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Review Article

Revolutionizing Drug Delivery: The Potential of Niosomes In Modern Therapeutics

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ABSTRACT

Niosomes are vesicular systems based on non-ionic surfactants that have gained recognition as a promising alternative to liposomes for drug delivery and targeted therapy. Their different features, including improved stability, cost efficiency, and the ability to encapsulate both hydrophilic and lipophilic drugs, make them highly attractive for improving therapeutic outcomes. This review critically examines the potential of niosomes to transform drug delivery systems. It thoroughly discusses aspects such as formulation, characterization, and the functional benefits of niosomes. Additionally, the review covers their uses in areas like cancer therapy, antimicrobial treatment, and vaccine delivery. It also addresses the challenges and limitations of niosomal systems, such as scalability, drug release kinetics, and regulatory issues. Despite these hurdles, niosomes are a versatile platform that offers innovative solutions to enhance bioavailability, enable targeted delivery, and provide controlled drug release. This overview highlights the current research landscape of niosomes and their promising role in advancing modern drug delivery technologies.

INTRODUCTION

In recent years, the field of drug delivery has made impressive strides toward enhancing how medicines behave in the body—with aims like increasing absorption, improving stability, and boosting effectiveness. Among the standout developments are niosomes—tiny, self-assembled vesicles made from non-ionic surfactants and

cholesterol. They are often seen as a strong alternative to liposomes because they combine flexibility in design, affordability, straightforward production, and excellent stability. This makes them ideal for carrying both water-soluble and fat-soluble drugs.⁽¹⁾

Niosomes bring more benefits to the table. They maintain drug stability better than liposomes, they

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don't require harsh storage conditions, and they can steadily release drugs over time. Their structure allows both hydrophilic and lipophilic drugs to be encapsulated effectively, and they can be tuned for targeted, site-specific delivery—potentially reducing side effects and improving treatment outcomes. These vesicles have applications in therapeutic fields like cancer treatment, vaccine delivery, and fighting infections. Their skilfulness allows for controlled release and targeted delivery, which can limit systemic exposure and help tackle issues like drug resistance.⁽²⁾

Despite their promise, niosomal systems face difficulties in moving from the lab to real-world use. Scaling up production can be tricky, with issues like vesicle aggregation, drug leakage, and inconsistent loading efficiency that can arise. The processes often involve specialized techniques and equipment, which will lead to costs and complicate mass manufacturing.

This review aims to provide a complete overview of the current landscape of niosome research by examining how they have been formulated, how they work, and key practical applications. By exploring the innovations and strategies, we hope to highlight how niosomes could transform drug delivery approaches in the future.⁽³⁾

Mechanism of Drug Release from Niosomes

The mechanism of drug release from niosomes is a critical aspect that determines the efficiency and therapeutic outcomes of niosomal drug delivery systems. Niosomes are non-ionic surfactant-based vesicular carriers, and their drug release characteristics depend on several factors, including the type of drug, the surfactant composition, the nature of the membrane, and the environmental conditions. Below are the key

mechanisms by which drugs are released from niosomes.^{(4),(5)}

1. Diffusion Mechanism⁽⁵⁾⁽⁶⁾

- The most common mechanism of drug release from niosomes is diffusion. In this process, the drug molecules gradually diffuse from the interior of the niosomal vesicle to the surrounding environment. The rate of diffusion depends on factors such as the solubility of the drug (hydrophilic or lipophilic), the drug concentration gradient, and the properties of the niosomal membrane (e.g., thickness and permeability).
- **Hydrophilic drugs:** Hydrophilic drugs are typically encapsulated in the aqueous section of the niosome, and their release depends on the diffusion of the drug from the core to the outer part. The release rate of hydrophilic drugs may be influenced by the size of the niosomal vesicle and the viscosity of the surrounding medium.
- **Lipophilic drugs:** Lipophilic drugs are incorporated or fixed in the lipid bilayer of the niosomal membrane. The release of lipophilic drugs will occur via diffusion through the bilayer into the external environment, and this process is slower when compared to hydrophilic drug diffusion due to the dense nature of the lipid layer.

