AN OVERVIEW ON SOLID LIPID NANOPARTICLE BASED DRUG DELIVERY SYSTEM

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ABSTRACT

Improvement of solubility as well as bioavailability of drug is our main motto for this purpose solid lipid nanoparticles (SLNs) are the new approach in drug delivery system. Since a decade, several research works are performed to utilize solid lipid nanoparticles as alternative drug delivery system to colloidal drug delivery systems such as lipid emulsions, liposomes and polymeric nanoparticles. SLNs offer great promise to controlled drug delivery and site specific and gene delivery. Nanostructures lipid carrier, lipid drug conjugates, polymer lipid hybrid nanoparticles are the new emerging drug delivery system. This review concentrated on drug incorporation models, advancement in lipid nanoparticles, method of preparation, secondary production steps, characterization, application and future of SLNs. This review presents a broad treatment of solid lipid nanoparticles discussing their advantages, limitations.

KEYWORDS

Solid lipid nanoparticles (SLNs), Polymer lipid hybrid nanoparticles (PLNs), Acoustic method**,** Membrane Contractor technique.

INTRODUCTION

Targeted delivery of a drug molecule is a challenge and a wide area for pharmaceutical research scientist. Development of colloidal delivery systems such as nanoparticles, liposomes, and micelles are the new approach for improving drug delivery. A nanoparticle is the most fundamental component in the fabrication of a nanostructure, and is far smaller than the world of everyday objects that are described by Newton's laws of motion, but bigger than an atom or a simple molecule that are governed by quantum mechanics [1]. Drug and gene delivery, production of improved biocompatible materials and *in vitro* and *in vivo* diagnostics are examples of nanotechnology application [2]. Penetrability through several anatomical barriers, sustained release of their contents and their stability in nanometer size are the dependent barriers for the successful implementation of nanoparticles for drug delivery. As the regulatory approval and high cast of the polymers have limited the use of nanoparticles to clinical medicine. To overcome these, lipids are used as an alternative carrier, particularly for lipophilic drugs.

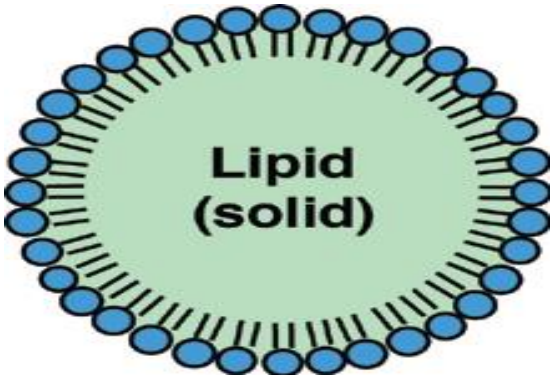


Fig -1 Structure of solid lipid nanoparticle

These lipid nanoparticles are known as solid lipid nanoparticles (SLNs) [Figure1]. Since a decade, trials are being made to utilize solid lipid nanoparticles as alternativedrug delivery system to colloidal drug delivery systems such as lipid emulsions, liposomes and polymeric nanoparticles. SLN combines the advantages of different colloidal carriers and also avoids some of their disadvantages [3]. SLNs have abilityto incorporate drugs into nanocarriers and promise for attaining the bioavailability enhancement along with controlled and site-specific drug delivery. SLN's are considered too well tolerated in general, because of their similar composition to physiological lipids. A clear advantage of SLN is the fact that the lipid matrix is made from physiological lipids which decreases the danger of acute and chronic toxicity [4,5]. In SLNs as compared to other colloidal carriers' liquid lipid is replaced by solid lipid. The use of solid lipid as a matrix material for drug delivery is well known from lipid pellets for oral drug delivery (e.g. Mucosolvan® retard capsules) [5,6]. Solid lipid nanoparticle may be a promising sustained release and drug targeting system for lipophilic CNS antitumor drugs [7]. The lipid core is stabilized by surfactants (emulsifiers) [Table1]. The term lipid is used here in a broader sense and includes triglycerides (e.g., tristearin), diglycerides, monoglycerides

(e.g. glycerolmonostearate), fatty acids (e.g. stearic acid), steroids (e.g. cholesterol), and waxes (e.g. cetyl palmitate). All classes of emulsifiers (with respect to charge and molecular weight) have been used to stabilize the lipid dispersion. It has been found that the combination of emulsifiers might prevent particle agglomeration more efficiently [8]. SLNs as an advanced drug and gene delivery nanosystems present significant opportunities for improving medical therapeutics [9].

