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Solid Lipid Nanoparticles: A New Drug Delivery Formulation Approach

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Abstract

Solid lipid nanoparticles, that have numerous powerful advantages for clinical therapy, drug transportation, investigation, as well as a large array of many other fields of science, are among the forefront of a quickly developing field of nanotechnology. Lipid nanoparticles also have potential to contribute to the creation of novel therapeutics because of their unique size-dependent properties. Opioids can now be added to nanocarriers, creating a novel drug delivery prototype which could be used for therapeutic targeting at the secondary and tertiary levels. So, because solid lipid nanoparticles have a great deal of potential for attaining the goal of controlled and site-specific drug delivery, researchers are particularly interested in them. This paper examines a variety of solid lipid nanoparticles and discusses their advantages, disadvantages, as well as potential remedies. The various types of lipid-based solid nanocarriers, including lipid drug conjugates, solid lipid nanoparticles, and nanostructured lipid carriers, are presented along with their structural variations. Solid lipid nanoparticles can be produced in a variety of ways and for a variety of purposes on a large scale. The appropriate analytical techniques, such as scanning electron microscopy, photon correlation spectroscopy, and differential scanning calorimetry, for characterising solid lipid nanoparticles are highlighted. Additionally taken into account are the solid lipid nanoparticle delivery strategy and biodistribution. If thoroughly investigated, solid lipid nanoparticles could completely alter how difficult diseases are treated.

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INTRODUCTION

Nanotechnology were colloid nanoparticles with such a size among 10 and 1000 nm. They are excellent for enhancing drug distribution as well as reducing toxic effects and they can be produced with natural or synthetic materials. These evolved into such a versatile alternative to liposomes for drug delivery carriers throughout time. Nanoparticles should be capable of crossing a variety of anatomical barriers, have a sustained release of their contents, as well as be stable inside the nanometer range in order to be used in medication delivery. Furthermore, their widespread usage nanoparticles through therapeutic treatment has been constrained by the lack of safe polymers with regulatory permission and their expensive price [1].

For lipophilic medications in particular, lipids have been suggested as an alternative carrier to get around these polymeric nanoparticle limitations. These lipid nanoparticles were called as solid lipid nanoparticles (SLNs), and they are attracting a lot of formulators' interest worldwide. In the last ten years, SLNs, a new class of colloidal carriers, have been developed as an alternative to currently used conventional carriers (emulsions, liposomes and polymeric nanoparticles). They fall under a novel

class of submicron-sized lipid emulsions where the liquid lipid has been swapped out for a solid lipid (oil). The performance of drugs, neutraceuticals, and other materials can be improved by SLN, making them appealing [2]. Small size, huge surface area, high drug loading, and phase interaction at the interfaces are only a few of these special characteristics.

SLNs are receiving a lot of attention as cutting-edge colloidal drug carrier for intravenous applications. The physiological lipid-based SLNs, or submicron colloidal carriers, are dispersed in water or an aqueous surfactant solution. Therefore, SLNs may present fresh opportunities for research and treatment if they are well investigated [3].

SLNs and other nanoparticles: Successes and Problems

Table 1 demonstrates how SLNs combine the advantages of many colloidal carriers while avoiding their drawbacks. Potential downsides have included low Opioid ejection at polymeric transformation while storing, drug loading capacity, as well as the relatively high amount of water of dispersions (70-99.9%) also are factors. A drug's solubility inside the lipid melt, its composition of a lipid matrix, as well as the polymerization state of liposomes all have an impact on the capacity to load drugs in conventional SLN. Whether extremely similar molecules are present in the lipid matrix, a perfect crystal with few faults will form (such as tristearin or tripalmitin). Although integration medications were present An highly complex crystalline structure cannot exists among fatty-acid chains, phospholipid layer, as well as crystal flaws might store considerable quantity of medication. Accordingly, using highly complex triglycerides for more loading of medication makes more sense [4].

Nanostructured lipid carriers (NLC):

NLC were created to address any potential SLN issues [5]. The goals were to increase medication loading and prevent drug ejection. There are three different ways you could picture this. The first idea entails combining lipids (such glycerides), which are composed of numerous spatially different fatty acids. Due to various crystallographic faults and the use of spatially different lipids, the fatty acid chains of the glycerides are spaced farther apart, giving guest molecules more room to stay. The biggest drug load would be produced by combining modest amounts of liquid lipids with solid lipids (oils). This model is known as incomplete type NLC. Drugs can dissolve in oils that are more soluble than in solid lipids while yet being protected from deterioration by the solid lipids around them. These varieties of NLC, also known as numerous types of NLC and comparable to w/o/w emulsions, are an oil-in-solid-lipid-in-water dispersion.