2. Osmotic Drug Release⁽⁷⁾

- Osmotic release is the infiltration of water into the niosomal vesicle because of the osmotic gradient between the internal and external settings. This influx of water has the potential to swell the vesicle, rupture the niosomal membrane, and deliver the drug that was in the niosome.
- This mechanism is often observed in niosomes that contain hydrophilic drugs, as



the drug is surrounded by an aqueous core. The osmotic pressure difference can also be enhanced by the presence of electrolytes in the formulation.

3. Membrane Permeability (Leakage)

- Niosomes possess semipermeable membranes, and drug release is also possible through leakage of the drug through the disruption or thinning of the membrane. This may occur as the result of alterations in the external environment (e.g., pH, temperature, or ionic strength) or through breakdown of the surfactant molecules in the niosomal membrane.
- As an example, the structural stability of the niosomal membrane can be disrupted by changes to pH (acidic or basic), resulting in the destabilization of the niosomal and the release of the drug. The mechanism of leakage is especially of interest in sustained or controlled drug release over long time-scales.⁽⁸⁾⁽⁹⁾

4. Erosion and Degradation of Niosomal Membrane

- In some cases, erosion or degradation of the niosomal membrane contributes to the release of the drug. This mechanism is particularly relevant for niosomes composed of biodegradable surfactants or polymers.
- Such a niosomal membrane may contain surfactant or lipid components that undergo enzymatic and/or hydrolytic degradations over time, providing slow and controlled release of encapsulated drug.
- This release mechanism due to degradation is useful towards the considerably sustained therapy effect particularly in cases of drug requirements with long release profiles.⁽⁵⁾⁽¹⁰⁾

5. pH-Sensitive Drug Release

- Niosomes may be developed to behave in terms of releasing their drug payload under pH fluctuations. This is particularly helpful in the targeted release to those parts of the body, such as the stomach (acidic pH) or tumor locations (slightly acidic pH), due to natural environmental triggering effects of the acidic environment.
- pH- responsive niosomes usually contain those surfactants, polymers or excipients that can alter their structure under changing pH conditions. The effects on the membrane structure may augment its permeability, resulting in the liberation of the drug that has been encapsulated.⁽¹¹⁾

6. Thermally-Triggered Drug Release

- Other niosomal system releases drugs when there is a change in temperature. This process takes advantage of the temperature-sensitive characteristics of some surfactants or lipids whose structure and permeability change at high temperatures.
- The thermal transition of the niosomal membrane from gel phase to liquid crystalline phase can result in the leakage of encapsulated drugs. This approach is often used for targeted drug delivery systems that respond to localized hyperthermia (e.g., in tumor tissues).⁽¹²⁾

7. Enzyme-Mediated Drug Release

- Enzyme-mediated release is another mechanism by which drugs are selectively released from niosomal carriers. This mechanism is highly relevant for the delivery of drugs to specific sites where enzymes are overexpressed, such as in cancer or inflammation.



- Phospholipases or esterases can also disrupt surfactant components in niosomal membrane to trigger its destabilization and a controlled release of the drug. Such a methodology can provide high specificity in therapeutics.

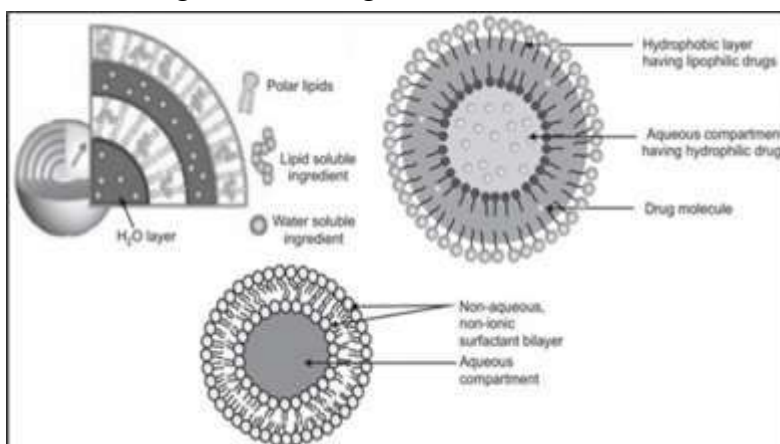
8. Active Targeting and Triggered Release

- Active targeting Niosomal systems may also be designed to target specific cells or tissues, in which surface modifications (ligands or antibodies) allow the niosomes to bind to specific receptors in the target cells/tissues. External triggers that can stimulate this drug release in this case can include ultrasound, magnetic field, or laser light.
- This process promotes the specificity of the administration of the drug, minimizing

systemic toxicity and overall improving therapeutic effect.

