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The Liposome Revolution:
Advances and Applications in Drug Delivery

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Abstract
Due to their distinct characteristics and wide range of uses, liposomes—Nano scale lipid-based vesicles—have attracted a lot of interest in the fields of biotechnology and medication delivery. The current advances in liposome research and their prospective effects on numerous sectors are thoroughly reviewed in this article. The introduction properly explains the subject of liposomes and emphasises its importance in biotechnology and medicine delivery. By highlighting the adaptability and significance of liposomes in contemporary research, it establishes the reader's expectations. However, it may incorporate a quick discussion of some particular current advancements or discoveries in liposome technology to make the abstract more educational. This would help the reader understand what to anticipate from the whole review. Moreover, mentioning the possible uses or advantages of these the abstract might get more interesting with advancements.

Keywords
Classification of liposome, Method of Liposome, Structural Components, Characterization of Liposome, Stability of Liposomes, Recent Advances in Liposomes

INTRODUCTION
The invention of the liposome, a spherical, small vesicle made of membrane proteins, long-chain fatty acids, sphingolipids, glycolipids, non-toxic surfactants, cholesterol, and more, by Paul Ehrlich in 1906 marked beginning the era of targeted drug delivery. Ehrlich referred to these vesicles as "magic bullets" because they could deliver drugs directly to diseased cells. Phospholipids are when dissolved on water, they spontaneously create a closed system with phospholipid bilayer membranes enclosing an internal aquatic environment, which facilitates the transfer of drugs. Because they serve as a vehicle for a number of medications and may have therapeutic effects, liposomes are particularly beneficial (Alavi et al., 2017). Liposome is colloidal carriers, which range in size from 0.01 to 5.0µm diameter. Drug obtained through liposome encapsulation long-term therapeutic level since the medicine must first be at a preceding metabolism and excretion, liposome release. Phospholipids, amphiphilic molecules with a lipid-soluble, hydrophobic tail part and a water-soluble, hydrophilic head region, are the primary components of liposomes (Ann et al., 2009). The ability of phospholipids to self-seal in aqueous medium gives liposomes their distinctive properties. This capability makes liposomes an attractive carrier system with uses in a variety of industries, including food, cosmetics, agriculture, and pharmaceutics. They have the capacity to accept both hydrophilic and lipophilic molecules, preserving the medicine from deterioration and allowing the regulated release of the active components. A molecule's backbone has been discovered to be glycerol, which is why phospholipids containing glycerol were discovered to be a crucial component of liposomal

formulation and to represent lipid weight. It serves as a delivery system for both pharmaceutical medications and nutrients (Article, n.d.).

Additionally, liposomes can be modified to have certain features, PEGylation, for instance, enables Nano carrier to operate "stealth" mode and prevent phagocytes of the in-vivo immune system from engulfing it. Additionally, the encapsulation, targeted distribution, and release capabilities of liposomes have been effectively improved (Maurya et al., 2010).

ADVANTAGES OF LIPOSOMES (K et al., 2010; Crommelin & Stonn, n.d.)

- Due to its amphipathic structure, it may entrap both types of drugs—water soluble and insoluble—in its pores.
- Offers tumour tissue specific passive targeting.
- Prevent drug oxidation.
- Liposomes boost the drug's stability.
- More effective protein stabilisation.
- Biocompatible.
- Site avoidance effect.
- Drug and cell contact directly.
- To fit either smaller or bigger medication molecules, the container's size can be changed.
- Reduce the exposure of sensitive tissues to hazardous substances.

DISADVANTAGES OF LIPOSOMES

- It's possible for a drug's encapsulation to leak or fuse.
- Minimal solubility.
- Short half-life.
- Less stable
- An allergic response to liposomal components is possible.

CLASSIFICATION OF LIPOSOMES (Laouini et al., 2012; Gregory Gregoriadis and Christine Davis, 1979; Patel et al., 2009; Soleiman, 2016)

Based on Structural Parameters

Small Unilamellar Vesicles

These vesicles have a low aqueous volume to lipids ratio (0.2:1.5:1) and are made up of a single bilayer. Sizes range from 10 to 100 nm.

