INTERNATIONAL RESEARCH JOURNAL OF PHARMACY

www.irjponline.com

ISSN 2230 – 8407

Review Article

TARGETED DRUG DELIVERY THROUGH SOLID LIPID NANOPARTICLES AND ITS APPROACH: A REVIEW

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Article Received on: 31/12/19 Approved for publication: 06/02/20

DOI: 10.7897/2230-8407.110212

ABSTRACT

Solid lipid nanoparticles SLNs are at the forefront of the rapidly developing field of nanotechnology with several potential applications in drug delivery, research and clinical medicine as well as other varied science. Due to their unique size- dependent properties, lipid nanoparticles offer the possibility to develop new therapeutics. Solid lipid nanoparticles (SLNs) consist of spherical solid lipid particles in the nanometer size range, which are dispersed in water or in an aqueous surfactant solution. SLN technology represents a promising new approach to deliver hydrophilic as well as lipophilic drugs. SLNs can also be used to improve the bioavailability of drugs. The incorporation of drugs into nanocarriers offers a new prototype in drug delivery that could be used for several levels of drug targeting. Hence, solid lipid nanoparticles hold great promise for reaching the goal of controlled and site-specific drug delivery and hence have attracted the wide attention of researchers. In the present review article focus on overview about the potential advantages, disadvantages and all the different method involved in their production methodology, principle of drug release, evaluation and application.

Keywords: Solid Lipid Nanoparticles (SLN), Colloidal Drug Carrier, Homogenization, Targeting etc.

INTRODUCTION

Solid lipid nanoparticles (SLN) are introduced in early nineties. Nanotechnology is defined by NNI national nanotechnology initiative is the study and use of structure roughly in the size range is 1-100 nm[1]. This is one of the most popular approaches to improve the oral bioavailability for poorly water-soluble drugs. It represents the optional carrier system to traditional colloidal carrier such as emulsion, polymeric micro and nanoparticles and liposome[2]. In solid lipid nanoparticles are lipid-based drug delivery system that exists in numerous sizes ranging from 30 to 1000 nm. In this system consists spherical solid lipid nanoparticle, which is dispersed into aqueous surfactant solution or in water. It is an identical oil-in-water (o/w) emulsion for parenteral nutrients but liquid lipid emulsion is replaced by solid lipid, therefore the yield of solid lipid emulsion[3]. Solid lipid nanoparticle (SLN) offer a unique property such as small size, large surface area, high drug loading and the interaction phases at the interface and are attractive for their potential to improve the pharmaceutics[4]. SLN productions are various methods which are suitable for large scale production and application solid lipid nanoparticles are described.

Merits

- Application versatile.
- Better control over release kinetics for encapsulated drug substance.
- Conventional emulsion manufacturing methods applicable.
- Excellent reproducibility with use of different methods as the preparation procedure.
- Organic solvents are avoided.
- To enhance the bioavailability of entrapped bio active material in the formulation of solid lipid nanoparticles (SLNs).
- It is flexible in sterilization.
- Low cost for solid lipid as compared to biodegradable polymer and phospholipids.
- Protection for drug sensitive and liable for photochemical, oxidative degradation or chemical.
- The nanoparticles and solid lipid nanoparticles (SLNs) particularly those in the range of 120-200 nm are not taken up readily by the cell of reticuloendothelial system (RES) and bypass the liver and spleen filtration.
- High drug can be loaded.
- Solid lipid nanoparticles (SLNs) have better stability when compared to the liposome.

Demerits

- Poor drug loading capacity in solid lipid nanoparticles.
- They have relatively high water content (70-99.9 %).
- Unpredictable gelatine tendency.
- Unexpected dynamic for polymer transition.

