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Advancement in Novel Drug Delivery System: Niosomes

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ABSTRACT

Niosomes represent a promising drug delivery module. Noisome same as to liposome and Noisome represent alternative vesicular drug delivery systems with respect to liposomes, due to the noisome ability to encapsulate the different type of drugs within their multi environmental structure. Niosomes are thoughts to be a better system for drug delivery as compared to liposomes due to various factors like cost, stability etc. They are many types of drug deliveries that can be possible using niosomes like targeting, ophthalmic, topical, parenteral, etc. In recent research, comprehensive research carried over noisome as a drug carrier. Various drugs are enlisted and tried in noisome surfactant vesicles. Niosomes proved to better drug carrier system and has the potential to reduce the side effects of drugs and increased therapeutic effectiveness in various diseases. Noisome used more than fifty drugs are tried in niosomal formulations by the intravenous route, per oral administration, trans-dermal route of administration, and inhalation preparation, ocular nasal route of administration. Treatment of infectious diseases and immunization has undergone a revolutionary work in recent years. The large numbers of disease-specific biological have been developed, and also emphasis has been made to effectively deliver these biological. Niosomes shows an emerging class of novel vesicular systems. Niosomes are self-assembled vesicles composed primarily of synthetic surfactant and cholesterol. Comprehensive research carried over noisome as a drug carrier. Various drugs are enlisted and tried in noisome surfactant vesicles. This article presents an overview of the techniques of preparation of noisome, types of noisome, characterization and their applications.

Keywords-Niosomes; Method of preparation; Evaluation study; Application of Niosomes

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INTRODUCTION

Niosomes are a novel drug delivery system, which entrapped the hydrophilic drug in the core cavity and hydrophobic drugs in the non-polar region present within the bilayer hence both hydrophilic and hydrophobic drugs can be incorporated into niosomes [1]. The niosomes are amphiphilic in nature, in which the medication is encapsulated in a vesicle which is made by nonionic surfactant and hence the name niosomes. The niosomes size is very small and microscopic [2]. The first niosome formulations were developed and patented by L'Oréal in 1975. In the presence of proper mixtures of surfactants and charge inducing agents from the thermodynamically stable vesicles. Niosomes are mostly studied as an alternative to liposomes because they alleviate the disadvantages associated with liposomes [3]. Niosomes overcome the disadvantages associated with liposomes such as chemical instability. The chemical instability of liposomes is due to their predisposition to oxidative degradation and variable purity of phospholipids. The main purpose of developing a niosomal system is chemical stability, biodegradability, biocompatibility, chemical stability, low production cost, easy storage and handling, and low toxicity [4, 5]. Niosomes can be administrated through various routes such as oral, parental, topical. Niosomes are used as a system to deliver different types of drugs such as synthetic and herbal, antigens, hormones, and other bio-active compounds [6, 7, and 8]. This article presents some features of niosomes along with an overview of the preparation techniques and the current formulations of niosomes are encapsulation for the delivery of bio-active compounds.

SALIENT FEATURES OF NIOSOMES: [2, 9, AND 10]

- Niosomes can entrap solutes.
- Niosomes are osmotically active and stable.

- Niosomes have an infra-structure comprising of hydrophobic and hydrophilic for the most part together thus likewise oblige the medication atoms with an extensive variety of dissolvability.
- Niosome discharge the medication in a controlled manner by means of its bilayer which gives supported the arrival of the encased medication, so niosomes fill in as medication warehouse in the body.
- Targeted medication conveyance can likewise be accomplished utilizing niosomes the medication is conveyed specifically to the body part where the remedial impact is required. Thereby lessening the measurement required to be managed to accomplish the coveted impact.
- They improve the solubility and oral bioavailability of poorly soluble drugs and enhance the skin permeability of drugs when applied topically.
- Niosomes exhibits flexibility in their structural character (composition, fluidity, and size) and can be designed according to the desired situation.
- Niosomes can improve the performance of the site of action of the drug.
- Better availability to the particular site of action, just by protecting the drug from a biological environment.
- Niosomes increase the stability of the entrapped drug in some manner.