Table 1: List of excipients used in SLNs preparation. [5, 12]

Type	**Example**

Lipids	Triglycerides
	Tricaprin
	Trilaurin
	Trimyristin (Dynasan 114)
	Tripalmitin (Dynasan 116)
	Tristearin (Dynasan 118)
	Hydrogenated coco-glycerides (Softisan O 142)
	Hard fat types
	Witepsol O W 35
	Witepsol O H 35
	Witepsol O H 45
	Witepsol O E 85
	Acyl glycerols
	Glyceryl monostearate (Imwitor O 900)
	Glyceryl distearate (Precirol)
	Glyceryl monooleatate (Peceol)
	Glyceryl behenate (Compritol O 888 ATO)
	Glyceryl palmitostearate (Precirol O ATO 5)
	Waxes
	Cetyl palmitate
	Fatty acid
	Stearic acid
	Palmitic acid
	Decanoic acid
	Behenic acid
	Acidan N12
	Cyclic complexes
	Cyclodextrin para-acyl-calix-arenes
Surfactants phospholipids	Soy lecithin (Lipoid OS100)
	Egg lecithin (Lipoid E80)
	Phosphatidylcholine (Epikorun 170, Epikorun 200)
	Ethylene oxide/ Propylene oxide copolymers
	Poloxamer 188
	Poloxamer 182
	Poloxamer 407
	Poloxamer 908
Sorbitanethylene oxide / Propylene oxide copolymers	Polysorbate 20
	Polysorbate 60
	Polysorbate 80
Alkylaryl polyether alcohol polymers **Bile salts**	Tyloxapol
	Sodium cholate
	Sodium glycocholate
	Sodium taurocholate
	Sodium taurodeoxycholate
Alcohols	Ethanol
	Butanol
	Butyric acid
	Dioctyl sodium sulfosuccinate
	Monooctylphosphoric acid sodium

ADVANTAGES OF SLNs

There are various advantages of Structure of solid lipid nanoparticle they are easy manipulation of particle size and surface characteristics of nanoparticle to achieve both passive and active drug targeting after parenteral administration. Site-specific targeting achieved by attaching targeting ligands to surface of particles. Magnetic guidance can be used for targeting. Drug loading is relatively high. Controlled release and particle degradation characteristics can be changed by changing matrix constituents. SLNs used for various routes of administration including oral, nasal, parenteral, intra-ocular etc. Use of biodegradable physiological lipids whichdecreases the danger of acute and chronic toxicity and avoidance of organic solvents in production methods [10]. Increased bioavailability of poorly water-soluble molecule can be achieved [11]. Lyophilisation can be done. Avoidance of organic solvents is possible.

Disadvantage of SLNs

Though there are several advantages but SLN also have some disadvantages also Particle-particle aggregation due to small size and large surface area. Difficult in physical handling Limited drug loading and burst release. Unexpected polymeric transitions dynamics.

DRUG INCORPORATION MODELS

Solubility of drug and drug loading capacity are inversely proportional. Thus, enhanced solubility results in reduced entrapment efficacy. To overcome this, Müller et al reported a cold homogenization technique which is performed at room temperature or below (0°C) [13].