Large Unilamellar Vesicles

These vesicles are ideal for carrying hydrophilic drugs since they are composed of a single bilayer and have a high-water volume to lipid ratio (7:1 mole lipid). The range of sizes is 100nm to 1um.

Multilamellar Vesicles

There are several bilayers; the lipid-to-water ratio is roughly 0.5. (mole lipid: water):1. It can range in size from 100 nm to 20 ums.

Oligolamellar Vesicles

A middle ground between LUV and MUV. The size of these spans from 0.1 to 1 um, and there are more than one of them but less than MLVs.

Based on Composition and its Characteristics

Conventional Liposomes

Made up of cholesterol and phospholipids, both of which have neutral or negative charges. These liposomes' (RES) main aim is the reticuloendothelial system.

PH Sensitive

Phospholipids, such as phosphatidyl ethanolamine and dioleoyl phosphatidyl ethanolamine, make up the substance. Low PH triggers the fusion of coated pit endocytosis-sensitive substances with cell or endosome membranes, allowing their contents to escape into the cytoplasm.

Cationic Liposomes

Phospholipids, such as phosphatidyl ethanolamine and dioleoyl phosphatidyl ethanolamine, make up the substance. Low PH triggers the fusion of coated pit endocytosis-sensitive substances with cell or endosome membranes, allowing their contents to escape into the cytoplasm.

Immunolipids
Liposomes with an antibody or recognition sequence attached, whether they are traditional or stealthy. Drug diffusion across the plasma membrane, cell-specific binding, extracellular content release close to the target tissue, and receptor-mediated endocytosis all contribute to therapeutic effect.

Temperature or heat sensitive liposomes
Dipalmitoyl phosphatidylcholine makes up its composition. At 41oY, vesicles show their highest discharge. The temperature at which the phase change of dipalmitoyl osphatidylcholine occurs. Liposomes released the molecules they had trapped at the surface of the target cell.

MECHANISM OF ACTION OF LIPOSOMES (Dhanvir & Sandeep, 2018; Hong et al., 2001; Jesorka & Orwar, 1965)
When moistened, thin lipid films swollen, fat vesicles are created. When agitated, the hydrated lipid sheets separate into huge Water-resistance MLV from interacting with margins of the Core hydrocarbon of a bilayer. Once created, particles are extruded or sonicated to minimise their size.

Endocytosis
This is accomplished by phagocytic reticuloendothelial system cells, such neutrophils.

Adsorption
Electrical forces that are not specified or interactions Using cell surface elements cause it to affect cell surface.

Fusion
It happens when a liposomal bilayer is inserted into the plasma membrane and continuously releases liposomal material into the cytoplasm.

Lipid Exchange
Here, liposomal lipids are transferred to the cellular membrane without the associated liposomal contents.

STRUCTURAL COMPONENTS OF LIPOSOMES (Press, 2011; Of et al., 2016; Bunker et al., 2016)
Phospholipids
The majority of a liposome's structural elements phospholipids are. The most abundant form is phosphatidylcholine kind of phospholipid utilised in the manufacture of liposomal. An amphipathic compound called phosphatidyl choline contains:

- The phosphocholine polar head group is hydrophilic.
- A pair of acyl chains of hydrocarbons that are hydrophobic.
- A glycerol bridges.

The composition of spontaneously occurring a moiety of glycerol is joined a pair of acyl chains, which might if it is saturated or not, to form phosphatidylcholine. The arrangement the lipid molecules' hydrocarbon chains determine the liposome membrane's resilience kind of fatty acid present in substances under regulated conditions. A molecule's backbone has been discovered to be glycerol, which is why phospholipids which included glycerol discovered to necessary a liposomal formulation's component account for 505 of the lipid weight. Additionally, liposomes can be modified to have certain features, such as PEGylation, which enables the nanocarrier to operate in "stealth" mode and prevent phagocytes of the in-vivo immune system from engulfing it. Additionally, modifying liposomes has effectively improved their capacity for encapsulation, targeted distribution, and release.
Phospholipids include, for instance,

- phosphotidyl choline (Lecithin) PC and
- phosphotidyl serine (PS).
- PG, or phosphotidyl glycerol
- Cephalin (phosphotidyl ethanolamine)-PE

There is the degree when the fluidity of all lipid’s changes. The transition temperature (TC) is another name for this temperature. The acyl chain's length directly relates to the TC; chain, longer the greater TC and stiffer the membrane. Further stiff membranes limit leakage by keeping medications that are trapped inside. The TC is crucial because it can influence how membrane responds stability, aggregation, and merging with other liposomes, and permeability in addition to how liposomes respond when contact with biological processes.

