WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.074
Volume 8, Issue 3, 406-422. Review Article ISSN 2277– 7105

A COMPREHENSIVE REVIEW ON NIOSOMES: A FUTURE OF TARGETED DRUG DELIVERY SYSTEM

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Article Received on
24 December 2018,

Revised on 14 January 2019,
Accepted on 05 Feb. 2019,

DOI: 10.20959/wjpr20193-14185

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ABSTRACT

Designing of the drug in the vesicular system has brought a new life to the old pre-existing drugs and thus has improved their therapeutic efficacies by controlling and sustaining the actions. Different novel approaches used for delivering these drugs include liposomes, microspheres, nanotechnology, micro emulsions, antibody-loaded drug delivery, magnetic microcapsules, implantable pumps and niosomes. Niosomes and liposomes are equiactive in drug delivery potential and both increase drug efficacy as compared with that of free drug. Niosomes are preferred over liposomes because the former exhibit high chemical stability and economy. Niosome are non-ionic surfactant vesicles obtained on hydration of synthetic nonionic surfactants, with or without incorporation of cholesterol or their lipids. They are vesicular systems similar to liposomes that can be used as carriers of amphiphilic and lipophilic drugs. Noisome are promising vehicle for drug delivery and being non-ionic; and Niosomes are biodegradable, biocompatible nonimmunogenic and exhibit flexibility in their structural characterization. Niosomes have been widely evaluated for controlled release and targeted delivery for the treatment of cancer, viral infections and other microbial diseases. Niosomes can entrap both hydrophilic and lipophilic drugs and can prolong the circulation of the entrapped drug in body. Encapsulation of drug in vesicular system can be predicted to prolong the existence of drug in the systemic circulation and enhance penetration into target tissue, perhaps reduce toxicity if selective uptake can be achieved.

KEYWORDS: Hydrophilic, Lipophilic, Liposomes, Niosomes, Therapeutic efficacy.

INTRODUCTION

For many decades, medication of an acute disease or a chronic illness has been accomplished by delivering drugs to the patients via various pharmaceutical dosage forms like tablets, capsules, pills, creams, ointments, liquids, aerosols, injectables and suppositories as carriers. To achieve and then to maintain the concentration of drug administered within the therapeutically effective range needed for medication, it is often necessary to take this type of drug delivery systems several times in a day. This results in a fluctuated drug level and consequently undesirable toxicity and poor efficiency. To minimize this fluctuation, novel drug delivery systems have been developed, which include niosomes, liposomes, nanoparticles, microspheres microemulsions and magnetic microcapsules.[1]

At present there is no specific drug delivery system which achieves the site specific delivery with controlled release kinetics of drug in predictable manner. Paul Ehrlich, in 1909, initiated the era of development for targeted delivery when he envisaged a drug delivery mechanism that would target directly to diseased cell. Since then, numbers of carriers were utilized to carry drug at the target organ/tissue, which include immunoglobulins, serum proteins, synthetic polymers, liposomes, microspheres, erythrocytes, niosomes etc. Among different carriers liposomes and niosomes are well documented drug delivery. Drug targeting can be defined as the ability to direct a therapeutic agent specifically to desired site of action with little or no interaction with nontarget tissue.[2]

Niosomes are the vesicles which are formed by hydrating mixture of cholesterol and non-ionic surfactants. These are formed by self assembly of non-ionic surfactants in aqueous media as spherical, unilamellar, multilamellar system and polyhedral structures in addition to inverse structures which appear only in nonaqueous solvent. Niosomes are non-ionic surfactant vesicles obtained on hydration of synthetic nonionic surfactants, with or without incorporation of cholesterol or other lipids. They are vesicular systems similar to liposomes that can be used as carriers of amphiphilic and lipophilic drugs.[3]

