INTERNATIONAL JOURNAL IN PHARMACEUTICAL SCIENCES

Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Review On Lipid Based Carrier As A Drug Delivery System

Pranali Jadhav*[1], Pranali Hatwar[2], Gajanan Sanap[3]

Department of Pharmaceutics, LBYP College of Pharmacy, Pathri, Ch.Sambhajinagar. Maharashtra, India

ARTICLE INFO

Received: 06 Dec 2023
Accepted: 09 Dec 2023
Published: 12 Dec 2023

Keywords:
Lipid nanocarriers ,liposome, Designal Structure.

DOI:
10.5281/zenodo.10352354

ABSTRACT

Lipid nanocarriers represent an alternative to polymeric nanoparticles, liposomes, and emulsions. Nanostructured Lipid Nanocarriers (NLCs), considered as the second-generation lipid carriers, aim to address the limitations of Solid Lipid Nanoparticles. They are employed across diverse therapeutic approaches and were initially designed for delivering lipophilic drugs, but their effectiveness with hydrophilic drugs is now well-established. The biocompatibility of lipids underpins their emergence as a promising avenue for drug delivery, exhibiting superior traits compared to other lipid formulations. This article delves into NLCs, covering their structures, preparation methods, characterization, stability, and advantages over first-generation lipid nanoparticles. The review predominantly highlights the manifold therapeutic applications of NLCs and their specificity concerning various physiological contexts. Given their biologically benign, non-immunogenic, and harmonious traits, NLCs are poised to become extensively explored systems among lipid nanocarriers.

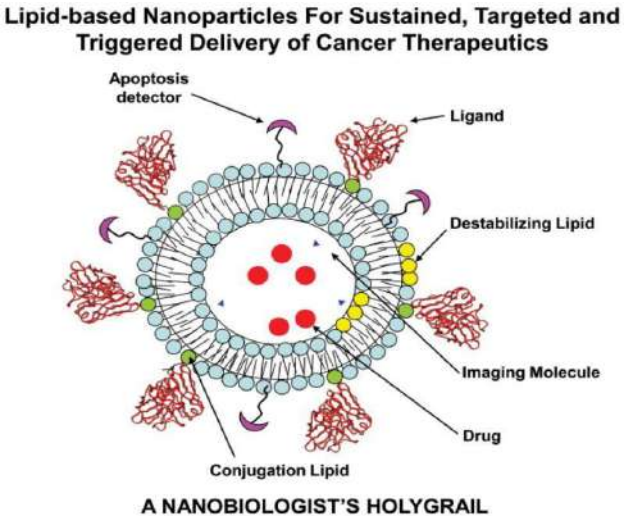
INTRODUCTION

Solid lipid nanoparticle (SLN) synthesis served as the foundation for the investigation of innovative lipid nanoparticulate drug delivery systems. A possible method of drug delivery using lipid nanocarriers is the incorporation of the drug into different biocompatible lipids that have been synthesized at the nanoscale. In order to tackle physiological difficulties, this first-generation lipid nanocarrier system was further improved to enable medication delivery through a variety of administration routes. Researchers noticed some SLN limitations, which led Muller to design a novel lipid carrier known as nanostructured lipid carriers (NLCs) in 1999/2000. A portion of the solid lipids in NLCs were switched out for liquid lipids to create a matrix that incorporates drugs. NLCs are currently regarded as potential medication carriers because of their excellent biocompatibility.Thecreation,characterization,and demonstrationoftheeffectivenessofdrug loaded NLCs is currently a hot topic in drug delivery and targeting. Since most pharmaceuticals have a lipophilic character, one of the most important

***Corresponding Author:** Pranali Jadhav
Address: *Department of Pharmaceutics, LBYP College of Pharmacy, Pathri, Ch.Sambhajinagar. Maharashtra, India*
Email : pranalijadhav2026@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

factors in the development of NLC is their solubility.



1.2. Lipid nanocarriers

The creation of liposomes with entrapped solutes was originally proven by British professor A.D. Bangham in a paper 38 that was published. Since their introduction, liposomes have been investigated as potential medicationandpharmaceuticaldeliverysystems.4,39-41. They represent a well-researched class of drug carriers that are often identified by the presence of a lipid bilayer that is largely made of amphipathic phospholipids and encloses an inner aqueous space. While some liposome formulations are now being used in clinical settings to treat cancer and infectious disorders, others are awaiting the results of clinical studies(for the most recent information, please visit the website www.clinicaltrials.org). A partial list of liposomes that have been approved for use in clinical settings is summarized in Table 1; this list is continuously growing. A partial list of liposomes that are presently undergoing clinical studies is summarized