ADVANTAGES: [6, 11]

1. Bioavailability Improvement: The term bioavailability alludes to the part of a dosage that is accessible at the site of activity in the body. Niosomes have unmistakable preferences over regular plans since the vesicles can go about as medication stores and shields sedate from acidic and enzymatic debasement in the gastrointestinal tract which brings about bioavailability improvement and furthermore expanded the capacity to cross the anatomical hindrance of the gastrointestinal tract.
2. They enhance the restorative execution of the medication particles by postponed leeway from the dissemination, shielding the medication from the natural conditions and limiting impacts to target cells.
3. Niosomal dispersion in an aqueous system can is emulsified in a non-aqueous system to regulate the delivery.
4. Rate of drug and administer normal vesicle in the external non-aqueous phase.
5. They are osmotically active and stable, as well as increase the stability of the entrapped drug.
6. Handling and storage of surfactants require no special conditions.
7. They can improve the oral bioavailability of poorly absorbed drugs and enhance skin penetration of drugs.
8. They can be made to reach the site of action of the system by oral, parenteral as well as topical routes.

COMPARISON OF LIPOSOMES AND NIOSOMES: [11-13]

In spite of the fact that the liposomes and niosomes are practically same, both can be utilized as a part of focused and managed sedate conveyance framework, property of both relies on structure of the bilayer and strategies for their planning and both increment bioavailability and abatement the body leeway. Niosomes are prepared from uncharged single-chain surfactant and cholesterol whereas liposomes are prepared from double chain phospholipids, he major differences between liposomes and niosomes are described as follows, (Table 1, Figure 1)

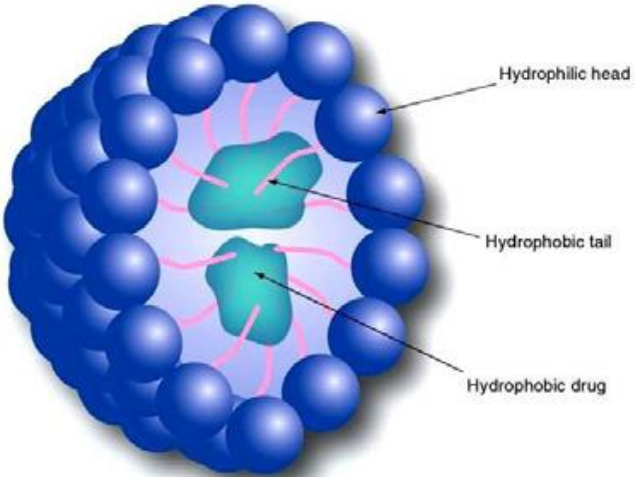

Figure 1: Structure of Niosome.

Table 1: Differences between Liposomes and Niosomes.

Sr.no.	Liposomes	Niosomes
1	More expensive	Less expensive
2	Phospholipids are prone to oxidative Degradation.	But non-ionic surfactants are stable toward this.
3	Required special method for storage, handling and purification of phospholipids.	No special methods are required for such formulations Comparatively.
4	Phospholipids may be neutral charged.	Non-ionic surfactants are uncharged.

Types of Niosomes:[2,4]

Bola surfactant-containing niosomes:

Bola surfactant-containing niosomes the surfactant used in Bola surfactant-containing niosomes are made of omega hexadecylbis-(1-aza-18 crown-6) (bola surfactant): span- 80/cholesterol in 2:3:1molar ratio.

Proniosomes:

Proniosomes is made from the carrier and surfactant mixture. After the hydration of proniosomes, Niosomes are produced.

Aspasomes:

Aspasomes is produced using the mix of acorbylpalmitate, cholesterol, and exceptionally charged lipid diacetyl phosphate prompts the arrangement of vesicles. Aspasomes are first hydrated with water/fluid arrangement and afterward, it is subjected to sonication to get the niosomes. Aspasomes can be utilized to build the transdermal saturation of medications. Aspasomes have likewise been utilized to diminish scatter caused by responsive oxygen species as it has innate cell reinforcement properties.

Niosomes in carbopol gel:

Niosomes were prepared from drug, spans, and cholesterol than it is incorporated in carbopol-934 gel (1%w/w) base containing propylene glycol (10% w/w) and glycerol (30% w/w).

Vesicles in water and oil system (v/w/o):

In this strategy, the aqueous niosomes into an oil stage frame vesicle in water in oil emulsion (v/w/o). This can be set up by the expansion of niosomes suspension figured from a blend of sorbitol monostearate, cholesterol and solulan C_{24} (Poly-24-Oxyethylene cholesteryl ether) to the oil stage at 60°C.This results in the formation of vesicle in water in oil (v/w/o) emulsion which by cooling to room temperature for the formulation vesicle in water in oil gel (v/w/o gel). The v/w/o gel thus obtained can entrapped proteins/ proteinous drugs and also protect it from enzymatic degradation after oral administration and controlled release.