Material used for solid lipid nanoparticle preparation

The following lipids and surfactant/ co-surfactants are used in the formulation of solid lipid nanoparticle are enlisted given below

Table 1: List of lipids and surfactant/co-surfactant used for preparation of SLNs

Lipids	Surfactant/ Co-surfactant
Acyl glycerols	**Alcohols**
Glycerol monostearate	Butanol
Glycerol behenate	Butyric acid
Glycerol distearate	Di-octyl sodium sulfosuccinate
Glycerol monooleate	Ethanol
Glycerol palmitostearate	Mono-octyl phosphoric acid sodium
Cyclic complexes	**Alkyl poly ether alcohol polymers**
Cyclodextrine	Tyloxapol
Para-acyl-calix-arenes	
Fatty acids	**Bile salts**
Acidan N 12	Sodium cholate
Behenic acid	Sodium glycocholate
Decanoic acid	Sodium taurocholate
Palmitic acid	Sodium taurodeoxycholate
Stearic acid	Taurocholic acid sodium salts
Hard fat types	**Ethylene oxide / propylene oxide copolymers**
Witepsol E 85	Poloxamer 182
Witepsol H 35	Poloxamer 188
Witepsol H 45	Poloxamer 407
Witepsol W 35	Poloxamine 908
Tri acyl glycerols	**Phospholipids**
Hydrogenated co-glycerols	Egg lecithin
Tricaprin	Phosphatidylcholine
Triglycerides	Soy lecithin
Trilaurin	
Trimyristin	
Tripalmitin	
Tristearin	
Waxes:	**Sorbitan ethylene oxide/propylene oxide copolymer:**
Cetyl palmitate	Polysorbate 20
	Polysorbate 60
	Polysorbate 80

Preparation of solid lipid nanoparticle

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

High Pressure Homogenization (HPH)

High pressure homogenization techniques were initially used for production solid lipid nanodispersion. It is reliable and suitable method for the preparation of SLN, NLC and LDC and can be performed elevated temperature (hot high pressure homogenization) or at or below the room temperature (cold high pressure homogenization). High pressure homogenizer pushes liquid with high pressure (100-2000 bar) through a narrow gap (in the range of few microns). The fluid accelerates on a very short distance to very high velocity (over 1000 km/hr). Very high shear stress and cavitations force disrupt the particle down to the submicron range. Generally 5-10% lipid content is used but up to 40% lipid content has also been investigated. High pressure homogenization technique is used to produce SLN by melt emulsification; investigated the influence of difference process parameters, including emulsification time, stirring rate and cooling condition on the particle size and zeta potential. Lipids used in this study include trimyristin, tripalmitin, a mixture of mono, di and triglycerides (witepsol W35, witepsol H35) with glycerol behenate and poloxamer 188 used as steric stabilizers (0.5%w/w). For witepsol W35 dispersion the best SLN quality was obtained after stirring for 8 minutes at 20,000 rpm followed by cooling 10 minutes and stirring at 5,000 rpm at a room temperature. In contrast, the best conditions for Dynasan116 dispersions were a 10 minutes emulsification at 25,000 rpm and 5 minutes of cooling at 5,000 rpm in cool water (≈16˚). Higher stirring rates did not significantly change the particle size, but slightly improve the poly dispersity index.[5-8]

Hot homogenization technique

The drug is dissolved or dispersed in melted solid lipid for SLN or in a liquid lipid (oil) and melted solid lipid for nanostructure lipid carrier. In the hot homogenization technique the lipids soften containing drug is scattered in a solution of the hot surfactant at a similar temperature (5-10°C over the liquefying point of the solid lipid or lipid blend) by high speed stirring. This pre-emulsion passed through a high pressure homogenizer changed in accordance with a similar temperature for the most part applying three cycles at 500 bar or two cycles at 800 bars.

The hot homogenization strategy can be utilized for lipophilic and insoluble medications. As the presentation time to high temperature is generally short, many warmth touchy medications can be securely prepared. The method is not homogenization result in low entrapment efficiency.

Cold homogenization technique

Cold homogenization has been developed to overcome a problem associated with hot homogenization such as: temperature-induced drug degradation, drug distribution into the aqueous phase during homogenization polymorphic transition of the lipid due to complexity of the crystalline step of the nano emulsion leading to several modification and/or super cooled melts. Drug is incorporated into melted lipid and the lipid melt is cooled up to solidification. Solid material is ground by a mortar mill. Obtained lipid micro particles is dispersed in a cold surfactant solution at a room temperature or an even at temperature distinctly below room temperature. To ensure the solid state of lipid during homogenization, effective temperature regulation is needed. However, compared to hot homogenization, larger particle sizes

and a broader size distribution are typical of cold homogenization samples.[9,10]