Structure of Niosomes

Niosomes are vesicular structures made with non-ionic surfactants in a bilayering arrangement, with both hydrophilic and hydrophobic ends out and inside, respectively. They trap an aqueous core that can load hydrophilic drugs. Surfactants, such as Span and Tween, and may be mixed with cholesterol to improve stability. Niosomes are flexible at the unilamellar level and can be large multilamellar structures. Their composition enables them to deliver both hydrophilic and lipophilic drugs effectively and with a higher stability than liposomes.⁽¹³⁾⁽¹⁴⁾



1.2. Advantages

- Niosomes are water-based vehicles, hence, they offer high patient compliance over oily vehicles.
- They increase the stability of drugs entrapped and make them stable.
- No special conditions are required for the storage and handling of surfactants.
- They enhance the penetration of drugs into the skin and also improve the bioavailability of poorly absorbed drugs.
- Niosomes protect the drug from the biological environment, delay the drug clearance, and improve the therapeutic performance.
- Niosomes can be used for site targeting through oral, parenteral, and topical routes.
- They have longer shelf life and chemical stability compared to liposomes.
- They do not carry any surface charge. Hence, they are less toxic and more compatible.
- They can entrap both hydrophilic and lipophilic drugs.
- They are used for sustained and controlled drug delivery. – GSC biological

1.3. Disadvantages

- Besides several advantages, there are some disadvantages of Niosomes.
- The shelf life of Niosomes is limited because of the leakage of drugs from the vesicles.
- Aggregation and fusion of vesicles can occur.
- There may be small physical and chemical instability problems.
- In aqueous suspensions, the drug may undergo hydrolysis which affects the stability.
- Preparation of Niosomes is a time-consuming process.
- They require specialized equipment.

2. Composition of Niosomes ⁽¹³⁾⁽¹⁵⁾

The three main components used in the preparation of Niosomes are

- Non-ionic surfactants
- Cholesterol

2.1. Non-ionic surfactants

Non-ionic surfactants play an important part in the medication of Niosomes. They're the introductory factors. They correspond of a polar head and a hydrophobic tail. They arrange themselves in a bilayer with their hydrophilic head towards waterless media and hydrophobic or non-polar tail facing outside. In order to attain thermal stability, they fold inwards to form a vesicle. They're banal because they don't carry any charge. They beget lower hemolysis in the apkins. They beget lower vexation. They enhance permeability, ameliorate the solubility, and also they're also good wetting down agents and used as emulsifiers. They enhance immersion and targeting because they inhibit p-glycoprotein. Selection of non-ionic surfactants depends on HLB value, liquid transition temperatures, and CPP (critical packaging parameter). High HLB value

surfactants aren't suitable for medication of Niosomes. Loftiest ruse effectiveness is set up with an HLB value of 8.

Examples:

- Spans like span 60, 40, 20, 85, and 80
- Tweens tween 20, 40, 60, 80.

2.2. Cholesterol

Cholesterol also acts as an important part of Niosomes. Cholesterol isn't needed for the expression of Niosomes, but it provides several parcels to the expression. Cholesterol imparts several characteristics to the expression, like an increase in stability, ruse effectiveness, permeability, rehydration of dried Niosomes, etc. Stability of the vesicle is increased if cholesterol is used with low HLB value surfactants, and helps in the conformation of a bilayer of vesicles if the HLB value is lesser than 6.

2.3. Charged molecules

They're added to help the coalescence of Niosomes and increase their stability. Only 2.5–5 spook attention is tolerable. However, it inhibits the conformation of Niosomes if the concentration of charged moieties is high in the expression. Niosomes having a composition of cholesterol, Span 20, diacetyl phosphate (10101, 15151, and 20201) were prepared and estimated for vaccine encapsulation effectiveness using the HI test. The values attained from the different rates were analogous, and the loftiest encapsulation was 50.

Examples:

- diacetyl phosphate
- phosphatidic acid.

