



**INTERNATIONAL JOURNAL OF
PHARMACEUTICAL SCIENCES**
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: <https://www.ijpsjournal.com>



Review Article

Liposomes as a Novel Drug Delivery System: A Comprehensive Review on Component, Classification, Preparation Methods, Mechanism of Action, Stability, Marketed Formulations and Therapeutic Application

Pradnya Patil*, Bhagyesh Varule, Gargi Kulkarni, Dr. Vipulata Yeole

Gokhale Education Society's Sir Dr. M.S. Gosavi College of Pharmaceutical Education and Research, Nashik, Maharashtra, India.

ARTICLE INFO

Published: 16 Oct 2026

Keywords:

Liposomes, Liposomal Drug Delivery, Phospholipid Bilayer, Vesicular Drug Delivery Systems, Nanocarriers.

DOI:

10.5281/zenodo.23424924

ABSTRACT

Liposomes are spherical, concentric vesicles originating from greek words lipos meaning fat and soma meaning body. The science of liposomolgy was founded by British scientist alec bangham and associate at babraham Cambridge in mid-1960, who in 1961 accidentally scattered phosphatidylcholine molecules in water and discovered closed bilayer structure in 1964 liposomes are self-assembling (phosphor) lipid-based drug vesicles that enclose a core aqueous compartment in a bilayer (uni-lamellar) or a concentric series of several bilayer multilamellar. They are colloidal carries with diameter ranging from 0.01 to 5.0 um with phospholipid bilayer thickness 4-5 nm ranging from 30 nm to micrometre scale, though for drug delivery application typically unilamellar with diameter 50-150 nm as bigger liposomes are quickly eliminated from blood stream .they are tiny, spherical artificial vesicles made from natural nontoxic phospholipid and cholesterol. The main structural elements are phospholipid – phosphatidylcholine (lecithin) pc being most widely utilized amphipathic molecule consisting of hydrophilic polar head group phosphocholine Glycerol Bridge and two acyl hydrophobic polar head group.

INTRODUCTION

The Greek terms lipos, which means fat, and soma, which means body, were the source of the spherical, concentric vesicles known as liposomes [1]. In 1961, Bangham et al. developed the first liposome by accidentally scattering phosphatidyl

choline molecules in water. He discovered that the molecules were creating a closed bilayer structure with an aqueous phase that were trapped by a lipid bilayer [2]. Liposomes are particularly helpful since they can carry a wide range of medications with possible therapeutic effects or other qualities. Liposomes are colloidal carriers with diameters

***Corresponding Author:** Pradnya Patil

Address: Gokhale Education Society's Sir Dr. M.S. Gosavi College of Pharmaceutical Education and Research, Nashik.

Email ✉: pradnya2004patil@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.



ranging from 0.01 to 5.0 μm . Because the drug must be released from the liposome prior to metabolism and excretion, drugs encapsulated in liposomes achieve therapeutic levels for extended periods of time [3]. These are tiny, spherical artificial vesicles that can be made from natural, non-toxic phospholipids and cholesterol. Liposomes are attractive drug delivery devices because of their size, hydrophobic and hydrophilic nature, and biocompatibility [4]. Liposomes are appealing drug delivery methods for both hydrophilic and hydrophobic medicines because of their special capacity to entrap pharmaceuticals in both the aqueous and lipid phases.

Another definition of liposomes is artificial tiny vesicles with an aqueous compartment encircled by one or more concentric layers of phospholipid. More substances, including peptides, proteins, hormones, enzymes, antibiotics, antifungals, and anticancer chemicals, are contained within the sphere-like liquid interior. Liposomes are tiny synthetic spherical vesicles that can produce phospholipid, which is naturally non-toxic, and cholesterol. Size, hydrophobicity, and hydrophilicity are the determining factors. A liposome is a spherical vesicle with a minimum of one lipid bilayer. Both pharmacological

medications and minerals are administered through it. It exhibits both traits:

- 1) Hydrophilic head
- 2) Lipophilic

Liposomes are self-assembling (phospho) lipid-based drug vesicles that enclose a core aqueous compartment in a bilayer (uni-lamellar) or a concentric series of several bilayers (multilamellar) [5]. The phospholipid bilayer is 4–5 nm thick, while liposomes range in size from 30 nm to the micrometer scale [6]. The British scientist Alec Bangham and associates at Babraham Cambridge founded the science of liposomology in the middle of the 1960s [7], and in 1964 they reported the structure of liposomes [8]. Since then, liposomes have been extensively studied as delivery systems for proteins, nucleic acids, small molecules, and imaging agents [9].