Niosome can enhance bioavailability of encapsulated drug and provide therapeutic activity in a controlled manner for a prolonged period of time. Niosome basically made of Non-ionic surfactants which provide advantages over the phospholipids because they are more

economical and are chemically more stable as they are not easily hydrolysed or oxidized during storage.[4]

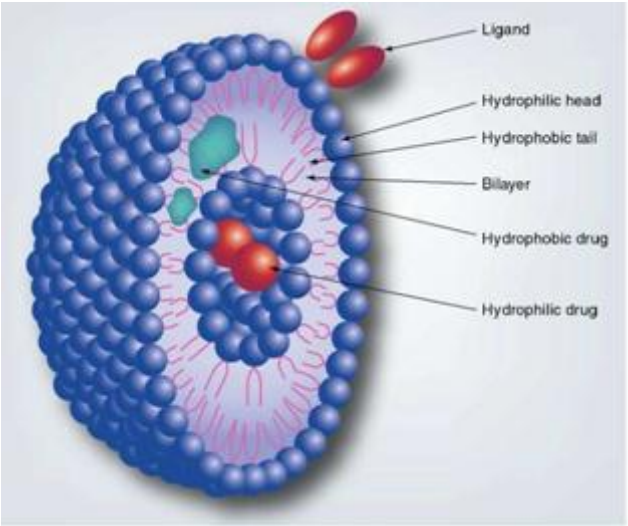


Fig. 1: Structure of Niosome.

Difference in the niosomal and liposomal system is that niosomal bilayer is formed by non-ionic surfactant where as liposomal bilayer made up of phospholipids. Niosomes are formed by the self assembly of non-ionic surfactants in aqueous media as spherical, unilamellar, bilayered, multilamellar system and polyhedral structures depending on the method used to prepare and the inverse structure in case of non-aqueous solvent. The orientation of the surfactant in niosome in hydrophilic ends exposed outwards while hydrophobic ends face each other forming bilayer of the surfactant. The size of the niosomes ranges between 10 to 1000nm. Addition of cholesterol and a small quantity of anionic surfactant for instance dicetyl phosphate stabilizes the niosomal vesicles formed by the non-ionic surfactant. Niosomes are suggested to be better than liposomes because of the higher chemical stability of surfactants than phospholipids which are easily hydrolyzed due to the ester bond and cost effective Niosomes illustrate a promising drug delivery. Various methods of administration of niosomal formulation include intramuscular, intravenous, peroral and transdermal.[5]

Types of Niosomes

The various types of niosomes are described below: i) Multi lamellar vesicles (MLV), ii) Large unilamellar vesicles (LUV), iii) Small unilamellar vesicles (SUV).

1. Multi Lamellar Vesicles (MLV)

These vesicles consists of a number of bilayer surrounding the aqueous lipid compartment

separately (approximate size of these vesicles is 0.5-10 μm diameter). Multilamellar vesicles are the most widely used niosomes.

2. Large Unilamellar Vesicles (LUV)

Large volumes of bioactive materials can be entrapped in these type of vesicles. Niosomes of this type have a high aqueous or lipid compartment ratio.

3. Small Unilamellar Vesicles (SUV)

This small unilamellar vesicles are mostly prepared from multi lamellar vesicles by sonication method.[6]

Advantages of Niosomes

a) Since the structure of the noisome offers place to accommodate hydrophilic, lipophilic as well as ampiphilic drug moieties, they can be used for a variety of drugs.
b) Niosomes exhibits flexibility in their structural characteristics (composition, fluidity and size) and can be designed according to the desired situation.
c) They improve the therapeutic performance of the drug by protecting it from the biological environment and restricting effects to target cells, thereby reducing the clearance of the drug.
d) Niosomes can act as a depot to release the drug slowly and offer a controlled release.
e) They can increase the oral bioavailability of drugs.
f) They are osmotically active and stable.
g) They increase the stability of the entrapped drug.
h) They can enhance the skin penetration of drug.
i) They can be made to reach the site of action by oral, parenteral as well as topical routes.
j) The surfactants are biodegradable, biocompatible, and non immunogenic.
k) Handling and storage of surfactants do not require any special conditions.
l) The vesicle suspension being water based offers greater patient compliance over oily dosage forms.[7]