The so lid lipid's ongoing transformation into crystals or other forms leads to drug ejection; consequently, the creation of a third type of NLC—the amorphous type—can halt this from occurring. The combination of certain lipids as hydroxyl octacosanol, hydroxyl stearate, and isopropyl myristate in this case prevents cooling-induced crystallisation despite the firmness of the particles. For the administration of ascorbyl palmitate [6], ketoconazole [7], other antifungal imidazoles [8], clotrimazole [9], and other antifungal imidaoles [10], the NLCs have primarily been explored in topical and dermatological preparations.

Lipid drug conjugates (LDC):

A significant problem is that SLNs have a restricted ability to load hydrophilic medications due to partitioning effects during the manufacturing process. Only extremely potent low-dose hydrophilic medications can efficiently integrate the solid matrix of lipids [11]. As such LDC nanomaterials containing drug loading capabilities of up to 33% have now been developed to overcome this restriction. The initial step in producing an insoluble drug-lipid conjugate mass is covalent bonding or salt formation (using, for instance, an acid fatty) (e.g., to ester or ethers). Through order to formulate a nanoparticle composition, this resulting LDC is then treated utilizing highly pressurized homogenization as well as an aqueous surfactants mixture (such as Tweens) (HPH). These matrices may be helpful for hydrophilic drug targeting in the brain during severe protozoal infections [12].

SLN Preparation:

SLNs are composed containing surfactant, water/solvent, as well as solid lipid (Table 2). Lipids (tri-stearin), partially glycerides (Imwitor), essential fats (tartaric acid, linoleic acid), steroid (cholesterol), as well as paraffin are a few of the triglycerides that may be used (cetyl palmitate). For consolidate its lipids dispersal, numerous emulsifiers as well as their mixtures (Pluronic F 68, F 127) have now been utilised. Emulsifiers can be added to avoid particle agglomeration more successfully [13]. An undeniable advantage of SLN is the fact that the lipid matrix is made up of physiological lipids, which lowers the risk of both acute and long-term toxicity. The selection of emulsifier is influenced by the mode of delivery, with a respectable number of emulsifiers suitable for parenteral administration. Many methods are listed in Table 3 for establishing SLNs.

SLN Preparation Method

Homogenization at high shear:

High-shear homogenization techniques were originally used to produce solid lipid nanodispersions. Both strategies are common and practicable. However, the quality of the dispersion is frequently diminished by the presence of minute particles. The high-speed homogenization technique is used to produce SLN utilising melt emulsification. Olbrich et al. investigated the impact of various process variables on particle size and zeta potential, including cooling conditions, emulsification time, and stirring rate. The lipids used in this experiment included trimyristin, tripalmitin, and a mixture of mono, di, and triglycerides (Witepsol W35, Witepsol H35). As steric stabilisers, glycerol behenate and poloxamer 188 were utilised (0.5% w/w). After stirring at 20,000 rpm for 8 minutes, letting the mixture cool for 10 minutes, and then stirring at 5000 rpm at room temperature, the ideal SLN quality for Witepsol W35 dispersions was attained. The ideal emulsification and chilling times for Dynasan 116 dispersions were 10 minutes at 25,000 rpm for emulsification and 5 minutes at 5,000 rpm in cool water ($\approx 16^0$) for chilling [14]. Faster stirring did not significantly change the particle size, although it did slightly raise the polydispersity index.

Intense or hoi homogenization:

At temperature above the melting temperature of a lipid, heated homogenization was done, very similar to the homogenized of such an emulsification. The drug-loaded triglyceride melts the aqueous emulsifier phase are mixed together to form a pre-emulsion utilising high-shear mixing apparatus (such as a silk version-type homogenizer) at the same temperature. The ideal droplet size is since the quality of the pre-quality emulsion seems to have a substantial effect on the final product, within region of just few micrometres. High pressure is applied to homogenise a pre-emulsion just above triglyceride melting temperature. Most frequently, low particle sizes produced because the lipid phase is less viscous at higher processing temperatures [15], albeit this could also speed the breakdown medicament as well as its carrier. Several passing it through strong homogenizer are followed by, typically 3-5 passes, superior commodities were generated. A sample's temperature goes up (about roughly 10° at 500 bar) throughout high pressure processing. Among 500 but also 1500 bar, 3-5 homogenization cycles were generally sufficient. Particles crystallisation was produced either by particles' high kinetic energies. which increases particle size as homogeneity increases.