Cholesterol
Further crucial part the liposome's structural makeup is cholesterol. It is a frequently used sterol. Sterols are added, which modifies the function of stability and stiffness and lengthens the period that blood is in circulation. It cannot create a bilayer structure on its own. An extremely high concentration of it, up to a cholesterol to fat molar ratios of 1:1 or 2:1

Phosphotidyl choline, is integrated becoming phospholipids. The lipid bilayer becomes more stable and forms a highly organised and stiff membrane structure when cholesterol is present. Cholesterol increases the ease of movement and steadiness of cellular membrane and decreases permeability of molecules that are water soluble. Cholesterol hindered the interaction and destabilisation of liposomes.

METHODS OF PREPARATION OF LIPOSOMES

To create liposomal formulations, a wide range of standard methods can be applied. Every approach for creating liposomes has to mix lipids with an aqueous phase in some way.

Detergent Depletion Method (Z. Huang et al., 2014)

A gentle way for creating several vesicle kinds and very homogenous liposomes is the technique of detergent depletion. The method is founded on creation of lipid-detergent micelles, which are then removed to create liposomes. This approach has the drawbacks of a low final concentration of liposomes in the solution and a poor level of hydrophobic chemical entrapment. The composition still contains the detergent. The rate of detergent removal and the initial detergent to phospholipid ratio determine the size and homogeneity of liposomes produced by detergent depletion. The procedure takes a long time, and while removing the detergent, other tiny hydrophilic compounds could also be removed.

Injection Method (Šturm, 2021)

In 1973, Batzri and Korn published the first description of the ethanol injection technique. The lipid is dissolved into a step of synthesis using the ethanol and ether injection procedures, followed by the lipid solution is injected into a wettable medium to create liposomes. The use of ethanol injection is straightforward procedure; however, ethanol does not readily dissolve certain lipids, if appropriate mixing is not obtained, heterogeneous liposomes develop. The ether is immiscible with the aqueous phase, which is also heated to remove the solvent from the liposomal product, making the ether injection technique different from the ethanol injection method. Using this technique, Jaafar-Maalej and colleagues were able to encapsulate both Drugs that are hydrophobic and hydrophilic. They discovered that hydrophobic drug had a higher encapsulation efficiency of about 100% and the hydrophilic drug had a higher encapsulation efficiency of about 16%. When in contrast to ethanol injection approach, ether injection method has the advantage of producing concentrated liposomal products very excellent efficiencies of entrapment. The infusion of ethanol approach produces a ready-to-use liposome solution quickly, easily, and consistently. The ratio of drugs to lipids, type and concentration of the lipids, and the mix of Aquatic phase and organic solvent all affect liposomes' particle size.

Hand Shaken Method (Sherpa et al., 2020)

The simplest and most popular approach is this one. In a chloroform and methanol combination (2:1), The charged components and lipid combination are dissolved before being added to round-bottomed 250 ml flask. The bottle is spun at 60 rpm while being linked to a rotating evaporator using a vacuum pump. At a temperature of roughly 30 degrees, the organic solvents evaporate. After the flask's walls started to produce a dry residue, spinning was kept going for another 15 minutes. The vacuum pump is disconnected from the evaporator, which is then filled with nitrogen. After that, the flask is taken out of the evaporator and put into lyophilization to get rid of any remaining solvent. Following another nitrogen flush, To the flask, 5 ml of phosphate buffer are added. Once further secured to evaporator, the flask is spun for 30 minutes at a speed of roughly 60 rpm once all lipid has been removed, eliminated from flask wall. Finally, white milky suspension form. In order to provide MLVs, the swelling process for the suspension must be completed by letting it stand for two hours.