Niosomes of hydroxyl propyl methylcellulose:

In this type, a base containing 10% glycerin of hydroxyl propyl methylcellulose was first prepared and then niosomes were incorporated in it.

Deformable niosomes:

The mixture of non-ionic surfactants, ethanol, and water forms the deformable niosomes. These are smaller vesicles and easily pass through the pores of stratum corneum, which leads to increase penetration efficiency. It can be used in topical preparation [15, 16]

The niosomes are classified according to the number and size of bilayer which is as follows,

i) Multi Lamellar Vesicles (MLV): Multilamellar vesicles are the most widely used niosomes. It consists of a number of bilayers. The approximate size of the vesicles is 0.5-10 µm diameter. It is simple to formulate and is mechanically stable upon storage for long periods.

ii) Large Unilamellar Vesicles (LUV): These are the large unilamellar vesicles which having a high aqueous/lipid compartment ratio so that larger volumes of bio-active materials can be entrapped.

iii) Small Unilamellar Vesicles (SUV): These small unilamellar vesicles are prepared from multilamellar vesicles by sonication method, French press and extrusion method.

Components of Niosomes:

The two major components utilized for the readiness of niosomes are Cholesterol and Nonionic surfactants. Cholesterol is utilized to give unbending nature and appropriate shape, adaptation to the niosomes. The part surfactants assume a noteworthy part in the development of niosomes. The accompanying non-ionic surfactants are for the most part utilized for the arrangement of niosomes the spans (span 60,40,20,85,80), tweens (tween 20,40,60,80) and (Brij 30,35,52,58,72,76).

Cholesterol [9]

Cholesterol is an amphiphilic nature; and it orients its OH group towards aqueous phase and aliphatic chain towards surfactant's hydrocarbon chain. Cholesterol a waxy steroid metabolite is usually added to the non-ionic surfactants to provide rigidity Cholesterol is also prevent leakage by abolishing gel to liquid phase transition.

Non-ionic surfactants [9,17]

Niosomes are non-ionic surfactant unilamellar or multilamellar vesicles formed from synthetic non-ionic surfactants. Non-ionic surfactant possesses hydrophilic head group and a hydrophobic tail. As HLB value increases, therefore, alkyl chain increases the size of niosome increases. Formulation of niosome is not suitable on the HLB value 14-17. HLB values 8 have the highest entrapment efficiency. Nonionic surfactants are as follows, Ether linked surfactant: These are surfactants contain hydrophilic and hydrophobic moieties which are linked by ether, polyoxyethylene alkyl ethers with the general formula (CnEOm), where n; i.e. the number of carbon atoms vary between 12 and 18 and m; i.e. the number of oxyethylene unit varies between 3 and 7.

Di-alkyl chain surfactant:

Surfactant was used as a principal component of niosomal preparation of stibogluconate and its potential in delivering sodium stibogluconate in experimental marine visceral leishmaniasis has been explored.

$C_{16}H_{33}CH\text{-}O\ [\text{-}CH_2\text{-}CH\text{-}O]_{7}\text{-}H$

$|\ |$

CH_2CH_2OH

$|$

$C_{12}H_{25}\text{-}O$ (mol. Wt. 972)

Ester linked: These surfactants have ester linkage between hydrophilic and hydrophobic groups; hence it is also called as Ester linked surfactants.

$C_{15}H_{31}CO\ [O\text{-}CH_2\text{-}CH\text{-}CH_2]_2\text{-}OH$

$|$

OH (mol. Wt. 393)

This surfactant also used in the preparation of stibogluconate bear the niosomes drug delivery and delivery the sodium stibogluconate to the experimental marine visceral leishmaniasis.

Sorbitan esters:

These are the ester-linked surfactants. The commercial sorbitan esters are prepared by the mixtures of the partial esters of sorbital and its mono and di-anhydrides with oleic acid.

CH_2

|

H-C-OH

|

RCOO- C-H

|

H-C-OH

|

H-C-OOC-R

|

CH_2OOC-R

Where R is H or an alkyl chain. These have been used to entrap a wide range of drugs viz doxorubicin. **Fatty acid and amino acid compounds:**

Long-chain fatty acids and amino acid moieties have also been used in niosomes preparation which forms "Ufasomes" vesicles.

