MOHANRAJ.S *et al*, International Journal of Pharmaceutical Sciences & Medicine (IJPSM),
Vol.7 Issue. 5, May- 2022, pg. 1-17

ISSN: 2519-9889
Impact Factor: 5.721

A SHORT-TERM REVIEW ON SOLID LIPID NANOPARTICLES

MOHANRAJ.S*[1]; JAYANTHI.B[2]

1. M. Pharm, Department of Pharmacy, Annamalai University, Tamilnadu, Annamalai Nagar-608002
2. Assistant Prof, Department Of Pharmacy, Annamalai University, Tamilnadu, Annamalai Nagar-608002
*Corresponding Author Email: mogas9696@gmail.com

DOI: 10.47760/ijpsm.2022.v07i05.001

ABSTRACT: In recent years, Solid lipid nanoparticles (SLNs) have been given a lot of attention as a potential drug distribution alternative to existing colloidal dispersion technologies. The use of SLNs as a pharmaceutical carrier has gotten a lot of focus in recent years. Nanostructure lipid carriers and SLNs are non-toxic since they are biodegradable. SLNs have various distinct properties in terms of therapeutic uses. SLNs are lipid-based nanocarriers with sizes ranging between 10 to 1000 nanometers. Decomposition of the drug can be protected by the drug entrapped in a lipid, physical stability; controlled drug release and remarkable acceptability are all benefits of SLNs over traditional drug carriers. The capacity to incorporate pharmaceuticals into nanocarriers opens up a new paradigm in drug delivery that could hold enormous promise in terms of improving bioavailability while also allowing for controlled and site-specific drug delivery. This article covers the manufacture and characterization of SLNs, as well as the administration and medicinal uses.

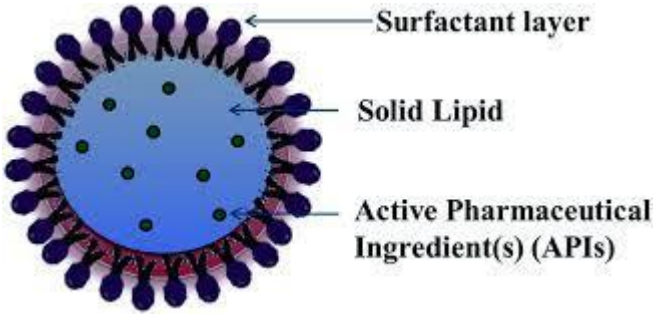
Keywords: Solid Lipid Nanoparticles, Characterization, Colloidal Dispersions, Preparation Methods and Applications.

INTRODUCTION

Nanoparticles of solid lipids (SLNs) were first introduced in December 1991 as a medication carrier system to replace traditional colloidal carriers, they are generally dispersed in a fluid surfactant arrangement or in water and are constructed up of nanometer ranges of spherical stable of lipid cells. The goal of nanotechnology in pharmacy is to create medications in the form of effectively absorbable nanoparticles, the use of a controlled drug release mechanism results in a pharmacological response with minimal adverse effects [1]. SLNs are covered with hydrophilic surfactant. The utilization of solid lipid as a medication carrier is broadly known among lipid particles for oral medication delivery [2]. In the manufacture of SLNs, lipids such as waxes, oil, fat, hard fat, glycerides and triglycerides are employed. They benefit SLNs since the lipid matrix is made up of physiological lipids and has a minimal risk of severe and chronic toxicity. The solid lipid has been shown to improve the controlled release qualities and chemical stability of entrapped medicines. The physicochemical features related with regard to the lipid state's physical condition account for these benefits of solid lipid over liquid lipid [3]. Various common SLN

ISSN: 2519-9889
Impact Factor: 5.721

excipients include aqueous surfactants. They function as an emulsifier in the production of o/w emulsions and as a stabiliser in SLN dispersion. Their selection is mostly determined by the application route. SLNs are typically made from a solid lipid in which the medication is diffused or dissolved [4].



Solid lipid nanoparticles

ADVANTAGES OF SLNs

The chronic and acute poisoning of drug can be minimized by the production process involved in the manufacturing of SLNs and it utilize the organic solvents and biodegradable physiological lipids.

1. It improves the bioavailability of compounds that are poor water soluble.
2. It governs both the probability of drug delivery and drug targeting.
3. SLNs have a higher stability than liposomes.
4. It promotes trapped bioactive bioavailability and a labile chemical synthesis compound that is incorporated.
5. Lyophilization is a viable option [5-7].