Micro emulsion technique

Micro emulsion method is based on the dilution of micro emulsion. As micro emulsion is two-phase systems composed of on inner and outer phase (e.g. o/w micro emulsion). They are made by stirring an optically transparent mixture at 65-70°C which is typically composed of a low melting fatty acid (e.g. stearic acid), an emulsifier (e.g. polysorbate 20, polysorbate 60 soy phosphatidylcholine and taurodeoxycholic acid sodium salts), co-emulsifier (e.g. butanol, sodium monooctylphosphate) and water. The hot micro emulsion is dispersed in cold water (2-3°C) under stirring. The precipitation of the lipid particles in water is a dilution of the system that leads to reduction of solid content of SLN dispersion. The SLN scattering can be utilized as granulation liquid for moving in to solid product (pellets, tablets) by granulation process, however if there should be an occurrence of low molecule content excessively water needs to be removed. In micro emulsion, the temperature gradient and the p^H value fix the product quality in addition to the composition of the micro emulsion.[2,9,11]

Solvent emulsification - diffusion technique

In the solvent emulsification-diffusion technique, the solvent used (benzyl alcohol, butyl lactate, ethyl acetate, isopropyl acetate, methyl acetate) must be halfway miscible with water and this method can be completed either in aqueous phase or in oil. At first, both the dissolvable and water were commonly soaked all together to ensure the initial thermodynamic equilibrium of both liquid. When heating required solubilizing the lipid, the saturation steps was performed at the 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 stabilizers (dispersed phase) using mechanical stirrer. After the formation of o/w emulsion, water (dilution medium) in typically ratio from 1:5 to 1:10, were added to the system in order to allow solvent diffusion into a continuous phase, thus forming conglomeration of the lipid in the nanoparticles. Consequently the both stage were keep up at same raised temperature and the dissemination step was performed either at room temperature or at the temperature under which lipid was broken down. All through the procedure consistent blending was maintained. Finally, the diffused solvent was eliminated by vaccum distillation or lyophilization.[12,13]

Solvent emulsification/evaporation technique

For the production of nanoparticle scatterings by precipitation in o/w emulsion; the lipophilic material broke up in water-immiscible natural dissolvable (cyclohexane, toluene, chloroform, dichloromethane) that is emulsified in a watery stage. Endless supply of the dissolvable nanoparticle scattering is shaped by precipitation of the lipid in the watery medium. The mean width of the acquired particles was 25 nm with cholesterol acetic acid derivation as model of medication and lecithin/sodium glycocholate mix as emulsifier. The reproducibility of the outcome was affirmed by siekmann and westesen, who delivered the cholesterol acetic acid derivation nanoparticles of mean size 29 nm.[14,15]

Ultrasonication technique

In this ultrasonication procedure SLN were additionally created by rapid mixing or sonication. A most advantage is that, gear whatever utilization here is extremely regular in each lab. The issue of this technique is more extensive molecule size conveyance going into micrometer run. This lead physical insecurity likes molecule development upon capacity. Potential metal defilement because of ultrasonication is additionally a major issue in this technique. So for making a steady plan, considers have been performed different research bunches that rapid blending and ultrasonication are utilized consolidated and performed at high temperature.[16,17]

Super critical fluid technique

In this super critical fluid liquid technique is generally new strategy for SLN generation and has the upsides of dissolvable less handling. There are a few varieties in this stage innovation for powder and nanoparticle readiness. SLN can be set up by the rapid expansion of super critical carbon dioxide solution (RESS) technique. Carbon dioxide (99.99%) was the acceptable decision as a dissolvable for this technique.[4,16]

Spray drying technique

It's an elective technique to lyophilization so as to change a fluid SLN scattering into a medication item. This technique causes molecule accumulation because of high temperature, shear power and incomplete dissolving of the molecule. Freitas and Mullera prescribes the utilization of lipid with liquefying point > 70˚ for spray drying. The best result was obtained with SLN concentration of 1% in a solution of trehalose in water or 20% trehalose in ethanol-water mixtures (10/90 v/v)[16,18]

Double emulsion technique

In double emulsion technique the drug (mainly hydrophilic drugs) was dissolved in aqueous solution and then was emulsified in melted lipid. The primary emulsion was stabilized by adding stabilizer (e.g. gelatine, poloxamer-407). Then this stabilized primary emulsion was dispersed in aqueous phase containing hydrophilic emulsifier (e.g. PVA). Thereafter, the double emulsion was blended and was confined by filtration. Double emulsion system maintains a strategic distance from the need to liquefy the lipid for the readiness of peptide-stacked lipid nanoparticles and the outside of the nanoparticles could be changed so as to sterically balance out them by means of the incorporation of a lipid-PEG derivatives. Sterical stabilization significantly improved the resistance of these colloidal systems in gastrointestinal fluid. The technique mainly used to encapsulate hydrophilic drug (peptides).[19,20]

