WORLD JOURNAL OF PHARMACY AND PHARMACEUTICAL SCIENCES
SJIF Impact Factor 7.421
Volume 8, Issue 3, 433-450 Review Article ISSN 2278 – 4357

A REVIEW ON SOLID LIPID NANOPARTICLES: AS A PROMISING APPROACH FOR TARGETED DRUG DELIVERY SYSTEM

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Article Received on
10 Jan. 2019,

Revised on 31 Jan. 2019,
Accepted on 21 Feb. 2019,

DOI: 10.20959/wjpps20193-13273

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ABSTRACT

Nanoparticles are solid colloidal particles ranging in size from 1 to 1000 nm and composed of macromolecular material. Nanoparticles could be polymeric or lipidic (Solid Lipid Nanoparticles). Industry estimates suggest that approximately 40% of lipophilic drug candidates fail due to solubility and formulation stability issues, prompting significant research activity in advanced lipophilic delivery technologies. Solid lipid nanoparticles (SLN) are most developing formulations of nanotechnology with several applications in different fields like drug delivery, clinical medicine and research as well as in other varied sciences. SLN are defined as the spherical particles of nanometer range which immersed in water or aqueous surfactant solution either using lipophilic and hydrophilic drug. Solid lipid nanoparticle technology represents a promising new approach to lipophilic drug delivery. The bioacceptable and biodegradable nature of SLNs makes them less toxic as compared to polymeric nanoparticles. Supplemented with small size which prolongs the circulation time in blood, feasible scale up for large scale production and absence of burst effect makes them interesting candidates for study. In this present review this new approach is discussed in terms of their advantages, disadvantages, preparation methods, characterization and special features and their applications. And it was found that, if properly investigated, SLNs may open new vistas in therapy of complex diseases.

KEYWORDS: Solid lipid nanoparticles (SLN), colloidal drug carriers, homogenization, Targeted drug delivery.

INTRODUCTION

Targeted delivery of a drug molecule to specific organ sites is one of the most challenging research areas in pharmaceutical sciences. By developing colloidal delivery systems such as liposomes, micelles and nanoparticles, new frontiers have opened for improving drug delivery.[1] solid lipid nanoparticles (SLN) introduced in 1991 represent an alternative carrier system to tradition colloidal carriers such as emulsions, liposomes and polymeric micro and nanoparticles .Nanoparticles made from solid lipids are attracting major attention as novel colloidal drug carrier for intravenous applications as they have been proposed as an alternative particulate carrier system. The system consists of spherical solid lipid particles in the nanometer ranges, which are dispersed in water or in aqueous surfactant solution. Generally, they are made of solid hydrophobic core having a monolayer of phospholipids coating. The solid core contains the drug dissolved or dispersed in the solid high melting fat matrix. The hydrophobic chains of phospholipids are embedded in the fat matrix. They have potential to carry lipophilic or hydrophilic drugs or diagnostics.[2] Solid lipid nanoparticles are one of the novel potential colloidal carrier systems as alternative materials to polymers which is identical to oil in water emulsion for parenteral nutrition, but the liquid lipid of the emulsion has been replaced by a solid lipid shown on Fig. 1. They have many advantages such as good biocompatibility, low toxicity and lipophilic drugs are better delivered by solid lipid nanoparticles and the system is physically stable.[3]

ADVANTAGES OF SLN.[2, 3]

1. Control and / or target drug release.
2. Excellent biocompatibility
3. Improve stability of pharmaceuticals
4. High and enhanced drug content.
5. Better control over release kinetics of encapsulated compounds.
6. Enhanced bioavailability of entrapped bioactive compounds.
7. Chemical protection of labile incorporated compounds.
8. Much easier to manufacture than biopolymeric nanoparticles.
9. No special solvent required.
10. Conventional emulsion manufacturing methods applicable.

11. Raw materials essential the same as in emulsions.
12. Very high long-term stability.
13. Application versatility.
14. Can be subjected to commercial sterilization procedures.

DISADVANTAGES OF SLN[2]

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 water soluble drugs due to partitioning effects during the
5. Production process.

Types of solid lipid nanoparticles[4]

The types of SLNs depend on the chemical nature of the active ingredient and lipid, the solubility of actives in the melted lipid, nature and concentration of surfactants, type of production and the production temperature. Therefore 3 incorporation models have been proposed for study.