Homogenising cold:

The cold homogenization process is akin to high pressure grinding of a solution since it utilises the solid lipid. To ensure Following homogenization, a lipid is solid; efficient temp control is necessary [16]. The creation of cold homogenization addressed the following problems with the heat homogenization method: divided drug payloads as well as subsequent aqueous phase following homogeneity, causing a loss, temperature-mediated fast drug degradation, Unknown triglyceride polymorphism transition brought on by the challenging crystallisation process of the nano-emulsion, which may lead to several alterations or super-cooled melts.

The first preliminary stage, which is the same as in the heat homogenization procedure, solubilizes or disperses the medication in the lipid melt. But the succeeding stages are distinct. The uniform dispersion of the medication in the lipid matrix is facilitated by the quick chilling from the opioid melting utilising liquid nitrogen but rather dry ice. Solid lipids of a medication content is efficiently reduced to microparticles using ball/mortar milling. The normal range of particle sizes is 50–100 microns. Particle milling was made much simpler by the increased lipid fragility caused by cold processing. A cooled emulsifier solution is combined with the SLNs. High-pressure homogenization of dispersal is conducted out together with appropriate temperature regulation either at or below room temp and consideration for the expected temperature rise during high pressure processing. In comparison to hot homogenised samples, cold homogenised samples frequently show a wider size dispersion and larger particle sizes [17].

The cold homogenization method lessens but does not completely eliminate a molecule's presence to heat as either a result of a lipid/drug interaction first melts.

High-speed homogenization or ultrasonication:

These two procedures were also used to construct SLN. The fact that every piece of equipment employed in this facility is very standard is one of the main advantages. The broader particle size distribution of this approach, which can reach the micrometre range, is negative. Particle growth during storage was one of the physical instability effects of this. This method's potential metal contamination caused by A significant issue is ultrasonication. Through in order to produce a consistent formula, swift mixing, as well as ultrasonication in conjunction with high temperature are therefore required, according to studies undertaken by numerous research organisations [17].

SLN produced by solvent evaporation/emulsification:

In order to produce dispersal of nanoparticles A lipophilic substance was dispersed in such a water-impermeable organic liquid (cyclohexane) which is emulsified inside an aqueous solution through precipitating into o/w emulsions [18]. As soon as the water evaporates and also the triglyceride precipitates into aqueous medium, a nanoparticle dispersal was generated. While cholesterol acetate functioned as such model drug as well as a lecithin/sodium glycocholate mixture provided as emulsion, the generated nanoparticles had such an average diameter around 25 nm. Siekmann but also Westesen, whom produced cholesterol acetate nanoparticles with such a mean size of 29 nm, demonstrated the repeatability of an outcome.

SLN preparations based on microemulsions:

By diluting microemulsions, Gasco and coworkers created SLN preparation techniques [19]. The mixture that is optically clear comprises such a co-emulsifier (sodium monooctylphosphate), the lower melting point lipids (stearic acid), an emulsifier (polysorbate 20, polysorbate 60, soy phosphatidylcholine, as well as sodium taurodeoxycholate), but also water. A mixture has been stirred at a temperature between 65-70^0 degrees Fahrenheit. The hot microemulsion dissolves in the cold water while being stirred (2–30). A ratio of hot microemulsion over ice water usually falls within 1:2 as well as 1:50. A makeup of the microemulsion has a significant impact on the dilution process.

According to the literature, since the microemulsion already has the droplet structure, no energy is required to generate particles of submicron dimensions. Given the similarities between other processes and the polymer nanoparticle formation method described by French researchers [20], several mechanisms might be taken into account. Fessi created polymeric particulates through diluting polymer solutions using water indicating that the speed of its dispersion processes is a key factor in defining the particle size. Only the relatively fast-diffusing solvent acetone can produce nanoparticles; other, more lipophilic solvents produce larger particle sizes. Microemulsion's hydrophilic co-solvents may contribute to the formation of lipid nanoparticles in a manner similar to how acetone generates polymer nanoparticles.

