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Niosome: A Novel Drug Delivery System

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Abstract: *An unique medicine delivery method called niosomes involves encasing the medication in a vesicle. Niosomes get their name from the fact that the vesicle is made up of a bilayer of non-ionic surface active substances. Because they are composed of a bilayer, niosomes and liposomes share structural similarities. In contrast to liposomes, which include phospholipids in their bilayer, niosomes have non-ionic surface active agents. When submerged in water, the majority of surface active chemicals produce micellar structures; nevertheless, certain surfactants can produce bilayer vesicles, or niosomes. Depending on how they are prepared, niosomes can be either unilamellar or multilamellar.The niosomes are categorized either according to size or according to the number of bilayers (MLV, SUV, etc.). (e.g., LUV, SUV) or depending on the preparation technique (e.g., REV, DRV). Because niosomes can contain many medication types within their multienvironmental structure, they can represent alternate vesicular systems in comparison to liposomes. Although niosome technology is still relatively new, it is already showing promise in the treatment of infectious diseases and cancer.*

Keywords: Phospholipids, multienvironmental, niosomes, unilamellar, and multilamellar

I. INTRODUCTION

Niosomes are non-ionic surfactant vesicles that are produced when synthetic nonionic surfactants are hydrated, either with or without the addition of cholesterol or other lipids.[1] Amphiphilic and lipophilic medications can be transported by these vesicular structures, which resemble liposomes. The assumption that surfactants have more chemical stability than phospholipids, which are utilized to prepare liposomes, is one of the motivations behind the development of niosomes. Phospholipids are readily hydrolyzed because of the ester bond.[2] Scientists are looking for vesicles made from different materials, such nonionic surfactants, because the usage of lecithin in liposomes causes unreliable repeatability, which causes further issues.

Microscopic lamellar structures known as non-ionic surfactant vesicles are created when non-ionic surfactants of the alkyl or dialkyl polyglycerol ether class are mixed with cholesterol and then hydrated in aqueous environments.The vesicles that create amphiphiles in niosomes are non-ionic surfactants like Span-60, which are often stabilized by the addition of cholesterol and a tiny quantity of anionic surfactants like dicetyl phosphate.

Key Characteristics of Niosomes:-

Niosomes can trap solutes similarly to liposomes.Niosomes are stable and osmotically active.Niosomes can accept med icinal molecules with a wide range of solubility because they have an inner structure that is primarily composed of hydr ophobic and hydrophilic elements.The structural characteristics of niosomes, such as composition, fluidity, and size, are flexible and can be tailord to suit specific needs.The therapeutic molecule's performance can be enhanced by niosomes. Improved accessibility to the specific location simply by shielding the medication from the biological environmentNios ome surfactants are nonimmunogenic

Benefits of Niosomes:-

L'Oreal was the first company to use niosomes in cosmetics because they provided the following benefits [4]: The wate r-based vesicle suspension offers better patient compliance than oil-
based systems because the structure of the niosome allows for the accommodation of hydrophilic, lipophilic, and ampip

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hilic drug moieties; they can be used for a variety of drugs.
Depending on the need, the vesicle's size, lamellarity, and other features can be changed.
The vesicles can serve as a depot for a controlled and gradual release of the medication.
They improve the stability of the medicine that is trapped. No additional conditions are needed while handling or storin g surfactants. may improve a drug's oral bioavailability.
They can be applied topically, orally, or parenterally, and they can improve the skin penetration of medications.Enhanc e the medication's therapeutic efficacy by shielding it from the biological environment and limiting its effects to certain cells, which lowers the drug's clearance.To regulate the drug's release rate and provide regular vesicles in an external no n-aqueous phase, niosomal dispersions in an aqueous phase can be emulsified in a non-aqueous phase.