Factors affecting loading capacity of a drug in lipid are: [14]

> solubility of drug in lipid melt,

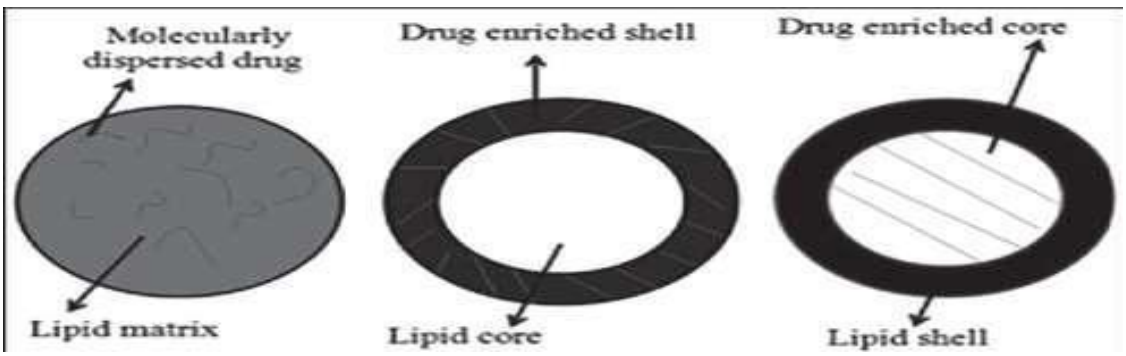
> miscibility of drug melt and lipid melt,

> chemical and physical structure of solid matrix lipid,

> polymorphic state of lipid material solubility

There are three models of drug incorporation: [Figure2]

- **Solid lipid solution**
- **Drug enriched shell**
- **Drug enriched core**



Solid solution

In the case of the solid solution model, the drug is molecularly dispersed in the lipid matrix when the particles are produced by the cold homogenization technique and using no surfactant or no drug-solubilizing surfactant. The drug has strongly pronounced interactions with the lipid [15, 16].

Drug enriched shell

According to the drug-enriched shell model of drug incorporation, a solid lipid core forms when the recrystallization temperature of the lipid is reached. On reducing the temperature of the dispersion, the drug concentrates in the still liquid outer shell of the SLNs [16, 17, 18].

Drug enriched core

According to the drug-enriched core model of drug incorporation, cooling the nano emulsion leads to a super saturation of the drug which is dissolved in the lipid melt at or close to its saturation solubility and the drug precipitates prior to lipid recrytallization. Further cooling finally leads to the recrytallization of the lipid surrounding the drug as a membrane [13,16].

ADVANCEMENT IN SLNs

As SLNs have several advantages of controlled and targeted drug delivery but have some limitations i.e., Limitation of drug load by the solubility of the drug in the solid lipid. Drug expulsion phenomenon when lipid crystallizes to the stable β-form. Particle concentration in the aqueous dispersions ranging from about 1% to a maximum of only 30%. It was observed that drug was expelled out of SLN during storage due to highly ordered crystalline lipid matrix which was leaving very little space for drug molecules. To overcome these limitations of SLNs, Lipid Drug Conjugates (LDCs), Nanostructured Lipid Carriers (NLCs) and Polymer lipid hybrid nanoparticles (PLNs) are introduced [19].

METHODS OF PREPARATION OF SOLID LIPID NANOPARTICLES. [7, 18]

1. **High pressure homogenization**
   a. Hot homogenization
   b. Cold homogenization
2. **Ultra-sonication/ High speed homogenization**
   a. Probe Ultra sonication
   b. Bath Ultra sonication
3. Solvent evaporation method
4. Solvent emulsification-diffusion method
5. Super critical fluid method
6. Micro emulsion-based method
7. Spray drying method
8. Double emulsion method
9. Precipitation Technique
10. Film-Ultrasound dispersion

High pressure homogenization:

It is a reliable and powerful technique, which is used for the production of SLNs. High pressure homogenizer push a liquid with high pressure (100-2000 bar) through a

narrow gap (in the range of a few microns). The fluid accelerates on a very short distance to very high velocity (over 1000km/h). Very high shear stress and cavitation forces disrupte the particles down to the sub-micron range. Generally, 5-10% lipid content is used but upto 40% lipid content has also been investigated work on the same concept of mixing the drug in bulk of lipid melt.