Solvent injection method

In this solvent injection method basic principle for the formation of SLNs is similar to the solvent diffusion method. The solid lipid was dissolved in water miscible solvent (e.g. acetone, ethanol, 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. Finally, the dispersion is filtered to remove excess lipid. Emulsion within the aqueous phase aids to produce lipid droplets at the site of injection and stabilize SLN until solvent diffusion completes.[19,21,22]

Precipitation technique

In this precipitation technique can also produce solid lipid nanoparticles which are characterized by need for solvents. The glycerides are dissolved in an organic solvent (e.g. chloroform) and solution will be emulsified in an aqueous phase. After

evaporation of the organic solvent the lipid will be precipitated forming nanoparticles.[23]

Membrane contactor technique

In this method membrane contactor was used to prepare SLNs, lipid phase was pressed at the temperature above the melting point of lipid through the membrane pore allowing the formation of small droplets. The advantages of this, the control of the SLN particle size by proper choice of process parameters. The aqueous phase was stirred continuously and circulated tangentially in the membrane module and sweeps away the droplets being formed at the pore outlets. SLNs were formed by cooling of the preparation at the room temperature. Here both the aqueous and organic phases were placed in the thermostatic bath to maintain the required temperature and nitrogen was used to create the pressure for the lipid phase.[24,25]

Drug release from SLN

There are mainly three drug incorporation models which is describe the incorporation of drug into SLN[26]

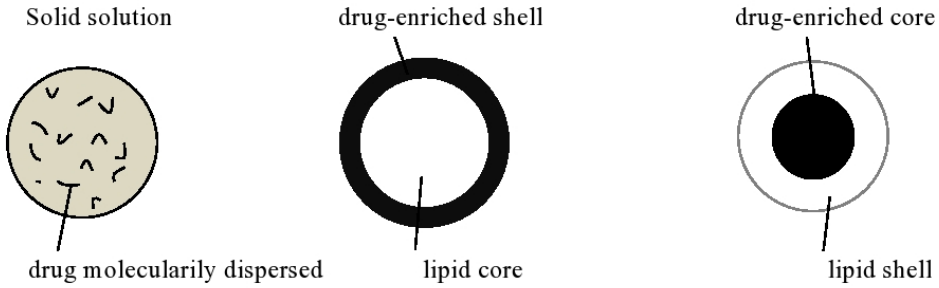

Figure1. Drug Incorporation Model

Figure 1: Drug Incorporation Model

Homogeneous matrix

Homogeneous matrix model or solid solution model with drug being present in amorphous clusters or molecularly dispersed is mainly obtained when incorporating highly lipophilic drug into SLN with using hot homogenization technique or applying cold homogenization methods or by avoiding potentially drug solubilising surfactants. In the cold homogenization technique the drug (in molecularly dispersed forms) is dispersed in bulk of melted lipid. Then the mechanical force of high pressure hot homogenization leads to breakdown of molecular form to Nanoparticles and giving rise to homogenization matrix model.

Drug enriched shell with lipid core model

The drug enriched shell with lipid core model will be obtained performing the production. During the generation, the medication parcelled to water stage. After cooling, the lipid hastens first, shaping an especially sedate free lipid centre because of stage detachment. Simultaneously, the medication re-parcels into the staying fluid lipid stage and medication fixation in the external shell expanding gradually. Finally drug enriched shell crystallizes as depicted in Figure 1. The amount of drug partitioning to the aqueous phase will increase 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.

Drug enriched core with lipid shell

Drug enriched core with lipid shell model obtained when dissolving drug (e.g. predisolone) in the lipid melts. In this model, cooling of the shaped nanoemulsion will prompt super saturation of medication in softened lipid and it further leads drug precipitation preceding lipid precipitation. Further cooling will prompt precipitation of lipid encompassing the medication enhanced centre as a layer as shown in Figure 1. Due to increased diffusional distance and hindering effect of surrounding solid lipid shell, the carrier system shows sustained release profile.