One or more concentric lipid bilayers that encapsulate an interior aqueous volume or volumes make up liposomes. Liposomes are typically unilamellar and have a diameter of between 50 and 150 nm for drug delivery applications. Bigger liposomes are quickly eliminated from the bloodstream.

DIAGRAM:

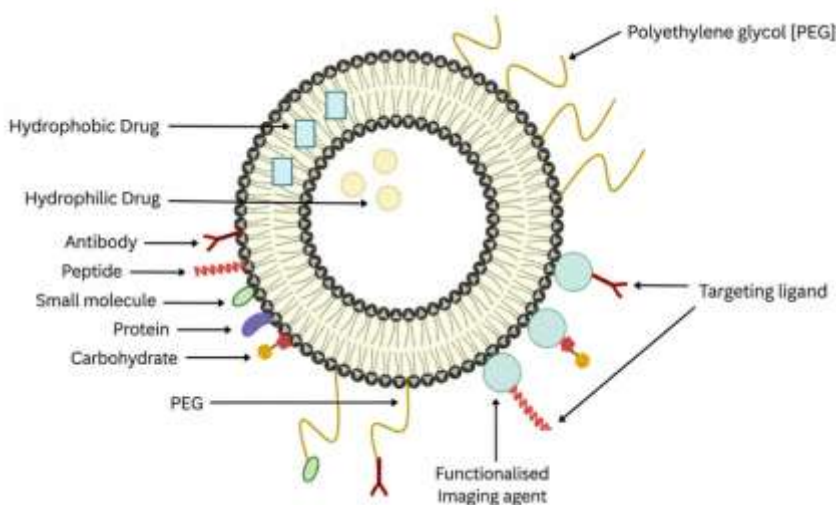


Figure 1. Schematic representation of Liposomes.

COMPONENTS:

The structural components are:

1) Phospholipids

The main structural elements of liposomes are phospholipids. Phosphatidylcholine (PC) is the most widely utilized phospholipid in liposomal preparation. The amphiphatic molecule phosphatidylcholine is made up of • Phosphocholine, a hydrophilic polar head group A bridge made of glycerol • Two acyl hydrocarbon chains that are hydrophobic The composition of spontaneously occurring The glycerol component of phosphatidylcholine is joined to two acyl chains, which can be either unsaturated or saturated. The packing of the lipid molecules' hydrocarbon chains determines the stability of the liposome membrane. Bilayer characteristics including elasticity and phase behavior are caused by the characteristics of the fatty acid in the lipid molecule, such as the quantity of double bonds in the chain [10]. Liposomes are made from phospholipids, which are common in nature and include choline. Phospholipids include, for example: • Phosphatidyl serine (PS) • Phosphatidyl ethanolamine (Cephalin)-PE • Phosphatidyl choline (Lecithin) PC • PG, or phosphatidyl glycerol

2) Another crucial structural element of liposomes is cholesterol.

It is a sterol that is frequently utilized. Stability and stiffness functions are modulated by the presence of sterols. It doesn't create a bilayer structure on its own [11]. Up to a 1:1 or 2:1 molar ratio of cholesterol to phosphatidyl choline, it is integrated into phospholipids at extremely high concentrations. The lipid bilayer's stability is improved and a highly organized, stiff membrane

structure is formed when cholesterol is present [12]. Cholesterol increases the fluidity and durability of cellular membranes while decreasing the permeability of water-soluble substances. Cholesterol inhibited the interaction and instability of liposomes [13].

CLASSIFICATION CHART:

Liposomes based on vesicle type²⁴:

Vesicle Type	Diameter size	No. of lipid Layer
Multi lamellar large vesicles [MLV]	More than 0.5 μm	5-25
Oligo lamellar vesicles [OLV]	0.1-1.0 μm	Approx 0.5
Uni lamellar vesicles [UV]	All size ranges	1
Small Uni lamellar vesicles [SUV]	20-100 nm	1
Medium sized uni lamellar vesicles [MUV]	More than 100nm	1
Large uni lamellar vesicle [LUV]	More than 100nm	1
Giant uni lamellar vesicle [GUV]	More than 1.0 μm	1
Multi vesicular vesicle [MVV]	More than 1.0 μm	Multi compartmental structure