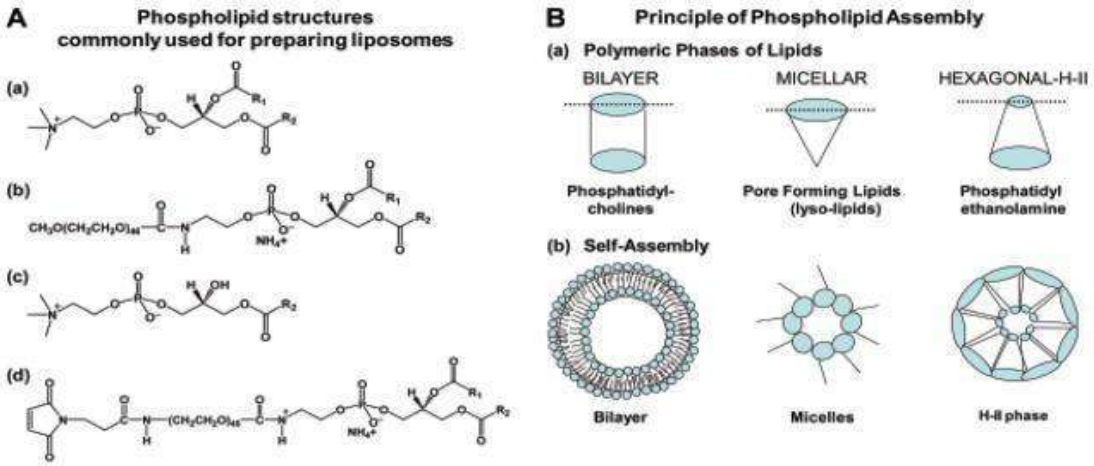


Fig no. 2 Depicts the chemical structures of frequently employed phospholipids for liposome preparation: Matrix lipids like DPPC or DSPC (in A); PEGylated lipid (typically DSPE-PEG2000) designed to enhance circulation time.

Drug name and company	Indications/Target
Marqib-Vincristine sulfate liposomes injection is a medication developed by Hana Biosciences. It consists of Vincristine encapsulated liposomes enclosed with in a lipid bilayer made of sphingomyelin.	This medication is used for the treatment of adult patients diagnosed with acute lymphoblastic leukemia
Dauno Xome: Daunorubicin in citrate-liposome injection(NeXstar Pharmaceuticals)	Advanced HIV-associated Kaposi's sarcoma for first-line use
AmBisome®:Lipid-based formulations, including liposomal amphotericin B (Fujisawa Healthcare)	Treatment of fungal infection and visceral leishmaniasis
Doxil®, caylex: PEGylated liposomal loaded with doxorubicin (PLD) (Ben Venue Laboratories for Johnson & Johnson)	Treatment of metastatic breast cancer, advanced ovarian cancer, multiple myeloma, and AIDS-related Kaposi's sarcoma
Amphocil: Lipid form of amphotericin B stabilized with cholesteryl sulfate (Samaritan Pharmaceuticals)	Amphocil binds to lipoproteins and ergosterol in cell membranes of infecting fungi; also indicated for the treatment of invasive aspergillosis and leishmaniasis
ABELCET®: Amphotericin B lipid complexed with two phospholipids (DMPC:DMPG, 7:3 molar ratio) in a 1:1 drug-to-lipid molar ratio (The Liposome Company)	ABELCET® consists of amphotericin B, a polyene, antifungal antibiotic for invasive fungal treatment
Depocyt™: Liposomal cytarabine or liposomal Ara-C are antimetabolite cytarabine, encapsulated into multivesicular lipid-based particles (Enzon Pharmaceuticals)	DepoCyt is a sustained release formulation of the chemotherapeutic agent cytarabine, used for the treatment of patients with lymphomatous meningitis

1.3. Liposome Design Principles and Lipid Molecule Assembly

The primary components of liposomes (phosphatidylcholines, sometimes referred to as "lecithins") are phospholipids. They easily form concentric bilayers due to their amphipathic characteristics (also previously referred to as "bangosomes" by A.D. Bangham). These multilamellar lipid dispersions can be transformed into single bilayer structures known as unilamellar liposomes or vesicles using a variety of methods and techniques. The most often used laboratory techniques include solvent injection, reverse-phase evaporation, extrusion, and sonication. The size, circulatory stability, batch-to-batch fluctuations, efficacy of drug loading, etc., of formulations that adhere to Food and Drug Administration (FDA) regulatory criteria must all be taken into account.47 In addition to these characteristics, triggerable liposomes, which allow for localized drug administration, are another essential component for enhancing the efficacy of pharmaceuticals and therapeutics contained within liposomes. We'll talk about "triggerable liposomes" later on in this section. Chemical modifications in phospholipid molecules for tunable liposomes occur at specific sites. In atypical phosphatidylcholine (PC) molecule, modifications are made in three major regions: pink indicates head group modifications, orange represents glycerol backbone modifications, and green denotes fatty acyl modifications. Specific examples of these modifications are provided at the bottom.

2.TARGETING LIPOSOME:-

Triggerable liposomes may function as more effective drug delivery systems, as was covered in the preceding sections. It Is conceivable that adding particular ligands to the liposome surface

will enhance medication delivery to selected cells and or organs.

Antibody- coated liposomes, also known as immune liposomes, have been studied for this purpose for many years. Immuno liposomes' clinical efficacy is still up in the air, though. Other small compounds, including vitamins, peptides, aptamers, and Affibodies 94-96, have also been investigated to enhance liposome targeting in addition to using antibodies as ligands. The idea that "targeted liposomes" are superior to non-targeted liposomes has been contested and is the topic of a lot of discussion. This section will give age neural overview of the different liposome targeting techniques (including examples of specific ligands, conjugation methods, and biological systems employed, as well as weigh the advantages and disadvantages of target Ed versus non targeted liposomes and their capacity to target particular molecular signatures expresses don cell surfaces.