Characterization of SLN

Characteristic of solid lipid nanoparticles is a serious challenge due to the small size of the particles and complexity of the system. The significant parameters which should be assessed for the solid lipid nanoparticles are, particle size, size distribution kinetics (zeta potential), degree of crystallinity and lipid change (polymorphism), conjunction of extra colloidal structures (micelles, liposome, super cooled, softens, tranquilize nanoparticles), times scale of circulation forms, medicate content, *in-vitro* drug release and surface morphology.

Particle size and shape

SLNs are submicron sized, particle size and shape is determined by:

a. Photon Correlation Spectroscopy (PCS).
b. Electron microscopy.
c. Atomic Force Microscopy (AFM).

Photon Correlation Spectroscopy (PCS)

In photon correlation method determine the hydrodynamic diameter of the nanometers. This technique is based on dynamic laser light scattering due to Brownian movement of particles is dispersion medium. PCS measures the fluctuation of the intensity of scattered light, which is caused by the particle movement. This method is suitable for the measurement of particles in the size range of few nanometers to 3 µm. The PCS device consists of laser source, a sample cell (temperature controlled) and a detector. Photomultiplier is used as detector to detect the scatter light. The PCS diameter is based on the intensity of the light scattering from the particle.[27]

Electron Microscopy

Transmission electron microscopy (TEM) and Scanning electron microscopy (SEM) provide way to directly observe nanoparticles. However, SEM is better for morphological examination. Transmission Electron Microscopy (TEM) is used to measure the physical characterization like overall shape and morphology of lipid nanoparticles. It permits the determination of particle size and distributions. TEM has a small size limit of detection.[28]

Atomic Force Microscopy (AFM)

It is a progressed microscopic system which is applied as another apparatus to picture the first unaltered shape and surface properties of the particles. AFM measures the force acting between surface of the element and the tip of the probe, when the probe is kept in nearness to the element which results in a spatial resolution of up to 0.01 nm for imaging.

Measurement of zeta potential

Zeta potential is a significant item normal for SLNs since its high worth is relied upon to prompt de-aggregation of particles without other confounding elements, for example, steric stabilizers or hydrophilic surface members. It is typically estimated by zetameter. Malvern Zetasizer is most widely used instrument for measurement of Zeta potential. Zeta potential below -25 mV and above + 25 mV are required for full electrostatic stabilization of the formulation.[29]

Dynamic light scattering

In dynamic light scattering (DLS) are also known as photon correlation spectroscopy (PCS) or quasi-elastic light scattering (QELS) record the variety in the force of the dissipated light on the microsecond time scale. This variety results from obstruction of light dispersed by singular particles affected by Brownian movement and is evaluated by aggregation of an autocorrelation work. This capacity is fit to an exponential, or some mix or adjustment thereof, with the comparing rot constant(s) being identified with the dispersion coefficient(s). Utilizing standard suspicions of circular size, low fixation and known thickness of the suspending medium, molecule size is determined from this coefficient. The upsides of the strategy are the speed of investigation, absence of required alignment, and affectability to sub micrometer particles.[30]

Entrapment efficiency

The entrapment efficiency of the drug is determined by measuring the concentration of free drug in the dispersion medium. In ultracentrifugation was carried out using centrist, which consist of filter membrane (molecular weight cut off 20,000 Daltons) at the base of the recovery sample. The SLNs along with encapsulated drug remain in the outer chamber and aqueous phase moves into the sample recovery chamber. The amount of the drug present in the aqueous phase is determined by HPLC or UV spectrophotometer.[31,32]

$$\% \text{ Entrapment efficiency} = [(\text{Initial drug weight} - \text{weight of free drug}) / \text{Weight of initial drug}] \times 100\%$$

***In-vitro* drug release**

In the *in-vitro* drug release studies are used for quality control studies as well as for the prediction of *in-vivo* kinetics. In this SLN's due to very small size of the particles, the release rate observed *in-vivo* can differ greatly from the release obtained in buffer solution. Hence *in-vitro* release studies remain useful for quality control as well as for evaluation of influence of process parameters on release rate of active components.[33]