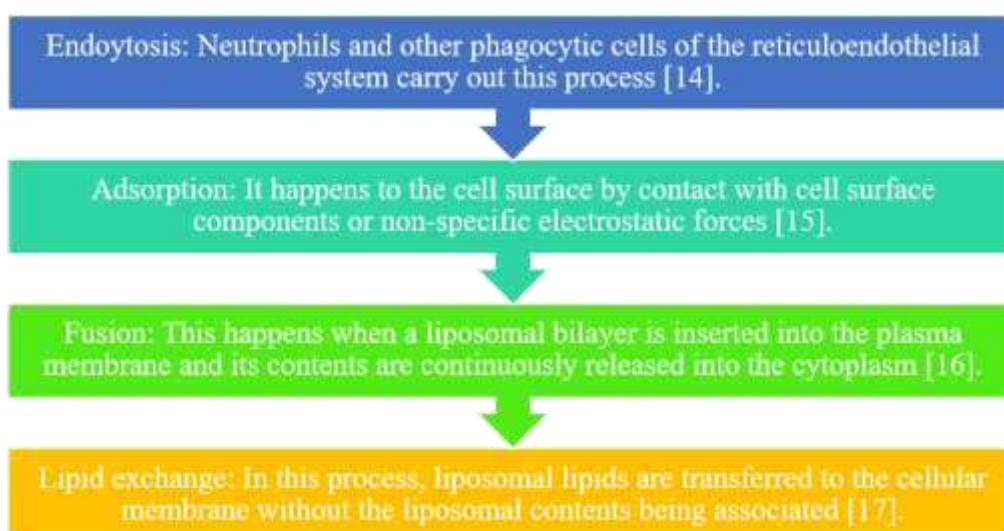
Liposomes based on vesicle type:

Vesicle Type	Method of preparation
REV	Prepared by Reverse phase evaporation method
MLV	By Reverse phase evaporation method
VET	Prepared by extrusion method
FUV	Vesicles prepared by fusion
FPV	Vesicles prepared by French press

MECHANISM OF ACTION:

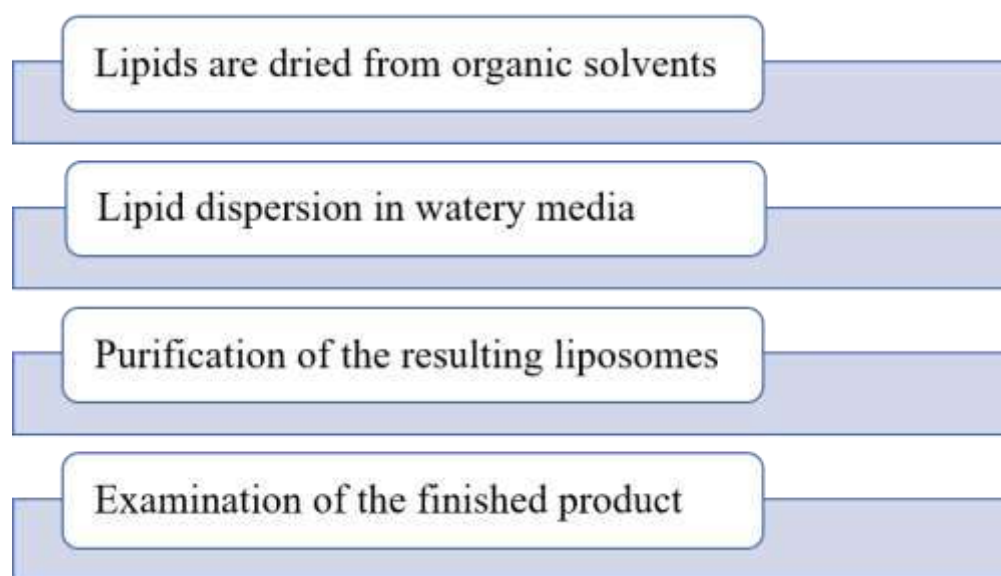
Liposomes work through four distinct mechanisms. They are as follows:





METHOD OF PREPARATION:

The manufacture of liposomes involves various techniques. General preparation method: There are four processes involved in making liposomes [18].



1. Passive Loading Techniques:

A) Mechanical dispersion methods Lipid

hydration method: The most popular way to prepare MLV is this. This procedure involved drying the lipid solution until a thin film formed at the bottom of the RBF. The film was then hydrated by adding water buffer and vortexing the mixture. The temperature used for the hydration process is higher than the gel liquid crystalline transition temperature.