1. SLN, Type I or homogenous matrix model: The SLN Type I is derived from a solid solution of lipid and active ingredient. A solid solution can be obtained when SLN are produced by the cold homogenization method. A lipid blend can be produced containing the active in a molecularly dispersed form. After solidification of this blend, it is ground in its solid state to avoid or minimize the enrichment of active molecules in different parts of the lipid nanoparticles.
2. SLN, Type II or drug enriched shell model: It is achieved when SLN are produced by the hot technique, and the active ingredient concentration in the melted lipid is low during the cooling process of the hot o/w nanoemulsion the lipid will precipitate first, leading to a steadily increasing concentration of active molecules in the remaining melt, an outer shell will solidify containing both active and lipid. The enrichment of the outer area of the particles causes burst release. The percentage of active ingredient localized in the outer shell can be adjusted in a controlled shell model is the incorporation of coenzyme Q 10.
3. SLN, Type III or drug enriched core model: Core model can take place when the active ingredient concentration in the lipid melt is high & relatively close to its saturation solubility. Cooling down of the hot oil droplets will in most cases reduce the solubility of

the active in the melt. When the saturation solubility exceeds, active molecules precipitate leading to the formation of a drug enriched core.

SOLID LIPID NANOPARTICLE STABILITY[4]

Lipid nanoparticle stability must be considered from two perspectives, the particle size distribution and the lipid crystalline state. Particle size is a critical safety factor for parenteral administration and self life, as noted previously. Particle size greatly affects biodistribution and RES clearance mechanisms. Particle size also affects the physical appearance of the product, since the human eye can only detect light scattered by particles that are greater than ~ 1. The degree of polydispersity can impact particle size growth via Ostwald ripening and can impact the overall drug release kinetics. The lipid crystalline state strongly correlates with drug incorporation, drug release, and the particle geometry.

PREPARATION METHODS[3, 5]

SLNs are prepared from lipid, emulsifier and water/solvent by using different methods and are discussed below.

1. High pressure homogenization
a) Hot homogenization
b) Cold homogenization
2. Ultrasonication/high speed homogenization
a) Probe ultrasonication
b) Bath ultrasonication
3. Solvent evaporation method
4. Solvent emulsification-diffusion method
5. Supercritical fluid method
6. Micro emulsion based method
7. Spray drying method
8. Double emulsion method
9. Precipitation technique
10. Film-ultrasound dispersion

1. High pressure homogenization (HPH)

It is a reliable and powerful technique, which is used for the production of SLNs. High pressure homogenizers 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 1000 Km/h). Very high shear stress and cavitation forces disrupt the particles down to the submicron range. Generally 5-10% lipid content is used but up to 40% lipid content has also been investigated.

A. 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. HPH 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 the degradation rate of the drug and the carrier. Increasing the homogenization pressure or the number of cycles often results in an increase of the particle size due to high kinetic energy of the particles.

B. 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 nanoemulsions 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 to break the lipid microparticles directly to solid lipid nanoparticles.

Advantages

™ Low capital cost.
™ Demonstrated at lab scale.

Disadvantages

Energy intensive process.

Demonstrated at lab scale Biomolecular damage.

Polydisperse distributions.

Unproven scalability.

2. Ultrasonication/high speed homogenization

This ultrasonication technique is a dispersing technique, which was initially used for theproduction of solid lipid nanodispersion. Ultrasonication based on the mechanism ofcavitation. In first step, the drug was added to previously melt solid lipid. In second step, the heated aqueous phase (heated to same temperature) was added to the melted lipid and emulsifiedby probe sonication or by using high speed stirrer or aqueous phase added to lipid phase drop bydrop followed by magnetic stirring. The obtained pre-emulsion was ultrasonicatedusingprobesonicator with water bath (at 0ºC). In order to prevent recrystalization during the process,the production temperature kept at least 5ºC above the lipid melting point. The obtainednanoemulsion (o/w) was filtered through a 0.45µm membrane in order to remove impuritiescarried in during ultrasonication.[8] Then they obtained SLN is stored at 4ºC. To increase thestability of the formulation, was lyophilized by a lyophilizer to obtain freeze-dried powder andsometimemannitol (5%) was added into SLNs as cryoprotector.

Advantage

1. Reduced shear stress.

Disadvantages

1. Potential metal contamination.
2. Physical instability like particle growth upon storage.

3. Solvent evaporation

SLNs can also prepared by solvent evaporation method. The lipophilic material is dissolved in a water-immiscible organic solvent (e.g.cyclohexane) 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 25 nm 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 (40–60 mbar).