Charge inducers:

There are two types of charged inducers such as Positive and Negative charge inducers. It increases the stability of the vesicles by induction of charge on the surface of the prepared vesicles. It acts by preventing the fusion of vesicles due to repulsive forces of the same charge and provide higher values of zeta potential. The commonly used positive charge inducers are stearylamine and cetylpyridinium chloride and negative charge inducers are dicetyl phosphates, dihexadecyl phosphate and lipoamide acid. [9]

Method of Preparation:

Ether injection- [18]

In this method, the slow injection of surfactant: cholesterol (150micro.mol.) in 20ml ether through a 14 gauze needle (25ml/ min.) in preheated 4ml aqueous phase maintained at 600c. The ether the solution was evaporated using rotary evaporator, after evaporation of the organic solvent forms single-layered vesicles.

Sonication: [19]

Niosomes using the sonication method were prepared by Baillieet al 1986. In this method, surfactant: cholesterol (150micro.mol.)The mixture was dispersed in a 2ml aqueous phase in the vial. The dispersion is subjected to probe sonication for 3 min. at 600c.This method involved the formation of MLVs which are subjected to ultrasonic vibration. Sonicator is two type Probe and Bath sonicator. Probe sonicator is use when sample volume is small and Bath sonicator is used when sampling volume is large.

Hand shaking method: [19]

In this method, surfactant: cholesterol (150micro.mol.) mixture was dissolved in 10ml diethyl ether in RBF. The ether is evaporated under vacuum at room temperature in rotary evaporated. Upon hydration, the surfactant swells and is peeled off the support into a film. Swollen amphiphiles eventually fold to form vesicles. The liquid volume entrapped in vesicles appears to be small which 5-10% is.

Extrusion method: [19]

In this method, niosomes were prepared using $C_{16}G_2$, a chemically defined non -ionic surfactant by extrusion through a polycarbonate membrane. These studies not only demonstrate the effect of the number of extrusion on vesicles size but also the effect of size on encapsulation of drug.

Reverse phase evaporation technique: [18, 19]

In this method, the surfactant is dissolved in chloroform and added into the 0.25 volume phosphate saline buffer solution is emulsified to get w/o emulsion. The mixture is then solicited and subsequently, chloroform is evaporated under reduced pressure. The lipid or surfactant forms a gel first and subsequently hydrates to form vesicles.

Bubble method: [6, 18]

It is a novel technique for the one-step preparation of liposomes and niosomes without the use of organic solvents. It consists of the round-bottomed flask with three necks placed in a water bath to control the temperature. Water-cooled reflux and thermometer are positioned in the first neck and second neck and nitrogen supply through the third neck. Cholesterol and surfactant are mixed together in this buffer (pH7.4) at 70°c. A continuous stream of nitrogen gas bubbles is generated and introduced through the dispersion process and produce a niosomes.

Micro fluidization method [20]

Micro fluidization is a current strategy to plan unilamellar vesicles of characterized estimate circulation. Based on the submerged jet principle, in this strategy, two fluidized streams connect at ultrahigh speeds, incorrectly characterized smaller-scale channels inside the interaction chamber. The impingement of thin liquid sheet along a common front is arranged in such a way that the energy supplied to the system remains within the area of niosomes formation. The outcome is a more prominent consistency, smaller size and better reproducibility of niosomes shaped.

Separation of unentrapped drug [21-27]

The separation of unentrapped solute from the vesicles can be done by various techniques, such as dialysis, gel filtration and Centrifugation.

(i) **Dialysis:** Dialysis is one of the most important techniques used for removal of unentrapped drug from vesicles. In this technique, the aqueous niosomal dispersion is filled in dialysis tubing against phosphate buffer or normal saline or glucose solution.

(ii) **Gel Filtration:** In this technique, the unentrapped drug is separated by gel filtration of niosomal dispersion through a Sephadex-G-50 column and elution with phosphate-buffered saline or normal saline.

(iii) **Centrifugation:** The niosomal suspension is centrifuged and the supernatant is separated. The pellet is washed and then resuspended to obtain a niosomal suspension solution free from unentrapped drug [26,28].

Factors Affecting Physico-chemical Properties of Niosomes:

Various factors that affect the physico-chemical properties of niosomes are discussed further.