DISADVANTAGE OF SLNs

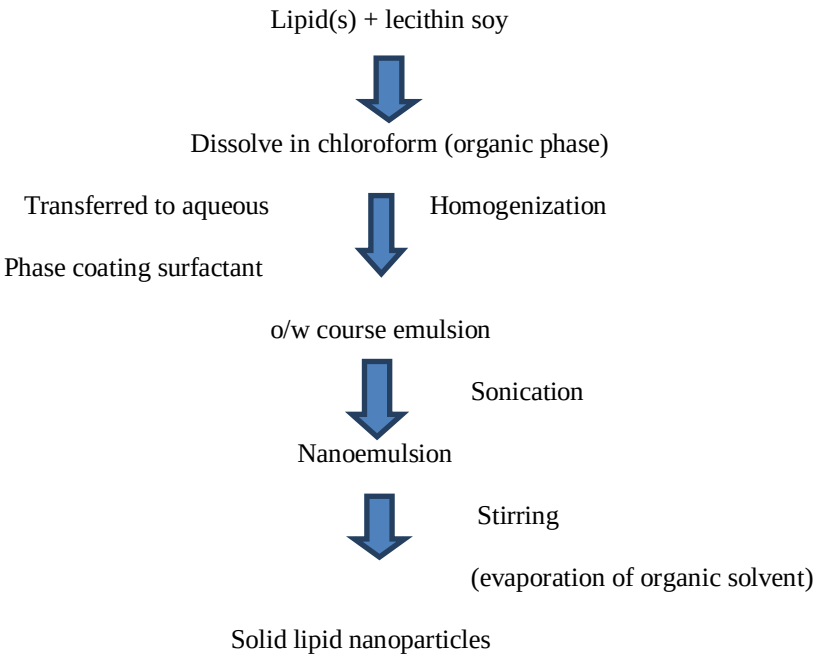
1. Limited capacity for storing medicines.
2. Exclusion of medications due to polymeric changes during storage.
3. The partitioning effects limit the loading capacity of water-soluble medicines during the production cycle [8].
4. Tendency to gel.
5. Awe-inspiring polymeric transition motion [9-11].

ISSN: 2519-9889
Impact Factor: 5.721

SLNS PREPARATION TECHNIQUES

Emulsification solvent evaporation technique

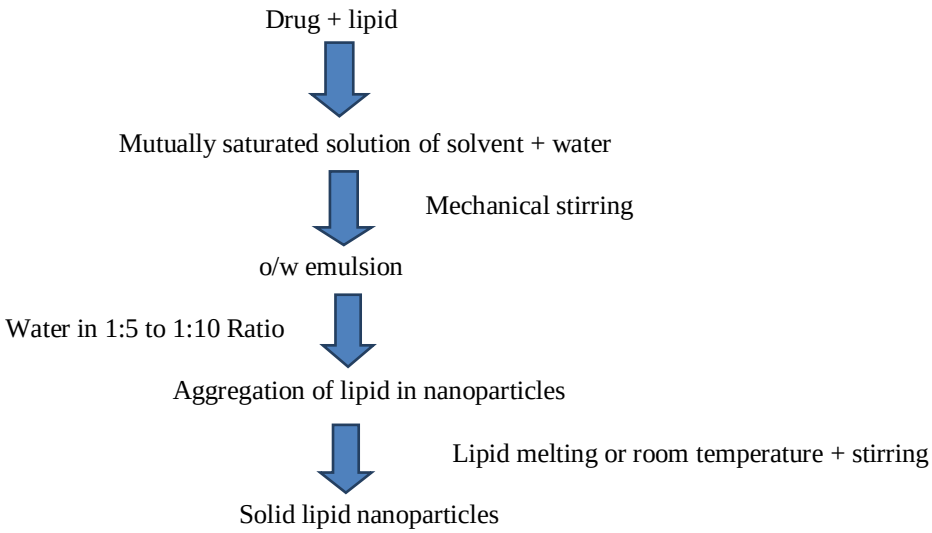
The O/W emulsions are used in the precipitation of SLN precipitation process. The lipophilic particles are go through dissolvable in a water insoluble natural dissolvable, for example, cyclohexane and afterward emulsified in a aqueous stage. The lipid precipitates in the aqueous media after the solvent has evaporated, generating SLN dispersion. The model drug is cholesterol acetic acid, while the emulsifier is a mixture of lecithin and sodium glycocholate, the SLN generated had a mean diameter of 25 nm. By generating SLN having mean size of 29 nm with cholesterol acetate, Siekmann and Westesen validated the reproducibility of the result [12,13].



ISSN: 2519-9889
Impact Factor: 5.721

Solvent emulsification-diffusion technique

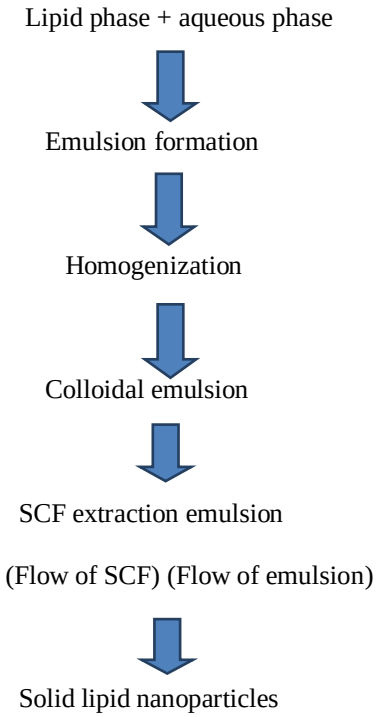
SLNs may likewise be made using dissolvable emulsification-dissemination processes. The concentration of lipid in the natural stage and the emulsifier utilized impacts the normal molecule size. Particles with a normal size of 30-100 nm might be made as a result of this process. The decrease of hotness during formation is the main advantage of this methodology. In this process, the lipid matrix is broken up in a water-insoluble natural dissolvable prior to being emulsified in a watery stage. The dissolvable is evaporated at a low pressure, coming about in a nanoparticulate scattering produced by lipid precipitation in a watery stage [14].