II. NIOSOMES COMPONENTS

The following categories of components are primarily found in niosomes:

2.1. Surfactants that are nonionic:

The nonionic surfactants form bilayer lattices in which the hydrophobic head or hydrocarbon segments align to reduce i nteraction with the aqueous media, while the polar or hydrophobic heads align facing the aqueous bulk (media).
Each bilayer folds over itself as a continuous membrane, creating vesicles, in order to achieve thermodynamic stability, would be reduced
Each bilayer folds over itself as a continuous membrane, or creates vesicles, to achieve thermodynamic stability and eli minate the hydrocarbon/water barrier. The following kinds of nonionic surfactants are primarily utilized in niosome for mation: Alkyl Ethers L'Oreal listed a few surfactants for making niosomes with medications or substances as Surfactant-
I is a C16 monoalkyl glycerol ether with an average of three glycerol units and a molecular weight of MW 473.
Diglycerol ether with an average age of seven glycerol units is Surfactant-II (MW 972).
3) Ester-linked surfactant is Surfactant III (MW 393).
In addition to alkyl glycerol, niosome formulas also contain alkyl glycosides and alkyl ethers with polyhydroxyl head g roups.
2.1.3. Alkyl Amides Niosomal vesicles have been created using alkyl amides, such as glucosides and galactosides.13)
2.1.4. Compounds of Fatty Acids and Amino Acids
Certain niosome preparations have also made use of long-
chain fatty acids and amino acid moieties.14) 2.2. The presence of cholesterol steroids in the cell membrane influences the fluidity and permeability of the bilayer.
A steroid derivative, cholesterol is primarily utilized in the creation of niosomes.
It may not play a part in bilayer development, but its significance in niosome formation and layer characteristic manipul ation cannot be disregarded.
PREPARATION METHODS:- The following are some crucial techniques for creating niosomes:
Method of Ether Injection
Using the designated gauze needle, a solution with a certain ratio of cholesterol and surfactant in ether is gradually inje cted into the drug's preheated aqueous solution that is kept at 60 °C.Unilameller vesicles of the drug-
containing surfactants are created when ether vaporizes.
Alternatively, because fluorinated hydrocarbons evaporate at a significantly lower temperature than ether, they have be en employed as a substitute for ether in thermolabile pharmaceuticals.
The niosomes produced with this technique range in size from 50 to 1000 mm.
Method of Hand Shaking
First, an organic solvent (such as ether, chloroform, benzene, etc.) is used to dissolve the cholesterol and surfactant.
The mixture of solid surfactant and cholesterol is then left on the walls of the round-
bottom flask after the solvent is evaporated under low pressure in a vacuum evaporator.

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After that, this layer was rehydrated with a drug-
containing water solution while being continuously shaken, causing the surfactant layer to swell.
Eventually, swollen amphiphiles fold into vesicles that capture the medications.
It was discovered that the liquid volume trapped in vesicles was just 5–10%.
The surfactant-cholesterol mixture is first distributed throughout the aqueous phase using the sonication method.
Multilameller vesicles (MLV) are created when this dispersion is probe sonicated for 10 minutes at 60°C.
These MLVs undergo additional ultrasonication using a bath sonicator or probe sonicator, which results in the creation of unilameller vesicles.4, 18)