Dialysis tubing

In vitro medication discharge could be accomplished utilizing dialysis tubing. The solid lipid nanoparticle scattering is set in pre - washed dialysis tubing which can be hermetically fixed. The dialysis sac at that point dialyzed against a reasonable disintegration medium at room temperature. The samples are pulled back from the disintegration medium at appropriate interims, centrifuged and investigated for the medication content utilizing a reasonable diagnostic technique.[34]

Reverse dialysis

In this reverse dialysis system various little dialysis sacs containing 1 mL of dissolution medium are set in SLN scattering. The SLN's are then uprooted into the medium. The SLNs are then placed into the dissolution medium. The immediate weakening of the SLNs is conceivable with this strategy; anyway the fast discharge can't be measured utilizing this technique.[35,36]

Franz diffusion cell

The solid lipid nanoparticle scattering is put in the donor socket of a Franz diffusion cell fitted with a cellophane layer. The scattering is then dialyzed against an appropriate dissolution medium (reproduced gastric medium/recreated intestinal medium/re-enacted plasma) at room temperature, the examples are pulled back from the disintegration medium at reasonable interims and analysed for drug content using suitable instrumental method. The maintenance of sink condition is essential and the method suffers from the limitation of lack of direct dilution of SLNs by the dissolution medium.[37,38]

Application of solid lipid nanoparticles

Solid lipid Nanoparticles possesses a better stability and ease of upgradability to production scale as compared to liposomes. This property may be very important for many modes of targeting. SLNs form the basis of colloidal drug delivery systems, which are biodegradable and capable of being stored for at least one year. They can deliver drugs to the liver *in vivo* and *in vitro* to cells which are actively phagocytic.

There are several potential applications of SLNs some of which are given in Table 2.

SLN as potential new adjuvant for vaccines

Adjuvants are used in vaccination to enhance the immune response. The safer new subunit vaccines are less effective in immunization and therefore effective adjuvants are required. New developments in the adjuvant area are the emulsion systems. These are oil-in-water emulsions that degrade rapidly in the body. Being in the solid state, the lipid components of SLNs will be degraded more slowly providing a longer lasting exposure to the immune system.[60]

Table 2: A list of drugs and polymers used for the preparation of SLNs

Drugs	Polymer	Method of preparation	Reference
5-fluorouracil	Dynasan 114,118,triglyceroids,soyalecithin	Double emulsion solvent evaporation	(39)
Alendronate NP	PLGA, ethyl acetate,PF68	Double emulsion solvent diffusion	(18, 40)
Calcitonin	Trimyristin, poloxamer 407	Double emulsion technique	(41)
Clozapine Tetracaine	Dynasan 114,116, tristearine, Dynasan 112	Hot homogenization	(42)
Cyclosporine A	Glyceryl monostearate, and glyceryl palmitostearate	High pressure homogenization	(43)
Diazepam	Compritol888ATO, imwitor 900K	Modified high shear homogenization, ultra sound technique	(44)
Dexamethasone	Compritol 888ATO	High pressure homogenization	(45, 46)
Doxorubicin	Glyceryl caprate	Solvent emulsification –diffusion method	(19, 43)
Etomidate, prednisolone	Compritol 888ATO, lipoid S75	Hot homogenization	(18, 39)
Ibuprofen	Stearic acid, Trilaurin, tripalmitin	High pressure homogenization	(47)
Insulin	Cetyl palmitate	Solvent emulsification evaporation	(18, 48)
Irbesartan	Glyceryl monostearate, poloxamer 407	Solvent emulsification method	(49, 50)
Ketoprofen	Glyceryl monostearate, poloxamer 407	Solvent injection method	(51)
Lopinavir	Compritol 888 ATO, poloxamer 407	High pressure homogenization	(52)
Methotrexate	Cetyl alcohol, campritol 888 ATO, tween 80	Micro emulsion congealing technique	(18, 39, 43)
Mitoxantrone	Glyceryl behenate, Compritol 888ATO, lecithin	Ultra sonication technique	(18, 40)
Olanzaprine	Hydrogenated soyaphosphatidyl choline	Modified high pressure homogenization	(43)
Palcitaxel	Tripalmitin, phosphatidylcholine	Micro emulsion technique	(18, 53, 54)
Penciclovir	Glyceryl monostearate	Double emulsion technique	(55, 56)
Repaglinide	Stearic acid, pluronic F68, soya lecithin	Solvent injection method	(57)
Rizatriptan	Tristearin, phospholipon80	Modified solvent injection method	(18, 39, 58)
Tetracycline	Glyceryl monostearate and stearic acid	Micro emulsion technique	(59)
Vinpocetine	Glyceryl monostearate, DCM, soyalecithin	Ultrasonic solvent emulsification	(18, 40, 43)
Vitamine A Retinol	Compritol 888ATO, Miglycol 812, Dynasan 116	Hot homogenization	(18, 43)