Sonication Method (X. Huang et al., 2013)

This is the method used to transform many lamellar vesicles into a single lamellar vesicle. The MLVs are exposed to ultrasonic irradiation to produce the SUVs. Either the bath approach or the probe approach is used to apply sonication. The probe is used for dispersion, which calls for a lot of energy in a small area (such a viscous aqueous phase or a lot of lipids), although it is better suited for enormous quantities of diluted liquid. This device is utilised dispersal, which calls for a lot of power in a little area (such a concentrated lipid solution or an aqueous phase that is viscous), but it works best with enormous volumes of diluted liquid. Overheating of the liposomal dispersion causes the breakdown of lipids, whereas probe tip sonicators provide a strong energy input to the liquid dispersion.

Heating Method (Venkata et al., 2022)

The components of phospholipid are hydrated in a water-based solution that contains 3% (vol) glycerol as part of Muzaffar's heating technique, which then raises the temperature either 60°C or 120°C, depending on cholesterol is present either. Since glycerol was medically acceptable chemical that is water soluble and capable of acting as an isochronizing agent, it is used to strengthen the lipid vesicles' resilience by inhibiting Sedimentation and coagulation. There have been no reports of lipid components degrading in liposomes made using the heating technique. Additionally, once reached a high temperature (120°C), is employed in this procedure, sterilisation is not required. The encapsulation and targeted distribution a food-grade nature antibacterial nisin have recently been accomplished using a further enhanced variation of the heating technique known as the Muzaffar method. The Muzaffar technique enables the production of carrier systems on a wide scale in a single step without the need to perhydrate the constituent material or use hazardous solvents or detergents.

Detergent Removal Method (Diponegoro, 2023)
This technique uses a surfactant, a detergent to solubilize lipids during the manufacture of LUVs. Non-ionic surfactants, such as n-octyl beta, D-glucopyranose (octyl gluside), dodecyl sulphate, and cationic as well as anionic surfactants, such as trimethyl hexadecyl ammonium bromide, are used as detergents. Aqueous solutions and the protein(s) to be encapsulated of the detergent are used in the technique to solubilize the lipids. To be quickly eliminated, the detergent has to have a high critical micelle concentration (CMC). The detergent is then eliminated by chromatography or dialysis. LUVs with a diameter of 0.08 to 0.2 μm are created during detergent elimination. When non-ionic detergent is removed from detergent/phospholipid mixtures employing the right detergent adsorbents, huge Unilamellar vesicles can form. Through the use of detergent, which is linked to phospholipid molecules from water, phospholipid is delivered into close exposure to the aqueous phase in this method. The resulting structural formations referred to as micelles, which can have hundreds individual constituent molecules. Their size form is determined by the concentration, other lipids, and chemical makeup of the detergent. Critical micelle concentration (CMC) is the detergent concentration in water at which micelles form.

Reverse Phase Evaporation Method (Shi & Qi, 2018)
The technology of liposomes has advanced because to this technique. Reverse phase evaporation is based on the formation of flipped micelles, which produced using ultrasound to combine an organic phase with amphiphilic molecules are solubilized, when a buffered aqueous phase that includes the compounds that are water soluble to encapsulated into a liposome. These flipped micelles transform into a viscous fluid condition and a gel upon removal of the organic solvent. When the gel state collapses at a crucial stage in this process, there are several disrupted inverted micelles, and an abundance in the phospholipids surrounding environment contributes to construction of full trilayer around the remaining micelles are leads to the production of liposomes. The method's principal drawback is the brief durations of sonication and interaction using organic solvents to encapsulate the materials, which might cause DNA strand breaks or denaturation of certain proteins.

Active Trapping Techniques (Gubernator, 2014)
"Empty" liposomes are combined with a concentrated drug solution in the active trapping approach, and the mixture is then incubated until the drug is evenly dispersed via diffusion. Vesicle bilayers are porous enough for medications enable Diffusion into the internal liposomes an acceptable period, which gives this approach some benefits. When balance exists between the vesicle's interior and its surroundings media reached, the drug passes along the gradient of concentration via the lipid bilayers and into the vesicles. Thus, liposome preparations for this class of medications vary dramatically amongst agents since the quantity actually rely on packing of hydrophobic medication that may penetrate a liposome limitation inside of the lipid bilayer. Liposomes engage in interaction with phospholipids' polar head groups to sequester water-soluble medicines; however amphiphilic compounds are frequently challenging to keep inside liposomes since they may quickly penetrate lipid bilayers. However, the active loading method is only effective with a limited number of medicines that can penetrate bilayers in the uncharged state but not in the charged state and exhibit mild amphipathic bases or acids. Because during the liposome the active component is not yet present synthesis, there are some benefits to active loading that may reduce the need for handling-related safety precautions.