Depending on its solubility, the drug to be encapsulated is introduced to either an organic solvent or an aqueous buffer [19].

Micro emulsification: SLV is prepared using this technique. It can be accomplished by employing high shearing stress produced by a high pressure homogenizer to microemulsify lipid mixtures. **Reconstituted dried vesicles:** This technique involves adding liposomes to a drug-containing aqueous solution or mixing

them with lyophilized protein, then dehydrating the mixture. Freeze-thaw method: SUVs were quickly frozen using a gradual thawing technique. This is the cause of unilamellar formation.

B) Solvent Dispersion – Ethanol injection: A lipid solution of ethanol was added to an aqueous buffer which immediately forms MLV. Ether infusion: A solution of lipids dissolved in diethylether and is slowly injected to a solution of the material to be encapsulated at temperature 55-60° C29

C) Detergent: Detergents were used to dissolve lipids at their critical miscelles concentration. Miscelles get richer in phospholipids as

detergent is eliminated, and eventually they come together to form LUVs.

2. Active Loading Techniques Proliposomes:

In this method lipid and drug were coated onto a soluble carrier to form free flowing granular material in pro-liposome which forms an isotonic liposomal suspension on hydration [20]. Lyophilization: The removal of water from products in a frozen state at a reduced pressure is called Lyophilization. This method is generally used to dry the products that are thermolabile.

MARKETING PRODUCT:

Market product of liposomes:

Sr. No	PRODUCT NAME	DRUG	COMPANY
1.	Ambisome	Amphotericin B	NeXstar pharmaceuticals Inc.CO
2.	Abelcet	Amphotericin B	The Liposome company N.J.
3.	Amphocil	Amphotericin B	Sequus pharmaceuticals Inc.CA
4.	Doxil	Doxorubicin	Sequus pharmaceuticals Inc.CA
5.	DaunoXome	Daunorubicin	NeXstar pharmaceuticals Inc.CO
6.	Mikasome	Amikacin	NeXstar pharmaceuticals Inc.CO
7.	DC99	Doxorubicin	Liposome CO.,NJ,USA
8.	Epaxel	Hepatitis A vaccine	Swiss Serum Institue,Switzerland
9.	ELA max	Lidocaine	Biozone Labs,CA,USA

STABILITY:

Therapeutic efficacy of drug molecule is governed by stability of liposomes. There are two types of stability-

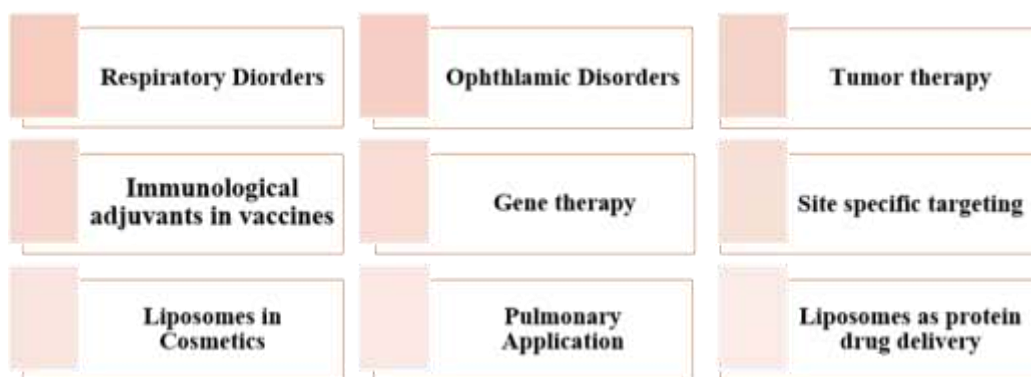
Physical Stability- There are various physical processes which effects the shelf life of liposomes like fusion , aggregation and shape and size .The general problem that occurs is leakage of drug material. The morphology and size distribution are important parameters for accessing stability. Physical stability can be maintained by avoiding

excess unsaturation in the phospholipids. They must be stored at 4°C with no freezing and light exposure [21].

Chemical Stability- Phospholipids are unsaturated fatty acids prone to hydrolysis alter the stability of drug product. Liposomes can be prevented from oxidative degradation by adding antioxidants such as butylated hydroxy anisole [22].