Amount and type of surfactant [29]

The mean size of niosomes increases proportionally with an increase in the HLB values of surfactants like Span 85 (HLB 1.8) to Span 20 (HLB 8.6) because of the surface free energy decreases with an increase in hydrophobicity of surfactant. The bilayers of the vesicles are either in the supposed fluid state or in a gel state, contingent upon the temperature, the kind of lipid or surfactant and the nearness of different segments, for example, cholesterol. In the gel state, alkyl chains are available in an all-around requested structure, and in the fluid express, the structure of the bilayers is more confused. The surfactants and lipids are portrayed by the gel-fluid stage change temperature (TC). Phase transition temperature (TC) of surfactant also affects entrapment efficiency i.e. Span 60 having higher TC, provides better entrapment.

Nature of Surfactants [29]

A surfactant utilized for the readiness of niosomes must have a hydrophilic head and hydrophobic tail. The hydrophobic tail may comprise of maybe a couple of alkyl or per-fluoro-alkyl gatherings or now and again a solitary steroidal gathering. The hydrophobic tail of ether sort surfactants with single-chain alkyl is more poisonous than comparing the dialkyl ether chain. The ester type surfactants are chemically less stable than the ether type surfactants and the former is less toxic in nature than latter due to ester-linked surfactant degraded by esterase's to triglycerides and fatty acid. The surfactants with an alkyl chain length from Carbon-12-Carbon-18 are suitable for the preparation of niosomes. Surfactants such as $C_{16}EO_5$ (poly-oxyethylene-cetyl ether) or $C_{18}EO_5$ (polyoxyethylene stearyl ether) are used for the preparation of polyhedral vesicles. Span series surfactants having HLB number of between 4 and 8 can form vesicles.

Nature of encapsulated drug: [30]

The physical-synthetic properties of the typified medicate impact charge and the unbending nature of the niosome bilayer. The medication cooperates with surfactant head gatherings and builds up the charge that makes shared aversion between surfactant bilayers and subsequently expands vesicle estimate. The aggregation of vesicles is prevented due to the charge development on the bilayer. In Polyoxyethylene Glycol (PEG) coated vesicles; entrapped some drug is in the long PEG chains, thus reducing the tendency to increase the size. The hydrophilic-lipophilic balance of the drug affects the degree of entrapment.

Structure of surfactants: [31]

The geometry of vesicle to be shaped from surfactants is influenced by surfactant's structure, which can be characterized by basic pressing parameters. The geometry of vesicle to be shaped can be predicated on the premise of basic pressing parameters of surfactants. Critical packing parameters can be defined using the following equation,

CPP (Critical Packing Parameters) =V/lc × a0

Where,

V = hydrophobic group volume,

lc = the critical hydrophobic group length,

a0= the area of the hydrophilic head group

Critical packing parameter value type of micellar structure formed can be ascertained as given below,

If **CPP** < ½ formation of spherical micelles,

If ½ < **CPP** < 1 formation of bilayer micelles product,

If **CPP** > 1 formation inverted micelles.

The temperature of hydration: [30]

Hydration temperature influences the shape and size of the niosome, the temperature change of the niosomal system affects the assembly of surfactants into vesicles by which induces vesicle shape transformation. Ideally, the hydration temperature for noisome formation should be above the gel to the liquid phase transition temperature of the system.

Resistance to osmotic stress: [8]

Adding of a hypertonic salt solution to a suspension of niosomes brings about reduction in diameter. In hypotonic salt solution, there is initial slow release with a slight swelling of vesicles probably due to inhibiting of eluting fluid from vesicles, followed by faster release, which may be due to mechanical loosening process of vesicles structure under osmotic stress.

Evaluation: [2, 8, 29, 30]

Entrapment efficiency: after preparing niosomal dispersion, the unentrapped drug is separated by dialysis centrifugation and gel filtration. The drug remains entrapped in niosomes s determined by complete vesicle disrupting using 50% n-propanol or 0.1% Triton X-100 and analyzed resultant solution by appropriate assay method using the following equation.

$$\%\ Entrapment\ efficiency = \frac{Amount\ entrapped}{total\ amount)} \times 100$$

Bilayer Formation:

Assembly of non-ionic surfactants to form a bilayer vesicle is characterized by an X-cross formation under light polarization microscopy.

Size: The shape of niosomal vesicles is assumed to be spherical, and their mean diameter can be determined by laser light scattering method. Also, the diameter of these vesicles can be determined by using electron microscopy, molecular sieve chromatography, ultracentrifugation, photon correlation microscopy, optical microscopy and freeze-fracture electron microscopy.

Numbers of lamellae:

This is determined by using Nuclear Magnetic Resonance (NMR) spectroscopy, small-angle X-ray scattering, and electron microscopy.