Disadvantages of Niosomes

1. Physical instability
2. Aggregation
3. Fusion
4. Leaking of entrapped drug

5. Hydrolysis of encapsulated drugs which limiting the shelf life of the dispersion

Compositions of Niosomes

The two major components used for the preparation of niosomes are:

1. Cholesterol
2. Non ionic surfactants

1. Cholesterol

Cholersterol is used to provide rigidity and proper shape, conformation to the niosomes preparations.

2. Non Ionic Surfactants

The role surfactants play a major role in the formation of niosomes.The following non ionic surfactants are generally used for the preparation of niosomes.

Ex;

Spans (span 60, 40, 20, 85, 80)

Tweens (tween 20, 40, 60, 80) and

Brijs (brij 30, 35, 52, 58, 72, 76)

The non ionic surfactants possess a hydrophilic head and hydrophobic tail.[8]

Surfactants used in formation of niosomes

Niosomes are non-ionic surfactant unilamellar or multilamellar vesicles formed from synthetic non-ionic surfactants.

The surfactants that are reported to form niosomes are as follows

1. Ether linked surfactant

These are surfactants in which the hydrophilic hydrophobic moieties are ether linked, polyoxyethylene alkyl ethers with the general formula (CnEOm), where n; and m; i.e. number of oxyethylene unit varies between 3 and 7.

2. Dialkyl chain surfactants

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

$$C_{16}H_{33}CH\text{-}O\ [\text{-}CH_2\text{-}CH\text{-}O]_7\text{-}H$$

$$\|$$

CH_2CH_2OH

|

$C_{12}H_{25}$-O [Mol.wt.972].

3. Ester linked

These are the surfactants in which hydrophilic and hydrophobic moieties are ester linked. Ester linked surfactant.

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

OH (mol. Wt. 393)

This surfactant was also studied for its use in the preparation of stibogluconate bearing niosomes and in delivery of sodium stibogluconate to the experimental marine visceral leishmaniasis following administration of niosomal system. The commercial sorbitan esters are H-C-OH mixtures of the partial esters of sorbita.

4. Sorbitan Esters

CH_2 where, R is H or an alkyl chain.

|

H-C-OH

|

RCOO- C-H

|

H-C-OH

|

H-C-OOC-R

|

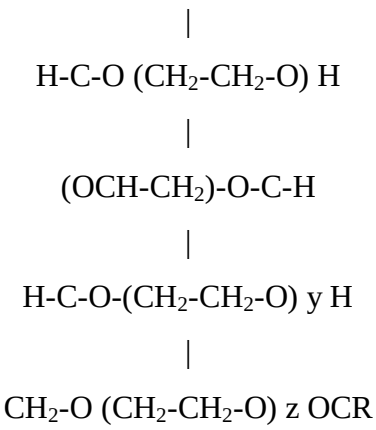
CH_2OOC-R

The formula of a representative component is shown above. Sorbitan esters based niosomes bearing methotrexate were prepared and evaluated for pharmacokinetics of the entrapped methotrexate in tumour bearing mice.

5. Poly-sorbates

The typical structural formula of polysorbates is

CH_2



When n = x + y + z + 2 and R is an alkyl chain this series of surfactants has been used to study the pharmacokinetics of niosomal entrapped methotrexate.[9]

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 act 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 sterylamine and cetylpyridinium chloride and negative charge inducers are dicetyl phosphate, dihexadecyl phosphate and lipoamine acid.[10]

METHODS OF PREPARATION

A. Hand shaking method (Thin film hydration technique)

The mixture of vesicles forming ingredients like surfactant and cholesterol are dissolved in a volatile organic solvent (diethyl ether, chloroform or methanol) in a round bottom flask. The organic solvent is removed at room temperature (20°C) using rotary evaporator leaving a thin layer of solid mixture deposited on the wall of the flask. The dried surfactant film can be rehydrated with aqueous phase at 0-60°C with gentle agitation. This process forms typical multilamellar niosomes.

