



Formulation and Characterization of Solid Lipid Microparticles

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ABSTRACT

The aims of review are the latest research development of the lipid based carriers according to the recent relevant literatures. Each preparation of the lipid based microparticles (SLMs) has advantages and disadvantages. The SLMs is an excellent drug delivery system and has broad prospects in the pharmaceutical field. This review discusses the advantages, therapeutic application of SLMs, various techniques of preparation, and different routes of administration, material use and characterization of solid lipid microparticles.

Keywords: SLM, Production technique, Lipid based carrier, Pharmaceutical application.

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INTRODUCTION

In the today scenario and developing technology, solid lipid microparticle (SLMs) is relatively recent and new developments of the dosage form. Interest in this systems is largely driven by the fact that among lipid based drug delivery systems, SLMs well comply with the needs of the drug development process, as for instance safety, stability, different application fields (pharmaceutical, veterinary, cosmetics as well as food additives) and administration pathways (oral, mucosal and topical delivery), ease of modifying the release of actives, taste masking ability, rapidity and availability of several processing techniques.¹

Development of colloidal carrier systems has attracted increasing attention in recent years as an innovative approach to get over frequent therapeutic failures due to unpredictable drug bioavailability when administered in conventional dosage forms. The most investigated particulate drug carriers for controlled drug delivery are simple and multiple emulsions, leptosomes, polymeric micro and nanoparticles.²

Solid lipid microparticles (SLMs) are micro- and nano-scale drug carriers possessing matrix made from fatty acid, glyceride, fatty alcohol and solid wax with high melting points. They are manufactured from synthetic/natural polymers and ideally suited to optimize drug delivery and reduce toxicity.³ The successful implementation of microparticles for drug delivery depends on their ability to penetrate through several anatomical barriers, sustained release of their contents and their stability in the micrometer size.⁴

To overcome these limitations of polymeric microparticles, lipids have been put forward as an alternative carrier, particularly for lipophilic pharmaceuticals.⁵ These lipid microparticles are known as Solid Lipid Microparticles (SLMs), SLMs offer unique properties such as small size, large surface area, high drug loading and the interaction of phases at the interfaces, and are attractive for their potential to improve performance of pharmaceuticals, nutraceuticals and other materials.⁶

Solid Lipid Microparticles are at the forefront of the rapidly developing field with several potential applications in drug delivery, clinical medicine and research as well as in other varied sciences.⁷ Due to their unique size-dependent properties, lipid microparticles offer the possibility to develop new therapeutics. The ability to incorporate drugs into microparticle offers a new prototype in drug delivery that could be used for secondary and tertiary levels of drug targeting. Hence, solid lipid microparticles hold great promise for reaching the goal of controlled and site specific drug delivery and hence have attraction.⁸

SLMs are in the size range of 1-1000 μ m and composed of biocompatible and biodegradable materials capable of incorporating lipophilic and hydrophilic drugs. The general structure of solid lipid particles.⁹

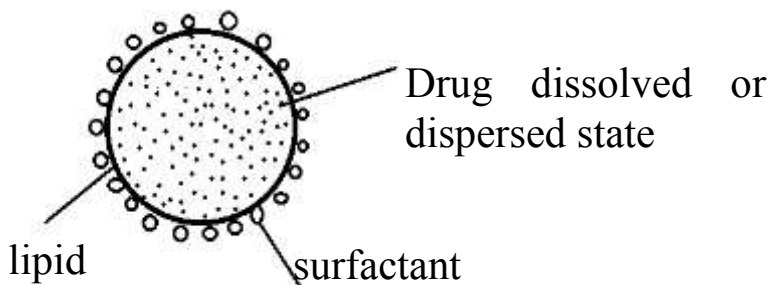


Figure 1. General structure of SLM

SLMs are attractive carriers for oral formulations, since it was proven, from many years ago, that the co-administration of poorly water-soluble drugs (PWSD) with a meal rich in fat enhanced their oral bioavailability.¹¹

