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LIPOSOMES: A NOVEL DRUG DELIVERY SYSTEM

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Abstract:

liposomes are the microscopic vesicles in which an aqueous volume is entirely enclosed by a membrane of lipid molecule. Liposomes are sphere-shaped vesicles made up of one or more bilayers of phospholipid. Site-targeting sustained or controlled release, protection of pharmaceuticals from degradation and clearance, improved therapeutic benefits, and fewer harmful side effects are among the many of the advantages liposomes have over standard drug delivery systems. Currently, a number of liposomal-based drug delivery methods are clinically licensed to treat a variety of illnesses, including cancer, fungal infections, and viral infections; more liposomes have advanced to the phase of clinical testing. With continuous developments broadening their potential impact, liposomes constitute a promising platform in biotechnology and medicine, providing adaptable solutions for drug delivery, diagnostics, and other applications. This review describes liposome's structure, composition, preparation methods, and clinical applications

Key words: Liposomes, drug delivery, phospholipid.

Introduction:

The deliberate creation, characterization, manufacturing, and application of materials, structures, devices, and systems by regulating their size and form in the nanoscale range (1 to 100 nm) is known as nanotechnology. Nanotechnology may be helpful in the medical field since nanoparticles can be created to perform a variety of tasks and share similarities in scale with biologic molecules and systems. The goal of the field of nanomedicine is to diagnose and treat diseases at the molecular level by utilizing the physical and chemical properties of nanomaterials. (1) Liposomes are closed, spherical structures made of phospholipids with a colloidal size range of 5–200 nm. They have one or more concentric or non-concentric membranes with a thickness of around 4 mm. The liposomes' distinctive properties, such as their ability to self-seal in aqueous conditions, are made possible by their amphiphilic phospholipid composition, which has a hydrophilic head and a hydrophobic tail. (2)

At the Babraham Institute, British haematologist Dr. Alec D. Bangham FRS initially described liposomes in 1961 (published in 1964). in Cambridge. They were found when R. W. Horne and Bangham added negative stain to dry phospholipids in order to test the institute's new electron microscope. The images captured by the microscope provided the first concrete proof that the cell membrane is a bilayer lipid structure, as the similarity to the plasmalemma was evident. Originating from two Greek words, "Lipos" (fat) and "Soma" (body), comes the term liposome. (3) Apart from the particular medications, liposomes are a great way to distribute drugs. Nevertheless, the benefits of liposomes have not yet been completely realized, as there are now just 14 different kinds of liposomal products on the market. As a result, we compiled our knowledge of commercial liposomal products that have received FDA and EMA approval in this review. The materials used in commercial products and the production processes used are taken into consideration. Furthermore, the regulatory landscape of today, the CQAs of liposomes, and future directions are presented. This review's main goal is to offer crucial reference material that will hasten the development of liposomes.

Composition of liposomes:

Liposomes composed of

A) phospholipids

B) cholesterols

C) surfactant

A) **phospholipids**

Phospholipids are liposome's main structural components. The hydrophilic heads of phospholipids are paired with hydrophobic tails. Phosphatidylcholine, phosphatidylethanolamine, and phosphatidylserine are examples of commonly utilized phospholipids. Phosphatidylcholine has had a significant influence on medication delivery technology in recent years. The first and most significant benefit of the phospholipid-based vesicular system is that phospholipids are compatible with both the human skin's exterior membrane and interior membrane. glycerophospholipid (GP), sphingomyelin (SM), are the basic components used in the marketed products. GP contains glycerol, which links a pair of hydrophobic fatty acid chains and a hydrophilic polar head group. The hydrophilic group in the lipids may be negatively, positively charged, or zwitterionic (both negative and positive charge in the same molecule). The charge of the hydrophilic group provides stability through electrostatic repels. The hydrophobic group of lipids varies in the acyl chain length, symmetry, and saturation. (4)

The lipid which are used in the preparation of the liposomes are classified as follows:

a) Natural lipid:

Normal cell membrane bilayers are mostly made of glycophospholipids. A glycerol unit is joined to two fatty acid molecules and a phosphate group (PO_4^{2-}) to form phospholipids. The Phosphate groups can also form bonds with small, vital chemical molecules like choline. Egg yolks and soy beans are two common sources of natural phospholipids. Phospholipids are classified as phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidylserine (PS), phosphatidylinositol (PI), phosphatidylglycerol (PG), and phosphatidic acid (PA) regarding to the polar head groups. Phospholipid contain various fatty acid in saturated fatty acid it contains palmitic acid, margaric acid and in unsaturated fatty acid contain oleic acid. (5)

b) Synthetic lipid:

The polar and non-polar portions of natural phospholipids are chemically modified to create synthetic phospholipids. An infinite variety of clearly defined and categorized phospholipids are made possible by the alteration. (6)

c) Steroid:

steroids are a class of lipids characterized by a specific four-ring structure, usually arranged in a configuration known as the steroid nucleus. This nucleus consists of three cyclohexane rings (designated as rings A, B, and C) and one cyclopentane ring (designated as ring D). cholesterol is the major steroid that are used in the preparation of the liposomes. (7)

B) **cholesterol:**

cholesterol is classified as a sterol, a subgroup of steroids. Chemically, it is a waxy, fat-like substance that is insoluble in water. Cholesterol molecules consist of a four-ring structure with a hydrocarbon tail. the cholesterol can promote the lipid chain packing and bilayer formation. Cholesterol dose not by itself form bilayer structure, but can be incorporated into phospholipid membranes in very high concentration up to 1:1 or even 2:1 molar ration of cholesterol to phosphatidylcholine. The cholesterol incorporation increases the separation between the choline head group and eliminates the normal electrostatic and hydrogen bonding interaction. the cholesterol plays important role in the formation of the bilayer. Cholesterol act as fluidity buffer. After the intercalation with the phospholipid molecule alter the freedom of motion of carbon molecule in the acyl chain. (8)

C) surfactant:

Surfactants were added to liposome formulations to change the liposome's encapsulation and release characteristics by reducing surface tension between various immiscible phases. Surfactants are single-acyl-chain amphiphiles that increase the deformability of nano-vessels by disrupting the lipid bilayer of liposomal nanoparticles. span 60, span 80, tween 60, tween 80 and sodium cholate are the mostly used surfactant in the formulation of the liposomes. The various surfactant containing liposomes are used in the drug delivery system. (9)

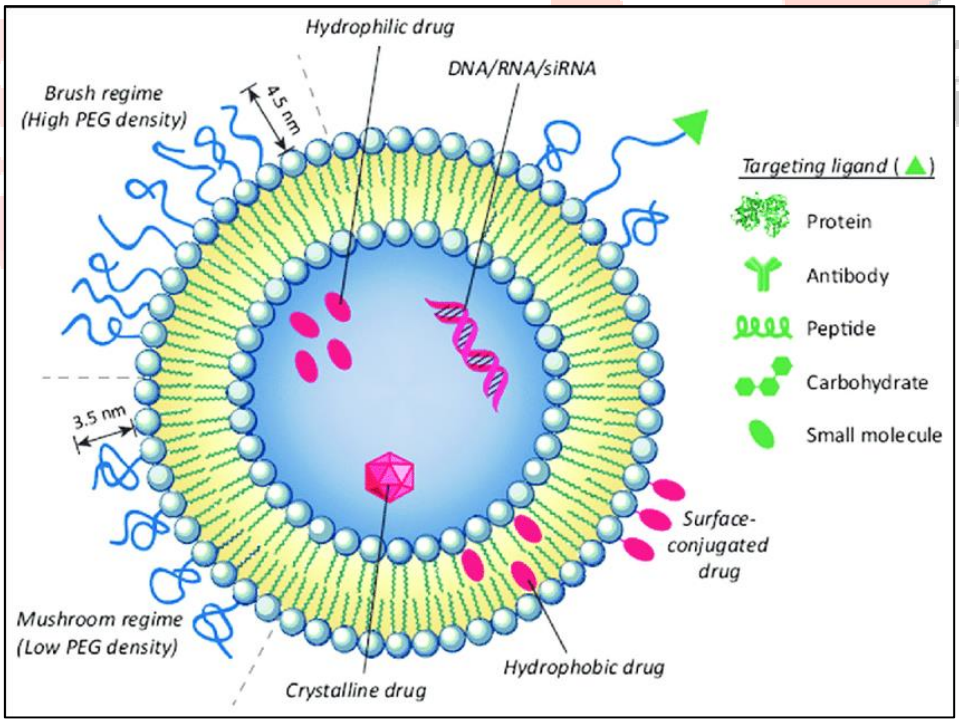


Fig. structural features of liposomal drug delivery

Mechanism of formation of liposomes:

phospholipids contain a hydrophobic tail and a hydrophilic or polar head, phospholipids are amphipathic, meaning they exhibit affinity for molecules of both polar and aqueous moieties. The two fatty acid chains, each with 0–6 double bonds and 10–24 carbon atoms, make up the hydrophobic tail. The macroscopic structures that are most frequently created are liposomes, hexasomes, or cubicosomes, which are colloidal nano constructs (artificial membranes) that are distributed as lamellar, hexagonal, or cubic phases.