1. TARGETING LIPOSOMES: GENERAL CONSIDERATION

The benefit of delivering anticancer drugs to tumor tissue utilizing nanocarriers, such as liposomes (size range100-200 nm), has been extensively addressed.2 Because drug-loaded nanocarriers are known to accumulate in the tumor area due to the leaky vasculature-enhanced permeability and retention (EPR) effect (non-targeted liposomes), this anticancer therapy strategy uses "passive targeting" of the drug-loaded nanocarriers. This result, caused by the increased permeability of capillaries in the tumor location, illustrates the anatomical differences between healthy and malignant tissue. The level of tumor vascularization and angiogenesis, as well as the porosity and pore size of tumor arteries, which vary depending on the kind and stage of the tumors, are all important factors that affect the passive targeting impact. The pharmacokinetics and biodistribution of the liposomes are influenced y these variables. The outcome of a successful treatment will also be influenced by other "passive targeting" relate dissues, such as the kinetics of drug release, efflux released drug in to the tumor cells ,and tumor retention.

2. TARGETING LIGANDS:-

To target liposomes to tumors and take advantage of over expressed receptors, a number of potential ligands have been investigated ; they include antibodies, affibodies, and tiny ligands including folate, aptamers, peptides and lectins. The following characteristics of a possible ligand can be broadly categorized based on their potential for targeting liposomes for site-specific drug delivery: Large-scale ligand synthesis methods, stable ligand purification methods, and ligand-liposome conjugation methods without sacrificing the characteristics of the ligand or the liposomes itself. Antibodies have received the most attention out of all the ligands that have been researched so far, and they will be covered in great detail. In this section, we also give a summary of affi bodies and folate targeting

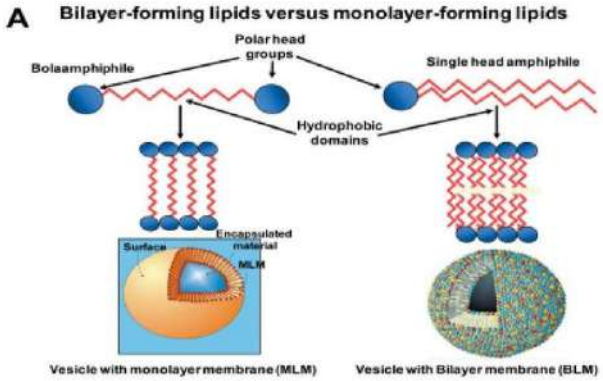
2.1. Immunoliposomes

Since the availability of phage display technology, monoclonal antibodies (mAb), and detailed structural analysis of antibodies (for more information on therapeutic antibodies, see Therapeutic Antibodies: Methods and Protocols by A.S. Dimitrov, Humana Press, NY), immunotherapy has been studied. mAbs, which include Herceptin for breast cancer and Epratuzumab for B-cell lymphoma, are currently accessible therapeutic antibodies; for this reason, they have been the favored choice of molecules for producingimmunoliposomes.Onebenefitofemploy ingmAbsistheirstabilityandincreasedbindingavidit y,whichresult from the molecule's two binding sites. The Fc-receptor binding of mAb can result in antibody- and complement-dependent cellular cytotoxicity, which may improve the death of tumor cells. However, the Immune liposomes may

be highly absorbed by the liver and spleen and may become more immune genic as are sult of the Receptor-mediate responses. F(ab′)2, Fab′, and sc Fv fragments that lack the Fcdomain and the complement activating region are among the alterations to the entire antibody molecule (Fig.6B),which may lessen their immunogenicity. When kept in storage, 108 F(ab′)2 fragments can maintain two binding areas that are connected by disulfide bonds. Disulfide linkages are broken down under reducing circumstances to produce two Fab′ fragments, which are excellent for attaching to lipid- based nanoparticles. Due to the single binding domain in Fab′ and scFv fragments, their avidity for binding is reduced. However, the avidity can be increased by attaching multiple fragments to the surface of immune liposomes or by creating bivalent or multivalent fragments. The use of scFv fragments is appealing due to their simplicity in manufacture (through phage display)and identification, as well as the fact that they reduce immunogenicity. These little pieces, meanwhile, might not be as stable in storage as Fab′ fragments or entire mAbs. The use of antibody-directed nanotechnology systems for diagnostics, imaging, and therapy is the subject of intense research. One of these long-studied nanoparticles is the antibody-coated liposome (also known as an immunoliposome), and as was already said, there is still much disagreement over the real-world uses for these particles. In the past, chemical alterations of amine utilizing bifunctional reagents were used in the first attempts to attach the whole-antibody molecules to the liposome surface. The weakened active domains of the antibodies and lack of specificity made this technique problematic.112 Since scFv (with modified cysteines at the C-termini) is readily available, the pre dominant method for antibody conjugation is now based on the maleimide-cysteine reaction, which forms thio-ether linkages between proteins and liposomes. There are two ways to transform liposomes into targeted liposomes. In the first procedure, ligands are attached to end- functionalized groups in PEG lipid micelles using a flexible "post-insertion technique."

2.2. Monolayer Membrane from Bola amphiphiles:-

Two hydrophilic head groups are present at both ends of a hydrophobic domaining special family of lipids known as bola amphiphiles (also known as bolalipids). Bola amphiphiles have the potential to create monolayer membranes128 as opposed to single-hydrophilic head amphiphiles, like phospholipids, which often form bi layer membranes. **Bola amphiphile**-based membrane esare more ro bustandless permeable than monopolar lipid-based membranes, according to studies. The potential use of bola amphiphiles as membrane-stabilizing substances in applications like medication delivery and membrane-protein-based biosensors has sparked interest due to this special mix of characteristics.



