of the obtained particles was 25 nm with cholesterol acetate as model drug and lecithin/sodium glycocholate blend as emulsifier. The reproducibility of the result was confirmed by Siekmann and Westesen (1996), who produced the cholesterol acetate nanoparticles of mean size 29 nm. (fig 4)

6. Solvent emulsification-diffusion

SLNs can also be produced by solvent emulsification-diffusion technique. The mean particle size depends upon lipid concentration in the organic phase and the emulsifier used. Particles with average diameters of 30-100 nm can be obtained by this technique. Avoidance of heat during the preparation is the most important advantage of this technique. Here, the lipid matrix is dissolved in water-immiscible organic solvent followed by emulsification in an aqueous phase. The solvent is evaporated under reduced pressure resulting in nanoparticles dispersion formed by precipitation of the lipid in aqueous medium. (fig 4),

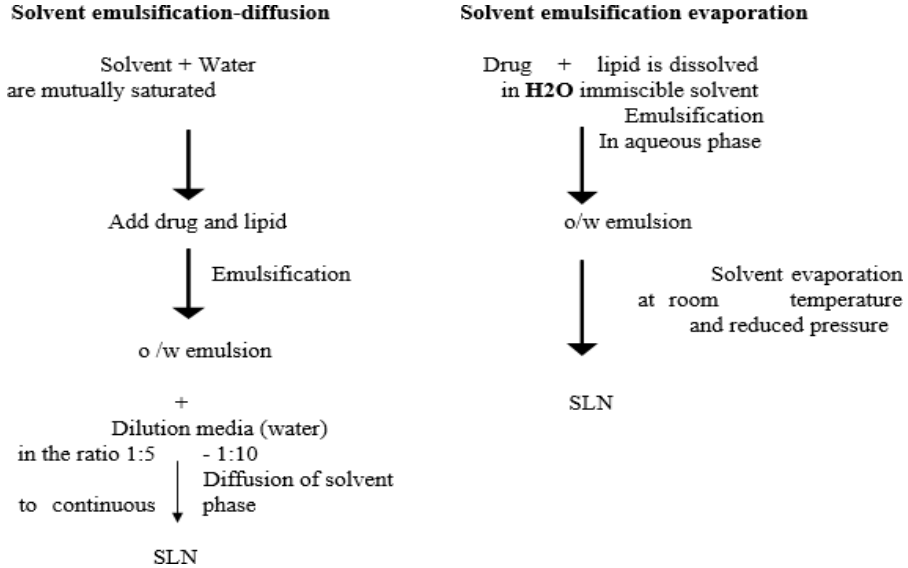


Fig.4 Differences between solvent diffusion and solvent evaporation technique.

7. Double Emulsion technique

In this method, the drug is encapsulated with a stabilizer to prevent drug partitioning to external water phase during solvent evaporation in the external water phase of w/o/w double emulsion. Li *et al.* (2010) prepared solid lipid nanoparticles loaded with bovine serum albumin (BSA) using double emulsion method.

8. Spray Drying

It is an alternative technique to lyophilization in order to transform an aqueous SLN dispersion into a drug product. This is a cost-effective method than lyophilization and recommends the use of lipid with melting point >70°C. This method causes particle aggregation due to high temperature shear forces and partial melting of the particle. According to Freitas and Mullera (1998) best results were obtained with SLN concentration of 1% in a solution of trehalose in water or 20% trehalose in ethanolwater mixtures (10/90 v/v).

9. Solvent injection technique

Here, the solid lipid is dissolved in water miscible solvent. The lipid solvent mixture is injected into stirred aqueous phase with or without surfactant. Finally, the dispersion filtered to remove excess lipid. Emulsion within the aqueous phase helps to produce lipid droplets at the site of injection and stabilize SLNs until solvent diffusion gets completed. Mishra *et al.* (2010) prepared and evaluated SLNs using Solvent injection method for delivery of Hepatitis B surface antigen for vaccination using subcutaneous route.