Phospholipids are naturally occurring polar phospholipids that are most commonly found. These are amphipathic molecules that are connected to two hydrophobic acyl hydrocarbon chains with phosphocholine, a hydrophilic polar head group, by a glycerol bridge. Phospholipids and their analogs can form closed, concentrated bilayers in the presence of water because of their amphipathic character. Thin lipid cakes or films are hydrated to produce liposomes, which are made of stacks of lipid crystalline bilayers that swell and become fluid. During agitation, the hydrated lipid sheets separate and self-close to form huge, multilamellar vesicles that block water from interacting with the bilayer's hydrocarbon core at its borders. The polar end molecules are mainly phosphoric acid bound to a water- soluble molecule. The hydrophilic and hydrophobic domain/segment molecular geometry of amphiphilic lipid orient and self-organize in ordered supramolecular structure confronted with solvent. (10,11)

Classification of liposomes:

There are various types of liposomes

1. Based on structure
2. Based on method of preparation
3. Based on composition and application
4. Based on the speciality of liposomes

1. Based on structure:

i. Multilamellar vesicles (MLV) (>0.5 um)
ii. Oligolamellar vesicles (OLV) (0.1-1 um)
iii. Unilamellar vesicles (ULV) (all size range)
iv. Small unilamellar vesicles (SUV) (20-200 nm)
v. Medium sized unilamellar vesicles (MUV)
vi. Large unilamellar vesicles (LUV) (>100 um)
vii. Giant unilamellar vesicles (GUV) (>1um)
viii. Multi vesicular vesicles (MUV) (>1 um)

2. based on the method of preparation:

i. Vesicles prepared by reverse phase evaporation method (REV)
ii. Multi lamellar vesicles by REV (MLV-REV)
iii. Stable plurilamellar vesicles (SPLV)
iv. Frozen and thawed MLV (FATMLV)
v. vesicles prepared by extrusion techniques (VET)
vi. dried reconstituted vesicles (DRV)

3. Based on application and composition

i. CL (conventional liposomes)
ii. Fusogenic liposomes
iii. Cationic liposomes
iv. Immuno-liposomes
v. PH sensitive liposomes
vi. Long circulatory liposomes (stealth)

4. Based Upon Speciality Liposome

i. Bipolar fatty acid.
ii. Antibody directed
iii. Methyl/ Methylene x- linked
iv. Lipoprotein coated
v. Carbohydrate coated
vi. Multiple encapsulated

1. based on structure

i). Generation of the small unilamellar vesicles (SUV)

Sonication and homogenization technique is used to produce the small unilamellar vesicles. The small size of these systems (e.g., 0.025 um for egg phosphatidylcholine) results in very small trapped volumes and trapping efficiencies and can exhibit instability, fusing to form larger structures. For drug delivery or model membrane studies it is therefore generally preferable to employ LUV system. (12,10)

ii) Generation of multilamellar vesicles (MLV)

The traditional method of producing MLVs is as easy as adding water to a lipid layer and then mechanically stirring it to spread. It has recently been demonstrated that this method results in low water-soluble agent trapping efficiency. In particular, non-equilibrium solute distributions can occur when solute concentrations in the aqueous intralayer gaps within the liposomes are significantly lower than in the external bulk aqueous phase. (12,10)

iii) generation of the large unilamellar vesicles (LUV)

It is now convenient to generate LUVs without the need for organic solvents or solubilizing chemicals. Extrusion of prefabricated MLVs through polycarbonate filters with specified pore sizes is the main method. This was originally done by sequentially extruding vesicles via gradually smaller pores at low pressure (less than 550 kPa). More recently, a rapid extrusion procedure employing a purpose-built high-pressure extrusion device has been developed. This procedure allows the direct extrusion of preformed MLVs at pressures up to 5.5 MPa through filters with pore size of 0.03 pm or larger, giving rise to the rapid production of reproducible LUV preparations in the size range of 50-200 nm. Lipids that have been dissolved in ethanol or ether can be injected into an aqueous buffer to create LUVs. The lack of repeatability and the frequently restricted solubility of certain lipids in the organic solvent are two disadvantages of these latter methods. Pentane, methanol, diethyl ether, or petroleum ether can be utilized to solve similar issues. However, these methods are becoming less appealing due to the extrusion process' broad applicability and the challenges associated with removing the solvent afterwards. (10)