Solid Lipid Nanoparticles in Cancer Chemotherapy

Outcomes of these studies have been shown to improve the efficacy of chemotherapeutic drugs, simultaneously reduction in side effects associated with them. Improved stability of drugs, encapsulation of chemotherapeutic agents of diversified physicochemical properties, enhanced drug efficacy, improved pharmacokinetics and less *in-vitro* toxicity are the important features of SLN which make them a suitable carrier for delivering chemotherapeutic.[61]

SLNs as a Targeted Carrier for Anticancer Drug to Solid Tumors

SLNs have been accounted for to be valuable as medication transporters to treat neoplasms. Tamoxifen, an anticancer medication consolidated in SLN to drag out arrival of medication after I. V. organization in bosom disease and to improve the penetrability and maintenance impact. Tumor focusing on has been accomplished with SLNs stacked with drugs like methotrexate and camptothecin.[62]

SLNs in Breast Cancer and Lymph Node Metastases

Mitoxantrone-stacked SLN nearby infusions were detailed to lessen the lethality and improve the safety and bioavailability of medication. Viability of doxorubicin (Dox) has been accounted for to be upgraded by joining in SLNs. In the philosophy the Dox was complexes with soybean-oil-based anionic polymer and scattered together with a lipid in water to shape Dox-loaded solid lipid nanoparticles. The system has improved its viability and diminished breast tumour cells.[63]

Solid Lipid Nanoparticles for Delivering Peptides and Proteins

Solid lipid particulate systems such as solid lipid nanoparticles (SLN), lipid microparticles (LM) and lipospheres have been sought as alternative carriers for therapeutic peptides, proteins and antigens. Formulation in SLN confers improved protein stability, avoids proteolytic degradation, as well as sustained release of the incorporated molecules. Important peptides such as cyclosporine A, insulin, calcitonin and somtostatin have been incorporated into solid lipid particles and are currently under investigation. There are several local or systemic therapeutic.[64]

SLNs as Cosmeceuticals

The SLNs have been applied in the preparation of sunscreens and as an active carrier agent for molecular sunscreens and UV blockers. Cosmeceuticals is rising as the major application target of these carriers. Carrier systems like SLNs and NLC were formulated with a point of view to meet manufacturing needs like scale up, qualification and validation, simple technology, low cost etc. The SLNs have been functional in the preparation of sunscreens and as an active carrier agent for molecular sunscreens and UV blockers.[65,66]

SLNs as Gene Vector Carrier

Cationic solid lipid nanoparticles have established themselves during the past decades. They can well bind DNA directly via ionic interaction and intervene gene transfection. SLNs can be used in the gene vector formulation.[67]

SLNs for potential agriculture application

Crucial oil extricated from *Artemisia arboreseens* L when joined in SLN, were able to lessen the fast vanishing compared with emulsions and the frameworks have been used in horticulture as a suitable transporter of naturally protected pesticides.

CONCLUSION

Solid lipid nanoparticle drug delivery technology presents considerable opportunities for improving medical therapeutics, but the technology's potential remains unrealized. The review has focused on the variety of aspects of SLNs and their applicability in the encapsulation of various drugs. SLN as colloidal drug carrier combines the advantage of polymeric nano-particles, liposome; like improved physical stability, feasibility of incorporation of lipophilic and hydrophilic drugs, economic,

eases of scale-up and manufacturing. SLNs can affect site specific and sustained release of drug. SLNs are prepared by various advanced techniques. SLNs have been used extensively for applications in drug discovery, drug delivery and diagnostics and for many others in medical field.

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Cite this article as:

Praveen K and Balamurugan K. Targeted Drug Delivery through Solid Lipid Nanoparticles and its approach: A Review. Int. Res. J. Pharm. 2020;11(2):7-14 http://dx.doi.org/10.7897/2230-8407.110212

Source of support: Nil, Conflict of interest: None Declared