Hot homogenization:

Hot homogenization is carried out at temperatures above the melting point of the lipid and can therefore be regarded as the homogenization of an emulsion. A pre-emulsion of the drug loaded lipid melt and the aqueous emulsifier phase (same temperature) is obtained by high-shear mixing device. High pressure homogenization of the pre-emulsion is carried out at temperatures above the melting point of the lipid. In general, higher temperatures result in lower particle sizes due to the decreased viscosity of the inner phase. However, high temperatures increase thedegradation rate of the drug and the carrier. Increasing the homogenization pressureor the number of cycles often results in an increase of the particle size due to high kinetic energy of the particles. The hot homogenization technique can be used for lipophilic and insoluble drugs. This technique is not suitable for incorporation of hydrophilic drugs into SLNs because higher portion of drugs in water during homogenization results in low entrapment efficiency.

Cold homogenization

Cold homogenization has been developed to overcome various problems associated with hot homogenization such as: Temperature-induced drug degradation, drug distribution into the aqueous phase during homogenization, Complexity of the crystallization step of the nanoemulsion leading to several modifications and/or super cooled melts. In this technique the drug containing lipid melt is cooled, the solid lipid ground to lipid microparticles and these lipid microparticles are dispersed in a cold surfactant solution yielding a pre-suspension. Then this pre-suspension is homogenized at or below room temperature, the gravitation force is strong enough tobreak the lipid microparticles directly to solid lipid nanoparticles.

Solvent evaporation method

The lipophilic material is dissolved in a water-immiscible organic solvent (e.g. cyclo hexane) that is emulsified in an aqueous phase. Upon evaporation of the solvent, nanoparticles dispersion is formed by precipitation of the lipid in the aqueous medium by giving the nanoparticles of 25nm mean size. The solution was emulsified in an aqueous phase by high pressure homogenization. The organic solvent was removed from the emulsion by evaporation under reduced pressure.

Micro emulsion-based method

This method is based on the dilution of microemulsions. As micro-emulsions are two-phase systems composed of an inner and outer phase (e.g. microemulsions). They are made by stirring an optically transparent mixture at 65-70°C, which typically composed of a low melting fatty acid (e.g., stearic acid), an emulsifier (e.g. polysorbate 20), co-emulsifiers (e.g butanol) and water. The hot micro emulsion is dispersed in cold water (2-3°C) under stirring. SLN dispersion can be used as granulation fluid for transferring in to solid product (tablets, pellets) by granulation process, but in case of low particle content too much of water needs to be removed. High-temperature gradients facilitate rapid lipid crystallization and prevent aggregation. Due to the dilution step; achievable lipid contents are considerablylower compared with the HPH based formulations.

Solvent emulsification-diffusion technique [18]

The particles with average diameters of 30-100nm can be obtained by this technique. In this technique, the solvent used must be partially miscible with water and this technique can be carried out either in aqueous phase or in oil. Initially, both the solvent and water were mutually saturated in order to ensure the initial thermodynamic equilibrium of both liquids. When heating is required to solubilize the lipid, the saturation step was performed at that temperature.

Then the lipid and drug were dissolved in water saturated solvent and this organic phase (internal phase) was emulsified with solvent saturated aqueous solution containing stabilizer (dispersed phase) using mechanical stirrer. After the formation of o/w emulsion, water (dilution medium) in typical ratio ranges from 1:5 to 1:10,were added to the system in order to allow solvent diffusion into the continuous phase, thus forming aggregation of the lipid in the nanoparticles .Here the both the phase were maintain at same elevated temperature and the diffusion step was performed either at room temperature or at the temperature under which the lipid was dissolved.Throughout the process constant stirring was maintained. Finally, the diffused solvent was eliminated by vacuum distillation or lyophilization.