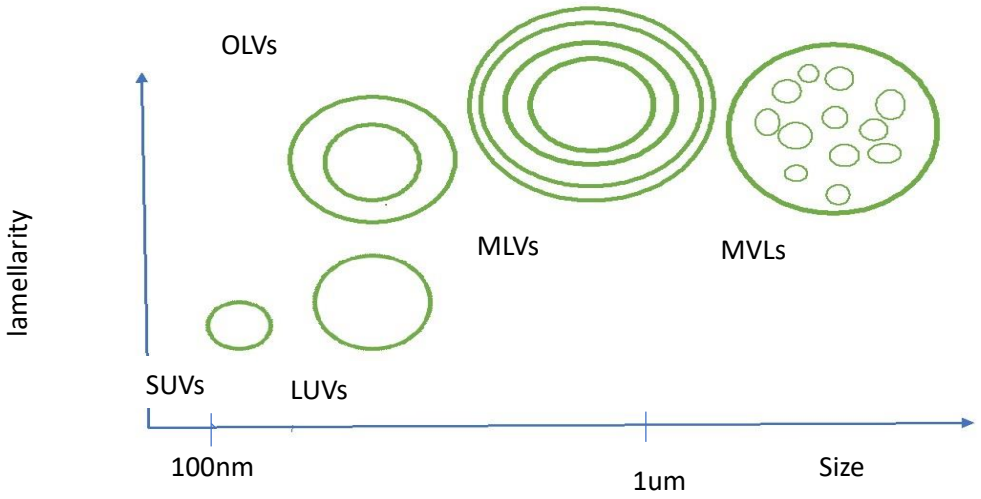


Fig.1 various types of liposomes

2) Based on the composition and application

i) Convectional liposomes (CL):

Vesicles with simple structure including; cholesterol and phospholipid are named conventional liposomes or "first-generation liposomes". This liposome was created as a liposome of the first generation using synthetic or natural phospholipids, either with or without cholesterol. By increasing liposome fluidity, cholesterol was introduced, which changed the stability and bilayer rigidity of the liposomes. Because they could be quickly accumulated in the spleen and liver and eliminated by the mononuclear phagocyte system, conventional liposomes had a short blood circulation time. As such, MPS limits the dissemination of traditional liposomes to other bodily tissues and prevents them from reaching the intended location. In vitro stability of conventional liposomes was also not very high. Consequently, higher blood circulation and improved in vivo liposome stability led to the development of stealth stable liposomes. Conventional liposomes are usually taken up into cells by phagocytosis or endocytosis and the main part of their content such as macromolecules might be degraded before reaching the cytoplasm. (13)

ii) fusogenic liposomes:

FLs are nanocarriers that have the ability to fuse with biological membranes, improving medication transport and interaction within cells. FLs are made of lipids that can destabilize biological membranes, such as cholesterylhemisuccinate (CHEMS) and dioleoyl-phosphatidylethanolamine (DOPE), which increase the fluidity of the lipid bilayer. Because of their makeup, FLs' bilayer structure effectively fuses with the cell's plasma membrane to transfer the liposomes' contents into the cytoplasm without causing any breakdown. Virosomes are among the most fascinating kinds of FLs. These FLs are created by combining UV-disabled Sendai virus with phospholipid-based conventional liposomes. Liposomes may quickly and directly fuse their membranes to deliver their contents into cells when the Sendai virus is present. These liposomes can therefore be employed as medication carriers for a specific reason. (14)

iii) PH sensitive liposomes:

It is possible to alter the composition of liposomes to achieve triggered release in reaction to external factors. The purpose of the pH-sensitive liposomes is to regulate the release of their contents in reaction to the endosomal system's acidic PH. Phosphatidylethanolamine (PE) and its derivatives, such as diacetylenic phosphatidylethanolamine (DAPE), phosphatidylethanolamine (POPE), and DOPE, are the usual lipids utilized to create pH-sensitive liposomes. They are combined with substances having an acidic group, which stabilizes the mixture at a pH of neutral. Typically, DOPE is mixed with amphiphiles that are mildly acidic, like oleic acid, CHEMS, and palmitoyl homocysteine. At neutral pH, the pH-sensitive liposomes remain stable. (15)

iv) Cationic liposomes:

Because of their ability to interact with negatively charged DNA, cationic liposomes vesicles made of positively charged lipids have found increased application in gene therapy. Positively charged cationic liposomes exhibit great reactivity with negatively charged biological membranes in cells, and they have the ability to fuse with cell membranes to transfer contents into the cell. Typically, a neutral phospholipid (DOPE) and a positive derivative are used to make them. (16)

v) long circulatory liposomes:

A variety of techniques have been proposed to attain prolonged liposome circulation in vivo. One such technique involves covering the liposome surface with inert, biocompatible polymers, like PEG, which creates a protective layer over the liposome surface and inhibits opsonin recognition of the liposome and the liposomes' subsequent clearance. Long-circulating liposomes exhibit higher bioavailability and non-saturable, log-linear kinetics that are dose-independent. (17)

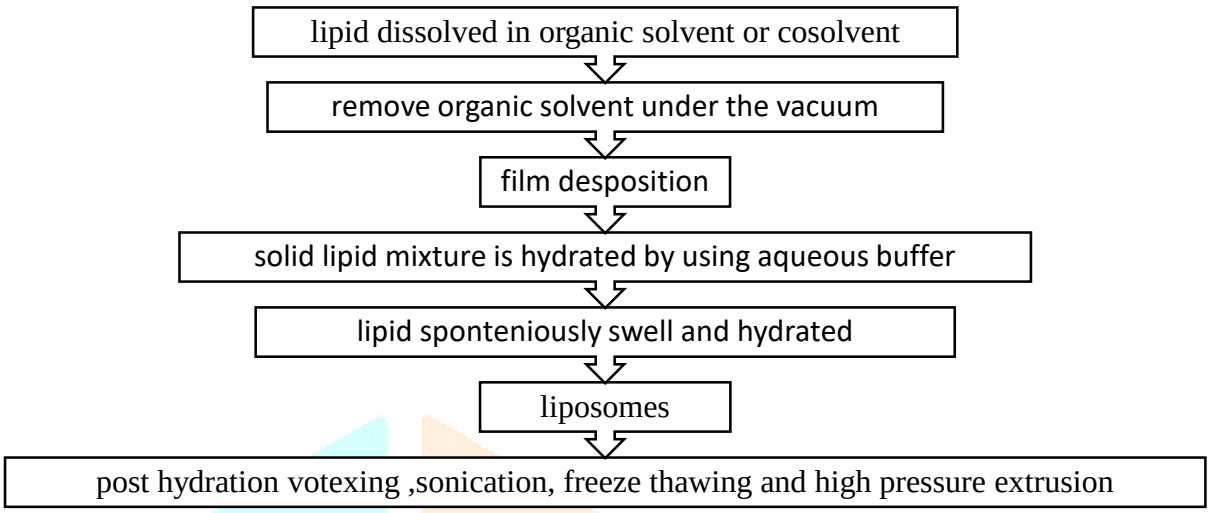
vi) immunoliposomes

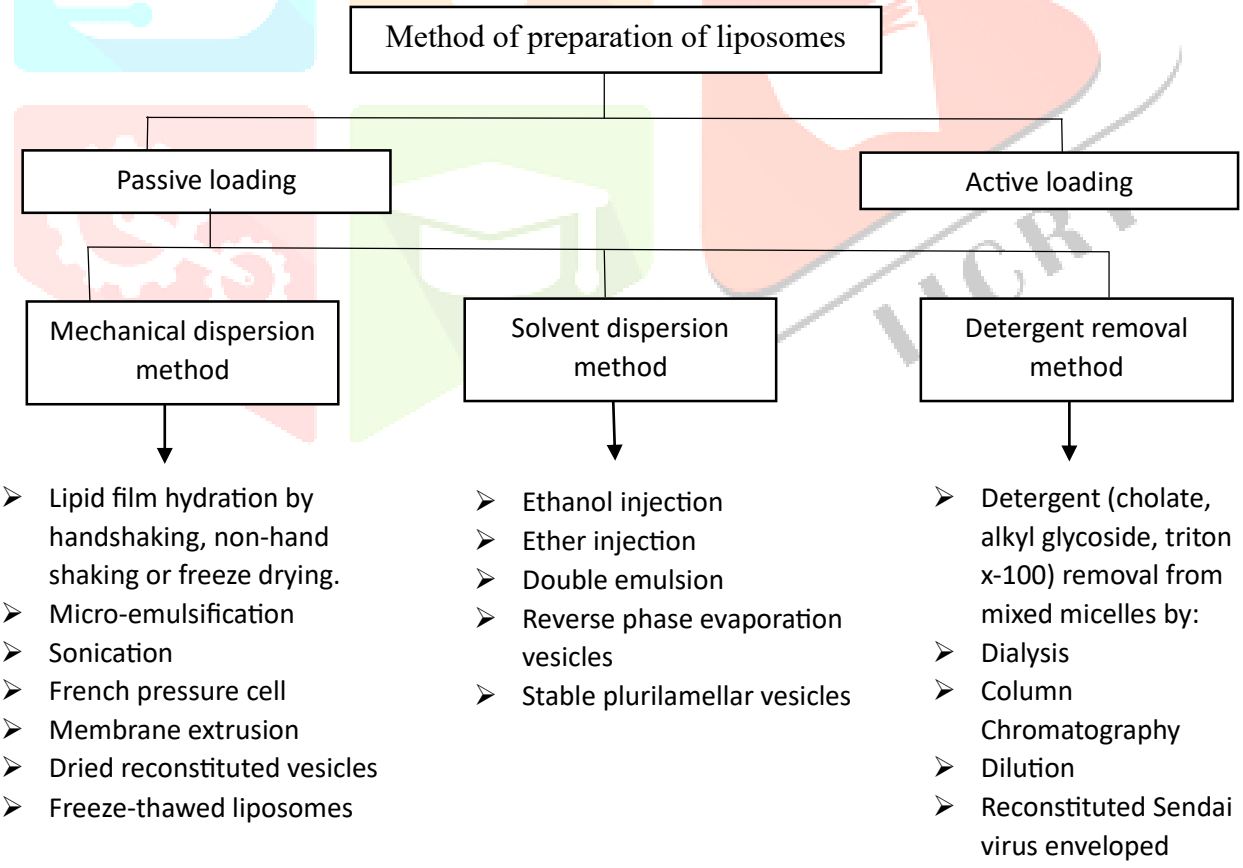
To increase liposomal drug accumulation in the desired tissues and organ, the use of targeted liposomes with surface-attached ligands capable of recognizing and binding to cells of interest has been suggested. Immunoglobulins (Ig) of the IgG class and their fragments are the most widely used targeting moieties for liposomes, which can be attached to liposomes, without affecting liposomal integrity or the antibody

properties, by covalent binding to the liposome surface or by hydrophobic insertion into the liposomal membrane after modification with hydrophobic residues. (18)

Methods of preparation of liposomes

General method for the preparation of the liposomes





A) Passive loading

There are two methods for implementing passive loading of pharmacological compounds into liposomes: (i) entrapment the liposomal membrane (bilayer) by hydrophobic interaction, electrostatic interaction, or a combination of these two mechanisms; or (ii) the entrapment of hydrophilic materials in the intra-liposome aqueous phase, such as salts (ionic chemicals), amino acids, proteins, and antibiotics.

1. Mechanical dispersion method:

a) Sonication:

Perhaps the most popular technique for preparing SUVs is sonication. This is where MLVs are sonicated using a bath-style sonicator or a investigate sonicator in a passive environment. The primary drawbacks of this technique include its extremely low internal volume/encapsulation efficacy, potential for phospholipid and chemical degradation, removal of big molecules, metal contamination from the probe tip, and existence of MLV in addition to SUV. there are two types of sonication techniques are used. (19)

bath sonication:

The cylinder containing the liposome dispersion is put inside a bath sonicator. Typically, regulating the lipid dispersion's temperature involves Unlike sonication by dispersal directly from the tip, this method is easier. The substance being sonicated can be shielded by an inert environment, a sterile vessel, or probe units.

probe sonication:

The liposome dispersion is immediately in contact with the sonicator's tip. Lipid dispersion in this case has a very large energy input. The vessel needs to be submerged in an ice or water bath because the coupling of energy at the tip causes local heat. (19)

b) French pressure cell:

MLV is extruded through a tiny aperture at 20,000 pressure and 4°C in this procedure. The approach is superior to the sonication method in a number of ways. The approach is easy to use, quick, repeatable, and requires handling unstable materials with care (Hamilton and Guo, 1984). Compared to sonicated SUVs, the resultant liposomes have a slightly bigger size. The main disadvantage of this method is that the temperature is difficult to achieve and working volume is relatively small. (20)

c) Freeze-thawed liposomes:

SUVs freeze quickly and thaw gradually. The combined components are dispersed to LUV by the brief sonication. The fusion of SUV during the freezing and thawing procedures results in the formation of unilamellar vesicles. Both raising the phospholipid concentration and the medium's ionic strength significantly prevent this kind of production. Results showed that the encapsulation efficacies ranged from 20% to 30%. (21)

d) Lipid film hydration by handshaking, non-hand shaking:

Step 1: Lipid mixture of various phospholipid and charge components in chloroform: a 2:1v/v methanol solvent combination is made first and then put into a flask with a ground glass neck and a circular bottom. Following that, a rotary evaporator is attached to this flask, and it is rotated at 60 rpm. The organic solvent evaporates at a temperature of around 30 degrees Celsius, or higher than the lipids' transition temperature. After adding nitrogen to the evaporator, the pressure at the cylinder head is gradually increased until the flask's inside and exterior are the same. To eliminate any remaining solvents, the flask is subsequently taken out of the evaporator and attached onto the lyophilizer's manifold.