Advantages

1. Scalable.
2. Mature technology.
3. Continuous process.
4. Commercially demonstrated.

Disadvantages

1. Extremely energy intensive process.
2. Polydisperse distributions.
3. Biomolecule damage.

4. Solvent emulsification-diffusion technique

In solvent emulsification-diffusion technique, the solvent used (e.g. benzyl alcohol, butyl lactate,ethyl acetate, isopropyl acetate, methyl acetate) must be partially miscible with water and thistechnique 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 thermodynamicequilibrium of both liquid. When heating is required to solubilize the lipid, the saturationstep was performed at that temperature. Then the lipid and drug were dissolved in watersaturated solvent and this organic phase (internal phase) was emulsified with solvent saturatedaqueous solution containing stabilizer (dispersed phase) using mechanical stirrer. After theformation 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, thusforming aggregation of the lipid in the nanoparticles. Herethe 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 + Water are mutually saturated.

5. Micro emulsion based method

This method is based on the dilution of micro-emulsions. As micro-emulsions are two-phase systems composed of an inner and outer phase (e.g. o/w micro-emulsions). 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 microemulsion 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 considerably lower compared with the HPH based formulations.

Advantages

1. Low mechanical energy input.
2. Theoretical stability.

Disadvantages

1. Extremely sensitive to change.
2. Labor intensive formulation work.
3. Low nanoparticle concentrations

6. Supercritical Fluid Method

This is an alternative method of preparing SLNs using particles from gas-saturated solutions (PGSS). This technique has several advantages such as (i) avoiding the use of solvents; (ii) particles are obtained as a dry powder, instead of suspension; (iii) it required mild pressure and temperature conditions. Carbon dioxide solution is a good choice as a solvent for this method.

Advantages

1. Avoid the use of solvents.
2. Particles are obtained as a dry powder, instead of suspensions.
3. Mild pressure and temperature conditions.
4. Carbon dioxide solution is the good choice as a solvent for this method.

7. Spray drying method

It's an alternative technique to lyophilization in order to transform an aqueous SLN dispersion into a drug product. It's a cheaper method than lyophilization. This method causes particle aggregation due to high temperature, shear forces and partial melting of the particle.

8. Double emulsion method

Here the drug is encapsulated with a stabilizer to prevent the partitioning of drug in to external water phase during solvent evaporation in the external water phase of w/o/w double emulsion.

9. Precipitation method

The glycerides are 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.

10. Film-ultrasound dispersion

The lipid and the drug were put into suitable organic solutions, after decompression, rotation and evaporation of the organic solutions, a lipid film is formed, then the aqueous solution which includes the emulsions was added. Using the ultrasound with the probe to diffuser at last, the SLN with the little and uniform particle size is formed.

CHARACTERIZATION OF SLNs[1, 2]

Adequate and proper characterization of the SLNs is necessary for its quality control. However, characterization of SLN is a serious challenge due to the colloidal size of the particles and the complexity and dynamic nature of the delivery system. The important parameters evaluated for the SLNs include particle size, size distribution kinetics (zeta potential), degree of crystallintity and lipid modification (polymorphism), coexistence of additional colloidal structures (micelles, liposome, super cooled melts, drug nanoparticles), time scale of distribution processes, drug content, in-vitro drug release and surface morphology.

1. Measurement of particle size and zeta potential

Photon correlation spectroscopy (PCS) and laser diffraction (LD) are the most powerful techniques for routine measurements 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. This method covers a size range from a few nanometers to about 3 microns. PCS is a good tool to characterize nanoparticles, but it is not able to detect larger micro particles. Electron Microscopy provides, in contrast to PCS and LD, direct information on the particle shape. The physical stability of optimized SLN dispersed is generally more than 12 months. ZP measurements allow predictions about the storage stability of colloidal dispersion.

2. Photon Correlation Spectroscopy (PCS)

It is an established method which is based on dynamic scattering of laser light due to Brownian motion of particles in solution/suspension. This method is suitable for the measurement of particles in the range of 3 nm to 3 mm.The PCS device consists of laser source, a sample cell (temperature controlled) and a detector.Photomultiplier is used as detector to detect the scattered light. The PCS diameter is based on the intensity of the light scattering from the particles.

3. Electron Microscopy

Electron Microscopy methods such as Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) are used to measure the overall shape and morphology of lipid nanoparticles. It permits the determination of particle size and distributions.SEM uses electrons transmitted from the surface of the sample while TEM uses electrons transmitted through the sample.

4. Atomic Force Microscopy (AFM)

It is an advanced microscopic technique which is applied as a new tool to image the original unchanged shape and surface properties of the particles. AFM measures the force acting between surface of the sample and the tip of the probe, when the probe is kept in close proximity to the sample which results in a spatial resolution of up to 0.01 nm for imaging.