3.4. Method of Reverse Phase Evaporation

Using this approach, a 1:1 mixture of ether and chloroform is used to prepare the cholesterol and surfactant solution.
This is followed by the addition of the drug's aqueous solution and sonication at 4–5°C.
After adding phosphate buffer saline, the resulting solution is further sonicated gel formation.
After that, the temperature is increased to 40°C and the pressure is lowered to remove the solvent.
To produce niosomes, the PBS is added once more and heated in a water bath at 60°C for ten minutes.4,21
3.5. Transmembrane pH Gradient (Inside Acidic) Process of Drug Uptake (Remote Loading)
This principle states that the niosome's inside has a lower pH (acidic pH) than its exterior.
This technique boosts the entrapment efficiency of such medications because the additional unionized basic drug passes the niosome membrane but becomes ionized in an acidic solution after entering the niosome.
The medications are trapped intravesicularly by the acidic pH near the interior of niosomes.
Extrusion Method:
Using a rotating vacuum evaporator, a mixture of diacetyl phosphate and cholesterol is formed, and the solvent is then evaporated to leave a thin layer.
After hydrating the film with an aqueous drug solution, the resulting suspension is extruded through a polycarbonate m embrane with a mean pore size of 0.1 mm and put in series up to eight times to produce niosomes of uniform size.23, 2 4).The Method of Microfluidizationin this approach, twoIn the interaction chamber, fluidized streamsone containing m edication and the other surfactantinteract at extremely high speeds in carefully designed microchannels such that the en ergy given to the system stays in the vicinity of niosome formations. We refer to this as the submerged jet principle.
Niosome types:
4.1. Bola Surfactant Containing Niosomes These surfactants are composed of omega-hexadecyl-bis-(1-aza-18 crown-6) (bola surfactant): span-80/cholesterol in a 2: 3: 1 molar ratio.
4.2. Proniosomes Proniosomes are niosomal for mulation that need to be hydrated before use because they contain a car rier and surfactant.Aqueous niosome dispersion is created as a result of the hydration.
The aggregation, leakage, and fusion issues related to niosomal formulation are reduced by proniosomes.25) proniosom es, water niosomes, and carrier surfactant proniosomes
4.3. Aspasomes Vesicles known as aspasomes are created when acorbyl palmitate, cholesterol, and highly charged lipid diacetyl phosphate are combined.26) To obtain the niosomes, aspasomes are first hydrated with water or an aqueous so lution and then sonicated.
Aspasomes can be utilized to increase a drug's transdermal penetration.
Due to their innate antioxidant properties, aspartosomes have also been employed
to reduce disorders brought on by reactive oxygen species.26) aspasomes; aqueous solution hydration; sonication; nioso mes July 2011 947 Drug, spans, and cholesterol were used to create the niosomes in Carbopol Gel.
The resulting niosomes were subsequently added to a carbopol-
934 gel (1% w/w) basis that included glycerol (30% w/w) and propylene glycol (10% w/w).
In vitro diffusion experiments using niosomal gel.
) Multilamellar vesicles (MLV), ii) Large unilamellar vesicles (LUV), and iii) Small unilamellar vesicles (SUV).