Supercritical fluid technique

This is a new approach for making SLNs that was recently applied. When the pressure and temperature of a fluid reach their critical values, it is eligible as supercritical. It is impossible to make a gas liquefy by increasing pressure when the temperature exceeds the critical temperature. The thermophysical features of the supercritical fluids are different from ordinary fluids. The density of the gas increases when the pressure is increased without a considerable increase in viscosity and the fluid's ability to dissolve compounds improves as well. Under heavy pressure in the supercritical region, a gas having little or no capacity to dissolve a substance at ambient conditions may entirely dissolve the substance. As a result, careful management of temperature and pressure variations affects its solvation power [15].

ISSN: 2519-9889
Impact Factor: 5.721



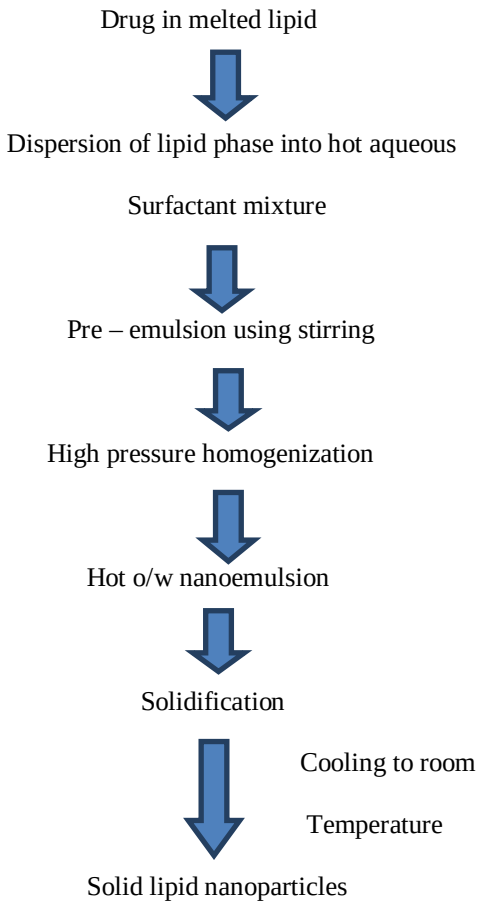
High pressure homogenization technique

Hot homogenization technique

Hot homogenization, which happens at temperatures over the melting point of the lipid, it is in some cases alluded to as stock collaboration emulsion homogenization. To make a pre-emulsion of the medicine stacked lipid melt and the liquid emulsifier stage (at a comparative temperature), a high shear mixing device is utilized (Ultra-Turrax). The characteristics of the pre-emulsion fundamentally affects the final result's quality and drops in the scope of a minuscule micrometers are wanted. More prominent temperatures make the inward stage's thickness drop, bringing about more modest molecule sizes. High temperatures, then again, hurry the weakening of both the prescription and the carrier. The homogenization association can be repeated relying upon the circumstance. It's significant's essential that high-pressure homogenization raises the model's temperature (around 10°C for 500 bar). 3–5 homogenization cycles at 500–1500 bar are by and large sufficient. In view of atom mix, which happens due to the particles' high dynamic energy, extending the homogenization pressure or the amount of cycles from time to

ISSN: 2519-9889
Impact Factor: 5.721

time achieves a raise in particle size. Since the lipid is in a liquid condition, the critical result is a nanoemulsion, which concretes when cooled to room temperature. Lipid crystallization may be inconceivably moved back in light of the little atom size and the presence of emulsifiers and the model may remain as a super cooled melt for several months [16,17].

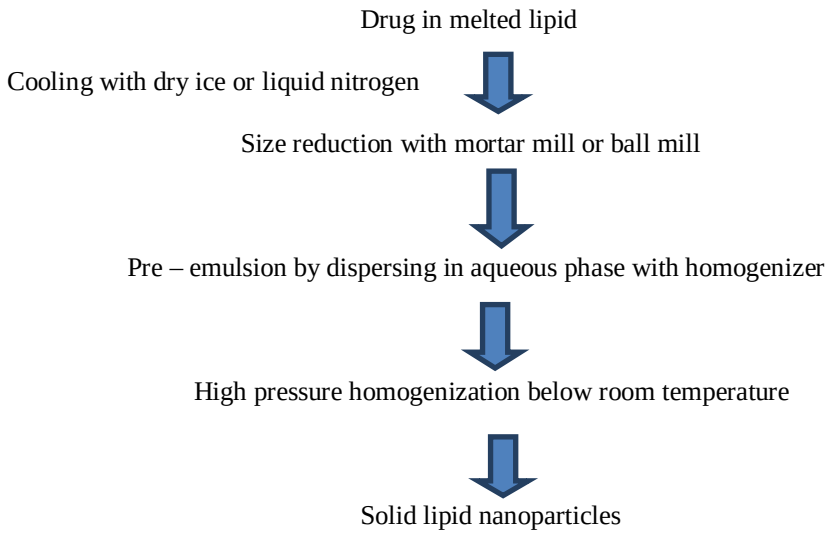


Cold homogenization technique

The cold homogenization approach was used to avoid the issues associated with hot homogenization, such as temperature-interceded medication and carrier corruption speed up and accordingly, drug discharge into the aqueous stage when homogenization. The principal level of cold homogenization is indistinguishable from that of