Solvent Injection technique [17]

It is a new approach to prepare SLNs. In this technique, the solid lipid was dissolved in water-miscible solvent (e.g., ethanol, acetone, isopropanol) or a water-miscible solvent mixture. Then this organic solvent mixture was slowly injected through an injection needle in to stirred aqueous phase with or without surfactant. Then the dispersion was filtered with a filter paper in order to remove any excess lipid. The presence of surfactant within the aqueous phase helps to produce lipid droplets atthe site of injection and stabilize the formed SLNs until solvent diffusion was complete by reducing the surface tension.

Membrane contactor technique

The liquid phase was pressed at a temperature above the melting point of the lipid through the membrane pores allowing the formation of small droplets. SLNs were formed by the cooling of the preparation at the room temperature. Here both the aqueous and organic phases were placed in the thermostated bath to maintain the required temperature and nitrogen was used to create the pressure for the liquid phase More recently, a process known as nanotemplate engineering technology (NET) is developed in which “direct cooling” is utilized.

The process consists of three steps.

Melting a pharmaceutically acceptable matrix comprised of lipids, polymers

Adding pre-heated water with stirring to form the o/w microemulsion

Cooling to room temperature with stirring to generate the SLNs.

Double emulsion method:

For the preparation of hydrophilic loaded SLNs a novel method based on solvent emulsification-evaporation has been used. Here 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.

Spray drying method:

It is an alternative technique to the lyophilization process. This indicates the use

of lipid with melting point more than 70oC. The optimum results were obtained with SLN concentration of 1% in a solution of trehalose in water or 20% trehalose in ethanol-water mixture.

SLN preparation by using supercritical fluid [20]

This is a relatively new technique for SLN production and has the advantage of solvent-less processing. SLN can be prepared by the rapid expansion of supercriticalcarbon dioxide solutions method. Carbon dioxide (99.99%) was the good choice as a solvent for this method.

Precipitation technique [21]

Solid lipid nanoparticles can also be produced by a precipitation method which is characterized by the need for solvents. The glycerides will be dissolved in an organic solvent (e.g. chloroform) and the solution will be emulsified in an aqueous phase. After evaporation of the organic solvent the lipid will be precipitated forming nanoparticles. Nanoparticles with wider size distribution due to presence of aggregates between the particles. The conditions of the freeze drying and the removal of water promote the aggregation of the solid lipid nanoparticles during the freeze – drying process.

Sterilization:

Sterilization of nanoparticles is desirable for parenteral administration and autoclaving which is applicable to formulations containing heat-resistant drugs. Effects of sterilization on particle size have been investigated and it was found to cause a distinct increase in particle size.

Spray drying:

Spray drying might be alternative procedure to lyophilization in order to transform an aqueous SLN dispersion ratio into a dry product. This method has been used scarcely for SLN formulation, although spray drying is cheaper as compared to lyophilization. The lipids with melting point at temperature greater than 70˚C had been recommended for spray drying.

Table 2 Different advantages and disadvantages of different methods

Sl No.	Method	Advantages	Disadvantages
1a	Hot HPH	Versatile, avoid use of organic solvent, easy scalability, short production time, instruments easily available and no regulatory problems.	High temperature lead to degradation , conformational changes in protein, coalescence of particles, burst release due to high emulsifiers.
1b	Cold HPH	Minimizes thermal exposure of the drug but does not avoid it completely. Useful in temperature laible drugs or hydrophilic drugs.	Higher Polydispersity index.
2	Emulsification	Avoidance of heat during production thus useful for	Solvent residues.

	solvent evaporation	thermolaible drugs. Simple procedure.	
3	Emulsification-Solvent diffusion	Simple procedure, Fast drug release (drawback when slow release is required)	Low lipid content, Low EE and DL, organic solvent residue, Lack of scaleup
4	Micro emulsion	No need for specialized equipmentand energy for production	high concentrations of surfactants and co-surfactants, presence of large amounts of water in system
5	Membrane Contactor	Simple method, Control of particlesize by selection of process parameters, and its scaling-up abilities	
6	PGSS	one step procedure, no need oforganic solvent, low processing temperature conditions	frequent nozzle blockage with hydro- phallic drugs, machinery is costly
7	Multiple emulsion	No need to melt lipids, high loading of hydrophilic drugs, useful for protein loading	Use of solvent and surfactant
8	Solvent injection	no need for high pressure homogenization, easy handling, fast production process, No need for specialized equipment	Use of solvent and surfactant
9	Film Ultra-sonication dispersion	Simple, No need for specializedequipment	Metallic particle contamination, broader particle size
10	Phase inversion	Useful for thermolabile drugs, avoid organic solvent, No need for specialized equipment	