B. Micro fluidization

Micro fluidization is a recent technique used to prepare unilamellar vesicles of defined size distribution. This method is based on submerged jet principle in which two fluidized streams interact at ultra high velocities, in precisely defined micro channels within the interaction chamber. The impingement of thin liquid sheet along a common front is arranged such that

the energy supplied to the system remains within the area of niosomes formation. The result is a greater uniformity, smaller size and better reproducibility of niosomes formed.

C. Reverse Phase Evaporation Technique (REV)

Cholesterol and surfactant (1:1) are dissolved in a mixture of ether and chloroform. An aqueous phase containing drug is added to this and the resulting two phases are sonicated at 4-5°C. The clear gel formed is further sonicated after the addition of a small amount of phosphate buffered saline (PBS). The organic phase is removed at 40°C under low pressure. The resulting viscous niosome suspension is diluted with PBS and heated on a water bath at 60°C for 10 min to yield niosomes.

D. Ether injection method

This method provides a means of making niosomes by slowly introducing a solution of surfactant dissolved in diethyl ether into warm water maintained at 60°C. The surfactant mixture in ether is injected through 14-gauge needle into an aqueous solution of material. Vaporization of ether leads to formation of single layered vesicles. Depending upon the conditions used, the diameter of the vesicle range from 50 to 1000nm.

E. Trans membrane pH gradient (inside acidic) Drug Uptake Process (remote Loading)

Surfactant and cholesterol are dissolved in chloroform. The solvent is then evaporated under reduced pressure to get a thin film on the wall of the round bottom flask. The film is hydrated with citric acid (pH 4.0) by vortex mixing. The multilamellar vesicles are frozen and thawed 3 times and later sonicated. To this niosomal suspension, aqueous solution containing 10 mg/ml of drug is added and vortexed. The pH of the sample is then raised to 7.0-7.2 with 1M disodium phosphate. This mixture is later heated at 60°C for 10 minutes to give niosomes.

F. The "Bubble" Method

It is novel technique for the one step preparation of liposomes and niosomes without the use of organic solvents. The bubbling unit consists of round-bottomed flask with three necks positioned in water bath to control the temperature. Water-cooled reflux and thermometer is positioned in the first and second neck and nitrogen supply through the third neck.Cholesterol and surfactant are dispersed together in this buffer (pH 7.4) at 70°C, the dispersion mixed for 15 seconds with high shear homogenizer and immediately afterwards "bubbled" at 70°C using nitrogen gas.

G. Sonication

A typical method of the vesicles is by sonication of solution as described by Cable. In this method an aliquot of drug solution in buffer is added to the surfactant/choleste mixture in a 10-ml glass vial. The mixture is probe sonicated at 60°C for 3 minutes using a sonicator with a titanium probe to yield niosomes.

H. Formation of niosomes from proniosomes

Another method of producing niosomes is to coat a water-soluble carrier such as sorbitol with surfactant. The result of the coating process is a dry formulation. In which each water-soluble particle is covered with a thin film of dry surfactant. This preparation is termed "Proniosomes". The niosomes are recognized by the addition of aqueous phase at T > Tm and brief agitation. T=Temperature. Tm = mean phase transition temperature. Blazek-Walsh A.I. *et al.*[18] have reported the formulation of niosomes from maltodextrin based proniosomes. This provides rapid reconstitution of niosomes with minimal residual carrier. Slurry of maltodextrin and surfactant was dried to form a free flowing powder, which could be rehydrated by addition of warm water.[11]

Separation of Unentrapped Drug

The removal of unentrapped solute from the vesicles can be accomplished by various techniques, which include

1. Dialysis

The aqueous niosomal dispersion is dialyzed in a dialysis tubing against phosphate buffer or normal saline or glucose solution.