Solid lipid Microparticles (SLM) represents an alternative carrier system to the traditional carriers such as emulsions, leptosomes, polymeric micro and nanoparticles. Particles in the micro/nanometer ranges, which are actually dispersed in the aqueous surfactant solution. They are made up of solid hydrophobic core having a monolayer of phospholipids coating. SLMs have attracted increasing attention as a potential drug delivery carrier owing to their advantages such as possibility of simple and large scale production and low toxicity.^{13,14} Polymeric micro/nanoparticles may contain toxic monomer residues or solvents and may form toxic degradation products. SLMs consist of a biocompatible lipid core and an amphiphilic surfactant as an outer shell. Surfactants are of great importance in the stability of SLM in addition to the appropriate choice of lipid material. A broad range of surfactants was investigated in order to improve the stability of the particle. Its composition affects the particle size from the production process, the physical long-term stability during storage, the drug release profile or the enzymatic degradation rate.¹⁵

Gastrointestinal solubilization and absorption via selective lymphatic uptake. Further mechanistic understanding of their impact on drug disposition is emerging. The maximum advantage from a lipid formulation could only be drawn if the drug remains in lipid solution throughout its residence in the GI tract. The choice of lipid formulations according to the Lipid Formulation Classification System (LFCS) in relation to the physicochemical properties of the drug as well as the properties of excipients, criteria for their selection for lipid-based

formulations and the fate of these materials during dispersion and digestion, and the likely consequences of their use in formulations have been also reviewed elsewhere.^{16,17}

The o/w emulsion has been introduced in 1950's for parenterals nutrition and subsequently drug containing emulsions were developed. In spite of excellent tolerability, the number of products available in market is relatively low, indicating their limited success. A major disadvantage is physical instability of drug containing emulsion due to a reduction of zeta potential which can lead to agglomeration drug expulsion and eventually breaking of emulsion.¹⁸ In addition, oils for medical use exhibit low solubility for most drugs.

The drawback associated with emulsion were addressed to with the development of second generation colloidal drug delivery system, liposomes.¹⁹ However, the use of liposomes was limited by physical instability, lack of large scale production method. Drug burst release kinetics, and finally production cost making them more expensive than other drug delivery systems.²⁰

Polymeric particulate devices made from non-biodegradable and biodegradable polymers, are yet another innovative carrier system offering significant controlled drug released.²¹ Main disadvantages include lack of an efficient, large scale production method and cytotoxicity of polymers after internalization into cells.²²

Since the beginning of 1990's various researchers have focused their attention on alternative colloidal carriers made from solid lipids called 'solid lipid microparticle/nanoparticles'. Solid lipid particles have been considered as promising drug carrier system and as other colloidal carriers like emulsion liposomes, polymeric micro and nanoparticles.²³ Basic work in the area of solid lipid particles was conducted by Speiser who produced lipid microparticles by spray congealing²⁴ followed by lipid nanopellets for peroral administration.²⁵

SLMs have been proposed as colloidal drug carrier systems for different administration routes such as oral, topical,²⁶ ophthalmic, subcutaneous and intramuscular injection²⁷ and particularly for parenteral administration.^{28,29} SLMs combine the advantages of other colloidal carriers, for instance, like emulsion these are physiologically acceptable, have good tolerability and allow large scale production and like polymeric particles provide controlled drug release from solid matrix and protect are better carriers than conventional emulsion as they offer better protection of drug against chemical the incorporated drug against chemical degradation.³⁰

SLMs degradation and more prolonged release. As compared to liposomes, SLMs provide better protection to incorporated drug and there is little or no access of water to inner core of lipid particles. The use of lipid based drug formulations that enhance the bioavailability of poorly water-soluble drugs has gained much interest, because they utilize the well known food effect of

the ingested lipids. Lipid based formulations can reduce slow and incomplete dissolution, facilitate the formation of solubilize phases and, if lipophilic, increase the amount of drug transported via the intestinal lymphatic system, thereby increasing absorption from the gastrointestinal tract^{31,32}.