Membrane rigidity:

Membrane rigidity can be measured by means of the mobility of fluorescence probe as a function of temperature.

In-vitro release:

A method of in-vitro release rate study includes the use of dialysis tubing. A dialysis sac is washed and soaked in distilled water. The vesicle suspension solution is pipetted into a bag made up of the tubing and sealed. The bag contains the vesicles that are placed in 200ml of buffer solution in a 250ml beaker with constant shaking at the temperature of 25°C or 37°C. At different time intervals, the buffer is analyzed for the drug content by an appropriate assay method.

Microscopic evaluation:

Transmission electron microscopy was used for microscopic evaluation of niosomal dispersions. TEM used for determination of size and used for identified whether it is spherical or not.

Application of Niosomes:

Niosome as a carrier for hemoglobin: Niosomal suspension shows a visible spectrum superimposable onto that of free hemoglobin so it can be used as a carrier for hemoglobin. Vesicles are also permeable to oxygen and hemoglobin dissociation the curve can be modified similarly to non-encapsulated hemoglobin [1].

Niosomes as drug carriers:

Niosomes have likewise been utilized as transporters for iobitridol, asymptomatic operator utilized for X-ray imaging. Topical niosomes may fill in as solubilization grid, as a neighborhood station for maintained arrival of dermally dynamic mixes, as the entrance enhancers, or as rate-restricting layer obstruction for the tweak of foundational ingestion of medications [2].

Ophthalmic drug delivery:

It is difficult to achieve excellent bioavailability of drug from ocular dosage forms like an ophthalmic solution, suspension, and ointment due to tear production, impermeability of corneal epithelium, nonproductive absorption and transient residence time. But to achieve good bioavailability of drug niosomal vesicular drug delivery systems have been proposed [29]. Carter et al. reported that multiple dosing with sodium stibogluconate containing niosomes was found to be effective against parasites in the liver, spleen and bone marrow as compared to simple solution of sodium stibogluconate [17, 29].

Delivery of peptide drugs

Yoshida et al investigated the stability of peptide increased by niosomes. In Yoshida et al for an oral route for drug delivery of 9-desglycinamide, 8-arginine vasopressin entrapping in niosomes in an in-vitro intestinal loop model and reported that the stability of peptide increased by niosomes. [30]

Transdermal delivery of drugs by niosomes

In the transdermal route of delivery, when the drug is incorporated in niosomes penetration of the drug through the skin is enhanced. [30]

Neoplasia

The anthracycline antibiotics such as Doxorubicin which shows broad-spectrum antitumor activity, produces a dose depend an irreversible cardiotoxic effect. This drug increased the lifespan and decreased the rate of proliferation of sarcoma when administered by niosomal delivery into mice bearing S-180 tumor. [30]

Use in studying immune response: [32]

Because of their immunological selectivity, low danger and more noteworthy solidness; niosomes are being utilized to ponder the idea of the insusceptible reaction incited by antigens. Nonionic surfactant vesicles have plainly exhibited their capacity to work as adjuvant after parenteral organization with various distinctive antigens and peptides.

Anti-inflammatory agents [31]

Niosomal formulation of Diclofenac sodium with70% cholesterol exhibits greater anti-inflammatory activity as compared to free drug. Niosomal formulation of Nimesulide and Flurbiprofen shows greater anti-inflammatory activity as compared to free drug. Sharma et al (2009) were developed span-60 niosomal oral suspension of fluconazole in the treatment of fungal infection. It is effective as compare to capsule and tablets. [33]

Leishmaniasis [12, 34, 35]

Niosomes can be utilized for focusing on medication in the treatment of maladies in which the contaminating life form lives in the organ of the reticuloendothelial framework. Leishmaniasis is such an infection in which parasite attacks cells of liver and spleen.

Immunological application [12]

Niosomes have been also used for studying the nature of the immune response provoked by antigens. Brewer and Alexander have reported niosomes as a potent adjuvant in terms of immunological selectivity, low toxicity and stability.

Niosomes in gene delivery [20]

Novel niosome detailing in light of the 2, 3-di (tetra-decyl-oxy) propan-1-amine cationic lipid, joining with squalene and polysorbate 80 to assess the transfection productivity in rodent retinas. Lipoplexes at 15/1 proportion was 200 nm in a measure, 25mV in zeta potential and displayed circular morphology. At this proportion, it was seen that niosomes consolidated and secured the DNA from enzymatic processing.