ISSN: 2519-9889
Impact Factor: 5.721

hotness homogenization, however the ensuing cycles are distinct. The drug-loaded lipid dissolve is immediately cooled with ice or fluid nitrogen for drug scattering in the lipid matrix. The particle sizes accomplished with this strategy are in the 50-100 micron range. Cold homogenised samples have bigger particle sizes and a greater size distribution, which are drawbacks. However, this approach minimises the sampl's heat exposure [18].

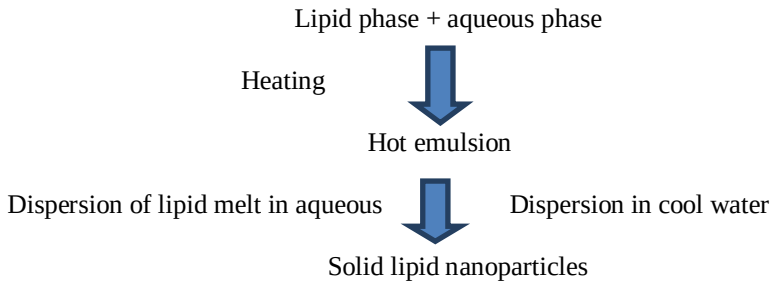


Microemulsion based technique

This procedure uses the dilution of microemulsions. Micro emulsions (o/w microemulsions, for example) are two-stage structures with an inward and outer stage. At 65-70°C, a low melting unsaturated fat (stearic acid), an emulsifier (polysorbate 20), co-emulsifiers (for instance butanol) and water are combined as one in an optically clear mix. The warmed microemulsion is dissipated in cold water (2-3°C) while blending. The SLN dissipating can be used as a granulation fluid to move solid items (tablets, pellets) through the granulation collaboration, however accepting the particle center is low, an exorbitant measure of water ought to be taken out. High-temperature inclinations help in lipid crystallization and eliminate aggregation [19].

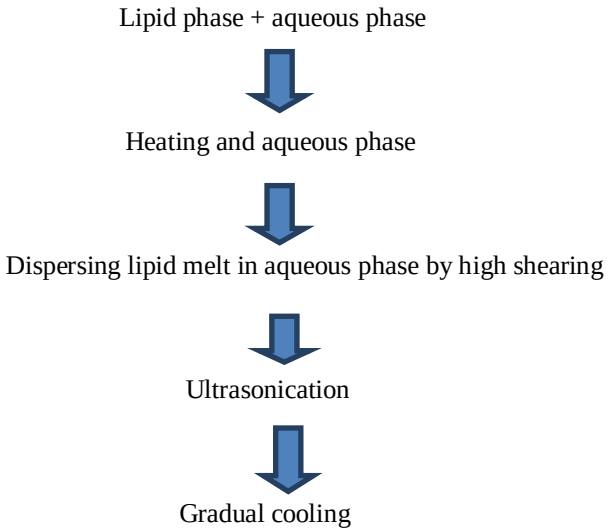
MOHANRAJ.S *et al*, International Journal of Pharmaceutical Sciences & Medicine (IJPSM),
Vol.7 Issue. 5, May- 2022, pg. 1-17

ISSN: 2519-9889
Impact Factor: 5.721



Ultrasonication /High speed homogenization technique

Ultrasonication or high speed homogenization procedures are also purpose to make SLNs. shorter particle sizes necessitate a mix of ultrasonication and high speed homogenization. It decreases shear stress, but it has several drawbacks, including the possibility of metal contamination and physical instability, such as particle development during storage. A probe sonicator or a bath sonicator is utilised in this procedure [20].



Precipitation technique

The lipid is emulsified into a aqueous stage subsequent to being broken up in a organic dissolvable (chloroform). Later the organic dissolvable has evaporated, the lipid precipitated and yielding nanoparticles [21].

ISSN: 2519-9889
Impact Factor: 5.721

Heating the lipid material and aqueous phase solution of drug

↓

Dispersing drug solution in lipid melt (Primary w/o emulsion)

↓

Dispersing primary emulsion in secondary aqueous phase

(w/o/w emulsion)

↓ Precipitation by cooling

Solid lipid nanoparticles

Double emulsion technique

The double emulsion method is mostly utilised for hydrophilic medicines. The medication was first dissolved in water, then emulsified in melted lipid. Stabilizer was added to this basic emulsion to make it more stable (e.g. gelatine, poloxamer-407). Aqueous phase with hydrophilic emulsifier was used to disperse the primary emulsion (e.g. poly vinyl alcohol). The double emulsion was then agitated and filtered to isolate it. SLNs were collected by centrifugation at 12000g for 30 minutes at 4°C after rotational evaporation of organic solvent.