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1. Multilamellar vesicles (mlv):
It is made up of many bilayers that encircle the aqueous lipid compartment independently. These vesicles have a diameter of between 0.5 and 10 µm. The most popular niosomes are multilamellar vesicles. They are easy to manufacture and remain mechanically stable after extended storage. These vesicles are excellent medication carriers for lipophilic substances.
2. Large vesicles that are unilamellar (luv):
Larger amounts of bioactive materials can be encapsulated with a very efficient use of membrane lipids according to the high aqueous/lipid compartment ratio of these niosomes.
3. SUVs, or small unilamellar vesicles:
Sonication is the primary method used to create these tiny unilamellar vesicles from multilamellar vesicles.
6] Method of preparation of niosomes(6). Niosomes can be prepared by a number of methods which are as follows: Ether Injection Method In this method, a solution of the surfactant is made by dissolving it in diethyl ether. This solution is then introduced using an injection (14 gauge needle) into warm water or aqueous media containing the drug maintained at 60°C. Vaporization of the ether leads to the formation of single layered vesicles. The particle size of the niosomes formed depend on the conditions used, and can range anywhere between 50-1000 µm.
factor influencing the physicochemical characteristics of niosomes:-
5.1. Additives for Membranes The quantity of chemicals used to niosomal mulation, together with surfactants and medications, can increase the stability of niosomes. Many additives have an impact on vesicle membrane stability, shape, and permeability. For example, adding cholesterol to the niosomal system makes the membrane more stiff and reduces drug permeability.28) C16G2/cholesterol/M-polyethylene glycol (PEG)-prepared niosomes
Temperature of Hydration Shape and size of niosome is also influenced by the hydration temperature. As sembly of the niosomes vesicles is affected by the tempera ture change of niosomal system. Temperature change can also induce the vesicle shape transformation. Polyhydral vesicles of C16G2 : solulan C24 (91:9) is formed at 25°C, but it is converted into spherical vesicles at 45 °C and on cooling from 55 to 49°C, the vesicles produced a cluster of smaller spherical niosomes.16,22,30) 5.3. Properties of Drugs The drug entrapment in nio somes is affected by molecular weight, chemical structure, hydrophilicity, lipophilicity as well as the hydrophilic lipophilic balance (HLB) value of the drug.15) Vesicle size may increase due to entrapment of drug. Drug particle inter act with the surfactant head groups, which may increase charge on polymer and thus cause repulsion of the surfactant bilayer which leads to increase in vesicle size.22,28,31) 5.4. Amount and Type of Surfactant As the HLB value of surfactants like span 85 (HLB 1.8) to span 20 (HLB 8.6) increased, the mean size of niosomes also increases pro portionally. It is due to the fact that surface free energy de creases with increase in hydrophilicity of surfactant. Alkyl chain is present in well ordered structure in gel state, while in the liquid state the structure of bilayer is more disordered. The gel–liquid phase transition temperature (TC) is used for characterization of surfactant and lipids. Entrapment effi ciency is also affected by phase transition temperature i.e. span 60 having higher TC, provide better entrapment effi ciency. Entrapment efficiency of the niosomes is affected by the HLB value for e.g. niosomes have high entrapment effi ciency at HLB value 8.6 but HLB value 14 to 17 is not suit able for niosomes formulation.9,22,27) 5.5. Cholesterol Content and Charge on the Surfac tant Hydrodynamic diameter and entrapment efficiency were found to be increased due to cholesterol content in the niosomal bilayer.32) Cholesterol can act by two ways. First, it can increase the chain order of liquidated bilayer and second, by decreasing the chain order of the gel state bilayer,32) cho lesterol affects the hydrodynamic diameter and entrapment efficiency. It has been reported that release rate of drug de creases and rigidity of bilayer increases due to high concen tration of cholesterol.32—34) 5.6. Structure of Surfactants The geometry of the vesicles formed during the niosomal preparation also de pends upon the critical packing parameter (CPP). According to CPP the geometry of the vesicles can be predicted.27) CPP can be calculated using following equation35): v critical packing parameter (CPP) where lc v hydrophobic group volume, a0 lc the critical hydrophobic group length, a0 the area of hydrophilic head group CPP is helpful in predicting the structure of niosome vesi cles in following way; spherical micelles formed if CPP 1/2 bilayer micelles is formed if 1/2 CPP 1 inverted micelles is formed if CPP 1. 5.7. Method of Preparation

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Method of preparations can also affect the niosomal properties. Different type of methods like ether injection, hand shaking; sonication etc. has been reviewed by Khandare et al.23) The average size of acyclovir niosomes prepared by hand-shaking process was larger (2.7 mm) as compared to the average size of niosomes 1.5mm prepared by ether injection method which may be at tributed to the passage of cholesterol and span-80 solution through an orifice into the drug solution.19) Reverse phase evaporation can be used to produce smaller size vesicles. Vesicles with smaller size and greater stability can be produced by microfluidization method. Niosomes ob tained by transmembrane pH gradient (inside acidic) drug uptake process showed greater entrapment efficiency andbetter retention of drug.36) 5.8. Resistance to Osmotic Stress Diameter of nioso mal vesicles was found to be decreased when niosomal sus pension is kept in contact with hypertonic salt solution. There is slow release with slight swelling of vesicles, which is due to inhibition eluting fluids from vesicles, fol lowed by faster release, which may be due to decrease in me chanical strength under osmotic stress.6,24,37) Volume of hydration medium and time of hydration of niosomes are also critical factors which affects the niosomal assembly along with the above mentioned factors. Improper selection of these factors may result in formation of fragile niosomes or creation of drug leakage problems.