3. Methods of Preparation ⁽¹⁶⁾⁽¹⁷⁾



Since the medication styles impact the number of bilayers, size, size distribution, and ruse effectiveness of the waterless phase and the membrane permeability of the vesicles, the medication styles should be chosen grounded on the use of the Niosomes.

3.1. Ether injection method

This process involves sluggishly introducing a result of surfactant dissolved in diethyl ether into warm water, which is maintained at 60°C. The surfactant admixture in ether is fitted into a waterless result through a 14-hand needle. Latterly, the ether is wracked, which results in the conformation of single-layered vesicles. The periphery of the vesicles may be around 50–1000 nm, depending on the conditions.

3.2. Hand shaking method / thin film hydration method

An admixture of surfactant and cholesterol is dissolved in an unpredictable organic detergent like chloroform or methanol, or diethyl ether, in a round-bottom beaker. Organic detergent is removed at room temperature at 20°C using a rotary evaporator, which leaves a thin subcaste of solids deposited on the walls of RBF. This dried surfactant film is rehydrated with a waterless phase at 0–60°C with agitation. This forms multilamellar vesicles.

3.3. Sonication method

A medicine in the buffer result is added to the surfactant admixture. This admixture is taken into a 10 ml glass vial. This vial containing a medicine and surfactant admixture is sonicated for 10 twinkles at 60°C using an inquiry sonicator with a titanium inquiry to produce multilamellar niosomes. Also, these Niosomes are ultrasonicated

by bath sonicator or inquiry sonicator to produce unilamellar niosomes.

3.4. Reverse phase evaporation method

Surfactant and cholesterol are taken in a 1:1 rate and dissolved in an admixture of chloroform and ether. A medicine in waterless result is added to the below admixture. As a result, 2 phases are formed. These are sonicated at 5°C after adding a small quantum of phosphate-softened saline. Under low pressure, the organic phase is removed at 40°C. The performing thick suspense of Niosomes is adulterated using PBS and hotted in a water bath for 10 twinkles at 60°C to form Niosomes.

3.5. Transmembrane pH gradient (Inside Acidic) Drug Uptake Process (Remote Loading)

In this system, surfactant and cholesterol are dissolved in chloroform. Under reduced pressure, the detergent is faded to get a thin film on the wall of round-bottom beaker. This film is doused with 300 mM citric acid of pH 4. The multilamellar Niosomes formed are sonicated. To this suspense of Niosomes, a waterless result of 10 mg medicine is added and vortexed and the pH is raised to 7.0–7.2 with 1 M disodium phosphate. This performing admixture is hotted at 60°C for 10 min to give Niosomes.

3.6. Membrane extrusion method

An admixture of surfactant and cholesterol and diacetyl phosphate in chloroform is made into a thin film by evaporation. The film is doused with a waterless medicine polycarbonate membrane with a mean severance size of 0.1 µm. The result and the attendant suspense is extruded which are placed in series for up to 8 passages. This is a good system for controlling the size of niosomal vesicles.



3.7. Microfluidization

This is a recent fashion that's used to prepare unilamellar vesicles of a particular size. This system is grounded on the submerged spurt principle. In this system, the two fluidized aqueducts interact with high rapidity in micro-channels within the commerce chamber. The result is also passed through the cooling circle to remove the heat produced during the process. This system produces Niosomes of lower size with great uniformity and better reproducibility.

3.8. Bubble method

This is a new fashion for single-step medication of Niosomes and liposomes without using organic detergents. The washing unit consists of a round-bottomed beaker with 3 necks kept in the water bath to control the temperature. Water-cooled influx and the thermometer are deposited in the first and alternate neck independently and nitrogen gas is supplied through the 3rd neck. Surfactant and cholesterol are dispersed in the buffer result of pH 7.4 at 70°C. The attendant dissipation is mixed in a high shear homogenizer for 15 seconds and incontinently gurgled using nitrogen gas at 70°C.

4. Evaluation of Niosomes ⁽¹³⁾⁽¹⁷⁾

There are several characterization techniques for Niosomes

4.1. Size, morphology, and size distribution\

Numerous ways like light microscopy, photon correlation spectroscopy, electron bitsy analysis, SEM (surveying electron microscope), TEM (transmission electron microscope), light scattering, and zeta sizer can be used to study their morphology and determine the size of Niosomes. Flyspeck size measured by the transmission electron microscope is lower than the dynamic light scattering (DLS) system because of the

different dimension principles used by the two ways.