Supercritical fluid preparation for SLN:

This SLN synthesis method is relatively new due to the benefit of processes without solvents. Such platforms technologies exists in a variety of formats for producing powder and nanoparticles. SLN can be created using the rapid expansion of supercritical carbon dioxide solutions (RESS) technique. Research has shown that carbon dioxide (99.99%) was the most effective solvent for this process [21].

Spray-drying technique:

The method of turning an aqueous SLN dispersion into a pharmaceutical product is distinct from lyophilization. The cost is less than lyophilization. This method results in particle aggregation because of the high temperature, shear pressures, as well as a portion of the particle melting. Mullera but also Freitas recommend using lipids with a melting point greater than 700 for spray drying. The best outcomes were shown 20% in ethanol-water mixes but rather 1% in such a trehalose through liquid solution whenever it concerns to SLN concentration (10/90 v/v) [22].

Double emulsion technique:

To make a novel technique based on solvent emulsification-evaporation named hydrophilic loaded SLN has now been invented adopted. The medication is here enclosed with a stabiliser to prevent drug partitioning to the outside water phase of the w/o/w double emulsion during solvent evaporation [23].

Characterization of SLN structure and quality

To guarantee the quality of the SLNs, it is necessary to characterise them appropriately and correctly. Characterizing SLN is such a substantial challenge, nevertheless, because the delivery system was intricate as well as dynamic and also the particles are colloidal in size. Size of the particles, size distribution kinetics (zeta potential), degree of triglyceride modifications (polymorphism), convergence of additional colloidal systems (micelles, liposomes, supercooled, melts, drug nanoparticles), time scale of distribution processes, drug content, in vitro drug release, as well as surface morphology a few of the essential factors that must be evaluated for SLNs. Numerous various methods can be utilized to examine the size of the particles as well as Size-distribution technologies comprise freeze-fracture electron microscopy (FFEM), atomic force microscopy, scanning tunnelling microscopy, photon correlation spectroscopy (PCS), transmission electron microscopy (TEM), scanning electron microscopy (SEM), as well as atomic force microscopy (AFM) [24].

Zeta potential and particle size measurements

The best techniques of photon correlation spectroscopy (PCS) as well as lasers diffract (L.D.) are applied to determine particle sizes in such a rou-

Table 1: Benefits of solid lipid nanoparticles

Solid lipid nanoparticle benefits
1. Organize and/or plan drug release. 2. increase the drugs' stability. 3. increased and higher drug content (compared to other carriers). 4. The ability to transport drugs which are both hydrophilic as well as lipophilic. 5. SLNs are highly biocompatible since the majority of triglycerides were biodegradable. 6. A technology based on water (avoid organic solvents). 7. Simple to sterilise and scale up. 8. more reasonably priced (cheaper than carriers based on polymers or surfactants). 9. Validation and regulatory approval are simpler to obtain.

Table 2: Ingredients Used in Nanoparticles Creation

Name of the Ingredient	Concentration
Tego care 450 (surfactant)	1.2%w/w
Pluronic F 68	40%
PEG 2000	0.25%
PEG 4500	0.5%
PEG 400	5%
Isopropyl myristate	3.60%
Lipid	3.33%w/v
Phospholipids	0.6-1.5%
Cetyl palmitate	10%w/w
Poloxamer 188	1.2-5%w/w
Compritol	10%
Ethyl oleate	30%
Na alginate	70%
Tristearin glyceride	95%
Ethanol/butanol	2%
Soy phosphatidylcholine	95%
Glycerol	2-4%
Tween 85	0.5%
Tween 80	50%

Table 3: SLN Preparation Methods

Different preparation methods of SLNs
Homogenization at high shear: Homogenization in heat Freezing and homogenising High-speed homogenization using ultrasound: probe ultrasound Ultrasonic bathing Evaporation and emulsification of solvents SLN preparations based on microemulsions Supercritical fluid preparation for SLN Using a sprayer to dry Using a double emulsion

tine manner. This is unusual for estimate SLN size of the particles by using Coulter technique so that it is difficult to assess small nanoparticles and because it requires electrolytes, which could make colloidal dispersions unstable. PCS, often referred to as dynamic light scattering, assesses variations in the scattered light's intensity brought on by particle mobility. Sizes between a few nanometers and about three microns can be handled by this method. In light of this, PCS is an effective method for characterising nanoparticles but it is unable to detect larger microparticles. They can be observed by using L.D. measurements. This strategy is based on the relationship between particle radius and the diffraction angle (Fraunhofer spectra). Smaller particles show stronger scattering at high angles compared to larger ones. It is without a doubt advantageous that L.D. spans a broad size range, from the nanoscale to the lower millimetre range.