Lipid-based dosage forms represent a distinct class of drug products that have drawn considerable interest and attention from pharmaceutical scientists. Most of the lipid-based drug delivery systems use lipid vesicles or excipients to solubilize lipophilic drugs that are poorly water-soluble in nature, thereby improving drug absorption in the body. The drug solubility and miscibility in melted lipid, chemical and physical structure of lipid materials, and their polymorphic state determine the loading capacity of drug in the lipid particles. The amount of drug encapsulated can vary from 1% to 5% for hydrophilic compounds and up to 80% for lipophilic compounds^{33,34}.

Lipids are ubiquitously distributed compounds that play fundamental roles in the architecture and functionality of all living cells. Therefore they are most commonly studied as components of food stuff and important energy source in the enteral nutrition. From the stand point of oral drug delivery, lipids are studied namely as components of various oily liquids and dispersions that are designed to increase solubility and bioavailability of drugs belonging to the class II and IV of the biopharmaceutical drug classification system.³⁵

Additional positive features potential use of solid lipid particles as drug carrier system are³⁶:

Better physical stability.

No appreciable drug leakage from particles due to reduced mobility of incorporated drug molecules.

Lack of coalescence after reaching room temperature.

They can be lyophilized, spray dried and also sterilized by autoclaving or gamma radiation.

Raw materials and production cost relatively low.

Advantages³⁷⁻⁴²

The advantages of SLMs are as follows:

1. Controlled and sustained release of the drug during the transportation and at the site of localization, altering organ distribution of drug and subsequence clearance of the drug so as to achieve increase in drug therapeutic efficiency and reduction in side effects.
2. Drug can be incorporated in to the system without any chemical reaction; this is an important factor for preserving the drug.
3. Controlled release and drug degradation characteristics can be readily modulated.

4. There is no wastage of drug and thus enhanced bioavailability of drug at specific site in right proportion for prolonged period of time.
5. It improve the solubility of poorly water soluble drugs, prolong half life of drug systemic circulation by reducing immunogenicity, release drug at sustained rate and lower the frequency of administration .
6. It provides comfort and compliance to the patient and yet improves the therapeutic performance of the drug over conventional systems.
7. Control and targeted drug release.
8. Improve stability of pharmaceuticals.
9. High and enhanced drug content (compared to other carriers).
10. Feasibilities of carrying both lipophilic and hydrophilic drugs.
11. Most lipids being biodegradable, SLMs have excellent biocompatibility.
12. Water based technology (avoid organic solvents).
13. Easy to scale-up and sterilize.
14. More affordable (less expensive than polymeric/surfactant based carriers).
15. Easier to validate and gain regulatory approval.

Therapeutic Application^{43, 44}

The therapeutic application of SLMs is as follows:

- 1) SLMs for topical use of SLM gel.
- 2) SLMs as cosmeceuticals.
- 3) SLMs as a targeted carrier for anticancer drug to solid tumors.
- 4) SLMs in breast cancer and lymph node metastases.
- 5) Oral SLMs in antitubercular chemotherapy

Administration Routs^{45, 46}

Peroral administration.

Peroral administration forms of SLM may include aqueous dispersions or SLM loaded traditional dosage forms e.g. tablets, pellets or capsules. The microclimate of the stomach favors particle aggregation due to the acidity and high ionic strength. . It can be expected that food will have a large impact on SLM performance.

The peroral route is the most often cited SLM administration rout in the literature. It includes aqueous SLM dispersion. SLM tablet pellets or capsule. However, data on in vivo drug release and biocompatibility studies are most often missing. Demirel has nevertheless perorally administered SLM suspension to rabbits; such suspensions were composed of compritol 888

ATO and Labrasol as lipidic matrix, Twen 80 as a surfactant and piribedil as the active substance. The bioavailability of piribedil- SLMs was found to be higher than with pure piribedil.