2. Gel Filtration

The unentrapped drug is removed by gel filtration of niosomal dispersion through a Sephadex-G-50 column and elution with

3. Centrifugation

The niosomal suspension is centrifuged and the supernatant is separated. The pellet is washed and then resuspended to obtain a niosomal suspension free from unentrapped drug.[12]

Characterizations of Niosomes

1. Entrapment efficiency

After preparing niosomal dispersion, unentrapped drug is separated by dialysis, centrifugation or gel filtration as described above and the drug remained entrapped in niosomes is determined by complete vesicle disruption using 50% n- propanol or 0.1% Triton X-100 and

analysing the resultant solution by appropriate assay method for the drug Where, % Entrapment efficiency (% EF) = (Amount of drug entrapped/ total amount of drug) x 100.

2. Vesicle diameter

Niosomes diameter can be determined using light microscopy, photon correlation microscopy and freeze fracture electron microscopy. Freeze thawing (keeping vesicles suspension at –20°C for 24 hrs and then heating to ambient temperature) of niosomes increases the vesicle diameter, which might be attributed to fusion of vesicles during the cycle.

3. 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 is pipetted into a bag made up of the tubing and sealed.

The bag containing the vesicles is placed in 200 ml of buffer solution in a 250 ml beaker with constant shaking at 25°C or 37°C. At various time intervals, the buffer is analyzed for the drug by an appropriate assay method.

4. Number of lamellae

It is determined by using NMR spectroscopy, small angle X-ray scattering and electron microscopy.

5. Membrane rigidity

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

6. Bilayer formation

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

7. Stability study

Stability studies are done by storing niosome at two different conditions, usually 4±10C and 25±2^{0}C. Formulation Size, shape and number of vesicles per cubic mm can be assessed before and after storing for30 days. After 15 and 30 days, 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 bhaemocytometer. Number of niosomes per cubic mm = Total number of niosomes x dilution factor x400.Total number of small squares counted.[13]

8. Vesicle Charge

The vesicle surface charge can play an important role in the behaviour of niosomes invivo and invivo. Ingeneral, charged niosomes are more stable against aggregation and fusion than uncharged vesicles. In order to obtain an estimate of the surface potential, and the zeta potential of individual niosomes can be measured by microelectrophoresis.

An alternative approach is the use of p^H –sensitive fluorophores. More recently, dynamic light scattering have been used to measure the Zeta potential of niosomes.

9. Homogeneity

In homogeneity can occur both within niosome structures themselves and between niosomes in dispersion and could be identified via p-NMR,differential scanning calorimetry (DSC) and fourier transform –infra red spectroscopy (FT-IR) techniques.Recently,fluorescence resonance energy transfer (FRET) was used to obtain deeper insight about the shape, size and structure of the niosomes.[14]

10. Stability Studies

To determine the stability of niosomes, the optimized batch was stored in airtight sealed vials at different temperatures Surface characteristics and percentage drug retained in niosomes and niosomes derived from proniosomes were selected as parameters for evaluation of the stability, since instability of the formulation would reflect in drug leakage and a decrease. In the percentage drug retained. The niosomes were sample at regular intervals of time (0, 1,2, and 3months), observed for color change, surface characteristics and tested for the percentage drug retained after being hydrated to form niosomes and analyzed by suitable Analytical methods (UV spectroscopy, HPLC methods etc).[8]

Table 1: Method for Evaluation of Niosomes.