3. SOLID LIPID NANOPARTICLES (SLN) AND NANOSTRUCTURED LIPIDCARRIERS (NLC):-

There is an to create alternative methods for nanoparticles based on lipid components other than phosphor lipids, even though liposomes have been the standard for lipid-based nanoparticles for site-specific delivery of medications and pharmaceuticals. It is believed that these drug carriers may enable more precise medication delivery of therapies that may not load into

liposomes as efficiently. The development of SLN and NLC in comparison to other drug-delivery systems makes them potentially appealing, marketable options because of their natural ingredients and simple, scale able production procedures. Both SLN and NLC are ideally suited for industrial manufacture since the high-pressure homogenization process may be used with current equipment to prevent the need of solvents. Additionally, the hydrophobic center of these molecules offer Sa favorable setting for the trapping of hydrophobic medicines. This is significant because 40% or so of recently produced medications have hydrophobic properties. Since the early 1990s and the late 1990s, numerous papers have discussed various SLN formulations and NLC formulations that may be used in drug delivery systems. A solid lipid core that may comprise triglycerides, glyceride mixes, or waxes that are solid at both room temperature and human body temperature makes up the SLN structure.

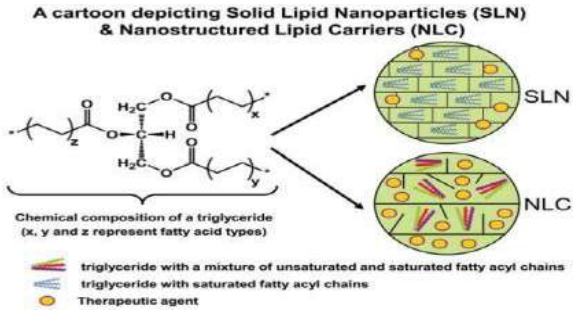


Figure 9 : shows a potential triglyceride assembly that could result in the production of SLN and NLC.

3.1.Formation of SLN and NLC:-

1. SLN:- Numerous techniques can be used to encapsulate drug solutions into SLN, including high-pressure homogenization, microemulsion formation, solvent injection (or solvent displacement), emulsification-solvent evaporation (precipitation), phase inversion, multiple emulsion technique, 206, 207ultrasonication, and membrane contractor technique.209-211 A typical SLN formulation includes 0.1% to 30% solid lipid content, including one or more of the base ingredients (trimyristin, tristearin, trilaurin, stearic acid, glyceryl caprate as Capmul ®MCM C10, the obroma oil, triglyceride coconut oil, 1-octadecanol, glycerol behenate as Compritol®888 ATO, glycerol palmitostearate as Precirol® ATO 5, and cetylpalmitate wax); 0.5% to 30% surfactant stabilizer (examples previously mentioned); and 5% of the incorporated drug. Curdlan and PEG molecules have been utilized for in vivo circulation times that are longer. Depending on their chemical characteristics, drug molecules can be encapsulated at different points inside the SLN. Due to their miscibility in the lipid matrix, lipophilic medications will disperse well, but hydrophilic pharmaceuticals are thermodynamically immiscible and will separate to the exterior of the lipid matrix. Drugs are often dispersed into a melted-lipid phase (precursor emulsion)during the SLN assembly process, either by employing the proper solvent(s) or by applying mechanical forces. The medication must properly partition into the lipid droplets in order for the drug to successfully load into the SLN. Fast cooling during the SLN synthesis process results in an unsteady and disordered -crystalline structure that enables the desired medicine to be stored in the amorphous regions of the nanoparticle. This -crystalline state can change into a thermodynamically stable -crystalline state throughout the storage period. Ther ate of lipid matrix recrystallization and the crystalline structure that results determine how precisely the medication is partitioned in SLN. A highly ordered and organized crystalline structure is not preferred for increased drug-loading capabilities because drug molecules integrate between the fatty acid chains, lipid layers, and in regions of crystal defects.

2. NLC

Similar to SLN, NLC is produced by combining lipids from the solid- and liquid-phases. Upon initial NLC manufacturing, roughly 5% of

medicine (byweight) is typically included in the lipid mixture, and approximately 3% to4% drug loading is accomplished (with typical encapsulation efficiencies of around 70%).199, 212 Mono stearin, stearic acid, glyceryl dilaurate, hydrine, glyceryl monostearate, cetyl alcohol, and imwitor 900 are examples of common solid-phase lipids used; oleic acid, capmul glyceryl mono-dicaprylate, and caprylic/caprictri glycerides are common liquid-phase lipids used. For the purpose of producing a stable drug-loaded NLC, the right lipid selection is essential. The type of solid lipid added to the NLC determines the drugs chemical stability. In as a me manner, drug incorporation into NLC lattice defects may affect particle stability, most likely improving
stability. Additionally, potential drug-lipid interactions before and after NLC synthesis need to be taken into account. For instance, medication degradation may be brought on by lipid auto-oxidation. Similar to this, the amount of integrated liquid-phase lipid can affect the size and surface shape of particles. Hu et al. demonstrated that particle size decreased and particle shape improved as the concentration of the liquid-phase lipid oleic acid rose upto roughly 30%. Additionally, their research suggests that the initial rate of medication release is regulated by the content of oleic acid. Based on the structure of their lipid matrix, NLC may be categorized into three groups: the imperfect type, multiple kinds, and amorphous or structureless type. As a result of flaws in the lipid matrix and drug storage compartments, the imperfect kind of NLC contains the least amount of liquid-phase lipid (oil) and is made up of saturated and unsaturated lipids with different fatty acid chain lengths.