Step 1:

Drug (Hydrophilic) + aqueous solution

Dissolved melted lipid ↓

w/o primary emulsion

Step 2:

w/o primary emulsion

↓ Dissolved in aqueous phase

containing hydrophilic emulsifier

w/o/w Double emulsion

Stirring and filtration ↓

Solid lipid nanoparticles

ISSN: 2519-9889
Impact Factor: 5.721

CHARACTERIZATION OF SLNS

Particle size analysis and Zeta potential

The size of the molecule decides the actual stability of SLNs. Laser Diffraction (LD) and Photon Correlation Spectroscopy are the two most pervasive strategies for deciding molecule size (PCS). The PCS, otherwise called dynamic light dissipating, is utilized to compute the power of scattered light brought about by irregular molecule movement. The PCS is utilized to quantify molecule size between 3 nm and 3 µm, though laser diffraction is utilized to assess molecule size between 100 nm and 180 µm. The PCS is an astounding instrument for deciding the size of nanoparticles, yet it might likewise be utilized to decide the size of microparticles. The LD approach depends on the diffraction impact of molecule size. More modest particles cause more dissipating with a higher diffraction point than bigger ones. The Zeta potential still up in the air with a Zeta meter or a Zeta possible analyzer. The scattering of SLNs is first weakened 50-fold utilizing the key scattering readiness mechanism for size assessment and zeta expected assurance. The higher zeta potential could prompt molecule disaggregation. The storage stability of dispersed phase can be predicted using the zeta potential [22].

X-ray diffraction and DSC- differential scanning calorimeter

The mathematical dispersing of radiation from precious crystal planes inside a solid permits the presence or nonattendance of the previous still up in the air, permitting the level of crystallinity to be estimated. DSC can be utilized to evaluate the qualities of drugs in nanoparticles just as their level of crystallinity [23].

Electron microscopy

The TEM and SEM are used to observe nanoparticles directly [24]. The SEM is utilised for more detailed morphological evaluation and has a small detection size limit.

AFM- Atomic force microscopy

This approach re-establishes an atomic-scale sharp probing tip across a material, yielding a topological map based on the forces between the tip and the surface. For getting ultrahigh-resolution particle pictures, atomic force microscopy is a helpful tool.

DLS- Dynamic light scattering

The DLS and PCS are the most famous and quickest techniques for evaluating molecule size. Nano and submicron range present in Brownian nanoparticles which in colloidal dispersion are regularly estimated utilizing the DLS. At the point when monochromatic light (laser) is sparkled upon a solution of circular particles (in the circumstance of arbitrary Brownian movement), the light causes Doppler shift. Accordingly, the frequency of the showing up light moves, and it's found that this shift is connected to particle size. The DLS can likewise be utilized to decide size

ISSN: 2519-9889
Impact Factor: 5.721

conveyances, particle flow in the medium, particle dispersion coefficients and the use of the autocorrelation work. The PCS is the most broadly utilized strategy for precisely deciding particle size and size distribution utilizing DLS [25].

Nuclear magnetic resonance (NMR)

NMR might be utilized to decide the subjective idea of nanoparticles just as their size. To offer information in regards to the physicochemical condition of the constituent inside the nanoparticles, the methodology is picked dependent on chemical shifting equilibriums and affectability to atomic adaptability [26].

Techniques	Particle size	Working temperature	Instruments needed
High pressure homogenisation	50- 1000nm	5-10°C upon lipid MP	High pressure homogeniser
High shear homogenization	5- 1000nm	5-10°C upon lipid MP	High shear homogeniser
Ultrasound homogenisation	5- 1000nm	5-10°C upon lipid MP	Ultrasound apparatus
Spray drying	0.3- 10µm	70°C	Spray drier
Solvent evaporation from emulsion	30- 500nm	25°C	High shear or High pressure Homogeniser
Solvent diffusion from emulsion	100- 2000nm	40-50°C	High shear or High pressure Homogeniser
Particles from gas saturated solution (PGSS)	0.2- 20µm	5-10˚C upon lipid MP	GAMA apparatus

Table 1: Various techniques used for preparation of SLNs.

ISSN: 2519-9889
Impact Factor: 5.721

Drug or therapeutic agent	Method	Excipients	Category	Targeted to
Lopinivir SLN	Hot homogenization ultrasonication	Compretol 888 glyceryl monostearate	Highly active antiretroviral agent	Intestinal lymphatic vessels (lymph and lymph nodes)
Clozapine	Hot homogenization ultrasonification	Dynasan 114, 116, triglycerides soylecithin 95% charge modifier sterylamine	Anti-psychotic drug	Especially in brain and reticulo endothelial call containing organ
Indomethacin	Supercritical fluid technology	Tripalmitin chitosan chloride	Non-steroidal antiinflammatory agent	Posterior segment of ocular tissues
Paclitaxel	Microemulsion method Hot homogenization	Tripalmitin phosphatidylcholine	Anticancer agent (chemotherape utic agent)	Targeted to rapidly growing tumor cells (lung, ovarian…)
Oridonin	Solvent emulsification evaporation technique	Stearic acid, pluronic F8	Anticancer agent	Liver, lungs and spleen.
Vitamin -A	Hot homogenization	Compritol 888ATO, Miglyol 812	Anti -oxidant	Topical use
Methotrexate	Microemulsion congealing technique	Cetyl alcohol, compritol 888ATO, Tween 80	Anticancer agent	Tumor cells