Micro Emulsification Liposomes (Celebi & Can, 2012)
Small MLVs are created from concentrated lipid dispersion using a microfluidizer. 10,000 psi of pressure are applied to the fluid as it passes through a 5-micrometer hole in the micro fluidizer. The fluid is then driven down predetermined microchannels that cause two fluid streams to collide at an acute angle while travelling at high speed, thereby transferring energy. Large MLVs or a slurry of lipids in an organic solvent media can both be used to introduce the lipids into the fluidizer. Up until vesicles with spherical dimensions are formed, the liquid accumulated can be circulated through the contact chamber and pump. Diameter; the vesicles shrunk to between 0.1 and 0.2 um in size after one pass.

CHARACTERIZATION OF LIPOSOME

Size and Size Distribution (Pushpendra Singha, b et al., n.d.)
According to Calvagno et al.'s research, the manufacturing process and lipid content both had an impact on the mean size of liposomes. They discovered that liposomes made of oleic acid and dipalmitoyl phosphatidylserine (DPPS) had the highest mean size and polydispersity values. Oleic acid can also improve the fluidity of the liposome bilayer. According to the suggested use of particular liposomal system, parameters mean size and size distribution must be modified. DLS, or dynamic light scattering in conjunction the average size of a liposome aqueous dispersion using heterodyne detection may determine. In addition to being utilised as direct imaging methods for liposomes, electron microscopy techniques (such as transmission and scanning) also provide for qualitative data on liposome size and form in addition to quantitative analysis (number of particles). lipid vesicles shape cannot established by DLS; only their size can. Direct inspection of the form of the liposomes and the existence of any fusion or aggregation is made feasible using contrast electron microscopy methods. Techniques for electron microscopy can also provide details about a liposome's bilayer thickness and interlayer distance.

Surface Charge (Rasnici et al., 2003)
Liposomes can have different surface charges. In physiological pH ranges, they can be neutral (by using phospholipids like phosphatidylcholine or phosphatidylethanolamine), negative (by using acidic phospholipids like phosphatidylserine, phosphatidylglycerol, phosphatidic acid, or dicetylphosphate), or positive (by using lipids like dioleoyl trimethyl ammonium propane. The key factor affecting liposome stability and encapsulation effectiveness is liposome charge. To improve entrapment effectiveness, charged bioactive will electrostatically attract liposomes.

Zeta Potential (Smith et al., 2017)
Zeta potential depends on the lipid vesicle's surface charge, the kind and composition of the medium in which the liposome is suspended, any adsorbed layer at the interface, and other variables. Although zeta potential cannot be directly measured, it may be calculated using theoretical models and an electrophoretic mobility or dynamic electrophoretic mobility that has been determined by experiment. The charged vesicles reject one another due to the higher zeta potential, which prevents them from aggregating naturally. This prevents the liposomal suspension from becoming unstable. During storage the coalescence, fusion, fluctuation, and precipitation of the lipid vesicles. Their stability can be improved by raising electrostatic or steric inter-particle repulsion. The rate of blood circulation may be affected by liposome surface charge. The lipid content of liposomes affects the values of zeta potential. Zeta potential measurements cationic lipids are used to create liposomes were performed by Doppler electrophoretic light scattering by Filion and Phillips using the application of an electric field to distribution of liposomes, zeta potential is measured using laser doppler electrophoresis (LDE) and zetasizer.

Determination of Lamellarity (Chiba et al., 2014)
Either spectroscopic methods or electron microscopy are used to assess the lamellarity of liposomes. nuclear power the liposome's magnetic resonance spectrum is both with and without the addition are commonly noted or bleaches the magnetic field of a paramagnetic agent signal from the nuclei that were seen on the outside of liposome. Measures of encapsulation effectiveness include carrying a hydrophilic marker within.