Tetanus toxoid (TT) [20, 36]

Yoshika et al defined Span/CHOL/DCP niosomes containing lockjaw toxoid which was a vesicle-in water-in oil framework. Cottonseed oil was utilized and gave better immunological properties when contrasted with free antigen. Katare et al (2006) developed the polysaccharide-capped niosomes for oral immunization of tetanus toxoid and he was concluded that the niosomes were good approaches for oral immunization of tetanus toxoid.

Diagnostic imaging with niosomes Niosomal framework can be utilized as demonstrative operators. Conjugated niosomal with N-palmitoylglucosamine (NPG), PEG 4400 and both PEG and NPG display essentially enhanced tumor focusing of an evaluated paramagnetic specialist evaluated with MR imaging. [37]

Wagh et al (2012), was developed itraconazole niosomes drug delivery system and study its antimycotic against Candida albicans. He was enhanced the skin permeability of itraconazole by niosomal drug delivery. [34]

Srivastav et al (2014) was developed the niosomes of ofloxacin and study its antimicrobial activity. He was prepared ofloxacin niosomes by using ether injection method [38].

Mishra et al (2014) was developed the formulation of Niosomes of Aceclofenac used as NSAID [39].

Bayindir et al (2010) was developed niosomes prepared with various nonionic surfactants for paclitaxel oral delivery. Paclitaxel is an antineoplastic agent. Paclitaxel niosomal formulation was prepared by various surfactants such as Tween 20, 60, Span 20, 40, 60, Brij 76, 78, 72 by film hydration method [40].

CONCLUSION

Drug consolidations in the niosomes to focus around the niosomes are a specific site that is a promising drug delivery model. They show a structure like a liposome and consequently, they can speak to elective vesicular frameworks as for liposomes, due to the niosome capacity to exemplify a distinctive sort of medications inside their multi environmental structure and furthermore because of different elements like cost, stability and so on. These advantages over the liposomes make it a better targeting agent. Ophthalmic, topical, parenteral and various other routes are used for targeting the drug to the site of action for better efficacy.