3. Stabilization:-

The stabilization of SLN and NLC in vitro and in vivo is often accomplished through PEGylation or polymer coating (e.g., PEG2000, PVA, poloxamers), 218-221 which has already been employed for the stabilization of doxorubicin formulated liposomes (i.e.,Doxil®). PEG molecules are added to limit immune protein adsorption and reduce macro phage phagocytic absorption, lengthening the duration that blood plasma circulates. PEG has been conjugated to monostearate (PEG-SA)and successfully integrated into lipid matrices. However, the addition of PEG-SA to NLC decreased the effectiveness of drug encapsulation and accelerated the rate of drug release. PEG lipids are typically melted together after being combined with other substances. Doxorubicin plasma concentration was found to be increased by an SLN carrier five times, while PEG-stabilized stearic acid SLN was found to increase the concentration by seven times.224 PEGylation has also been demonstrated to improve the oral absorption of peptide medications, such as calcitonin.225 However, research has shown that when lecithin-based (such as Epikuron 200) surfactants were used for stabilization, SLN itself enhanced drug circulation time considerably, resulting in higher drug concentration in the bloodstream. The" steal the effect" was not discovered to be significant in these SLN ,and further research is needed to comprehend this effect with SLN when PEGylation is used.

- **Advantages of liposphere and PNL drug delivery system:-**

1. From 1996 about the high dispersibility of a substance in an aqueous medium. Dispersibility refers to the ability of a substance to be dispersed or distributed evenly within a medium, such as water.
2. Ease of preparation and scale-up" likely refers to the simplicity and feasibility of preparing the substance or material in question on a larger scale without compromising its quality or properties.
3. Lipospheres" are lipid-based systems used to encapsulate active ingredients for various

purposes, such as drug delivery or cosmetic formulations.

4. Reduced mobility of incorporated drug molecules within a formulation, such as in lipospheres or other drug delivery systems, can indeed contribute to the reduction of drug leakage. When drug molecules have limited mobility or are more tightly bound within the carrier system, it can minimize their ability to diffuse out of the carrier structure.
5. The presence of a static interface in a system involving carrier particles with a solidified lipid matrix can be advantageous for surface modification. A static interface refers to a stable boundary or surface within the system that remains relatively unchanged or static over time.
6. Low cost of ingredients.
7. Sustained drug release following a solitary injection, where the drug encapsulated within a carrier is gradually released over an extended duration.
8. The controlled size of liposphere particles enables their administration at various locations, such as perineural, subcutaneous, or intramuscular sites. The smaller particle size, typically under 20 µm, is believed to be easily tolerated by individual cells, while larger particles, over 50 µm, tend to exhibit increased reactivity due to attractive forces like Van der Waals interactions.

- **Disadvantages of liposphere/PNL DDS:-**

1. The drug loading capacity for hydrophilic proteins is relatively low, as discussed by Chime and on yishi in their work published in 3037.
2. Insufficient stability data.
3. High pressure can indeed induce drug degradation in certain cases. When substances are subjected to high pressure, particularly in pharmaceutical formulations or chemical processes, it can lead to alterations in molecular structures and chemical compositions.
4. Variable kinetics of distribution process.
5. Various modifications to lipids and the coexistence of different colloidal species in a formulation can result in differences in the solubility and melting points of active ingredients and excipients. These alterations in lipid structures and colloidal compositions can impact how well substances dissolve and their temperature at which they melt, affecting the overall stability and characteristics of the formulation. Understanding and managing these variations are crucial in pharmaceutical formulation to ensure desired solubility, stability, and physical properties of the final product.

- **Therapeutic Drug Delivery**

Therapeutic drug delivery by SLN and NLC has multiple benefits: they can control and prolong drug release; they can encapsulate different medications; they can prolong blood circulation time and make use of the EPR effect to improve treatment. Drugs that are hydrophobic and have a short half-life in circulation make excellent candidates for delivery Via SLN and NLC .Many proteins and peptides with medicinal activity are currently being created. However, they frequently have a restricted ability to cross cell membranes and a brief half-life in the body. Because it can prevent the protein or peptide from degrading and possibly transport the treatment in to the cell interior, NLC may be the optimal carrier for their administration. However, it is not always possible to encapsulate peptides and proteins into these lipid carriers. Proteins may be denatured and degraded by high temperatures associated with HPG and solvents associated with other manufacturing techniques. By employing lipid drug conjugates, hydrophilic medications are also candidates for delivery by lipid nanoparticles. Chemical reactivity is frequently present in

pharmaceutical substances. Labileanticance medication's that are known to be prone to hydrolysis can be protected by SLN and NLC ,allowing the active medications to last longer in the bloodstream. One such is the SN-38 molecule, an irinotecan pro-drug that is comparatively hydrophilic and also contains a labile lactone structure similar to camptothecin. The hydrolysis of the medication was protected and the therapeutic efficacy was boosted by SLN loaded with SN-38. Additionally, in vivo investigations using naked mice revealed a prolonged half-life of the active lactone drug for min the entire blood. Prednisolone, doxorubicin, and retinol are just a few of the medications that have been successfully combined into SLN. The anticancer medication's doxorubicin and paclitaxel have also been effective onto NLC.