5. Determination of Incorporated Drug

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.

6. In vitro drug release

a) Dialysis tubing

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

b) Reverse dialysis

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

7. 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.

8. Acoustic methods

Another ensemble approach, acoustic spectroscopy, measures the attenuation of sound waves as a means of determining size through the fitting of physically relevant equations. In addition, the oscillating electric field generated by the movement of charged particles under the influence of acoustic energy can be detected to provide information on surface charge.

9. Nuclear magnetic resonance (NMR)

NMR can be used to determine both the size and the qualitative nature of nanoparticles. The selectivity afforded by chemical shift complements the sensitivity to molecular mobility to provide information on the physicochemical status of components within the nanoparticle.

10. X-ray diffraction (powder X-ray diffraction) and differential scanning calorimetry (DSC)

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, DSC can be used to determine the nature and speciation of crystallinity within nanoparticles through the measurement of glass and melting point temperatures and their associated enthalpies

Applications of Solid Lipid Nanoparticles[1, 3]

1. Controlled Release of Drug

SLNs offer an advantage to modulate release of loaded drug either by varying drug loading approach or by altering surface properties or composition. In a recent study, SLN loaded with TNF-α siRNA was developed to achieve its prolonged release in treatment of rheumatoid arthritis. SLNs were prepared via a solvent displacement method using biocompatible lecithin and cholesterol, and a complex of siRNA with 1,2-dioleoyl-3-trimethylammonium-propane was encapsulated therein.In vitro release study of siRNA from SLNs demonstrates absence of burst release, and only 5% of siRNA was released in 30 days. This prolonged release property without burst release was attributed to the presence of cholesterol and complex of siRNA in formulation.

2. SLNs for topical use

SLNs used for topical application for various drugsuch as anticancer[16], vitamin-A[17], isotretinoin, flurbiprofen.[18] Using glycerylbehenate, vitamineA-loaded nanoparticles can be prepared. This method isuseful for the improvement ofpenetration with sustained release. Theisotretinoin-loaded lipid nanoparticles wereformulated for topical delivery of drug. Productionof the flurbiprofen-loaded SLN gel for topical application offer a potential advantage ofdelivering the drug directly to the site of action, which will produce higher tissue concentrations.

3. SLN for Nasal Application

Nasal administration was a promising alternative noninvasive route of drug administration due to fast absorption and rapid onset of drug action, avoiding degradation of labile drugs (such as peptides and proteins) in the GI tract and insufficient transport across epithelial cell layers In order to improve drug absorption through the nasal mucosa, approaches such as formulation development and prodrug derivatization have been employed. SLN has been proposed as alternative transmucosal delivery systems of macromolecular therapeutic agents and diagnostics by various research groups. In a recent report, coating polymeric nanopar-ticles with PEG gave promising results as vaccine carriers (The role of PEG coating of polylactic acid nanoparticles in improving the transmucosal transport of the encapsulated bioactivemolecule reported to be successful. This concept can be useful for solid lipid nanoparticles.

4. SLN for Ocular Application

Ocular drug administration via SLN has been reported several times . Bio-compatibility and mucoadhesive properties of SLN improve their interaction with ocular mucosa and prolong corneal residence time of the drug, with theaim of ocular drug targeting. evaluated SLN as carriers for ocular delivery of tobramycin in rabbit eyes. As a result SLN signifi-cantly enhanced the drug bioavailability in the aqueous humor.also studied pilocarpine delivery via SLN, which is commonly used in glaucoma treatment, earlier. They reported very similar results in order to enhance the ocular bioavailability of drug.

5. SLN in Cancer chemotherapy

From the last two decades several chemotherapeuticagents have been encapsulated in SLN and their in-vitro and in-vivo efficacy have been evaluated.anticancer drug have been incorpo-rated in SLN to prolong the release of drug followingi.v. administration in breast

cancer. Tumor targeting has been achieved with SLN loaded with drugs likemethotrexate and camptothecin. Metoxantrone SLN local injections were formulated to reduce the toxicity and improve the safety and bioefficacy of the drug in treating breast cancer and lymph node metastases.

6. SLN for Respiratory Application

The lungs offer a high surface area for drug absorption by avoiding first-pass effects. Rapid drug absorption by aerosolization of drugs (in the 1-3 μm size range) occurs since the walls of alveoli in the deep lung are extremely thin. Lymphatic drainage plays an important role in the uptake of particulates in the respiratory system. SLN can be proposed as carriers of anti-cancer drugs in lung cancer treatment or peptide drugs to improve their bioavailability.