The development of polarisation intensity differential scattering (PIDS) technology has greatly increased the L.D.'s sensitivity to minute particles. Nevertheless, it is strongly encouraged to use PCS and L.D. together despite this advancement. Remember that neither method "measures" particle size. Instead, they search for light scattering effects that are used to estimate particle size. Nonspherical particle shapes, for instance, may result in uncertainties. Platelet forms are typically seen during lipid crystallisation in the SLN as well. Furthermore, it might be difficult to quantify PCS and L.D. for samples with numerous populations of different sizes. Therefore, alternative approaches might be useful. For instance, light microscopy is suggested even if it is not sensitive to the nanoscale size range.

It offers a fast indication of the existence and characteristics of microparticles, both those that exist as individual particles and those that are composed of aggregates of smaller particles. Electron microscopy provides exact information on particle shape in contrast to PCS and L.D. However, the investigator must pay close attention to any artefacts that the process of preparing the material may have introduced. For instance, changes that influence the particle's shape can result from the removal of the solvent. A key component of SLNs is their high zeta potential, which is likely to lead to the disaggregation of the particulate without additional problematic components like hydrophilic surface expansions with steric stabilisers. It is commonly measured using the zetameter [25].

DLS, or dynamic light scattering:

DLS, often termed quasi-elastic light scattering but rather PCS (QELS), measures variations in the strength of scattered light at such a given instant in time frame. This variation, which is caused by interference of light scattered by individual particles as a result of Brownian motion, is detected by assembling an autocorrelation function. This function is fitted a combination or modification of such an exponentially, via the connection between the related decay constant(s) and the diffusion coefficient(s) [26]. Under the typical circumstances of spherical size, low concentration, and known suspending medium viscosity, particle size is ascertained from this coefficient. The approach has several advantages, including a short analysis time, no need for sensitivities to submicrometer particulates as well as calibrating.

Fraunhofer diffraction and static light scattering:

The ensemble method known as static light scattering is used to collect and fit the pattern of light scattered from a particle solution to the fundamental electromagnetic equations, where size is the primary variable (SLS). The procedure is quick and reliable, but it calls for higher particle purity than DLS and prior knowledge of the particles' optical characteristics.

Acoustic techniques:

Another ensemble method is acoustic spectroscopy, which fits physical-meaningful equations to measurements of the attenuation of sound waves to determine size. The surface charge can also be studied by measuring the oscillating electric field generated as charged particles move under the influence of acoustic energy.

NMR: Nuclear magnetic resonance

NMR can be used to evaluate nanoparticles' size and qualitative make-up. Their sensitivities towards molecular mobility as well as the specificity offered through chemical shift combined to provide information on the physicochemical condition of components inside the nanoparticle.

Atomic imaging

Nanoparticle physical characterization 113 SEM and TEM are methods for visualising nanoparticles up close, with SEM being more useful for morphological examination. Along with the fact that TEM provides structural information, Having a smaller detection threshold for size, and is such a valuable One should be aware of the statistically small sample size and the impact that vacuum can have on the particles when validating alternative approaches [27].

AFM (atomic force microscopy):

By rastering a probe tip with an atomically sharp

edge of the sample, this technique produces a topological map of the sample based on the forces operating between the tip and the surface. The differences between the sub-techniques are based on the characteristics of the force that was applied. In contact mode, the probe can be moved across the sample, or it can be left hovering just above (noncontact mode). AFM is a helpful technology because it allows for the mapping of samples according to characteristics other than size, such as colloid connection rather than deformed resistant.

Both differential scanning calorimetry (DSC) and powder X-ray diffraction:

By identifying whether or not crystal planes are present in a solid through the geometric scattering of radiation from those planes, one can determine the degree of crystallinity of that solid. By measuring the temperatures at which glass and melting points are reached as well as the enthalpies that go along with those temperatures, DSC is a different technique from that used with bulk materials that can also be used to identify the type and speciation of crystallinity present in nanoparticles [28].