Evaluation Parameters	Method
Morphology	SEM, TEM, freeze fracture technique
Size distribution, polydispersity index	Dynamic light scattering particle size analyzer
Viscosity	Ostwald viscometer
Membrane thickness	X-ray scattering analysis
Thermal analysis	DSC
Turbidity	UV-visible diode array spectrophotometer
Entrapment efficacy	Centrifugation,dialysis,gel chromatography
Invitro release study	Dialysis membrane
Permeation study	Franz diffusion cell

Applications

Niosomal drug delivery is potentially applicable to many pharmacological agents for their action against various diseases. Few of their therapeutic applications are as follows:

Targeting of bioactive agents

To reticulo-endothelial system (RES)

The vesicles occupy preferentially to the cells of RES. It is due to circulating serum factors known as opsonins, which mark them for clearance. Such localized drug accumulation has, however, been exploited in treatment of animal tumors known to metastasize to the liver and spleen and in parasitic infection of liver.

To organs other than reticulo-endothelial system (RES)

By use of antibodies, carrier system can be directed to specific sites in the body. Immunoglobulins seem to have affection to the lipid surface, thus providing a convenient means for targeting of drug carrier. Many cells have the intrinsic ability to recognize and bind particular carbohydrate determinants and this property can be used to direct carriers system to particular cells.

Delivery of peptide drugs

Niosomal entrapped oral delivery of 9-desglycinamide, 8- arginine vasopressin was examined in an in-vitro intestinal loop model and reported that stability of peptide increased significantly. Immunological applications of Niosomes for studying the nature of the immune response provoked by antigens niosomes have been used. Niosomes have been reported as potent adjuvant in terms of immunological selectivity, low toxicity and stability.

Niosome as a carrier for Haemoglobin

Niosomal suspension shows a visible spectrum super imposable onto that of free haemoglobin so can be used as a carrier for haemoglobin. Vesicles are also permeable to oxygen and haemoglobin dissociation curve can be modified similarly to non-encapsulated haemoglobin.

Transdermal delivery of drugs by niosomes

An increase in the penetration rate has been achieved by transdermal delivery of drug incorporated in niosomes as slow penetration of drug through skin is the major drawback of transdermal route of delivery for other dosage forms. The topical delivery of erythromycin from various formulations including niosomes has studied on hair less mouse and from the studies, and confocal microscopy, it was found that non-ionic vesicles could be formulated to target pilosebaceous glands.

Table 2: List of Drugs formulated as Niosomes.

Routes of administration	Examples of drug
Intravenous route	Doxorubicin, Methotrexate, Sodium stibogluconate, Iopromide, Vincristine, Diclofenac sodium, Flurobiprofen, Centchronam, Indomethacin, Colchicine, Rifampicin, Tretinoin, Transferrin and Glucose ligands, Zidovudine, Insulin, Cisplatin, Amarogentin, Daunorubicin, Amphotericin B, 5-Fluorouracil, Camptothecin, Adriamycin, Cytarabine Hydrochloride
Peroral route	DNA vaccines, Proteins, Peptides, Ergot Alkaloids, Ciprofloxacin, Norfloxacin, Insulin
Transdermal routes	Flburiprofen, Piroxicim, Estradiol, Levonorgestrol, Nimesulide, Dithranol, Ketoconazole, Enoxacin, Ketorolac
Ocular route	Timolol Maleate, Cyclopentolate
Nasal route	Sumatriptan, Influenza Viral Vaccine
Inhalation	A11-trans retinoic acids

Diagnostic imaging with niosomes

Niosomal system can be used as diagnostic agents. Conjugated niosomal formulation of gadobenatedimeglcemine with [N-palmitoylglucosamine (NPG)], PEG4400, and both PEG and NPG exhibit significantly improved tumour targeting of an encapsulated paramagnetic agent assessed with MR imaging.

Ophthalmic drug delivery

From ocular dosage form like ophthalmic solution, suspension and ointment it is difficult to achieve excellent bioavailability of drug due to the tear production, impermeability of corneal

epithelium, non-productive absorption and transient residence time. But niosomal and liposomal delivery systems can be used to achieve good bioavailability of drug. Bio adhesive-coated niosomal formulation of acetazolamide prepared from span 60, cholesterol stearylamine or dicetyl phosphate exhibits more tendencies for reduction of intraocular pressure as compared to marketed formulation (Dorzolamide).