Entrapped Volume (Oku et al., 1982)
In order measurements of the total quantity of solute entrapped inside liposomes may commonly be used to quantify the entrapped volume of the solute to verify that the concentration of solute in the aqueous medium inside liposomes stays the same following separation from unentrapped material a population of liposomes (in L/ mg phospholipid). For instance, at the time of drying down process required remove the water loss from the inner compartment during two-phase preparation processes using organic solvent.

$$\%\ Entrapmet\ efficiency = \frac{Entrapment\ drug\ (mg)}{Total\ Drug\ Added\ (mg)} \times 100$$

Surface Charge (Rasnici et al., 2003)
Since lipids that impart charge are typically used to create liposomes, understanding how the charge on the vesicle surface works is crucial is imparted. In general, zeta potential testing and free-flow electrophoresis are utilised to evaluate the charge. Surface charge on the vesicles can be inferred from liposomal dispersion's mobility in a suitable buffer.

STABILITY OF LIPOSOMES
The stability of liposomes controls the therapeutic effectiveness of medicinal molecules. Two forms of stability exist:

Physical Stability (Yadav et al., 2011)
The shelf life of liposomes is impacted by several factors' physical factors, such as fusion, aggregation, shape, and size. Leakage of medication ingredients is the main issue that arises. For determining stability, the morphology is essential, as is size dispersion variables. The phospholipids' physical stability can be preserved by preventing excessive unsaturation. They must be stored at 4°C without being frozen or exposed to light.

Chemical Stability
Unsaturated fatty acids called phospholipids are capable of hydrolysing and changing a drug's stability. Antioxidants like butylated hydroxy anisole can be used to stop the oxidative breakdown of liposomes.

APPLICATIONS OF LIPOSOMES
Excellent medicinal uses for liposomes include oral and transdermal drug delivery systems. With the help of this drug delivery method, the harmful effects of medications can be decreased while their efficacy is increased. By attaching amino acid fragments that specifically target receptor cells, liposomes may be directed to the region of the action. Regarding the liposomal drug delivery method, a number of drug delivery methods have been suggested. A few of them are as follows;

Liposome as Vaccine Adjuvant (Tretiakova & Vodovozova, 2022)
The effectiveness of liposome as an immunological adjuvant, which enhances both cell-mediated and non-cell-mediated immunity, has been well documented. Liposomal immuno-adjuvant works by passively accumulating within the local lymph node as well as by gradual release of the encapsulated antigen following intramuscular injection. When antigens are present in the aqueous cavity or integrate them inside bilayers, depending on the lipophilicity of the antigens. With the aid of Phosphotidyl serine, when liposomes are targeted, they gather in lymphoid tissues. By injecting the liposomes with bacteria, soluble antigens, and cytokinesis of deoxyribonucleic acid, the liposomal vaccine may be created.

Liposome for Respiratory Drug Delivery System (Chennakesavulu et al., 2018)
Liposomes are used to treat a variety of respiratory ailments. It is possible to make lipid aerosols with a longer half-life, lower toxicity, and higher stability. Making liposomes for lung distribution requires consideration of their composition, size, charge, drug/lipid ratio, and drug delivery method. The liquid or dry form is taken to be breathed during nebulization. Drug powder liposome manufacturing processes include milling or spray drying.

Liposomes for Brain Targeting (Morse et al., 2022)
The biocompatibility and biodegradability of liposomes make them ideal for use in medication delivery systems for the brain. Large diameter (>100 nm) and small Liposomes of any diameter can readily go across the BBB. However, tiny Unilamellar vesicles (SUVs) attached to drug the brain delivery systems may cross the BBB via receptor- or absorptive-mediated transcytosis. Cationic liposomes are endocytosed by absorptive mechanisms into cells, but it is unknown if they are also transcytoses by absorptive mechanisms across the BBB. Mannose-coated liposomes enter the brain and aid in the transportation of loaded drugs via the BBB. When administered systemically, the neuropeptides leuenkephalin and metenkephalin kyotorphin typically do not penetrate the brain-blood barrier. Since the adaptability in technique, antidepressant amitriptyline often penetrates the BBB.