SLN Sterilization:

For distribution via intravenous and ocular routes, SLN must be sterile. The hot nanodroplets' size is likely to alter due to the hot o/w microemulsion that develops in the autoclave as a result of the maximum temperature which autoclaving attained sterilisation. After a subsequent progressive cooling, the SLN was reconstructed; nevertheless, certain nanodroplets may mix to form greater than the original SLN. Because SLN were rinsed before sterilisation, there may be less In the hot system, surfactants as well as co-surfactant, which could lead to improper stabilisation of the nanodroplets.

Formulations Based on Oral Lipid

Among the advantages that Using lipid-based oral compositions offer are the following [29]:

The capacity of poorly water-soluble, lipophilic medications to be absorbed through the G.I. tract is improved, and its variability is reduced. It may be possible to minimise or do away with several stages of creation as well as processing, such as salt selection, drug crystalline form discovery, coating, flavour decreased confinement, masking, as well as cleanup requirements during the creation of very potent or cytotoxic therapeutic products. diminution or elimination of eating's positive benefits. fabrication with relatively simple, readily available tools. Different oral lipid-based formulations include Self-emulsifying compositions, single-component lipoprotein formulations, but also solid dispersion formulations as well as pelletizing melt.

The most widely used To create oral lipid-based compositions, excipients were found to be moderate- but rather lengthy triglyceride-based nutritional oil, such as coconut or palm seed oil, as well as solvents that are lipophilic in nature, such as propylene, alcohol, as well as polyethylene glycol 400 and glycerin, as well as a variety of pharmaceutically acceptable surfactants like Cremophor® EL and RH40. When Standard techniques (solid dry or wet granulated, either water-miscible solutions in such capsules) did not produce enough bioavailability or when the medication itself was an oil, these formulations were used (dronabinol, ethyl icosapentate, indometacinfarnesil, teprenone, and tocopherol nicotinate). These formulations were available as liquid-filled hard or soft capsules, bulk oral solutions, or both. These formulations range in complexity from straightforward drug strategies for multi-excipient, self-emulsifying pharmaceutical delivery systems using nutritive oils, with total daily medication dosages ranging from less than 0.25 g to more than 2000 mg (SEDDS).

The medication content of unit-dose capsule products ranges from 0.25 μg to 500 mg, whereas that of oral solution solutions ranges from 1 μg/ml to 100 mg/ml. In a capsule formulation, the total amount of lipid excipient delivered in a single dose ranges from 0.5 to 5 g, whereas the amount for oral solution solutions might range from 0.1 to 20 ml. Several of these goods can only be kept at room temperature for very brief periods of time and must be kept at 2-8° for lengthy periods of time due to concerns with chemical and/or physical stability.

Administrative Strategies and Their Biodistribution

A solid lipid nanoparticles' in vivo course will be determined through significantly influenced based on the administration as well as distribution routes mechanism (biological material adsorbs onto nanoparticle surface whereas SLN components desorb through into biological environment). SLN are composed of lipids or waxes that are significant to or associated with biology. As a result, the carrier's in vivo fate may be greatly influenced by the body's metabolic and transport routes. The most important SLN breakdown enzymes are probably the lipases, which are present in several organs and tissues. Lipases break the ester bond to produce free fatty acids, glycerol, as well as partially linoleic acid. The majority of lipases require an oil/water contact to activate their catalytic core (lid opening). An in vitro experiment revealed that the properties of solid lipid nanoparticles (lipid matrix, stabilising

surfactant) influence how quickly pancreatic lipase breaks them down [30].

Per-oral administration

Two possibilities for SLN that can be consumed orally are aqueous dispersions and conventional dosage forms like tablets, pellets, or capsules that have been filled with SLN. Particle aggregation is promoted by the high ionic strength and acidity of the stomach. Although To our knowledge, no experimental findings have been published on the subject, food will probably have a major impact on SLN performance. Another unanswered problem is how stomach and pancreatic lipases affect the in vivo breakdown of SLN. Sadly, there haven't been many in vivo studies conducted yet.

Parenteral administration

SLN has been injected directly into animals. Doxorubicin incorporated into SLN produced blood levels after intravenous injection in rats that were higher than those of a commercial medication solution. It has been found that SLN had higher drug concentrations in the brain, spleen, and lung, whereas the solution boosted the medication's diffusion to the kidneys [31] as well as liver. Camptothecin's pharmacokinetics but also bodily distributions were discussed in a study by Yang et al, following intravenous injection into mice. Particularly in organs containing reticuloendothelial cells such as the brain, heart, and heart muscle, A mean residence durations (MRT) as well as AUC/dose of SLN was discovered to be significantly larger than those of a drug solution. Among the investigated The brain showed the greatest AUC ratio of SLN to drug solution among all the organs.