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REFERENCES

1. Shakya V. Niosomes: A Novel Trend in Drug Delivery. Ijrdp. 2014; 3: 1036- 1041.
2. Makeshwar K, Wasankar S. Niosomes: a novel drug delivery system. Asian J. Pharm. Res. 2013; 3: 16-20.
3. Punithavalli G, Vignesh M. Formulation of Niosomal Suspension with enhanced oral bioavailability of Diclofenac sodium. Journal of Global Trends in Pharmaceutical Sciences. 2012; 3: 656-671.
4. Katare R, Gupta P, Mahor S, Rawat A, Khatri K, Katare Y, Panda A, Vyas S. Development of polysaccharide-capped niosomes for oral immunization of tetanus toxoid. Journal Drug Del. Sci. Tech. 2006; 16: 167-172.
5. Shahiwala A, Misra A. Studies in topical application of niosomally entrapped Nimesulide. Journal of Pharm. Pharmaceut. Sci. 2002; 5: 220-225.
6. Bagheri A, Chu B, Yaakob H. Niosomal Drug Delivery Systems: Formulation, Preparation and Applications. World Applied Sciences Journal. 2014; 32: 1671-1685.
7. Sudheer P, Kaushik K. Review on Niosomes- A Novel Approach for Drug Targeting, Journal of Pharmaceutical Research. 2015; 1-14.
8. Sunilkumar M. Niosomes As novel drug delivery system. International Research Journal of Pharmaceutical and Applied Science. 2015; 5: 1-7.
9. Sankhyan A, Pawar P. Recent Trends in Niosome as Vesicular Drug Delivery System. Journal of Applied Pharmaceutical Science. 2012; 2: 20-32.
10. Gurjar P. Niosome: A Promising Pharmaceutical Drug Delivery. Int. J. Pharm Anal. 2014; 2: 425-431
11. Madhav N, Saini A. Niosomes: A novel drug delivery system. International journal of research in pharmacy and chemistry. 2011; 1: 498-511.
12. Gandhi A, Sen S, Paul A. Current Trends in Niosomes As vesicular drug delivery system. Asian Journal of Pharmacy and Life Science. 2012; 2: 339- 353.
13. Chauhan S, Laurence MJ. The preparation of polyoxyethylene containing non-ionic surfactant vesicles. J. Pharm. Pharmacol. 1986; 4: 6.
14. Verma A. A vital role of niosomes on Controlled and Novel Drug delivery. Indian Journal of Novel Drug Delivery. 2011; 3: 238-246.
15. Arul J, Shanmuganathan S, Nagalakshmi. An Overview on Niosome as Carrier in Dermal Drug Delivery. Journal of pharmaceutical sciences and research. 2015; 7: 923-927.
16. Moghassemi S, Hadjizadeh A. Nano-niosomes as Nanoscale Drug Delivery Systems: An illustrated review. Journal of Controlled Release. 2014; 2: 22-36.
17. Tangriet P. Niosomes: Formulation and Evaluation. International Journal of Biopharmaceutics. 2011; 2: 47-53.
18. Arul J. An Overview on Niosome as Carrier in Dermal Drug Delivery. J. Pharm. Sci. & Research. 2015; 7: 923-929.
19. Vyas S, Khar R. Targeted and Controlled Drug Delivery, Novel Carrier System. CBS publication. 2007; 1: 249-279.
20. Goswami S, Pathak D. Niosomes- A review of current status and application, World Journal of Pharmacy and Pharmaceutical Sciences. 2017; 6: 594-615.
21. Gayatri D, Venkatesh P, Udupa N. Niosomal sumatriptan succinate for nasal administration. Int. J. Pharm. Sci. 2000; 62: 479-481.
22. Hu C, Rhodes D. Proniosomes: A novel drug carrier preparation. Int J. Pharm. 1999; 185: 23-35.
23. Silver BL. The physical chemistry of membranes. New York: Alan/Unwin and Solomon Press. 1985; 209-230.
24. Khandare J, Madhavi G, Tamhankar B. Niosomes novel drug delivery system. The East Pharmacist. 1994; 37: 61-64.
25. Maver L, Bally M, Hope M, Cullis P. Biochem. Biophys. Acta. 1985; 816: 294-302.
26. Blazek-Walsh A, Rhodes D. SEM imaging predicts quality of niosomes from maltodextrin-based proniosomes. Pharm. Res. 2001; 18: 656-661.
27. Baillie A, Florence A, Hume L, Muirhead G, Rogerson A. The preparation and properties of niosomes non-ionic surfactant vesicles. J. Pharm. Pharmacol. 1985; 37: 863-868.
28. Debnath A, Kumar A. Structural and Functional significance of Niosome and Proniosomes in Drug Delivery System. International Journal of Pharmacy and Engineering. 2015; 3: 621-637.
29. Jindal K. Niosomes as a Potentials Carrier System: A Review. IJPCBS. 2015; 5: 947-959.
30. Kaur H, Dhiman S, Arora S. Niosomes: A novel drug delivery system. Int. J. Pharm. Sci. Rev. Res. 2012; 15: 113-120.
31. Navya M. Niosomes As novel vesicular drug delivery system- A review. Asian Journal of Research in Biological and Pharmaceutical Sciences. 2014; 2: 62- 68.
32. Verma N. Niosomes and Its Application -A Review. IJRPLS. 2014; 2: 182- 184.
33. Sharma S. Span-60 Niosomal Oral Suspension of Fluconazole: Formulation and *in vitro* evaluation. Asian journal of pharmaceutical research and health care. 2009; 1: 142-156.
34. Suzuki K, Sokan K. The Application of Liposomes to Cosmetics. Cosmetic and Toiletries. 1990; 105: 65 78.
35. Tabbakhian M, Tavakoli N, Jaafari M, Daneshamouz S. Enhancement of follicular delivery of finasteride by liposomes and niosomes. Int. J. Pharm. 2006; 323: 1-10.
36. Namdeo A, Jain N. Niosomes as drug carriers. Indian Journal of Pharm. Sci. 1996; 58: 41-46.
37. Rai A. Niosomes: An approach to current drug delivery-A Review. International Journal of Advances in Pharmaceutics. 2017; 06: 41-48.
38. Srivastav A, Das P. To Study the Formulation of Niosome of Ofloxacin and Its Evaluation for Efficacy of Anti-Microbial. International Journal of Innovative Research in Science, Engineering and Technology. 2014; 3: 17958-17965.
39. Mishra N, Srivastava V, Kaushik A, Chauhan V, Srivastava G. Formulation and *in vitro*- evaluation of Niosomes of Aceclofenac. JSIR. 2014; 3: 337-341.
40. Bayindir Z, Yuksel N. Characterization of niosomes prepared with various nonionic surfactants for paclitaxel oral delivery. Journal of Pharmaceutical Sciences. 2010; 99: 2049-2060.