Liposomes in Ophthalmic Disorders (Agarwal et al., 2016)
A number of eye conditions have been reported proliferative vitreous retinopathy, keratitis, corneal transplant rejection, uveitis, and endophthalmitis are among the conditions that liposomes can treat. Recently, a liposomal version of the medication verteporfin, which has been demonstrated to be beneficial against eye problems, was authorised.

Liposomes in Sustained Release Drug Delivery (Karumanchi et al., 2018)
It is sometimes essential to take this form of drug delivery system numerous times per day in order to establish and then maintain the concentration of drug delivered within the therapeutically effective range. This causes a fluctuating drug level, which leads to unfavourable toxicity and ineffectiveness. To reduce this fluctuation, innovative drug delivery methods, including as niosomes and liposomes, have been created.

Cosmetic Application (Feng, 2018)
The main component in medications like "Regaine" that claim to stop or slow down hair loss is the vasodilator minoxidil. Additionally, liposomes have been applied to the management of hair loss. Empty or moisture-loaded liposomes in skin care products reduce transdermal water loss and are helpful in treating dry skin. They also increase the availability of lipid and water to the stratum corneum.

Liposomes in anticancer therapy (Fulton & Najahi-missaoui, 2023)
Many anticancer medications have been found to be less dangerous when they are administered in liposome form. Anthracyclines are drugs that intercalate DNA to prevent dividing cells from reproducing, killing mostly quickly dividing cells as a result. This family of medications is very dangerous since these cells may be found in cancers, as well as gastrointestinal mucosa, hair, and blood cells.

Liposomes in Gene Therapy (Ropert, 1999)
The analytic sciences as well as the delivery of drugs and genes have both made extensive use of liposomes. A number of systemic disorders are brought on by a deficiency in enzymes or other components that results from missing or broken genes. By giving the appropriate exogenous DNA or genes to cells, various attempts have been undertaken in recent years to restore gene expression. Neutral and cationic lipids are mainly employed for gene transport due to polyanionic character of DNA, whereas anionic liposomes have mostly been used for the distribution of more therapeutic macromolecules. The compositions of cationic liposomes lipofection, catoctin, lipofectamine, and transfect ace are some of the more popular ones.

Liposomes in medicine and pharmacology
Use as a model, reagent, or tool in fundamental research on cells interaction, identification, and the way some drugs work, liposomes are used in medicine and pharmacology for both diagnostic and therapeutic purposes. Increased medication bioavailability to specific target cells in the bloodstream or, more specifically, to extravascular disease sites like tumours, may be the result of changes in liposomal drug pharmacokinetics. A more recent development is the liposomal formulation of all-trans retinoic acid.

RECENT ADVANCES IN LIPOSOMES

Liposomes with prolonged circulation lifetimes (Allen et al., 1989)

the use of specialist lipids that give liposomes with long circulation lifetimes, such as monosialoganglioside GMI or polyethylene glycol modified phosphatidyl ethanolamine PEG-PE, has significantly advanced the development of liposomal medications. On the other hand, cytotoxic drug entrapment may cause circulation times to be prolonged. Increased circulation lifetimes have been shown to improve the likelihood that systemically injected liposomes may exit the vascular compartment and access certain extravascular areas. For instance, leaky blood arteries seen in tumours are less able to hold onto circulating macromolecules. Liposomes may extravasate in certain areas, which might result in tumours accumulating there preferentially. Studies have now conclusively shown that, compared to typical liposomes, Long-circulating liposomes containing doxorubicin or PEG-PE or other cytotoxic drugs, concentrate preferentially within locations.

Drug loading (Sur et al., 2014)

Drug loading can be done actively (i.e., after liposome creation) or passively (i.e., the drug is encapsulated during liposome development). When vesicle formation occurs, hydrophobic medications like Direct integration of taxon, annamycin, or amphotericin B into liposomes is possible; the degree of absorption interactions between drugs and lipids determine retention. 100% trapping effectiveness is frequently possible, although this reliant on drugs in the liposome membrane, solubility Water-soluble drug passive encapsulation depends on liposomes' capacity to capture a drug-containing dissolved aqueous buffer solution during vesicle formation. The liposomes' confined volume and their drug's solubility restrict trapping eflqciencies (typically 30%). As an alternative, it is possible to actively entrap water-soluble medicines with protonatable amine functionalities by using pH gradients, which can result in trapping efficiencies approaching 100%.