ADVANTAGES ASSOCIATED WITH NIOSOMES:-

The niosomes as a drug delivery system offer the follow ing advantages: 1) Niosomes have better patient compliance and better therapeutic effect than conventional oily formulations.38) 2) Niosomes can be utilized in the delivery of wide vari ety of drugs as it has capability to entrap hydrophilic, lipophilic as well as amphiphilic drugs.39,40) 3) Niosomes show controlled and sustained release of drugs due to depot formation.32,41) 4) Shape, size, composition, fluidity of niosomes drug can be controlled as and when required.41) 5) Niosomes show a greater bioavailability than conven tional dosage forms.40) 6) Niosomes had been effectively used in targeting drugs to various organs.42) 7) Niosomes are more stable than liposomes.22) 8) Niosomes can increase the permeation of drugs through the skin.43) 9) Niosomes can be administrated via various routes like oral, parenteral and topical etc.24) 10) Niosomes are biodegradable, biocompatible and non immunogenic to the body.24) 11) Handling, storage and transportation of the niosomes is easy.38) 12) Oral bioavailability of the drug can be improved using niosome.44) 13) It can protect the drugs from biological enzymes and acid thereby increasing the stability of the drugs.38) 14) No tissue irritation and damage are caused by pene tration enhancers in the ocular drug delivery system3.

CHARACTERIZATIONS OF NIOSOMES:-

Entrapment Efficiency (EE) It is defined as the percentage amount of drug which is entrapped by the nio some.22) Entrapment efficiency is calculated by using the for mula: EE amountofentrapped drug total amount add eed 100 For the determination of entrapment efficiency, the un-en trapped drug is first separated using suitable method (e.g. by centrifugation method). The resulting solution is then sepa rated and supernatant liquid is collected. The collected super natant is then diluted as specified and estimated using appro priate method as described in monograph of that particular drug.7,16,45) Both the entrapment efficiency (EE) and yield of niosome depend on the method of preparation as well as physico chemical properties of drug. The number of double layers, vesicle size and its distribution, entrapment efficiency of the aqueous phase, and the permeability of vesicle membranes are influenced by the methodology used for formulation as well as the addition of cholesterol as they make the niosomes less leaky.15) Bhaskaran and Lakshmi reported that trans membrane pH gradient method had higher EE with respect to other processes like ether injection method and film hydra tion method. In this process the presence of a net charge, whether negative or positive can increase water uptake within the double layer.46) Such hydration leads to an increase with respect to un charged vesicles of loaded hydrophilic molecules that can probably be located within the bilayer as well as in the core of the aggregated structures. 7.2. Size, Shape and Morphology 7.2.1. Transmission Electron Microscopy (TEM) TEM is used to determine the size, shape and lamellarity of niosome. In brief, a suspension is prepared and mixed with 1% phosphotungstic acid (in sufficient amount). A drop of resultant was then used on carbon coated grid, draining off the excess and then the grid was observed and images are taken under suitable magnification under TEM after com plete