Table 2: Therapeutic agents and preparation of SLNs using different methods

ISSN: 2519-9889
Impact Factor: 5.721

ROUTE OF ADMINISTRATION OF SLNs

Parenteral administration

Peptide and protein medications are commonly accessible in the market for parenteral administration. Because of enzymatic breakdown in the GI system, traditional oral delivery is not viable. With enhanced bioavailability, parenteral administration of SLN minimises the risk of medication adverse effects. These systems are particularly well suited to drug targeting [27].

Oral Administration

The controlled delivery conduct of SLNs has been accounted for to permit the embodied medication to evade gastric and digestive debasement, just as plausible take-up and section through the gastrointestinal mucosa. Be that as it may, to gauge colloidal transporter propriety for oral conveyance, the stability of colloidal carriers in GI liquids should be evaluated.

Rectal administration

In some cases, parenteral or rectal delivery is chosen when a quick pharmacological effect is desired. Because of its simplicity, this method is preferred by paediatric patients.

Nasal administration

Nasal administration is selected because of its quick absorption and start of medication movement, just as the preventing of labile medication decay in the GIT and an inadequate vehicle epithelial cell layer.

Respiratory delivery

Nebulization of solid lipid particles containing anti-cancer, against asthmatic and anti-tubercular was viewed as successful in expanding drug bioavailability and decreasing the frequency of dose in order to improve regulate pulmonary effect.

Ocular administration

With the goal of ocular medication targeting, SLN's biocompatibility and muco-adhesive qualities boost its contact with the ocular mucosa and extend the drug's corneal residence time [28].

ISSN: 2519-9889
Impact Factor: 5.721

Topical administration

Beside the properties of a colloidal carrier framework, SLN are an extremely engaging colloidal carrier framework for skin application because of their changed wanted consequences for skin. Since they depend on non-harmful lipids, they are great for use on destroyed or inflamed skin.

APPLICATION OF SLNs

SLNs for Topical use

Corticosteroids are drugs that are commonly used to treat skin conditions like eczema and psoriasis. Topical SLN medicines have a lot of promise for treating dermatological diseases since they direct corticosteroids to disease areas on the skin while lowering systemic medication absorption. Topical drug application at pathological areas may have the benefit of conveying the medication straightforwardly to the site of activity [29]. SLNs are skin prescriptions that incorporate anticancer, nutrient A, isotretinoin and flurbiprofen. Nutrient A-loaded nanoparticles can be made with glyceryl behenate. This methodology is helpful for expanding entrance with a drawn out discharge. The isotretinoin-loaded lipid nanoparticles were intended to direct the medication topically. The ability to transfer the flurbiprofen-loaded SLN gel directly to the site of action, resulting in larger tissue concentrations, is a possible benefit of producing the flurbiprofen-loaded SLN gel for topical administration [30-32]. Dermal Doxorubicin (Dox) administration would be an ideal strategy to maximise therapeutic efficacy against skin cancer while minimising side effects [33].

Oral SLN in Antitubercular Chemotherapy

Rifampin, isoniazide and pyrazinamide-loaded SLN technology had the option to decrease the medicating frequence and improve patient consistence. Dissolvable dissemination was utilized to prepare antitubercular drug-loaded SLNs [34].

Lymph Node Metastases and SLNs in Breast Cancer

Mitoxantrone-stacked SLN local injection were made to decrease destructiveness and further foster medication prosperity and bioavailability. Doxorubicin sufficiency has been represented to be improved by uniting it into SLNs. The Dox was complexed with a soybean-oil-based anionic polymer and a short time later dispersed in water with a lipid to deliver Dox-stacked solid lipid nanoparticles. The structure's reasonability has been increased and breast cancer cells have been lessened [35,36].

ISSN: 2519-9889
Impact Factor: 5.721

SLNs as a Targeted Anticancer Drug Carrier in Solid Tumors

The use of SLNs as medication carriers in the therapy of neoplasms has been documented. SLNs filled with medicines such as camtothecin and methotrexate have been used to target tumours. Tamoxifen one of the anticancer medicine, is added to SLN to prolong drug release after intravenous injection [37].

Stealth Nanoparticles

These give a novel and exceptional medication conveyance procedure that evades quick clearance by the immune system. These nanoparticles can focus on specific cells. In animal models, stealth SLNs have been appropriately confirmed with marker particles and drugs. Stealth Lipobodies with antibody marks have shown upgraded transportation to target tissue in available spots [38].