- **Targeting Ligands:-**

1. SLN:-

To reduce side effects and increase specificity to regions of interest, SLN targeting techniques for tumor sites might be combined. Liposomal-targeting strategies (i.e., ligand binding to the surface of nanoparticles) have been directly adpted to SLN formulations. To precisely target the asialo-glyco protein receptor anhepatia cellular carcinoma cells, research ershave created docetaxel-loaded SLN with agalactosylated conjugated DOPE lipid. Afolate-targeted SLN system that was created for the delivery of the medication paclitaxel has undergone additional research. In comparison to non-targeted SLN, then targeted formulation increased drug uptake and cytotoxicity in folate receptor cell lines and markedly increased in vivo tumor growth suppression and tumor-bearing animal survival. SLN with galactosylatedormannosylated lipids have been used for liver targeting in particular. Glycosylated SLN revealed further boost when comparing in vitro activity and in vivo biodistribution of all formulations, even though SLN with and without glycosylation showed higher liver targeting when compared with free drug solutions .Additionally, these nanoparticles have been used to carry medications to the brain.

2.Future Outlook for Drug Delivery Using Lipid-Based Nanoparticles

Several nanotechnology platforms are being created right now with the goal of enhancing medicine delivery, particularly to fight cancer. Lipid-based nanoparticles are among the most extensively researched nanocarriers and one of the most promising drug delivery possibilities. Table 4 provides a summary of the several systems mentioned here. Only a small number of formulations have so far received clinical use approval, despite significant efforts. Additionally, the clinical uses of targeted nanoparticles are still unknown. It is essential to revisit the present methods and tactics used in the creation and development of these anticancer nanocarriers. Our opinion is that efforts should be concentrated mainly on two areas: technical aspects, such as fabrication strategies, the development of reproducible nanocarriers, large-scale production, and the conjugation of targeting molecules, such as scFvs and peptides, to the nanoparticle surface; and novel concepts and approaches to achieve on-demand release of drugs from the nanoparticles (based on the special properties of the assembly components of lipid-basic nanoparticles).We believe that on- demand drug-phospho lipid assemblies(liposomes) have a bright future since on-demand drug release from targeted nanoparticles is progressing. Bola lipids differ from glycerol-based phosphor lipids (used to make liposomes)in a number of ways, and research into their potential as nano carriers is still in its infancy. Therefore, it is unclear how bola lipid drug-delivery.

CONCLUSION

Numerous drug delivery systems are explored continuously on the laboratory and industrial

levels. Convenience of large-scale production and stability of drugs and carrier systems are two key factors in the dosage form development. Production of these lipid nanocarriers is possible on large scale by applying suitable method such as High-Pressure Homogenization. Several experiments have proved the improvement in stability of drugs and carriers itself by adapting NLC approach over other lipid systems. As lipid structure of carriers is having close resemblance with lipid structures of our bio membranes, drug delivered by using NLCs is advantageous over polymeric systems. Biocompatible and biodegradable nature of lipids allows the intravenous administration of carriers which is not recommended in case of certain synthetic and semi-synthetic polymeric carriers. Systemic exposure of NLCs does not cause any kind of toxicity; hence its use in the diagnostic fields is also possible. Surface of these carriers can be easily modified for specificity and targeting. Even drug delivery to central nervous system and resistant tumors can be achieved easily with the help of NLCs as compared to polymeric systems. This versatile drug delivery system is currently utilized in various cosmetics products and chemotherapeutic agents' delivery. Considering its biological suitability, higher drug load, stability and biocompatibility NLCs will be the most appreciated topic of research in the medicines

APPLICATION

In pharmaceutical technology, lipids and polymers are considered pillar excipients for the fabrication of most dosage forms, irrespective of the administration route. They play various roles ranging from support vehicles to release rate modifiers, stabilizers, solubilizers, permeation enhancers and transfection agents

REFERENCES

1. Müller, Rainer H., KarstenMäder, and Sven Gohla. "Solid lipid nanoparticles (SLN) for controlled drug delivery–a review of the state of the art." European journal of pharmaceutics and biopharmaceutics 50.1 (2000): 161-177.
2. Fang, Chia-Lang, Saleh A Al-Suwayeh, and Jia-You Fang. "Nanostructured lipid carriers (NLCs) for drug delivery and targeting." Recent patents on nanotechnology 7.1 (2013): 41-55
3. Khan, Saba, et al. "Nanostructured lipid carriers: an emerging platform for improving oral bioavailability of lipophilic drugs." International journal of pharmaceutical investigation 5.4 (2015): 182.
4. J. Pardeike, A. Hommoss, R.H. Muller, Lipid nanoparticles (SLN, NLC) in cosmetic and pharmaceutical dermal products, Int. J. Pharm. 366 (2009) 170–184, https://doi.org/10.1016/j.ijpharm.2008.10.003.
5. Beloqui, Ana, et al. "Nanostructured lipid carriers: Promising drug delivery systems for future clinics." Nanomedicine: Nanotechnology, biology and medicine 12.1 (2016): 143-161.
6. Selvamuthukumar, Subramanian, and RamaiyanVelmurugan. "Nanostructured lipid carriers: a potential drug carrier for cancer chemotherapy." Lipids in health and disease 11.1 (2012): 1-8.
7. Carbone, Claudia, et al. "Pharmaceutical and biomedical applications of lipid-based nanocarriers." Pharmaceutical patent analyst 3.2 (2014): 199-215.
8. Müller, R. H., M. Radtke, and SA12176234 Wissing. "Nanostructured lipid matrices for improved microencapsulation of drugs." International journal of pharmaceutics 242.1-2 (2002): 121-128.
9. Shidhaye, S. S., et al. "Solid lipid nanoparticles and nanostructured lipid carriers-innovative generations of solid lipid carriers." Current drug delivery 5.4 (2008): 324-331.