Targeted delivery (Liu et al., 2021)

The upcoming generation of liposomal medicines is expected to include drug-loaded liposomes with surface-associated targeting data. Both covalent and non-covalent techniques can be used to attach site-directing targeting ligands to liposomes, including monoclonal antibodies. In vitro target binding that is efficient and circulation times that are extended have been made possible by the development of new at the distal extremities of the PEG spacer, targeted ligands can be connected using PEG-PE lipids. Too far, only two studies have demonstrated how antibody-mediated targeting increases the therapeutic effectiveness of liposomal medicines in vivo. In all investigations, lung endothelial thrombomodulin (mAb 34A) and intravenously injected cancer cells were employed. Because of their possible immunogenicity, the usage of immunoliposomes may be restricted.

Intracellular delivery (Rad et al., 2021)

Drug transport to the eye can be made easier by liposomes by merging with the target cell. Liposomes can become more fusogenic in low pH compartments like endosomes due to changes in the lipid content that make them pH sensitive. When lipids that may create non-bilayer phases are present, such as dioleoyl phosphatidyl ethanolamine (DOPE), the bilayer can become more unstable, which can lead to fusion events. For plasmid DNA-coated cationic liposomes used in gene delivery, DOPE has been especially helpful.

Conventional Drugs (Izzo, 2012)

Many conventional medications may be made into liposomes, which frequently results in increased therapeutic action compared to the free medication, and/or reduced toxicity, according to a substantial body of literature. Generally speaking, altered liposomal drug pharmacokinetics can result in increased medication absorption by specific target cells found in the blood or, more crucially, to extravascular disease locations like tumours. Daunorubicin, which recently acquired FDA approval as a first-line treatment for advanced Kaposi's sarcoma associated with AIDS, and liposomal preparations of all-tram retinoic acid are examples of recent developments. Important examples are shown below.

Amphotericin B (Stone et al., 2017)

The sale of liposomal amphotericin B medications is currently permitted in several European nations, and regulatory clearance in North America is about to follow. With liposomal formulations, anaphoretic B's acute toxicities are significantly diminished without losing its broad-spectrum antifungal action. Early research on several liposomal amphotericin B formulations showed that mice with fungal infections might be successfully treated. Understanding the potential causes for decreased toxicities, such as altered pharmacokinetics and greater association with high-density lipoproteins, has been the focus of recent investigations. Amphotericin B liposomal can be administered as an aerosol to treat systemic Candida albicans or Cryptococcus neoformans infections in mice, even though the majority of uses involve intravenous delivery to treat systemic fungal infections.

CONCLUSION

In the fields of pharmacology, medication delivery, and aesthetic applications, liposomes are an intriguing and adaptable tool. This review has emphasised some of the salient characteristics and uses of liposomes, highlighting their potential to

completely alter a number of sectors. First, because liposomes may encapsulate both hydrophilic and hydrophobic medicines, they provide a viable drug delivery strategy. This adaptability enables the tailored administration of medicinal substances, increasing their bioavailability and lowering the possibility of negative effects. Liposomal preparations have previously demonstrated great promise in the treatment of cancer, gene therapy, and vaccinations. Additionally, the fact that liposomes are biocompatible and biodegradable makes them a safe option for drug delivery systems. In order to optimise their performance for particular applications, they may also be customised in terms of their size, surface charge, and lipid content. Beyond the realm of medicine, liposomes are used in cosmetics to improve the stability and penetration of active chemicals, producing more potent skincare solutions. Liposomes are a great option for creating premium cosmetics because of their capacity to encapsulate and shield delicate substances from oxidation and deterioration. In conclusion, liposomes have proven to have extraordinary potential for medication delivery and aesthetic formulations, opening up a promising path for advancement and better patient results. We may anticipate even more interesting discoveries in the use of liposomal systems in the future as technology develops and our understanding of liposomes grows.

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