10. Membrane contactor technique

It is a novel technique to prepare the SLN. In membrane contactor technique the liquid phase was pressed at a temperature above the melting point of the lipid through the membrane pore swallowing the formation of small droplets as indicated in Figure 5. The aqueous phase was stirred continuously and circulates tangentially inside the membrane module, and sweeps away the droplets being formed at the pore outlets. SLNs were formed by the cooling of the preparation at the room temperature. Here both the phases were placed in the thermostat bath to maintain the required temperature and nitrogen was used to create the pressure for the liquid phase. The influence of various process parameters (aqueous phase cross flow velocity, the lipid phase pressure, aqueous and lipid phase temperature, lipid phase amount and membrane pore size) were studied. The membrane contactor method is also used for the preparation of polymeric nanoparticles, by methods involving a polymerization of dispersed monomers (interfacial polymerization method) or a dispersion of preformed polymers (nanoprecipitation method). The advantages of this process of SLN preparation using a membrane contactor are shown to be its facility of use, the control of the SLN size by an appropriate choice of process parameters and it's scaling up ability.

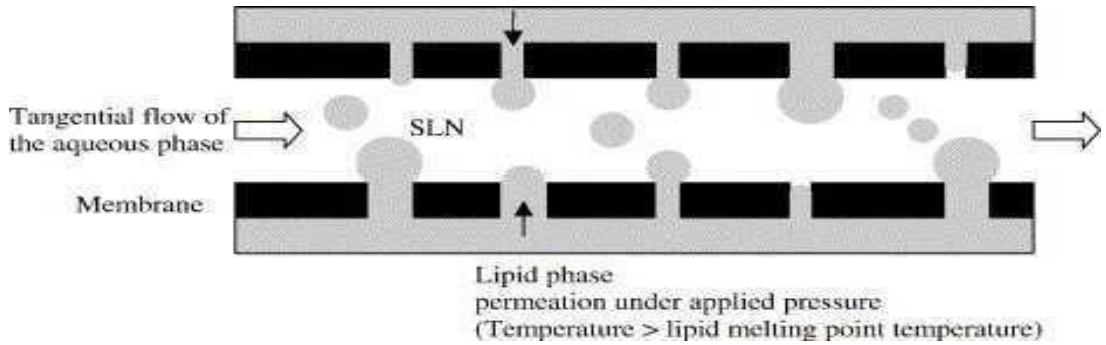


Fig. 5: Schematic drawing of the membrane contactor for the SLN preparation.

DRUG RELEASE FROM SLNs

There are mainly three drug incorporation models which describe the incorporation of drug into SLN.

1. Homogenous matrix model.
2. Drug enriched shell, core shell model.
3. Drug enriched core, core shell model.

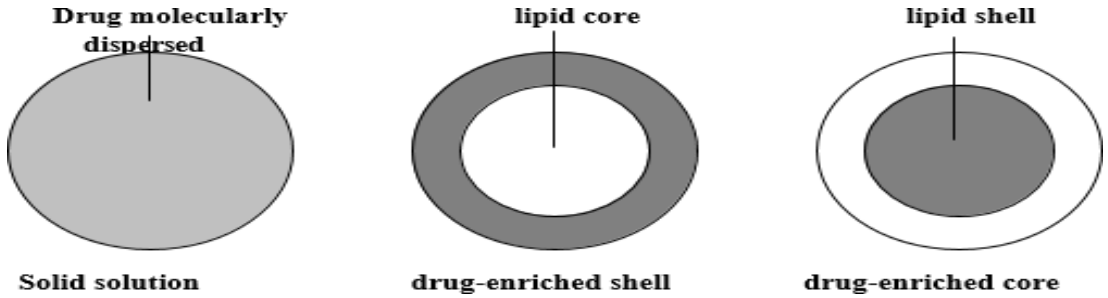


Fig. 6 Models of incorporation of active compounds into SLN: a. Homogeneous Matrix, b. Drug enriched shell with lipid core, c. Drug enriched core with lipid shell.