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drying (Philips TEM).1,7) 7.2.2. Freeze Fractured Microscopy The size and shape of niosome were found to be dependent on the drug entrapment, nature of drug used and the nature of surfactant. For the determination of size, vesicles are generally freeze thawed and then visualized under freeze fractured electromicroscope. Liquid propane is generally used for the cryo f ixation of the vesicular suspension (glycol may be used as cryoprotectant) at low pressure (10 2Pa). The cryofixed vesi cles are fractured at a specified angle. The resultant surface is then shadowed using platinum or carbon vapors at an angle of 45°. Carbon coating used in this method strengthens the formed replica. Replica is cleaned and then observed and ex amined using TEM.4) 7.2.3. Optical Microscopy Technique This technique is also used for observation of niosome size and shape. Nearly 100 niosome are used for particle size determination. In this method size of stage micrometer coinciding with the eye piece micrometer is recorded and size of niosome is then calculated.47) Nowadays laser beam based mastersizer is used for the de termination size distribution, mean surface diameter and mass distribution of niosome.4) Dynamic light scattering (DLS) analysis using Malvern Zeta Sizer is also used for the determination of size distribution, mean diameter and zeta potential. 7.3. In Vitro Release Study In this study dialysis membrane method is generally used. In this method small amount of niosomes are taken into dialysis bag and are tied at both the ends. Another beaker containing suitable dissolu tion media is maintained at 37°C and the dialysis bag is put into it and stirred by a magnetic stirrer. A sample solution is taken from the beaker at specified time intervals and replaced with fresh dissolution media. The samples were analyzed for the concentration of drug at specified wave length reported in respective monograph of that particular drug.46) 7.4. Tissue Distribution/In Vivo Study Tissue distri bution profile has been studied using suitable animal models. Bhaskaran and Lakshmi, used three groups of healthy albino rats (100—150gm) for tissue distribution profile, each group contain three animals (3 3 9). The first group was treated as control in which free niosome without drug were injected, to the second group free drug was injected. The third group was treated by lyophilized niosome. After sacrificing the ani mals, various tissue like liver, lungs, spleen, kidney and heart were removed. After washing the tissue with phosphate buffer (pH 7.4) the organs were homogenized and cen trifuged. The supernatant thus obtained was used for the de termination of drug content using suitable method.46) Simi larly, Jadon et al.45) used male albino rats for this study. After administration of the free drug and drug entrapped in nio somes, the amount of drug in plasma was determined. The animals were divided into three groups, each group contains f ive animals. First group was treated as control and was in jected with PBS (pH 7.4), the second and third groups were treated with the pure drug and niosomes containing drug re spectively by oral route, after predetermined time intervals, blood samples were collected, centrifuged and frozen imme diately and then analyzed using HPLC.45,47) 7.5. Stability Study Stability studies are done by stor ing niosome at two different conditions, usually 4 1°C and 25 2°C. Formulation size, shape and number of vesicles per cubic mm can be assessed before and after storing for 30d. After 15 and 30d, residual drug can also be measured. Light microscope is used for determination of size of vesicles and the numbers of vesicles per cubic mm is measured by haemocytometer.7,46

. Application Components Method used Drug used References 1 As a drug delivery carrier a,w-Hexadecyl-bis-(1-aza)18- Thin layer evaporation 5-Fluorouracil (5-FU) 2) crown-6(bola), Span 80, technique Cholesterol 2 To increase bioavailability Cholesterol, Sorbitan Film hydration method Acyclovir 40) monosrearate (span 60), Dicetylphosphare (DCP) Span 20, Span 40, Span 60, Thin film method, Ether Griseofulvin 45) Cholesterol, DCP injection method 3 For brain targeting N-Palmitoyl glucosamine (NPG), Probe sonication method Vasoactive Intestinal Peptide 59) Span 60, Cholesterol, (VIP) Solulan C24 4 To prolong the release time Sorbitan esters Reverse phase evaporation Rifampacin 66) method 5 For drug targeting Palmitic acid Sonication method Transferrin 59) N-Hydroxysuccinimide, Glucosamine, Sorbitan monostearate (Span 60), Cholesterol, Glycol chitosan Reverse phase evaporation Methotrexate 67) Sorbitan monostearate method (span 60) 6 In leishmaniasis Span 40, Cholesterol, DCP Solvent evaporation method 14-deoxy-11-oxoandograph-68) olide Span 20, Cholesterol, Mechanical shaking method Amarogentin 9) Phosphotidic acid without sonication 7 For anti inflammatory effect Cholesterol (CH), Dicetyl Reverse phase evaporation Diclofenac sodium 69) phosphate (DCP) and method Surfactants (Tween 85, Pluronic F108) 8 In anticancer therapy C16Monoalkyl glycerol ether Sonication method Doxorubicin 10) Span 60, Cholesterol, DCP Lipid layer hydration