Considering that SLM lipidic matrices are composed of physiological lipid and that most surfactant has already been used perorally, the authors cast no doubt on the biocompatibility SLM after oral administration.

Parenteral administration

SLN/SLM has been administered intravenously to animals. Pharmacokinetic studies of doxorubicin incorporated into SLN showed higher blood levels in comparison to a commercial drug solution after i.v. injection in rats. Concerning the body distribution, SLN/SLM were found to cause higher drug concentrations in lung, spleen and brain, while the solution led to a distribution more into liver and kidneys. In comparison to a drug solution SLN/SLM were found to lead to much higher AUC / dose and mean residence times (MRT) especially in brain, heart and reticuloendothelial cells containing organs. The highest AUC ratio of SLN/SLM to drug solution among the tested organs was found in the brain.

Topical administration

The smallest particle size is observed for SLN dispersions with low lipid content (up to 5%). Both the low concentration of the dispersed lipid and the low viscosity are disadvantageous for dermal administration. In most cases, the incorporation of the SLN dispersion in an ointment or gel is necessary in order to achieve a formulation which can be administered to the skin. The incorporation step implies a further reduction of the lipid content. An increase of the solid lipid content of the SLN dispersion results in semisolid, gel-like systems, which might be acceptable for direct application on the skin. SLN have also been found to modulate drug release into the skin and to improve drug delivery to particular skin layers invitro. Loss of water after application on the skin causes changes of lipid modification and SLN structure. Electron microscopy indicates that dense films are formed after drying (32°C) of SLN dispersions in contrast to spherical structures.

Pulmonary administration

SLMs can be considered as a promising drug carrier system for pulmonary administration even if they have been rather unexploited so far. However, a preliminary *in vivo* tolerance study has been carried out rats of with SLMs composed of glyceryl behenate (compritol 888 ATO) as matrix and poloxomer 188 (Lutrol F68) as a surfactant. SLM dispersion in phosphate buffer saline were administered intratracheally. Baronchoalveolar lavages were performed on the

anaesthetized rats. Total and differential cell counts (i.e. inflammatory cells) were then done with the collected bronchoalveolar liquids. Results did not show significant differences between placebo groups and SLM- treated rats. It has been concluded that the studied SLMs seem to be well tolerated by the lower airways, but tolerance must still be assessed after repeated administration.

Oral Administration of SLMs

The peroral route is the most often cited in the literature, it includes aqueous SLM dispersion, SLM tablets, pellet or capsules.⁴⁶

Among the benefits which oral lipid-based formulations can provide are included:

Improvement and reduction in the variability of GI absorption of poorly water-soluble, lipophilic drugs. Possible reduction in, or elimination of, a number of development and processing steps (salt selection or identification of a stable crystalline form of the drug, coating, taste masking, and reduced need for containment and clean-up requirements during manufacture of highly-potent or cytotoxic drug products). Reduction or elimination of positive food effect. Relative ease of manufacture using readily available equipment.^{47, 48}

Ingestion of a lipid-based dose form, the formulation is initially dispersed in the stomach where the digestion of exogenous dietary/formulation lipid is initiated by gastric lipase. Shear in the stomach and on gastric emptying assists in emulsification of the formulation prior to emptying into the duodenum. Within the small intestine, pancreatic lipase together with its co-factor colipase completes the breakdown of dietary glycerides to di-glyceride, monoglycerides and fatty acid (represented by different degree of shading on the surface of the lipid droplet). The presence of exogenous lipids in the small intestine expands the solubilization capacity of the small intestine for both lipid digestion products and drugs as shown in the **figure 2**.⁴⁸

The use of lipid based drug formulations that enhance the bioavailability of poorly water-soluble drugs has gained much interest, because they utilize the well-known food effect of the ingested lipids. Lipid based formulations can reduce slow and incomplete dissolution, facilitate the formation of solubilize phases and, if lipophilic, increase the amount of drug transported via the intestinal lymphatic system, thereby increasing absorption from the gastrointestinal tract