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. Localized drug action results in enhancement of efficacy of potency of the drug and at the same time reduces its systemic toxic effects e.g. Antimonials encapsulated within niosomes are taken up by mononuclear cells resulting in localization of drug, increase in potency and hence decrease both in dose and toxicity.[15]

Hormones

Luteinizing hormone releasing hormone (LHRH) was formulated in niosomes of Hexadecyl diglycerol ether (C16G2), cholesterol, and poly-24-oxyethylene cholesteryl ether (Solulan C24) in the ratio 91:0:9 which resulted in polyhedral niosomes. The prepared niosomes were stable in both muscle homogenate and plasma and had clearance of about 49 hours with sustained release.

Muscle Relaxants

Niosomes of baclofen a centrally acting muscle relaxant have been prepared to improve the low skin penetration and bioavailability characteristics shown by conventional topical vehicle. The prepared niosomes revealed advantages in vesicle surface morphology, entrapment efficiency, and in vitro drug release, Osmotic fragility, stability studies and showed improved muscle relaxation activity.

Anaesthetics

Interest in new delivery systems for local anaesthetics led to non-ionic surfactant vesicles of lidocaine. The performance of niosomes containing lidocaine hydrochloride is remarkably better than that observed with classical liposomes and Tween 20 micelles. The neutral vesicles, prepared with Tween 20 and cholesterol, entrap a higher lidocaine amount presenting it as novel delivery system for lidocaine hydrochloride.

Anti-Diabetic

Oral bioavailability of Gliclazide an oral ant diabetic drug was improved by entrapment in nonionic surfactant vesicles; also the release was sustained over a period of 24 hours for better therapeutic efficacy. The high values of zeta potential indicate stabilization of niosomes by electrostatic repulsive forces.

Contraceptive

The anti-fertility effect of cantchroman was enhanced by incorporation into niosomes. The prepared formulation showed 48.73% release in 8 hours and in vivo anti-fertility studies showed 83.3% protection against pregnancy. Histopathological studies showed no side effects and no other toxic effects. So the study presents the niosomes as suitable delivery system for contraceptives.[16]

Niosomes Vs Liposomes[17]

1. Niosomes are now widely studied as an alternative to liposomes, which exhibit certain disadvantages such as –they are expensive, their ingredients like phospholipids are chemically unstable because of their predisposition to oxidative degradation, they require special storage and handling and purity of natural phospholipids is variable.

2. Differences in characteristics exist between liposomes and niosomes, especially since niosomes are prepared from uncharged single-chain surfactant and cholesterol whereas liposomes are prepared from double-chain phospholipids (neutral or charged). Niosomes behave in-vivo like liposomes, prolonging the circulation of entrapped drug and altering its organ distribution and metabolic stability. Encapsulation of various anti neoplastic agents in these carrier vesicles has been shown to decrease drug induced toxic side effects, while maintaining, or in some instances, increasing the anti-tumour efficacy. Such vesicular drug carrier systems alter the plasma clearance kinetics, tissue distribution, metabolism and cellular interaction of the drug. They can be expected to target the drug to its desired site of action and/or to control its release.

3. As with liposomes, the properties of niosomes depends both on the composition of the bilayer and on method of their production. The intercalation of cholesterol in the bilayers decreases the entrapment volume during formulation and thus entrapment efficiency. As the concentration of cholesterol increases, entrapment efficiency decreases.