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method Bleomycin 70,71) Span 20, Span 60, Span 40, Thin layer hydration Paclitaxel 72) Tween 20, Tween60, Brij 76, method Brij 78, Brij 72 Span 40, Cholesterol Transmembrane pH gradient Vincristine 38) (inside acidic) drug uptake process (remote loading method) 9 In localized psoriasis Chitosan Lipid layer hydration method Methotrexate 60) Phosphotidyl choline, Thin film hydration method Dithranol 73) Span 60, Cremophor RH40, Cholesterol, Butylated hydroxy toluene 10 In oral delivery of peptide Brij 52, Brij72, Brij92, Film hydration method Insulin 74) drug Brij76, Brij97, Brij58, Brij35, DCP, Cholesterol 11 In diagnostic imaging N-Palmitoyl-glucosamine Ether injection method Gadobenate 59,63) (NPG), Polyethylene glycol (PEG)-4400 12 In transdermal drug delivery a,w-Hexadecyl-bis-Film hydration method Ammonium glycyrrhiinate 3) system (1-aza)18-crown-6(bola), Span 80, Cholesterol Brij 96, Cholesterol Sonication method Estradiol 75) 13 In opthalamic drug delivery Polyoxyethylene 20 sorbitan Thin film hydration technique Gentamicin sulphate 57) system monostearate (Tween 60), Polyoxyethylene 20 sorb-itan monooleate (Tween 80), Polyoxyethylene 23 Lauryl-ether, Cholesterol, DCP Chitosan, Carbopol Reverse-phase evaporation Timolol meleate 76) (REV) technique Span 20, Span 60, Cholesterol Reverse phase evaporation Acetazolamide 58) method, Thin layer hydration method 14 For lung targeting Span 85, Cholesterol Hand shaking method, Rifampicin 77) Ether injection method 15 In thromboembolic disease Hexadecyl poly(3)glycerol, Film method Urokinase 78) DCP, Cholesterol 16 For stability improvement Span 60, Cholesterol Ether injection method Fluconazole

Applications of Niosomes S. No. Application Components Method used Drug used References 1 As a drug delivery carrier a,w-Hexadecyl-bis-(1-aza)18- Thin layer evaporation 5-Fluorouracil (5-FU) 2) crown-6(bola), Span 80, technique Cholesterol 2 To increase bioavailability Cholesterol, Sorbitan Film hydration method Acyclovir 40) monosrearate (span 60), Dicetylphosphare (DCP) Span 20, Span 40, Span 60, Thin film method, Ether Griseofulvin 45) Cholesterol, DCP injection method 3 For brain targeting N-Palmitoyl glucosamine (NPG), Probe sonication method Vasoactive Intestinal Peptide 59) Span 60, Cholesterol, (VIP) Solulan C24 4 To prolong the release time Sorbitan esters Reverse phase evaporation Rifampacin 66) method 5 For drug targeting Palmitic acid Sonication method Transferrin 59) N-Hydroxysuccinimide, Glucosamine, Sorbitan monostearate (Span 60), Cholesterol, Glycol chitosan Reverse phase evaporation Methotrexate 67) Sorbitan monostearate method (span 60) 6 In leishmaniasis Span 40, Cholesterol, DCP Solvent evaporation method 14-deoxy-11-oxoandograph-68) olide Span 20, Cholesterol, Mechanical shaking method Amarogentin 9) Phosphotidic acid without sonication 7 For anti inflammatory effect Cholesterol (CH), Dicetyl Reverse phase evaporation Diclofenac sodium 69) phosphate (DCP) and method Surfactants (Tween 85, Pluronic F108) 8 In anticancer therapy C16Monoalkyl glycerol ether Sonication method Doxorubicin 10) Span 60, Cholesterol, DCP Lipid layer hydration method Bleomycin 70,71) Span 20, Span 60, Span 40, Thin layer hydration Paclitaxel 72) Tween 20, Tween60, Brij 76, method Brij 78, Brij 72 Span 40, Cholesterol Transmembrane pH gradient Vincristine 38) (inside acidic) drug uptake process (remote loading method) 9 In localized psoriasis Chitosan Lipid layer hydration method Methotrexate 60) Phosphotidyl choline, Thin film hydration method Dithranol 73) Span 60, Cremophor RH40, Cholesterol, Butylated hydroxy toluene 10 In oral delivery of peptide Brij 52, Brij72, Brij92, Film hydration method Insulin 74) drug Brij76, Brij97, Brij58, Brij35, DCP, Cholesterol 11 In diagnostic imaging N-Palmitoyl-glucosamine Ether injection method Gadobenate 59,63) (NPG), Polyethylene glycol (PEG)-4400 12 In transdermal drug delivery a,w-Hexadecyl-bis-Film hydration method Ammonium glycyrrhiinate 3) system (1-aza)18-crown-6(bola), Span 80, Cholesterol Brij 96, Cholesterol Sonication method Estradiol 75) 13 In opthalamic drug delivery Polyoxyethylene 20 sorbitan Thin film hydration technique Gentamicin sulphate