Step 2: Hydration of lipid layer

The flask is flushed with nitrogen when the vacuum is released and it is taken out of the lyophilizer. Next, 5 milliliters of saline phosphate buffer, which contains the solute that has to be entrapped, are added. After flushing with N2, the flask is reattached to the evaporator and rotated at room temperature and pressure at a speed of no more than 60 rpm. The flask is allowed to rotate for thirty minutes, or until the entire amount of lipid has been extracted from the flask wall and has produced a uniform, milky-white suspension that is particle-free.
To finish the swelling process and produce MLVs, the suspension is let to stand for a further two hours at room temperature or at a temperature higher than the lipid's transition temperature. (22)

e) Micro emulsification

Small MLVs are made from concentrated lipid dispersion using a micro fluidizer.

A 5 micrometer hole allows the fluid to be pumped through the micro fluidizer at a very high pressure of 10,000 psi. After that, it is driven through precisely designed microchannels that cause two streams of fluid to meet at an angle and at a very high speed, resulting in an effective energy transfer. Either big MLVs or a slurry of hydrated lipid in organic medium can be used to add the lipids to the fluidizer. Until spherically-dimensioned vesicles are achieved, the collected fluid can be recycled via the pump and interaction chamber. Measurement The size of vesicles is decreased to between 0.1 and 0.2um after a single pass. (23)

f) Membrane extrusion technique

The technique can be used to process LUVs as well as MLVs. The size of Liposomes is reduced by gently passing them through a membrane filter of defined pore size achieved at much lower pressure (<100psi) In this process, the vesicle contents are exchanged with the dispersion medium during the breaking and resealing of phospholipids players as they pass through the polycarbonate membrane. The Liposomes produced by this technique have been termed LUVETS. (23)

2. Solvent dispersion method

a) Ether injection

An aqueous solution of the substance to be encapsulated at is gradually injected with a solution of lipids dissolved in diethyl ether or an ether/methanol combination at 55–65°C or at lower pressure. Liposomes are formed when the ether is subsequently removed under vacuum. The method's primary shortcomings are the population's heterogeneity (ranging from 70 to 190 nm) and the chemicals that need to be encapsulates exposure to high temperatures or organic solvents. (24)

b) Ethanol injection

A large amount of extra buffer is quickly infused with an ethanol lipid solution. The MLVs come into being right away. The method's shortcomings include that the population is heterogeneous (30-110 nm), the liposomes are very diluted, the ethanol forms an azeotrope with water, making it difficult to remove all of the ethanol, and even modest concentrations of ethanol may cause many biologically active macromolecules to become inactive. (25)
c) Reverse phase evaporation method

By creating a water-in-oil emulsion, the reverse-phase evaporation approach is typically utilized as an alternative to thin-film hydration. The hydrophilic medication is first dissolved in an organic solvent and then immediately combined with an aqueous buffer containing the lipids. The organic solvent then evaporated under a reduced pressure rotary evaporator leading to form lipid vesicles dispersed in the aqueous solution. The average size and polydispersity of the preformed vesicles can be reduced by extrusion. This method is suitable for high molecular weight molecules, but therapeutic peptides may be denatured due to organic solvents and to sonication conditions. (26,27)

3. Detergent removal method

Using a round-bottom flask and an appropriate organic solvent, lipids and a high critical micelle concentration (CMC) surfactant were dissolved in this approach. At the flask's bottom, a thin layer formed after solvent slowly vanishing. The lipid film was then hydrated in an aqueous solution containing the drug molecules to produce a mixed micelles solution. The next steps involve dialysis, size-exclusion chromatography, adsorption onto hydrophobic beads, or dilution to remove the surfactant. After solution concentration, a LUV liposome vesicle will be created. The majority of hydrophilic medications dissociate from the liposomes during the detergent removal stage, which is a major disadvantage of this approach. (28,29)

a) Dialysis method

The molecules of detergent are removed from mixed micelle by dialysis by lowering the concentration of detergent in bulk aqueous phase.