1. **Homogenous matrix mode**l or solid solution model with drug being present in amorphous clusters or molecularly dispersed is mainly obtained when incorporating highly lipophilic drugs into SLN with using hot homogenization technique or applying cold homogenization method or by avoiding potentially drug solubilizing surfactants. In the cold homogenization technique the drug (in molecularly dispersed form) is dispersed in bulk of melted lipid, then the mechanical force of high pressure homogenization leads to the breakdown of molecular form to nanoparticles and giving rise to homogenous matrix model as shown in Figure 3a. Etomidate SLN represents the homogenization matrix model.

2. **The drug enriched shell with core shell model** will be obtained when performing the production. During the production, the drug partitioned to water phase. Upon cooling, the lipid precipitates first, forming a practically drug free lipid core due to phase separation. At the same time, the drug re-partitions into the remaining liquid-lipid phase and drug concentration in the outer shell increasing gradually. Finally drug enriched shell crystallizes as depicted in Fig. 3b. The amount of drug partitioning to the aqueous phase will increases with the increase of solubility of drug in the aqueous phase. Mainly two factors, increasing temperature of the aqueous phase and increasing surfactant concentration, are increasing the saturation solubility of drug in water phase. Tetracaine SLN were prepared by hot HPH shows drug enriched shell model.

3. **A drug enriched core** obtained when dissolving a drug (e.g. prednisolone) in the lipid melts at or close to its saturation solubility. In this model, cooling of the formed Nano emulsion will lead to super saturation of drug in melted lipid and it further leads drug precipitation prior to lipid precipitation. Further cooling will lead to precipitation of lipid surrounding the drug enriched core as a membrane as indicated in Figure 3c. Due to increased diffusional distance and hindering effect of surrounding solid lipid shell, the carrier system shows sustained release profile.

Preservation and storage of drug loaded SLNs

1. Sterilization of SLNs

Nanoparticle preparations which are to be administered by parenteral, ocular or pulmonary routes must be sterilized. Nanoparticle formulations which have particle size below 200 nm can be easily sterilized by membrane filtration but for larger particles autoclaving or gamma sterilization is needed. Excipients of SLNs can handle the high temperature of autoclaving, so autoclaving is better to be used as sterilization method for SLNs. During autoclaving the temperature of system rises to form hot oil in water emulsion, which may modify the size of final product. The stability of SLNs during autoclaving depends on surfactant used to stabilize the system and lipid matrix material. Particle size increased slightly after autoclaving but not to a reasonable extent and polydispersity index also increased. SLNs prepared by microemulsion by using stearic acid, behenic acid or Acidan N12 as lipid matrix material, epikuron 200 as surfactant and taurodeoxycholate as co-surfactant were sterilized by autoclaving. After autoclaving the particle size of stearic acid SLNs and behenic acid SLNs increased whereas Acidan N12 SLNs remain unaffected. Zeta potential remains unaffected after autoclaving of SLNs. For thermolabile materials gamma sterilization is used to sterilize the SLNs, but there are chances of free radical production which result in oxidation of excipients used in SLNs production.

2. Freeze drying of SLNs

Shelf life of SLNs suspension is less because the drugs may hydrolyse and/or surfactant may not formulate a stable system for longer duration. So freeze drying is needed to store the SLNs dispersion in dry form for longer duration. Trehalose (15%) is the best cryoprotectant which is to be used in freeze drying of SLNs dispersion. During freeze drying results very slightly change in particle size, but degree of crystallinity of particles increase. So drug loaded SLNs result in different size particles because free drug concentration leads to increase in particle size. The zeta potential of final product may decrease due to free drug content in suspension, so free drug must be removed from the product before freeze drying. Crystallization of the lipid matrix during freezing also leads to drug expulsion and zeta potential of the system decreases. Protective effect of cryoprotectant, freezing velocity, and thermal treatment affects the reconstituted product of SLNs powder obtained after dispersing it with water. Saccharide cryoprotectants affect the aggregation behaviour of SLNs during freeze drying, crystalline nature of cryoprotectant leads to aggregates of nanoparticles. Xylose on freeze drying leads to regular crystals and nanoparticles dispersed in suspension comes out to form aggregates.