APPLICATION:





- 1. Respiratory Disorders-** The liposomes have been found to possess beneficial effects in the treatment of several respiratory disorders, reason being their better sustained release, improved stability and reduced toxicity than ordinary aerosols. Liquid or dry form can be taken for inhalation of liposome and release of drug has been reported to occur during nebulization.
- 2. Ophthalmic Disorders-** Dry eyes, keratitis, corneal transplant rejection, uveitis, onchophthelmitis and proliferative vitreoretinopathy are the examples of eye disorders against which liposomes have been found to possess beneficial effects.
- 3. Tumor therapy-** Carrier of small cytotoxic molecule and vehicles used for macromolecule such as cytokines.
- 4. Immunological adjuvants in vaccines-** Liposomes used in immunoadjuvant, immunodiagnosis .
- 5. Liposomes as protein drug delivery-** They are used to enhanced drug solubilisation
- 6. Pulmonary Application-** They are useful tools for pulmonary delivery of drugs due to their solubilization capacity [23].
- 7. Liposomes in Cosmetics-** They are used in cosmetics because their physiology is similar to the cell membrane and they release materials to the cells [24].
- 8. Site specific targeting-** The immunoliposomes are able to recognize and binds to target cells with greater specificity.
- 9. Gene therapy-** Liposomes are used widely in gene applications to cure diseases.

REFERENCES

1. Soni V, Chandel S, Jain P, Asati S. Role of liposomal drug-delivery system in cosmetics. In Nanobiomaterials in galenic formulations and cosmetics 2016 Jan 1 (pp. 93-120). William Andrew Publishing.
2. Papahadjopoulos D, Kimelberg HK. Phospholipid vesicles (liposomes) as models for biological membranes: their properties and interactions with cholesterol and proteins. Progress in surface science. 1974 Jan 1;4:141-232.
3. Drummond DC, Noble CO, Hayes ME, Park JW, Kirpotin DB. Pharmacokinetics and in vivo drug release rates in liposomal nanocarrier development. Journal of pharmaceutical sciences. 2008 Nov;97(11):4696-740.
4. Nsairat H, Khater D, Sayed U, Odeh F, Al Bawab A, Alshaer W. Liposomes: structure, composition, types, and clinical applications. Heliyon. 2022 May 1;8(5).