Diabetes

One of the most frequent metabolic diseases in the world is diabetes mellitus. Diabetes-related hyperglycemia is a deadly pathologic problem that causes nerve and cardiovascular damage. Scientists are paying close caution to SLNs as carriers for peptides and proteins that are sensitive to physical conditions such as ionic strength, PH and temperature [39]. Zhang et al colleagues developed stearic acid octaarginine-coated SLNs as insulin carriers. Octaarginine is a cell-permeating peptide that can help some medications get into the cells [40].

SLNs for Potential Agriculture Application

SLN is the combination of both essential oils and Artemisia arboreseens L to prevent the hydration. When compared to liquid dosage forms and systems and also it is widely used in agriculture as environment friendly pesticide carriers [41].

CONCLUSION

Solid lipid nanoparticles are appealing drug carriers that are being assumed as a viable alternatives to conventional colloidal dispersion methods. Because of the biocompatibility of the utilised solid lipid, SLNs are a safe and effective drug carrier. Microemulsions, suspensions, liposomes and polymeric nanoparticles are examples of colloidal dispersions with changed properties of other nanoparticles. SLNs can be used to bypass the major issues associated with nanoparticles, resulting in a chemically stable and physiologically acceptable drug delivery system with fewer constraints. Higher efficiency, lesser toxicity in drug delivery and improved medical therapies are all advantages of SLNs. The benefits and drawbacks of SLNs, route of administration, characterisation and pharmaceutical uses were completely examined in this article.

ISSN: 2519-9889
Impact Factor: 5.721

REFERENCES

[1]. Yadav N, Khatak S, Sara U, 2013, Solid lipid nanoparticles-a review, Int J Appl Pharm, 5, 8-18.
[2]. Muller R, Radtke M, Wissing S, 2002, Solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) in cosmetic and dermatological preparations, Adv Drug Delivery Rev, 54, 131-155.
[3]. Mandawgade S, Patravale V, 2008, Development of SLNs from natural lipids: application to topical delivery of tretinoin, Int J Pharm, 363, 132-138.
[4]. Amoabediny G, Haghiralsadat F, Naderinezhad S, Helder M, Akhoundi Kharanaghi E, Mohammadnejad Arough J, *et al*, 2018, Overview of preparation methods of polymeric and lipid-based (niosome, solid lipid, liposome) nanoparticles: a comprehensive review, Int J Polym Mater Polym Biomater, 67, 383-400.
[5]. Geszke-Moritz M, Mortiz M, 2016, Solid lipid nanoparticles as attractive drug vehicles: composition, properties and therapeutic strategies, Mater Sci Eng C Mater Biol Appl, 68, 982-994.
[6]. Cavalli R, Marengo E, Rodriguez L, Gasco M.R, 1996, Effects of some experimental factors on the production process of solid lipid nanoparticles, Eur. J. Pharm. Biopharm, 43, 110-115.
[7]. MuÈller B.W, Mikroemulsionen als neue Wirkstoff - TraÈgersysteme, in: R.H. MuÈller, G.E, 1998, Hildebrand (Eds.), Pharmazeutische Technologie: Moderne Arzneiformen, Wissenschaftliche Verlagsgesellschaft, Stuttgart, 161-168.
[8]. Jaiswal S, Gupta G.D, 2013, Recent advances in solid lipid nanoparticles and challenges, Iajpr, 3(12), 1601- 1611.
[9]. Hashem F.M, Mohamed N, Khairy A, 2014, in vitro cytotoxicity and bioavailability of solid lipid nanoparticles containing tamoxifen citrate, Pharm Dev Technol, 19(7), 824-832.
[10]. Rahul N, ArunKumar K.S, Priya K.V, 2011, Recent advances in solid lipid nanoparticle based drug delivery systems, J Biomed Sci and Res, 3(2), 368-384.
[11]. Tupal A, Sabzichi M, Ramezani F, Kouhsoltani M, Hamishehkar H, 2016, Dermal delivery of doxorubicinloaded solid lipid nanoparticles for the treatment of skin cancer. J Microencapsul, 33(4), 372-380.
[12]. Beija M, Salvayre R, Lauth-de Viguerie N, et al, 2012, Colloidal systems for drug delivery: from design to therapy, Trends Biotechnol, 30(9), 485-96.
[13]. Dinda A, Biswal A, Chowdhury Pet al, 2013, Formulation Development and Evaluation of Paclitaxel Loaded Solid Lipid Nanoparticles Using Glyceryl Monostearate. J of App Pharm Sci, 3(08), 133-138.
[14]. Trotta M, Debernardi F, Caputo O, 2003, Preparation of Solid lipid nanoparticles by a solvent emulsification-diffusion technique, Int J of Pharm, 257, 153-160.
[15]. Rabinarayan P, Padilama S, 2010, Production of Solid Lipid Nanoparticles-Drug Loading and Release Mechanism. Jof Chem and Pharm Res, 2(1), 211-227.
[16]. Ekambaram P, Sathali AH, Priyanka K, 2012, Solid Lipid Nanoparticles: A Review, Scientific Reviews and Chemical Communication, 2(1), 80-102.
[17]. Sinha VR, Srivastava,S, Goel H, et al,2010 Solid Lipid Nanoparticles (SLN'S) – Trends and Implications in Drug Targeting, Int J of Adv in Pharma Sci, 1, 212-238.
[18]. Kamble VA, Jagdale DM, Kadam VJ, 2010, Solid lipid nanoparticles as drug delivery system, Int J Pharm Biol Sci, 1, 1-9.
[19]. Jain NK. Controlled and Novel Drug Delivery, 1997, 1st Edition, CBS Publishers and Distributors, 3-28.
[20]. Ekambaram P, Sathali AH, Priyanka K, 2012, Solid Lipid Nanoparticles: A Review. Scientific Reviews and Chemical Communication, 2(1), 80-102.
[21]. Sinha VR, 2010 Solid lipid nanoparticles (SLN'S) – trends and implications in drug targeting, Int J of Adv in Pharm Sci, 1, 12-238.