Lipid-based dosage forms represent a distinct class of drug products that have drawn considerable interest and attention from pharmaceutical scientists. Most of the lipid-based drug delivery systems use lipid vesicles or excipients to solubilize lipophilic drugs that are poorly water-soluble in nature, thereby improving drug absorption in the body. The drug solubility and miscibility in melted lipid, chemical and physical structure of lipid materials, and their

polymorphic state determine the loading capacity of drug in the lipid particles. The amount of drug encapsulated can vary from 1% to 5% for hydrophilic compounds and up to 80% for lipophilic compounds.^{48, 49}

Lipids are ubiquitously distributed compounds that play fundamental roles in the architecture and functionality of all living cells. Therefore they are most commonly studied as components of food stuff and important energy source in the enteral nutrition. From the stand point of oral drug delivery, lipids are studied namely as components of various oily liquids and dispersions that are designed to increase solubility and bioavailability of drugs belonging to the class II and IV of the biopharmaceutical drug classification system.^{50,51}

SLMs production procedures

.General ingredients

Commonly used materials for SLM manufacturing are lipids, surfactants and water.

Lipids

Lipids include fatty alcohols, fatty acid esters of glycol, waxes. Cholesterol, etc. the selected must have melting point higher than 45°C, to ensure that the SLMs has a solid matrix during storage. The lipid must be compatible with the drug to be incorporated and must possess sufficient loading capacity for lipophilic and possible also for hydrophobic drugs. A summary of regularly used is presented in table 1.

Emulsifiers/ co-emulsifiers

Emulsifiers selected must be nontoxic, compatible with minimum amount used, provide adequate stability to SLMs by covering their surface. **Table 1**⁵² represent emulsifier/co-emulsifier used in SLM production.

Table 1: Lipid excipients and emulsifiers used in preparation solid lipid microparticles

	Lipids	Emulsifiers
Fatty alcohol	Cetyl alcohol	Poloxomer188
	Stearyl alcohol	Poloxomer407
Fatty acid esters of glycerol	Glyceryl behenate	Polysorbate 80
	Glyceryl monostearate	Polysorbate 40
	Glyceryl palmistearate	Phosphatidylcholine
		Polyvinyl alcohol
Fatty acid	Stearic acid	Sodium lauryl sulphate
Others	Bees wax	Soya lecithin
	Cholesterol	

Preparation Techniques:

Various methods employed for the preparation of solid lipid particles are briefly describe in the following section.

I. High Pressure Homogenization

This is reliable and powerful technique that employs homogenizers to reduce particle size to micro or nanometer size range depending on composition and process parameters. Two general approaches of homogenization are hot and cold homogenization techniques.

a) Hot homogenization:

Lipid is melted to approximately 5°C above its melting point, the drug is dissolved or solubilized in the melted lipid, and the drug containing lipid melt is dispersed in an aqueous surfactant solution of the same temperature. The obtained preemulsion is then passed through a high pressure homogenizer. The product of this process is hot o/w emulsion and the cooling of this emulsion leads to crystallization of the lipid and the formation of solid lipid nanoparticle.

b) Cold homogenization-

Drug is incorporated into melted lipid and the lipid melt is cooled upto solidification. Solid material is ground by a mortar mill. Obtained lipid microparticle is dispersed in a cold surfactant solution at room temperature or even at temperature distinctly below room temperature. The solid state of the matrix mimics portioning of the drug to the water phase. It has merit over cold homogenization since even during storage of the aqueous solid lipid dispersion, the entrapment efficiency remains unchanged.⁵³

II. O/W Melt Dispersion Technique (For Lipophilic Drugs)

This is also called as hot melt microencapsulation technique (which can be carried out by normal or phase inversion technique). The drug is dissolved in the melted lipid (the melting temperature is depend on the lipid used). The hot mixture is emulsified into an aqueous surfactant solution that is heated above the melting point. The o/w emulsion can then be poured into a larger volume of ice-cooled aqueous phase. The emulsion, which is obtained by mixing with a high shear device (e.g., Ultra-Turax [IKA] , or Silverson mixer), is finally followed to cool either at room temperature or in ice bath.⁵⁴

Hardened microparticles are filtered, rinsed with water and dried in vacuum dessicator.