3. Spray drying of SLNs

Spray drying is a one step process used to dry the suspensions in dry form which may be constituted at the time of use. In case of SLN dispersion spray drying, melting point of lipid must be more than 65 °C. During spray drying moisture forms a film around SLN which lowers the temperature below 15–20 °C lower than the temperature of the outer environment. So thermo-labile drug also gets preserved and lipid will not melt during the drying process. Kinetic energy and shear forces are maximum while the process of spray drying is used. Dilute SLNs suspension results into a dispersible product because there were fewer chances of aggregation and particle damage during spray drying. Temperature also results in aggregations of nanoparticles during spray drying either by melting of lipid or damage of surfactant film on surface of nanoparticles, in order to avoid this

problem, carbohydrate or alcohol content was used in spraying.

Characterization of SLN

1. Particle size and

The physical stability of SLNs depends on their particle size. Photon correlation spectroscopy (PCS) and laser diffraction (LD) are the most powerful techniques for determination of particle size. PCS (also known as dynamic light scattering) measures the fluctuation of the intensity of the scattered light, which is caused by particle movement.

The particle size determination by photon correlation spectroscopy (PCS) detects size range of 3nm to 3µm and by laser diffraction in size range of 100 nm to 180 µm. Although PCS is a good tool to characterize nanoparticles, but is capable for the detection of larger micro-particles (Pandey *et al.*, 2005). The LD method is based on the dependence of the diffraction angle on the particle size. Smaller particles cause more intense scattering at high angles compared to the larger ones.

2. Zeta potential

Zeta potential measurement can be carried out using zeta potential analyser or zeta meter. Before measurement, SLN dispersions are diluted 50-fold with the original dispersion preparation medium for size determination and zeta potential measurement (Luo *et al.*, 2006). Higher value of zeta potential may lead to disaggregation of particles in the absence of other complicating factors such as steric stabilizers or hydrophilic surface appendages. Zeta potential measurements allow predictions about the storage stability of colloidal dispersions.

3. Differential scanning calorimetry (DSC)

DSC and powder X-ray diffractometric (PXRD) is performed for the determination of the degree of crystallinity of the particle dispersion. The rate of crystallinity using DSC is estimated by comparison of the melting enthalpy/g of the bulk material with the melting enthalpy/g of the dispersion.

4. Determination of Incorporated Drug or Entrapment efficiency

Amount of drug incorporated in SLNs influences the release characteristics hence it is very important to measure the amount of incorporated drug. The amount of drug encapsulated per unit wt. of nanoparticles is determined after separation of the free drug and solid lipids from the aqueous medium and this separation can be done by ultracentrifugation, centrifugation filtration or gel permeation chromatography. The drug can be assayed by standard analytical technique such as spectrophotometer, a spectroflurophotometry, HPLC or liquid scintillation counting.

$$\text{Entrapment efficiency (\%EE)} = \frac{W\text{initial drug} - W\text{free drug}}{W\text{ initial drug}} \times 100$$

5. *In vitro* drug release

1. Dialysis tubing

In vitro drug release could be achieved using dialysis tubing. The solid lipid nanoparticle dispersions placed in pre washed dialysis tubing which can be hermetically sealed. The dialysis sac then dialyzed against a suitable dissolution medium at room temperature; the samples are withdrawn from the dissolution medium at suitable intervals, centrifuged and analyzed for the drug content using a suitable analytical method.

2. Reverse dialysis

In this technique a number of small dialysis sacs containing 1 mL of dissolution medium are placed in SLN dispersion. The SLN's are then displaced into the medium.

6. Rheology

Rheological measurements of formulations can perform by Brookfield Viscometer, using a suitable spindle number. The viscosity depends on the dispersed lipid content. As the lipid content increases, the flow becomes non-Newtonian from Newtonian.

7. X-ray diffraction (powder X-ray diffraction)

The geometric scattering of radiation from crystal planes within a solid allow the presence or absence of the former to be determined thus permitting the degree of crystallinity to be assessed. Another method that is a little different from its implementation with bulk materials.