Niosomes as Drug Carriers Niosomes have also been used as carriers for iobitridol, a diagnostic agent used for Xray imaging. Topical niosomes may serve as solubilization matrix, as a local depot for sustained release of dermally active compounds, as penetration enhancers, or as rate-limiting membrane barrier for the modulation of systemic absorption of drugs. Drug Targetting One of the most useful aspects of niosomes is their ability to target drugs. Niosomes can be used to target drugs to the reticuloendothelial system. The reticulo-endothelial system (RES) preferentially takes up niosome vesicles. The uptake of niosomes is controlled by circulating serum factors called opsonins. These opsonins mark the niosome for clearance. Such localization of drugs is utilized to treat tumors in animals known to metastasize

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to the liver and spleen. This localization of drugs can also be used for treating parasitic infections of the liver. Niosomes can also be utilized for targeting drugs to organs other than the RES. A carrier system (such as antibodies) can be attached to niosomes (as immunoglobulin's bind readily to the lipid surface of the niosome) to target them to specific organs. Anti-neoplastic Treatment Most antineoplastic drugs cause severe side effects. Niosomes can alter the metabolism; prolong circulation and half life of the drug, thus decreasing the side effects of the drugs. Niosomes, is decreased rate of proliferation of tumor and higher plasma levels accompanied by slower elimination. Leishmaniasis Leishmaniasis is a disease in which a parasite of the genus Leishmania invades the cells of the liver and spleen. Use of niosomes in tests conducted showed that it was possible to administer higher levels of the drug without the triggering of the side effects, and thus allowed greater efficacy

Oral peptide drug delivery has long been faced with a challenge of bypassing the enzymes which would breakdown the peptide. Use of niosomes to successfully protect the peptides from gastrointestinal peptide breakdown is being investigated. In an in vitro study conducted by oral delivery of a vasopressin derivative entrapped in niosomes showed that entrapment of the drug significantly increased the stability of the peptide. Use in Studying Immune Response Due to their immunological selectivity, low toxicity and greater stability; niosomes are being used to study the nature of the immune response provoked by antigens. Non ionic surfactant vesicles have clearly demonstrated their ability to function as adjuvant following parenteral administration with a number of different antigens and peptides. Niosomes as Carriers for Haemoglobin Niosomes can be used as carriers for haemoglobin within the blood. The niosomal vesicle is permeable to oxygen and hence can act as a carrier for haemoglobin in anaemic patients. Other Applications(13-15). a) Sustained Release Sustained release action of niosomes can be applied to drugs with low therapeutic index and low water solubility since those could be maintained in the circulation via niosomal encapsulation. b) Localized Drug Action Drug delivery through niosomes is one of the approaches to achieve localized drug action, since their size and low penetrability through epithelium and connective tissue keeps the drug localized at the site of administration. 12]

II. CONCLUSION

Niosomes present a structure similar to liposome and hence they can represent alternative vesicular systems with respect to liposomes, due to the niosome ability to encapsulate different type of drugs within their multienvironmental structure. The technology utilized in niosomes is still greatly in its infancy, and already it is showing promise in the fields of cancer and infectious disease treatments. The system is already in use for various cosmetic products. Niosomes represent a promising drug delivery technology various type of drug deliveries can be possible using niosomes like targeting, ophthalmic, topical, parenteral, etc.

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