III. W/O Melt Dispersion Technique (For Hydrophilic Drugs)

This method is variant from o/w melt dispersion technique but is used for water soluble drugs. This process does not use water in order to avoid excessive drug solubility into the external aqueous phase and thereby low drug loading in microparticles. First, the drug is dispersed into melted lipid together with the surfactant. A hot non aqueous continue phase (e.g., silicon oil) is poured into molten lipid phase. The obtained dispersion is then rapidly cooled through cold oil

oil addition and immersion in an ice bath. solidified microparticle is separated from oil by centrifugation and are finally washed and dried.

IV. W/O/W Multiple Emulsion Technique for Water Soluble Drugs

A heated drug solution is emulsified into the melted lipid. The obtained primary W/O emulsion is put into an external aqueous phase and stirred so as to get a W/O/W emulsion. The latter is then cooled either in an ice bath or at room temperature under stirring. Hardend microparticles are filtered, rinse with water and finally dried in a vacuum dessicator.

V. Solvent Evaporation Method

The solvent emulsification/evaporation processes adapts techniques which have been previously used for the production of polymeric micro- and nanoparticles. The solid lipid is dissolved in a water-immiscible organic solvent (e.g. cyclohexane, or chloroform) that is emulsified in an aqueous phase. Upon evaporation of the solvent, microparticle dispersion is formed by precipitation of the lipid in the aqueous medium. A modified solvent evaporation method has also been widely described. In this technique the lipids are also first dissolved in an organic solvent. By mixing, the drug is incorporated in the organic phase either as a solid (s/o/w) which has been first grinded in mortar in the presence of liquid nitrogen, or dissolved in an aqueous solution (w/o/w). The obtained preparation is then emulsified into an aqueous surfactant solution. The emulsion is poured into an ice-cooled aqueous phase and stirred. Obtained microparticles are filtered, rinse with water and dried in a dessicator.⁵²

VI. Spray Congealing (Spray Chilling)

Lipophilic material is heated to a temperature above its melting point. The drug is then dissolved into the melt. the hot mixture is atomized with a pneumatic nozzle into a vessel that mixture is atomized with a pneumatic nozzle into a vessel that is stored in a carbon dioxide ice bath. Obtained particles are finally vacuum dried at room temperature for several hours.

In the first variant of this technique, the melted mixture is atomized by ultrasound energy into small droplets that fall freely and solidify by cooling at room temperature.

Another variant of the spray chilling method, using a rotating disc, has also been described. With this method the melted mixture is dropped onto a high-speed rotating disc. the rotation causes the molten mixture to spread and spray from the disc periphery onto a chilled surface from which microparticles are collected.⁵⁵

VII. Spray Drying

Spray drying might be an alternative procedure to lyophilization in order to transform an aqueous SLM dispersion into a dry product. This method has been used scarcely for SLM formulation,

although spray drying is more economical compared to Lyophilization. Spray drying might potentially cause particle aggregation due to high temperatures, shear forces and partial melting of the particles. The melting of the lipid can be minimized by using ethanol–water mixtures as a dispersion medium instead of pure water due to the lower inlet temperatures. Best result was obtained with SLM concentrations of 1% in solutions of 30% trehalose in water or 20% trehalose in ethanol–water mixtures (10 / 90 v / v).^{56,57}

It's an alternative procedure to lyophilization in order to transform an aqueous SLMs dispersion into a drug product. It's a cheaper method than lyophilization. This method cause particle aggregation due to high temperature, shear forces and partial melting of the particle. Freitas and Mullera recommends the use of lipid with melting point $>70^{\circ}\text{C}$ for spray drying.