ISSN: 2519-9889
Impact Factor: 5.721

[22]. Luo Y, Chen D, Ren L, Zhao X, Qin J 2006, Solid lipid nanoparticles for enhancing vinpocetine's oral bioavailability, J Controlled Release, 114, 53-9.
[23]. Butani D, Yewale C, Misra A, 2016, Topical amphotericin b solid lipid nanoparticles: design and development. Colloids Surf B, 139, 17-24.
[24]. Kunasekaran V, Krishnamoorthy K, 2016, Formulation and evaluation of nanoscale solid lipid particles containing a hydrophilic drugrasagiline mesylate. J Appl Pharm Sci, 6, 44-50.
[25]. De Assis N, Mosqueira F, Vilela C, Andrade S, Cardoso N, 2008, Release profiles and morphological characterization by atomic force microscopy and photon correlation spectroscopy of 99mTechnetium-fluconazole nanocapsules, Int J Pharm, 349, 152-60.
[26]. Ramteke K, Joshi S, Dhole, S, 2012, Solid lipid nanoparticle: a review. IOSR J Pharm, 2, 34-44.
[27]. Mudshinge S.R, Deore A.B, Patil S, et al, 2011, Nanoparticles: Emerging carriers for drug delivery, Saudi PharmaJ, 24, 129-141.
[28]. Hu F.Q, Yuan H, Zhang H. H, Fang M. et al, 2012, Preparation of solid lipid nanoparticles with clobetasol propionate by a novel solvent diffusion method in aqueous system and physicochemical characterization. Int.J. Pharma, 239, 121–128.
[29]. Jaiswal S, Gupta GD, 2013, Recent advances in solid lipid nanoparticles and challenges. Iajpr, 3(12), 1601-1611.
[30]. Nasimudeen R, Tabrez JS, Ashraf GMD, Shakil S, Damanhouri GA et al,2012, Nanotechnology-based approaches in anticancer research, Int J Nanomedicine, 7, 4391-4408.
[31]. Mathur V, Satrawala Y, Rajput MS, Kumar P**,** Shrivastava P, et al, 2010, Solid lipid nanoparticles in cancer therapy. Int J Drug Deliv, 2(3), 192- 199.
[32]. Hashem FM, Mohamed N, Khairy A, 2014, *in vitro* cytotoxicity and bioavailability of solid lipid nanoparticles containing tamoxifen citrate, Pharm Dev Technol, 19(7), 824-832.
[33]. Rahul N, ArunKumar KS, Priya KV, 2011, Recent advances in solid lipid nanoparticle based drug delivery systems, J Biomed Sci and Res, 3(2), 368-384.
[34]. Jenninga V, schafer-Korting M, Gohla S, 2000, Vitamin a-loaded solid lipid nanoparticles for topical use: drug release properties, J Control Release, 66(2-3), 115-126.
[35]. Soni K, Kukereja BK, Kapur M, 2014, Lipid nanoparticles: future of oral drug delivery and their current trends and regulatory issues, Ijcpr, 7(1), 1-18.
[36]. Ruckmani K, Sivakumar M, Ganeshkuma, PA, 2006, Methotrexate loaded solid lipid nanoparticles (SLN) for effective treatment of carcinoma, J Nanosci Nanotechnol, 6(9-10), 2991-2995.
[37]. Wang Y, Wei W, 2006, In situ evading of phagocytic uptake of stealth solid lipid nanoparticles by mouse peritoneal macrophages, Drug Deliv, 13(3), 189-192.
[38]. Almeida AJ, Souto E, 2007, Solid Lipid Nanoparticles As A Drug Delivery System For Peptides And Proteins, Adv Drug Deliv Rev, 59(6), 478-490.
[39]. Zhang ZH, Zhang YL, Zhou JP, Lv HX, 2012, Solid Lipid Nanoparticles Modified With Stearic Acid-Octaarginine for Oral Administration of Insulin, Int J Nanomed, 7, 3333-3339.
[40]. Moran G, Valeria F, David A, 2016, conjugates of HA2 with octaarginine-grafted HPMA copolymer offer effective sirna delivery and gene silencing in cancer cells, Eur J Biopharm, 109, 103-112.
[41]. Francesco L, Wissing SA, Müller RH, Fadda AM, 2006, *Artemisia arborescens l* essential oil-loaded solid lipid nanoparticles for potential agricultural application: preparation and characterization, AAPS PharmSciTech, 7(1), E2.