4.2. Transmission Electron Microscopy (TEM)

TEM is used in the determination of the shape, size, and lamellarity of Niosomes. The set suspense is mixed with 1 phosphotungstic acid (in the needed quantum), and also a drop of this attendant was used on a carbon-carpeted grid, and also the grid was observed after draining off the excess. The images are taken under suitable exaggeration under TEM after drying fully.

4.3. Optical Microscopy Technique

This fashion is also used for the observation of the shape and size of the Niosomes. The flyspeck size is determined by taking nearly 100 Niosomes are used for flyspeck size determination. The size of the Niosomes is also determined by coinciding the stage micrometer and eyepiece micrometer and calculating the measures.

4.4. Entrapment efficiency

Entrapment efficiency can be calculated by subtracting the amount of unloaded drug from the total amount of drug added. The unloaded drug can be determined using techniques such as filtration, exhaustive dialysis, centrifugation, or gel chromatography. The concentration of loaded drugs can be calculated by dissolving the Niosome in 50% n-propanol or 0.1% Triton X-100 and the resulting solution can be assayed using any specific method. The following equation can be used to calculate the % entrapment efficiency.

4.5. Charge on Niosome and zeta potential

The charge present on the Niosomes causes them to repel each other. This electrostatic aversion prevents aggregation and emulsion and keeps them stable. The face charge on Niosomes is determined



using zeta eventuality. Zeta eventuality is determined by the zeta sizer, master size, and DLS instrument.

5. Applications ⁽¹⁸⁾ ⁽¹⁹⁾ ⁽²⁰⁾

5.1. Ophthalmic Drug Delivery

Niosomes formulated for ophthalmic medicine delivery show dragged medicine release. The most effective gentamicin Niosomes for extending medicine release from the optical delivery system were those made of Tween 60, cholesterol, and DCP, according to an in-vitro comparison of gentamicin Niosomes and gentamicin result.

5.2. Transdermal Delivery of Drugs

Medicines like Lidocaine and estrogen derivations like estradiol, cyclosporine, etc. are used for topical operation and transdermal medicine delivery systems by formulating them as Niosomes.

5.3. Antiviral Drug Delivery

Niosomes are used in the delivery of numerous antiviral medicines. Ruckman and Sankar prepared Niosomes containing zidovudine and set up the ruse effectiveness and sustainability of medicine release. The Niosomes were made up of Tween 80, Span 60, and cholesterol in colorful proportions. Niosomes, which are prepared using Tween 80, displayed lesser ruse of the medicine zidovudine. The addition of diacetyl phosphate to Niosomes bettered the medicine release for a longer duration.

5.4. Anticancer Drug Delivery

Chemotherapy is the current treatment for cancer. Poor penetration into apkins and side goods on other healthy cells limit the remedial efficacy of numerous anti-cancer medicines. The application

of Niosomes as a new medicine delivery system is one of the multitudinous approaches that have been taken to overcome these limitations.

5.5. To Improve Oral Bioavailability

It has been reported that the oral bioavailability of the niosomal expression of acyclovir and griseofulvin was increased than the medicine alone.

5.6. To Modify the Physicochemical Properties of Drugs

Studies showed that the physicochemical parcels of the free medicine were bettered by using non-ionic surfactants.

5.7. Improvement of Stability of Peptide Drugs

The stability of peptide medicines was set up to be increased after formulating as Niosomes. The Niosomes prepared using Span 60-prepared are resistant to proteolytic enzymes and stable at storehouse temperature.

5.8. Other Applications Include

- Targeted drug delivery
- Improve anti-inflammatory activity
- Prolonged release of the drug from the formulation
- Used as a carrier for hemoglobin
- For treatment of localized psoriasis
- In diagnostic imaging
- For studying the immune response

REFERENCES

1. Marianecci C, Di Marzio L, Rinaldi F, Celia C, Paolino D, Alhaique F, Esposito S, Carafa M. Niosomes from 80s to present: The state of the art. *Adv Colloid Interface Sci.* 2014