Using a transdermal patch

The smallest particle sizes are found in SLN dispersions with low lipid contents (up to 5%). The disseminated lipid has a low concentration and poor viscosity, making cutaneous distribution challenging. Typically, an ointment or gel formulation containing the SLN dispersion is required to produce a product that may be applied topically. The inclusion stage is anticipated to result in a further decrease in the lipid content of the SLN dispersion, resulting in semisolid, gel-like solutions that would be appropriate for direct application to the skin [32].

Applications

In comparison to liposomes, stable lipid nanoparticles are more stable and easier to scale up for manufacture. This trait might be essential for a number of targeted strategies. SLNs are the fundamental components of biodegradable, at least a year-long colloidal drug delivery system. In the body and in a lab setting, drugs can be administered to liver cells that are phagocytic in motion. Potential uses of SLNs have included following, which are only a few of them [4, 33]:

As a gene vector, SLNs

The gene vector's makeup may include SLN. In one study, to improve gene transfer, an SLN gene vector contained a diametric HIV-1 HAT peptide (TAT 2). Recent reports of the production of SL-acid nanoparticles are abundant (70-100 nm). It's referred to as genospheres. It is precisely targeted by the inclusion of an antibody-lipo polymer conjugate in the particle. carrying genetic/peptide materials, including Nucleic acids include DNA, plasmid DNA, and others. These nanoparticles of liposomes acids are produced from a water-miscible organic solvent and liquid nanophase in which the lipid and DNA were separately dissolved before the organic solvent was removed.

SLNs used topically

Numerous drugs have been topically administered using SLNs and NLCs, including tropolide, imidazole antifungals, anticancers, vitamin A, isotretinoin, ketoconazole, DNA, flurbiprofen, and glucocorticoids. Podophyllotoxin-penetration SLNs of the stratum corneum and skin surface were the cause of the epidermal targeting. Glyceryl behenate can be used to make nanoparticles that are loaded with vitamin A. With continual release, the strategies aid in increasing penetration. The lipid nanoparticles containing isotretinoin were made to administer medications topically. For this, soybean lecithin, Tween 80, and the heat homogenization method are used. The method works well because the cumulative skin absorption of isotretinoin has increased. It may be advantageous to administer the drug directly to the site of action with the topical flurbiprofen-loaded SLN gel, leading to higher tissue concentrations. Utilizing polyacrylamide, glycerol, and water, this type of SLN gel was produced.

As cosmeceuticals, SLNs:

The SLNs have been applied to the creation of molecular sunscreens and U.V. blockers as active carriers. An in vivo investigation found that 4% SLN added to a regular cream after 4 weeks increased skin hydration by 31%. Topicals with novel regulated release, including SLN and NLCs, have been demonstrated. Glyceryl behenate SLNs demonstrated enhanced vitamin A localization in the deeper layers of skin compared to normal formulations.

SLNs as a targeted anticancer medication delivery system to solid tumours:

SLNs may be employed as drug delivery systems to treat neoplasms, according to findings. In order

to boost permeability and retention effects, prolong drug release after intravenous injection, and treat breast cancer patients, tamoxifen, an anticancer medicine, is added to SLN. Tumor targeting has been achieved by using SLNs infused with drugs like methotrexate and camptothecin.

SLNs in lymph node metastases and breast cancer:

In order to increase the medication's safety and absorption while reducing its toxicity, mitoxantrone-loaded SLN local injections were created. Integration in SLNs is reported to boost the efficacy of doxorubicin (Dox).

CONCLUSION

Paul Ehrlich developed his "magic bullet" theory in the early 20th century. According to this theory, medications should only be administered when they are at the appropriate concentration, at the correct spot in the body, and at the right time. It shouldn't cause any negative effects while being transported to the therapeutic target, once there, or while being used. These overarching goals may be attained, at least in part, through the SLNs. Aside from these, SLNs effectively accomplish the standard goal of regulated drug delivery. These were comparatively novel drug delivery techniques that have gained popularity since the early 1990s, as well as the possibilities for their thorough investigation and use appear promising. Future SLNs are inclined to be used for a large number of patentable dosage forms.

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