Table 1: Biopharmaceutical Classification System Class II drugs.[6]

Sr. No.	Category	Drugs
1	Antihypertensive	Felodipine, Nicardipine, Nifedipine, Nisoldipine
2	Antibiotics	Azithromycin, Ciprofloxacin, Erythromycin, Ofloxacin,
3	Antiarrhythmic agents	Amiodarone hydrochloride
4	Antifungal agents	Econazole nitrate, Griseofulvin, Itraconazole, Ketoconazole
5	Antidiabetic and Antihyperlipidemic	Atorvastatin, Fenofibrate, Glibenclamide, Glipizide, Lovastatin,Troglitazone
6	NSAIDs	Dapsone, Diclofenac, Diflunisal, Etodolac, Etoricoxib, Flurbiprofen, Ibuprofen, Indomethacin, Ketoprofen, Mefenamic acid, Naproxen, Nimesulide,Oxaprozin, Piroxicam
7	Cardiac drugs	Carvedilol, Digoxin, Talinolol
8	Anticoagulant	Warfarin
9	Anticonvulsants	Carbamazepine, Clonazepam, Felbamate, Oxycarbazepine, Primidone.
10	Antipsychotic drugs	Chlorpromazine Hydrochloride Antiretrovirals Indinavir, Nelfinavir, Ritonavir, Saquinavir
11	Antianxiety drugs	Lorazepam
12	Antiepileptic drugs and Steroids	Phenytoin, Danazol, Dexamethazone

Table No. 2: Example of solid lipid Nanoparticles.

Drug	Solid lipid nanoparticles vehicles	Category	Study	Ref.
Raloxifene HCl	Chloroform, Methanol	Non-steroidal drug	Bioavailability	[6]
Ciprofloxacin	Methanol,Acetonitrile	Broad spectrum Fluoroquinolone antibiotic	Invitro release & Anti-bacterial	[7]
Irbesartan	Ethanol ,Lipid- GMS	Anti-hypertensive	Characterization, Optimization & Pharmacokinetic studies	[8]
Rosuvastatin calcium	Lipid-GMS surfactant- Tween 80 & polaxomer188	HMG COA Reductase	Development studies	[9]
Celecoxib	Lipid-GMS Surfactant-sodium deoxycholate &Tween 80	NSAIDs	Characterization	[10]
Cloricromene	Lipid- palmitic acid Surfactant-Epikuron	–	Preparation & characterization	[11]
Docetaxel	Lipid - cholesterol	Breast cancer targeting	Development &characterization	[12]
Paracetamol	Lipid-GMS. Surfactant-Tween 80& soya lecithin.	NSAIDs	Preparation & Evaluation	[13]
Quercetin	Lipid-GMS Surfactant-Tween 80& soya lecithin.	Anti -oxidant & Anti-inflammatory	Prevents formation of skin scars	[14]
Meloxicam	Lipid-Geleol,Compritol&precirol, Surfactant-polaxomer188.	NSAIDs	Development & characterization	[15]
Tofacitinib		Immunosuppressive drug	Maturation & Alostomuoatory capacity	[16]
Berberine	Lipid-glyceryl Behenate Surfactant-sodium cremophorel	Isoquinolinederivatives	Anti-hepatocarcinoma	[17]
Pomegranate	Lipid- lecithin & Stearic acid	Antioxidant & Anticancer Activity	Design, Optimization & invitro cytotoxicity	[18]
Garlic oil	Lipid- GMS, stearic acid	Volatile oil	Evaluation & Characterization	[19]

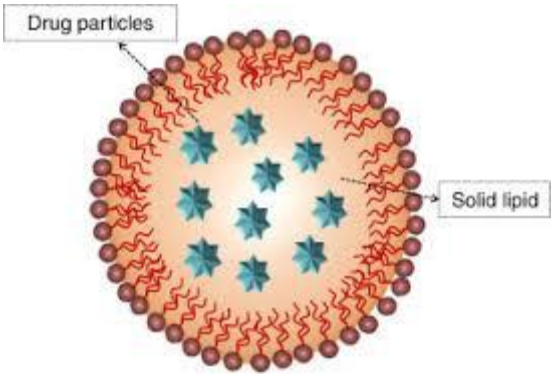

Fig No.1. Structure of Solid Lipid Nanoparticle.

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 variousadvanced techniques. The site specific and sustained release effect of drug can better achieved by using SLNs 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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