4. The entrapment efficiency increases with increase in the concentration and lipophilicity of surfactant. It was also observed that as HLB value of surfactant decreased, the mean size was reduced. Chandraprakashet al made Methotrexate loaded non-ionic surfactant vesicles using lipophilic surfactants like Span 40, Span 60 and Span 80 and found that Span 60 (HLB = 4.7) gave highest percent entrapment while Span 85 (HLB = 9.8) gave least entrapment.[4-11]

REFERENCES

1. Lohumi Ashutosh, Rawat Suman, Sarkar Sidhyartha, Sipai Altaf Bhai., Yadav M. Vandana. A Novel Drug Delivery System: Niosomes Reviews. Journal of Drug Delivery & Therapeutics, 2012; 2(5): 129-135.
2. Harsimran Kaur, Sonia Dhiman, Sandeep Arora. Niosomes: A Novel Drug Delivery System. International Journal of Pharmaceutical Sciences Review and Research, 2012; 15(1): 113-120.
3. Saurabh Bansal, Chandan Prasad Kashyap, Geeta Aggarwal and SL Harikumar. A Comparative Review on Vesicular Drug Delivery System and Stability Issues. International Journal of Research in Pharmacy and Chemistry, 2012; 2(3): 704-713.
4. Pravina Gurjar, Nivedita Naik, Sujay Chouksey. Niosomes: A Promising Pharmaceutical Drug Delivery. International Journal of Pharmaceutics and Drug Analysis, 2014; 2(5): 425-431.
5. Harini Chowdary Vadlamudi, M Sevakarajan. Niosomal Drug Delivery System-A Reveiw. Indo American Journal of Pharmaceutical Research, 2012; 2(9): 1-20.
6. Deepak Singh and Dr. Prashant Upadhyay. Niosomes: A Novel Vescular Approach. World Journal of Pharmacy and Pharmaceutical Sciences, 2016; 5(12): 1586-1592.
7. Navneet Kumar Verma and Asha Roshan. Niosomes and its Applications-A Review. International Journal of Research in Pharmacy and Life Sciences, 2014; 2(1): 182-184.
8. V. Pola Chandu, A. Arunachalam, S. Jegnath, K. Yamini, K.Tharangini. Niosomes: A Novel Drug Delivery System. International Journal of Novel Trends in Pharmaceutical Sciences, 2012; 2(1): 25-31.
9. Pranshu Tangri, Shaffi Khurana. Niosomes: Formulation and Evaluation. International Journal of Biopharmaceutics, 2011; 2(1): 47-53.
10. Sanklecha VM, Pande VV, Pawar SS, Pagar OB and Jadhav AC. Review on Niosomes. Austin Pharmacology and Pharmaceutics, 2018; 3(2): 1-7.
11. Madhav NVS and Saini A. Niosomes: A Novel Drug Delivery System. International Journal of Research in Pharmacy and Chemistry, 2011; 1(3): 498-511.

12. Vijay D. Wagh and Onkar J. Deshmukh. Niosomes as Ophthalmic Drug Delivery Systems: A Review .Journal of Pharmacy Research, 2010; 3(7): 1558-1563.
13. Mayur Gandhi, Sanket Paralkar, Mahendra Sonule, Dhiraj Dabhade and Sagar Pagar. Niosomes: Novel Drug Delivery System. International Journal of Pure and Applied Bioscience, 2014; 2(2): 267-274.
14. Kumar Abhinav, Pal Jogender Lal, Jaswal Amit, Singh Vishwabhan. Review on Niosomes as Novel Drug Delivery System. International Research Journal of Pharmacy, 2011; 2(5): 61-65.
15. V. Shakya, B.K. Bansal. Niosomes: A Novel Trend in Drug Delivery. International Journal of Research and Development in Pharmacy and Life Sciences, 2014; 3(4): 1036-1041.
16. Anchal Sankhyan and Pravin Pawar. Recent Trends in Niosome as Vesicular Drug Delivery System. Journal of Applied Pharmaceutical Science, 2012; 2(6): 20-32.
17. Sakthivel M, Kannan k, Manavalan R, Senthamarai R. Non Ionic Surfactant Vesicles-A Review. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 2012; 3(1): 604-614.