E.g. sodium cholate

b) Column chromatography

Removal of detergent achieved by passing the dispersion over a sephadexg-25 column pre-saturated with constitutive lipid and pre -equilibrated with hydrating buffer. (29)

E.g. deoxycholate

B) Active loading

In active loading, drug internalization into preformed liposomes is typically driven by a transmembrane PH gradient. The PH outside the liposomes allows some of the drug to exist in a unionized form, able to migrate across the lipid bilayer. Once inside the liposome, the drug becomes trapped there. (30)

Therapeutic applications of liposomes

1. Liposomes as a vehicle for the drug or protein delivery

Liposomes acts as the vehicle for the delivery of the protein and drug. it enhances the solubilization of drug.

2. liposomes in vaccination

Liposome formulations could protect DNA/RNA and proteins payload from biodegradation. Furthermore, their transfection efficiency could be enhanced by modifying surface charge, size, and lipid structure. For the immunopotentiation the immumodulating agent like muramyl dipeptide, lipopolysaccharide and lipid can be incorporated in to the liposomes.

3. Protection against enzyme degradation of drug

Liposomes are used to protect the entrapped drug against enzymatic degradation whilst in circulation. The basis is that the lipids used in their formulation are not susceptible to enzymatic degradation.

4. liposomes in tumour therapy

Liposomes as drug carriers can be administered I.V route. If liposome is modified more hydrophilic, with lipids their circulation time in blood stream increases. These are called stealth liposomes, used as carriers for hydrophilic anti-cancer drugs (Doxorubicin, Mitoxantrone) In this form they can extravasate the tumour vascular endothelium.

5. liposomes in gene delivery

he non-viral vector systems, are especially engineered liposome such as pH sensitive liposomes, cationic liposomes, fusogenic liposome, genosomes, lipoplex, and lipopolyplex have been extensively investigated for their gene delivery potential. **Cationic liposomes** deliver the content through membrane fusion, thereby avoiding lysosomal and nucleolus degradation of DNA. **pH sensitive liposomes** use endosomal acidification

for fusion with endosomal membrane. **Genosomes** are complex formulations of DNA with various cationic liposomes.

6. liposomes as an artificial blood surrogate

Liposome encapsulated haemoglobin products can be used as artificial RBC. Sterically stabilized liposome bearing haemoglobin are better Oxygen carriers. These have low toxicity, less platelet activation& aggregation & less haemostatic generation.

7. liposomes as a radiopharmaceutical and radiodiagostic carrier

Liposomal radio-diagnostic applications include imaging of liver, spleen, brain, lymphatics, tumour, blood pool, cardiovascular pathologies, visualization of inflammation, infection sites, bone marrow, eye vasculature. Liposome imaging agents are used for magnetic resonance, computed tomography & ultra sound imaging of tumours.

8. liposomes in cosmetics

Liposomes with the essential oils provide the nourishment and penetrate into the skin. Various creams, lotions, gels, hydrogels for the antiaging treatment are now a days liposome based. Liposomal preparation reduces the roughness because of its interaction with corneocytes, the intracellular lipid resulting in the softening and smoothing.

Advantages of liposomes

- Liposomes increases the efficacy and therapeutic index of the drug molecules.
- Liposomes increases the stability via encapsulation.
- Liposomes are the biocompatible, non-toxic, non-immunogenic, flexible for systemic and non-systemic administration.
- Liposomes are reduces the toxicity of the drug due to encapsulation.
- Site avoidance effect.
- Sustained, controlled release of the medication is possible.
- Liposomes have the site-specific targeting so the less toxicity happens.

Disadvantages of liposomes

- Production cost is high.
- Short half-life.
- Low solubility.
- Sometimes phospholipid undergoes oxidation or hydrolysis like reaction.

Conclusion

Liposomes have proven to be an effective medication delivery method for treating a variety of illnesses, from managing pain to treating cancer. Water insoluble, poorly bioavailable, and immunogenicity were all improved in terms of pharmacokinetics and pharmacodynamics by the biocompatible, biodegradable, and low immunogenicity liposome formulation. extremely harmful medication. To get over their early drawbacks, liposomes underwent multiple evolutions in terms of their components and production method. Currently, a number of liposomal formulations are approved for use in treating different disorders and over five hundred liposomal formulations are undergoing various stages of clinical development. However, the chemical and physical stability of liposomes poses significant hurdles. Therefore, the development of liposomes with high stability is imperative since it has a substantial impact on their therapeutic applicability. Consequently, computer research and in silico simulation may allow approximation for the ideal liposomal formulation in their constituents and the morphology of their three-dimensional structures.

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