Characterization of Prepared Slms

Measurement of size and zeta potential of SLMs

Extensive characterization of lipid particle properties made through various methods provides us with the opportunity to select a method depending on the costs, desired particle size distribution, and recovery efficiency.

Size measurements

Size is one of the deciding factors for pharmaceutical applications and characteristics of well-formulated system will include a narrow size distribution. When it comes to delivery of drugs via intravenous injections, particles larger than 5 μm can cause embolism. In addition, the size of the particles can trigger the capture mechanism through phagocytosis, a process in which large and insoluble particles are enveloped by the plasma membrane and internalized²³, subsequently influencing the bioavailability of the drug encapsulated particles. Particle size measurements are usually done using dynamic light scattering (also known as photon correlation spectroscopy (PCS)) and laser diffraction (LD) for particle size spanning micrometers to 5-6 μm , for particles larger than 6 μm , Coulter counter method²⁴ in which the electrical resistance produced by particles suspended in buffer solution, while passing through an aperture, is usually utilized. The resulting displaced volume of buffer solution, which is proportional to the particle size, will create a voltage pulse that is collected to create a particle size distribution²⁵.

Charge measurements

Zeta potential ζ is an assessment of the surface charge of colloidal dispersion and often the key to understanding dispersion and aggregation in particle population. The greater the zeta potential (ζ) the less likely the suspension is to become unstable, because charged particles repel one another

and therefore overcome the tendency to aggregate²². Surface charge is measured using a zeta sizer which measures the electrophoretic mobility across the diffusive layer of the particles.

Morphology

Particle morphology, studied using scanning electron microscopy (SEM), is an indicative of particle composition and origin and it also serves to better the understanding of *in vitro* controlled release in case of drug encapsulated particles. Particles with higher surface: volume ratio allows more buffer access and deeper penetration thus a faster degradation rate. Particle morphology also has an impact on the recognition process by the cells, thus becoming an important characteristic²⁶

Entrapment efficiency

The aqueous SLM suspension was filtered to isolate SLMs from aqueous phase. The obtained particles were dried. 50 mg of SLMs was then heated with 5 ml of methanol in which the drug is soluble and shaken in order to extract the drug in the solvent. The solvent was diluted with water to 50 ml and further diluted to analyze spectrophotometrically at 214 nm using UV-visible spectrophotometer (Shimadzu-1601, Japan) against a suitable blank. The entrapment efficiency was determined using the

Formula:

$$EE (\%) = (\text{amount of drug incorporated} \times 100) / \text{amount of drug initially used}$$

Drug release from lipid particles

Kinetics of drug release is an important aspect of the particle characterization. *In vitro* release gives an insight into the drug distribution inside the matrix as well as information about the release mechanism. It has been shown that the release profile is primarily influenced by modification on the lipid matrix, surfactant concentration and fabrication parameters^{27, 28}. Wissing *et al.*⁵⁸ proposed the following structural models for drug encapsulated lipid particles



Figure 2: Proposed structural models for drug-containing lipid particles⁵⁸

Depending on the nature of the encapsulated drug and method of preparation, the three primary outcomes are: a drug enriched core particle, a drug enriched shell or a particle with drug homogeneously dispersed throughout the matrix. Those particles with drug enriched shell often display a burst release behavior rather than sustained release over an extended period of time. Also, depending on the particle size, those enriched on the surface often display rather low encapsulation efficiency

CONCLUSION:

Lipid carriers have bright future due to their property to enhance bioavailability of lipophilic drug with poor solubility. Lipid based microparticle have the greater importance in the developing field of lipid based technology with several advantages apart from various carriers. Lipid based carriers is a promising microscaler delivery system for the pharmaceutical industry due to the fact that:

- Large scale production possible, no organic solvents needed
- High concentrations of functional compounds can be achieved
- Lyophilization possible
- Spray drying for lipids with $T > 70^{\circ}\text{C}$ to yield powders.

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