10. Das, Surajit, WaiKiong Ng, and Reginald BH Tan. "Are nanostructured lipid carriers (NLCs) better than solid lipid nanoparticles (SLNs): development, characterizations and comparative evaluations of clotrimazole-loaded SLNs and NLCs?." European journal of pharmaceutical sciences 47.1 (2012): 139-151.
11. Balguri, SaiPrachetan, Goutham R. Adelli, and SoumyajitMajumdar. "Topical ophthalmic lipid nanoparticle formulations (SLN, NLC) of indomethacin for delivery to the posterior segment ocular tissues." European Journal of Pharmaceutics and Biopharmaceutics 109 (2016): 224-235.
12. Wu, Miaojing, et al. "Vincristine and temozolomide combined chemotherapy for the treatment of glioma: a comparison of solid lipid nanoparticles and nanostructured lipid carriers for dual drugs delivery." Drug delivery 23.8 (2016): 2720-2725.
13. Das, Surajit, and AnumitaChaudhury. "Recent advances in lipid nanoparticle formulations with solid matrix for oral drug delivery." AapsPharmscitech 12 (2011): 62-76.
14. Lim, Wei Meng, et al. "Formulation and delivery of itraconazole to the brain using a nanolipid carrier system." International journal of nanomedicine (2014): 2117-2126.
15. Kutscher, Marika, et al. "Influence of salt type and ionic strength on self-assembly of dextran sulfate-ciprofloxacin nanoplexes." International journal of pharmaceutics 486.1-2 (2015): 21-29.
16. El-Helw, Abdel-Rahim M., and Usama A. Fahmy. "Improvement of fluvastatin bioavailability by loading on nanostructured lipid carriers." International journal of nanomedicine (2015): 5797-5804.
17. Shah, Nirmal V., et al. "Nanostructured lipid carriers for oral bioavailability enhancement of raloxifene: Design and in vivo study." Journal of advanced research 7.3 (2016): 423-434.
18. Iqbal, MdAsif, et al. "Nanostructured lipid carriers system: recent advances in drug delivery." Journal of drug targeting 20.10 (2012): 813-830.
19. Zhang, Kunchi, et al. "Preparation, characterization, and in vivo pharmacokinetics of nanostructured lipid carriers loaded with oleanolic acid and gentiopicrin." International journal of nanomedicine (2013): 3227-3239.
20. Joshi, M., and V. Patravale. "Formulation and evaluation of nanostructured lipid carrier (NLC)–based gel of Valdecoxib." Drug development and industrial pharmacy 32.8 (2006): 911-918.
21. A.M. Bhagurkar, M.A. Repka, S.N. Murthy, A novel approach for the development V.R. Salvi and P. Pawar Journal of Drug Delivery Science and Technology 51 (2019) 255–267 264 of a Nanostructured Lipid Carrier formulation by hot-melt extrusion technology, J. Pharm. Sci. 106 (2017) 1085–1091, https://doi.org/10.1016/j.xphs.2016.12. 015
22. Carbone, Claudia, et al. "Lipid-based nanocarriers for drug delivery and targeting: a patent survey of methods of production and characterization." Pharmaceutical patent analyst 2.5 (2013): 665-677.
23. Beloqui, Ana, et al. "Fate of nanostructured lipid carriers (NLCs) following the oral route: design, pharmacokinetics and biodistribution." Journal of microencapsulation 31.1 (2014): 1-8.
24. Shangguan, Mingzhu, et al. "Binary lipids-based nanostructured lipid carriers for improved oral bioavailability of silymarin." Journal of biomaterials applications 28.6 (2014): 887-896.
25. Tian, Cihui, et al. "N-acetyl-L-cysteine functionalized nanostructured lipid carrier for

improving oral bioavailability of curcumin: preparation, in vitro and in vivo evaluations." Drug delivery 24.1 (2017): 1605-1616.