5. Gopi S, Balakrishnan P, editors. *Liposomes for functional foods and nutraceuticals: from research to application*. CRC Press; 2022 Jun 15.
6. Tokumasu F, Jin AJ, Feigenson GW, Dvorak JA. Atomic force microscopy of nanometric liposome adsorption and nanoscopic membrane domain formation. *Ultramicroscopy*. 2003 Oct 1;97(1-4):217-27.
7. Heap B, Gregoriadis G. ALEC DOUGLAS BANGHAM: 10 November 192—9 March 2010. *Biographical Memoirs of Fellows of the Royal Society*. 2011 Jan 1;57:25-43.
8. Bangham AD. Liposomes: the Babraham connection. *Chemistry and physics of lipids*. 1993 Sep 1;64(1-3):275-85.
9. Xing H, Hwang K, Lu Y. Recent developments of liposomes as nanocarriers for theranostic applications. *Theranostics*. 2016 Jun 15;6(9):1336.
10. Rawicz W, Olbrich KC, McIntosh T, Needham D, Evans E. Effect of chain length and unsaturation on elasticity of lipid bilayers. *Biophysical journal*. 2000 Jul 1;79(1):328-39.
11. de Kruijff B. Lipids beyond the bilayer. *Nature*. 1997 Mar 13;386(6621):129.
12. Doole FT, Kumarage T, Ashkar R, Brown MF. Cholesterol stiffening of lipid membranes. *The Journal of Membrane Biology*. 2022 Oct;255(4):385-405.
13. Nakhaei P, Margiana R, Bokov DO, Abdelbasset WK, Kouhbanani MA, Varma RS, Marofi F, Jarahian M, Beheshtkhoo N. Liposomes: structure, biomedical applications, and stability parameters with emphasis on cholesterol. *Frontiers in bioengineering and biotechnology*. 2021 Sep 9;9:705886.
14. Dalmo RA, Ingebrigtsen K, Bøgwald J. Non-specific defence mechanisms in fish, with particular reference to the reticuloendothelial system (RES). *Journal of fish diseases*. 1997 Jul;20(4):241-73.
15. Dubiel EA, Martin Y, Vermette P. Bridging the gap between physicochemistry and interpretation prevalent in cell– surface interactions. *Chemical reviews*. 2011 Apr 13;111(4):2900-36.
16. Wickner W, Schekman R. Membrane fusion. *Nature structural & molecular biology*. 2008 Jul;15(7):658-64.
17. Bell FP. Lipid exchange and transfer between biological lipid-protein structures. *Progress in lipid research*. 1978 Jan 1;17(2):207-43.
18. Akbarzadeh A, Rezaei-Sadabady R, Davaran S, Joo SW, Zarghami N, Hanifehpour Y, Samiei M, Kouhi M, Nejati-Koshki K. Liposome: classification, preparation, and applications. *Nanoscale research letters*. 2013 Feb 22;8(1):102.
19. Herrmann J, Bodmeier R. Biodegradable, somatostatin acetate containing microspheres prepared by various aqueous and non-aqueous solvent evaporation methods. *European Journal of Pharmaceutics and Biopharmaceutics*. 1998 Jan 1;45(1):75-82.
20. Farooque F, Wasi M, Mughees MM. Liposomes as drug delivery system: an updated review. *J. Drug Deliv. Ther.* 2021 Oct 15;11(5-S):149-58.
21. Olson MR, Axler RP, Hicks RE. Effects of freezing and storage temperature on MS2 viability. *Journal of virological methods*. 2004 Dec 15;122(2):147-52.
22. Musakhanian J, Rodier JD, Dave M. Oxidative Stability in Lipid Formulations: a Review of the Mechanisms, Drivers, and Inhibitors of Oxidation: Oxidative Stability in Lipid Formulations. *AAPS pharmscitech*. 2022 May 20;23(5):151.
23. Mansour HM, Rhee YS, Wu X. Nanomedicine in pulmonary delivery. *International journal of nanomedicine*. 2009 Dec 29:299-319.
24. Lasic D. Liposomes. *American Scientist*. 1992 Jan 1;80(1):20-31.
25. Gregoriadis G, et al., Stability of liposomes in vivo and in vitro is promoted by their cholesterol content and the presence of blood cells, *Biochem. Biophys. Res. Commun.* 1979; 89:1287–1293.
26. Shailesh S, Neelam S, Sandeep K, Gupta GD, Liposomes: A review, *Journal of Pharmacy Research* 2009; 2(7):11631167.
27. Deshmukh RR, Gawale SV, Bhagwat MK, Ahire PA, Derle ND, A Review on:



- liposomes, World journal of pharmacy and pharmaceutical sciences, Issue 03, 506-517.
28. Godbole MD, Mathur VB, Selection of phospholipid and method of formulation for optimum entrapment and release of lamivudine from liposome. Journal of Drug Delivery and Therapeutics, 2018; 8(5-s):175-183. <https://doi.org/10.22270/jddt.v8i5-s.1935>
 29. John DF, Yunus AA, Chigbo UJ, Paul US, Ikenna E. Tolnaftate loaded liposomes-design, and in-vitro evaluation. Universal Journal of Pharmaceutical Research. 2016; 1(2): 48-53.
 30. Anwekar H, Patel S, Singhai AK, Liposomes as drug carriers , International journal of Pharmacy and life sciences, July 2011.
 31. Dwivedi C, Yadav R, Tiwari SP, Satapathy T, Roy A, Role of liposomes in novel drug delivery system, Journal of drug delivery and therapeutics 2014; 4(2):116-129.
 32. Priyanka R Kulkarni, Jaydeep D Yadav, Kumar A Vaidya. Liposomes: A Novel Drug Delivery System. International journal of current Pharmaceutical and Research 2011; 3(2).
 33. Yadav Y, Kumar S , Pandey D, Dutta RK, Liposomes for drug delivery ,Journal of Biotechnology and Biomaterials , 2017.
 34. Ugochukwu AE, Nnedimkpa OJ, Rita NO. Preparation and characterization of Tolterodine tartrate proniosomes, Universal Journal of Pharmaceutical Research. 2017; 2(2):2225.

HOW TO CITE: Pradnya Patil, Bhagyesh Varule, Gargi Kulkarni, Dr. Vipulata Yeole, Liposomes as a Novel Drug Delivery System: A Comprehensive Review on Component, Classification, Preparation Methods, Mechanism of Action, Stability, Marketed Formulations and Therapeutic Application, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 10, 2278-2285. <https://doi.org/10.5281/zenodo.23424924>