APPLICATION

1. Oral SLNs in ant tubercular chemotherapy

Ant tubercular drugs such as rifampicin, isonizide, pyrazinamide-loaded SLN systems, were able to decrease the dosing frequency and improve patient compliance.[15] By using the emulsion solvent diffusion technique this anti tubercular drug loaded solid lipid nanoparticles are prepared.

2. SLNs for topical use

SLNs used for topical application for various drug such as anticancer, vitamin-A, isotretinoin, flurbiprofen. Using glyceryl behenate, vitamineA-loaded nanoparticles can be prepared. Thismethod is useful for the improvement of penetration with sustained release. Theisotretinoin-loaded lipid nanoparticles were formulated for topical delivery of drug. Production of the flurbiprofen-loaded SLN gel for topical application offer a potential advantage of delivering the drug directly to the site of action, which will produce higher tissue concentrations.

3. SLNs as cosmeceutical

The SLNs have been applied in the preparation of sunscreens and as an active carrier agent for molecular sunscreens and UV blockers. SLN and NLCs have proved to be controlled release innovative occlusive topical. Better localization has been achieved for vitamin A in upper layers of skin with glyceryl behenate SLNs compared to conventional formulations.

4. SLNs as gene vector carrier

SLN can be used in the gene vector formulation. There are several recent reports of SLN carrying genetic/peptide materials such as DNA, plasmid DNA and other nucleic acids.[20] The gene transfer was optimized by incorporation of a diametric HIV-1 HAT peptide(TAT 2) into SLN gene vector. The lipid nuclic acid nanoparticles were prepared from a liquid nanophase containing water and a water miscible organic solvent where both lipid and DNA are separately dissolved by removing the organic solvent, stable and homogeneously sized lipid nuclic acid nanoparticle (70- 100 nm) were formed. It's called geno spheres. It is targeted specific by insertion of an antibody-lipo polymer conjugated in the particle.

5. SLNs in breast cancer and lymph node metastases

Mitoxantrone-loaded SLN local injections were formulated to reduce the toxicity and improve the safety and bioavailability of drug.[21] Efficacy of doxorubicin (Dox) has been reported to been enhanced by incorporation in SLNs. In the methodology the Dox was complexed with soybean-oil-based anionic polymer and dispersed together with a lipid in water to form Dox-loaded solid lipid nanoparticles. The system has enhanced its efficacy and reduced breast cancer cells.

6. SLNs as a targeted carrier for anticancer drug to solid tumors

SLNs have been reported to be useful as drug carriers to treat neoplasm's. Tumour targeting has been achieved with SLNs loaded with drugs like methotrexate and Camptothecin. Tamoxifen an anticancer drug is incorporated in SLN to prolong release of drug after I.V.

7. Stealth nanoparticles

These provide a novel and unique drug-delivery system they evade quick clearance by the immune system. Such nanoparticles can target specific cells. Stealth SLNs have been successfully tested in animal models with marker molecules and drugs. Antibody labelled stealth Lipobodies have shown increased delivery to the target tissue in accessible sites.

8. SLNs for potential agriculture application

Essential oil extracted from Artemisiaarboreseens L when incorporated in SLN, were able to reduce the rapid evaporation compared with emulsions and the systems have been used in agriculture as a suitable carrier of ecologically safe pesticides.

CONCLUSION

SLN as colloidal drug carrier combines the advantage of polymeric nanoparticles, fat emulsions and liposome; due to various advantages, including feasibility of incorporation of lipophilic and hydrophilic drugs, improved physical stability, low cost, ease of scale-up, and manufacturing. SLNs are prepared by various advanced techniques. The site specific and sustained release effect of drug can better achieved by using SLNs. Nanoparticles have been used extensively for applications in drug discovery, drug delivery, and diagnostics and for many others in medical field. They are relatively novel drug delivery systems, having received primary attention from the early 1990s and future holds great promise for its systematic investigation and exploitation. We can expect many patented dosage forms in the form of SLNs in the future.

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