Characterization of SLNs

Characterization of the SLNs is necessary for product development and quality but presents serious challenges due to colloidal size of particles and complexity and dynamic nature of delivery system.

Measurement of Particle Size and Zeta Potential:-

Particle size

Particle size analysis can be performed by photon correlation spectroscopy (PCS), laser diffractometry (LD) and Nanoparticle tracking analysis (NTA). PCS (also

known as dynamic light scattering) measures the fluctuation of intensity of the scattered light which is caused by particle movement [26]. This method can measure particle size ranging from few nanometers to about 3 microns. The LD method is based on the dependence of the diffraction angle on the particle size and it is useful for size ranges from 100 nm to 180 μm.NTA is a relatively new method of visualising and analysing particles from 10-1000nm in liquids. It measures particle size based on rate of Brownian motion, whichis related to the viscosity of the liquid, the temperature and the size of the particle [27,28].

Zeta potential

Zeta potential measurement, an indicator of the stability of colloidal dispersions, can be determined using a zeta potential analyzer. Before measurement, SLNs dispersions are diluted appropriately, often with deionized water, to measure zeta potential. The surface charge will reflect the type of lipid used in the formulation and can be used to inform long-term predictions about the storage stability of colloidal dispersions [29].

Determination of Drug Loading and Entrapment Efficiency

It is of primary importance to determine the amount of drug incorporated in SLNs, since this influences release characteristics and the feasibility of the formulation in terms of amount of formulated product to be delivered. The degree of encapsulation can be assessed ultimately by determining the quantity of drug remaining in the supernatant after centrifugation of a SLN suspension or, alternatively, by dissolution of the sediment in a suitable solvent and subsequent analysis. Standard analytical techniques such as spectrophotometry orhigh performance liquid chromatography can be used to assay the drug [30].

Electron Microscopy

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) are direct methods used for morphological examination of nanoparticles. TEM has a lower size limit of detection [31].

Atomic Force Microscopy (AFM)

In this technique, a probe tip with atomic scale sharpness is rastered across the sample to produce a topological map based on the forces at play between the tipand surface. The probe can be dragged across sample (contact mode), or allowed tohover just above (non-contact mode), with the exact nature of the particular force employed serving to distinguish among the sub-techniques. A high resolution is obtainable with this approach, which along with the ability to map a sample according to properties in addition to size, e.g., colloidal attraction or resistance to deformation, makes AFM a valuable tool [32].

Structural Analysis

Among a large number of analytical techniques, differential scanning calorimetry (DSC) and powder x-ray diffraction (XRD) can be used to elucidate structural information on the dispersed drug and lipids. Crystallinity of drug and excipients can be measured using XRD by scattering of radiation from crystal plane within the solid,while DSC can be used to determine nature of crystallinity within nanoparticles through the measurement of glass transitions and melting point temperatures and their enthalpies [8].

Nuclear Magnetic Resonance (NMR)

High-resolution NMR can be used to determine both the size and the qualitative nature of nanoparticles. The selectivity afforded by chemical shifts compliments the sensitivity to molecular mobility, thus providing information on the physicochemical status of components within the nanoparticle [33].