- Mar;205:187–206.
doi:10.1016/j.cis.2013.11.018
2. Murugesan N, Damodaran C, Krishnamoorthy S. Niosomal formulation of Quercetin and Resveratrol and in-vitro release studies. *Journal of Integrated Science and Technology*. 2022 Aug 10;10(2):134-8.
3. Shiri S, Gharanjig K, Tahghighi A, Hosseinneshad M, Etezad M. Formulation and characterization of BBR loaded niosomes using saponin as a nonionic biosurfactant investigating synergistic effects to enhance antibacterial activity. *Scientific reports*. 2025 Feb 12;15(1):5231.
4. Fouad SA, Teaima MH, Gebril MI, Abd Allah FI, El-Nabarawi MA, Elhabal SF. Formulation of novel niosomal repaglinide chewable tablets using coprocessed excipients: in vitro characterization, optimization and enhanced hypoglycemic activity in rats. *Drug Delivery*. 2023 Dec 31;30(1):2181747.
5. Judy E, Lopus M, Kishore N. Mechanistic insights into encapsulation and release of drugs in colloidal niosomal systems: Biophysical aspects. *RSC advances*. 2021;11(56):35110-26.
6. Aboubakr EM, Mohammed HA, Hassan AS, Mohamed HB, El Dosoky MI, Ahmad AM. Glutathione-loaded non-ionic surfactant niosomes: A new approach to improve oral bioavailability and hepatoprotective efficacy of glutathione. *Nanotechnology Reviews*. 2021 Dec 10;11(1):117-37.
7. Bajpai SK, Shukla S, et al. Controlled release niosome embedded chitosan system: effect of crosslink mesh dimensions on drug release. *J Biomed Mater Res B Appl Biomater*. 2012;100B(7):1919–1929. [Demonstrates stabilization against osmotic swelling]
8. Alany RG, et al. Current Advances in Specialised Niosomal Drug Delivery: pH-Responsive Mechanisms. *Int J Mol Sci*. 2022;23(17):9668.
9. Abdelkader H, Alany RG. pH-sensitivity of cisplatin/doxorubicin niosomes for enhanced drug release. *Drug Deliv*. 2014;21(2):87–100.
10. Gao et al. Current Advances in Specialised Niosomal Drug Delivery: Manufacture, Characterization and Drug Delivery Applications. 2024.
11. Barani M, Hajinezhad MR, et al. In vitro and in vivo anticancer effect of pH-responsive paclitaxel-loaded niosomes. *J Mater Sci Mater Med*. 2021;32(12):147.
12. Palmieri A, et al. Spontaneous temperature-sensitive Pluronic®-based niosomes: Triggered drug release using mild hyperthermia. 2016.
13. Masjedi M, Montahaei T. A Comprehensive Review of Niosomes: Composition, Structure, Formation, Characterization, and Applications in Bioactive Molecule Delivery Systems. *Mol*. 2025;30(17):3467.
14. Gao S, Sui Z, Jiang Q, Jiang Y. Functional Evaluation of Niosomes Utilizing Surfactants in Nanomedicine Applications. *Int J Nanomedicine*. 2024;19:10283–10305.
15. Nowroozi F, et al. Effect of Surfactant Type, Cholesterol Content and Various Downsizing Methods on the Particle Size of Niosomes. *Int J Pharm Res*. 2018.
16. Ravalika V, Sailaja AK. Formulation and evaluation of etoricoxib niosomes by thin film hydration technique and ether injection method. *Nano Biomed Eng*. 2017 Sep 1;9(3):242-8.
17. Sultana SS, Krishna Sailaja A. Formulation and evaluation of diclofenac sodium transferosomes using different surfactants by thin film hydration method. *Der Pharmacia Lettre*. 2015;7(11):43-53.
18. Shinde AJ, Sankar V, Mahadik KR. Niosome-encapsulated gentamicin for ophthalmic



- controlled delivery. AAPS PharmSciTech. 2008;9(3):740–747.
19. Patel V, Sharma B, Agrawal YK, Mahadik KR. Formulation and optimization of zidovudine niosomes. AAPS PharmSciTech. 2010;11(3):1119–1127.
20. Bhavani G, Lakshmi PV. Recent advances of non-ionic surfactant-based nano-vesicles (niosomes and proniosomes): a brief review of these in enhancing transdermal delivery of drug. Future J Pharm Sci. 2020;6:100.

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