26. Ling Tan, Janet Sui, Clive J. Roberts, and NashiruBilla. "Mucoadhesive chitosan-coated nanostructured lipid carriers for oral delivery of amphotericin B." Pharmaceutical development and technology 24.4 (2019): 504-512.
27. Khan, Saba, et al. "Tacrolimus-loaded nanostructured lipid carriers for oral delivery-in vivobioavailability enhancement." European Journal of Pharmaceutics and Biopharmaceutics 109 (2016): 149-157.
28. Zhuang, Chun-Yang, et al. "Preparation and characterization of vinpocetine loaded nanostructured lipid carriers (NLC) for improved oral bioavailability." International journal of pharmaceutics 394.1-2 (2010): 179-185.
29. Lin, Congcong, et al. "A novel oral delivery system consisting in “drug-in cyclodextrin-in nanostructured lipid carriers” for poorly water-soluble drug: Vinpocetine." International Journal of Pharmaceutics 465.1-2 (2014): 90-96.
30. Rizwanullah, Md, Saima Amin, and Javed Ahmad. "Improved pharmacokinetics and antihyperlipidemic efficacy of rosuvastatin-loaded nanostructured lipid carriers." Journal of drug targeting 25.1 (2017): 58-74.
31. Elmowafy, Mohammed, et al. "Atorvastatin-loaded nanostructured lipid carriers (NLCs): strategy to overcome oral delivery drawbacks." Drug delivery 24.1 (2017): 932-941.
32. Fang, Guihua, et al. "Cysteine-functionalized nanostructured lipid carriers for oral delivery of docetaxel: a permeability and pharmacokinetic study." Molecular pharmaceutics 12.7 (2015): 2384-2395.
33. Dudhipala, Narendar, KarthikYadavJanga, and ThirupathiGorre. "Comparative study of nisoldipine-loaded nanostructured lipid carriers and solid lipid nanoparticles for oral delivery: preparation, characterization, permeation and pharmacokinetic evaluation." Artificial cells, nanomedicine, and biotechnology 46.sup2 (2018): 616-625.
34. Elmowafy, Mohammed, et al. "Multifunctional carbamazepine loaded nanostructured lipid carrier (NLC) formulation." International journal of pharmaceutics 550.1-2 (2018): 359-371.
35. Czajkowska-Kośnik, Anna, Marta Szekalska, and KatarzynaWinnicka. "Nanostructured lipid carriers: A potential use for skin drug delivery systems." Pharmacological Reports 71.1 (2019): 156-166.
36. Puglia, Carmelo, and Francesco Bonina. "Lipid nanoparticles as novel delivery systems for cosmetics and dermal pharmaceuticals." Expert Opinion on Drug Delivery 9.4 (2012): 429-441.
37. Gaba, Bharti, et al. "Nanostructured lipid carrier system for topical delivery of terbinafine hydrochloride." Bulletin of Faculty of Pharmacy, Cairo University 53.2 (2015): 147-159.
38. Lin, Wen Jen, and Yi Shein Duh. "Nanostructured lipid carriers for transdermal delivery of acid labile lansoprazole." European Journal of Pharmaceutics and Biopharmaceutics 108 (2016): 297-303.
39. Kawadkar, Jitendra, et al. "Formulation, characterization and in vitro–in vivo evaluation of flurbiprofen-loaded nanostructured lipid carriers for transdermal delivery." Drug development and industrial pharmacy 39.4 (2013): 569-578.
40. Kutscher, Marika, et al. "Influence of salt type and ionic strength on self-assembly of dextran sulfate-ciprofloxacin nanoplexes."

International journal of pharmaceutics 486.1-2 (2015): 21-29.

41. Nagaich, Upendra, and NehaGulati. "Nanostructured lipid carriers (NLC) based controlled release topical gel of clobetasol propionate: design and in vivo characterization." Drug delivery and translational research 6 (2016): 289-298.
42. Tripathi, Priyanka, et al. "Carbomer gel bearing methotrexate loaded lipid nanocontainers shows improved topical delivery intended for effective management of psoriasis." International journal of biological macromolecules 120 (2018): 1322-1334.
43. Guo, Teng, et al. "Nanostructured lipid carriers for percutaneous administration of alkaloids isolated from Aconitum sinomontanum." Journal of nanobiotechnology 13 (2015): 1-14.
44. Shamma, Rehab Nabil, and Mona Hassan Aburahma. "Follicular delivery of spironolactone via nanostructured lipid carriers for management of alopecia." International journal of nanomedicine (2014): 5449-5460.
45. You, Peijun, Ran Yuan, and Chuanyu Chen. "Design and evaluation of lidocaine-and prilocaine-coloadednanoparticulate drug delivery systems for topical anesthetic analgesic therapy: a comparison between solid lipid nanoparticles and nanostructured lipid carriers." Drug Design, Development and Therapy (2017): 2743-2752.
46. Keck, C. M., et al. "A new concept for the treatment of atopic dermatitis: Silver–nanolipid complex (sNLC)." International journal of pharmaceutics 462.1-2 (2014): 44-51.
47. Brugè, Francesca, et al. "A comparative study on the possible cytotoxic effects of different nanostructured lipid carrier (NLC) compositions in human dermal fibroblasts." International Journal of Pharmaceutics 495.2 (2015): 879-885.
48. Sánchez-López, E., et al. "Lipid nanoparticles (SLN, NLC): Overcoming the anatomical and physiological barriers of the eye–Part I–Barriers and determining factors in ocular delivery." European Journal of Pharmaceutics and Biopharmaceutics 110 (2017): 70-75.
49. Fu, Tian, et al. "Ocular amphotericin B delivery by chitosan-modified nanostructured lipid carriers for fungal keratitis-targeted therapy." Journal of liposome research 27.3 (2017): 228-233.

HOW TO CITE: Pranali Subhashrao Jadhav*,Pranali Hatwar, Gajanan Sanap, Review On Lipid Based Carrier As A Drug Delivery System, Int. J. in Pharm. Sci., 2023, Vol 1, Issue 12, 179-191. https://doi.org/10.5281/zenodo.10352354