***In-vitro* Drug Release from SLNs**

SLN dispersions can be placed in prewashed dialysis tubing, which can be hermetically sealed. The dialysis sac is then dialyzed within an appropriate dissolution medium at (37 ± 0.5)°C. Samples are withdrawn at suitable intervals from the dissolution medium, centrifuged and analyzed for drug content using an appropriate analytical method [34,35]. inflammation. Apart from the treatment of the skin diseases by topical application, gastrointestinal side effects of non-steroidal anti-inflammatory drugs can be decreased by topical antirheumatic therapy, for example [38].

SLNs have been shown to sustain the delivery of sunscreens in human studies and that the results correlate well with *in-vitro* penetration studies [39]. Nanoparticle preparations are also currently under investigation for novel treatment of dermatological conditions such as acne vulgaris, recurrent condyloma accuminata, atopic dermatitis, and hyperpigmented skin lesions [40].

Routes of Administration of SLNs and their biodistribution [26,27]

The *in vivo* behavior of the SLN particles will mainly depend on the following points: Interactions of the SLN with the biological surroundings including: distribution processes (Adsorption of biological material on the particle surface and desorption of SLN components into to biological surroundings) and enzymatic processes. Various administration routes are

1. **Parenteral administration** Peptide and proteins drugs are usually available for parenteral use in the market. Since their conventional oral administration is not possible due to enzymatic degradation in GI tract. Parenteral application of SLN reduces the possible side effects of drug incorporated with the increasedbioavailability. These systems are very suitable for drug targeting.

2. **Oral administration** Controlled release behavior of SLNs is reported to enable the bypass of gastric and intestinal degradation of the encapsulated drug, and their possible uptake and transport through the intestinal mucosa. However, the assessment of the stability of colloidal carriers in GI fluids is essential in order to predict their suitability for oral administration.

3. **Rectal administration** When rapid pharmacological effect is required, in some circumstances, parenteral or rectal Administration is preferred. This route is used for paediatric patients due to easy application.

4. **Nasal administration** Nasal route is preferred due to its fast absorption and rapid onset of drug action also avoiding degradation of labile drugs in the GIT and insufficient transport across epithelial cell layers.

5. **Respiratory delivery** Nebulisation of solid lipid particles carrying anti-tubercular drugs, anti-asthmatic drugs and anticancer was observed to be successful in improving drug bioavailability and reducing the dosing frequency for better management of pulmonary action.

6. **Ocular administration** Biocompatibility and muco-adhesive properties of SLN improve

their interaction with ocular mucosa and prolong corneal residence time of the drug, with the aim of ocular drug targeting.

7. Topical administration SLN are very attractive colloidal carrier systems for skin applications due to their various desirable effects on skin besides the characteristics of a colloidal carrier system. They are well suited for use on damaged or inflamed skin because they are based on non-irritant and non-toxic lipids.

FUTURE OF SLNs

SLNs can be developed as more effective drug delivery in future by taking consideration of industrial needs like simple technology, low cost, regulatory excipient status, tolerability, scale up, qualification and validation. Research must continue to develop a therapy through localized medical implants. Yih *et al.* developed a bio-micro electro mechanical micropumps for controlled release of drug for local action. Factors that should be taken in consideration in future research are efficacy, drug loading, targeting and toxicity. Studies are essential to evaluate the efficacy of implants over time when encapsulated and stored. Implantable devices or nanochips will provide improved therapeutics in disease management and potentially applied as gene therapy, antitumor, vaccines and in repairing damaged tissue, detecting mutated genes or detecting high hormone levels indicative of certain malignance. Further work needs to be carried out to understand the structure and dynamics of SLNs at the molecular level in *in-vitro* and *in-vivo* studies.

CONCLUSION

The SLN are exciting carrier systems for encapsulating bioactive substances and their application. The present work has concentrated on newer approach of nano sized delivery carriers like solid lipid nanoparticle, nanostructure lipid carriers, lipid drug conjugates, Polymer lipid hybrid nanoparticles etc. Implantable devices or nanochips offer an economical system, patient compliance and avoid adverse effects on non-targeted tissues. As SLNs have potential of controlled drug delivery to a targettissue, there will be a vast area of investigation in improvement of quality, efficacy and safety of drug in future.

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