Niosomes as a Nanocarrier for Breast Cancer Drug Delivery Applications

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Niosomes are versatile in their structure, morphology and size as they can entrap both hydrophilic and lipophilic drugs in its bilayer. Multiple doses of medications are frequently needed to treat diseases, which increases the risk of side effects and hazardous interactions, noncompliance with the dosage schedule, etc. In order to achieve superior therapeutic activities than their plain counterparts, medicines with varied solubilities and modes of action can be entrapped within the bilayer membrane of these vesicles. It has previously been possible to carry out combinatorial drug administration using lipidic nanocarriers including liposomes, solid lipid nanoparticles, micellar particles, etc. Nonetheless, these suggested methods covered the enhancement of the Niosomes compounds' biological activity in breast cancer as well as their adaptable formulation and strong stability.

Keywords: public health, Nano technology, Niosomes.

1. Introduction

One of the deadliest cancers in women, metastatic breast cancer has a high death and morbidity rate. The main treatment option for breast cancer is chemotherapy, and adjuvant therapy with endocrinotherapy is advised in cases of advanced malignancies [1]. Combination medication therapy is a common therapeutic option for tumours. In these circumstances, using pharmaceuticals with diverse mechanisms and solubilities helps patients get well faster. A popular medication known for its effectiveness in treating several malignancies, including breast cancer, is doxorubicin [3]. It is frequently used in conjunction with other anti-cancer medications and is a member of the anthracycline antibiotic class. Analogously, the primary purpose of the anticancer medication tamoxifen is to treat breast cancer specifically (oestrogen receptor positive type) [9]. It is a member of the non-steroidal selective modulator of oestrogen receptors class. For an efficient therapy of breast cancer, doxorubicin is used with tamoxifen, 5-fluorouracil, etc. [2]. To reduce side effects and other harmful consequences, shorten the course of therapy, and achieve long-lasting results, it is imperative to create an efficient drug delivery method that lowers drug dosages [12][4]. Nanosized colloidal carriers are known as nanocarriers, and their usual particle sizes fall between 50 and 500 nm. Their primary function

is to include active molecules, including as proteins, medicines, and other biological agents, so that they can be delivered to various regions of the body [11]. These days, there is an unprecedented amount of research being done on the delivery of drugs via nanocarriers, as these systems have shown significant promise for improving treatment and control of diseases like cancer, viral and bacterial infections, neurological disorders, etc. [5] [6].

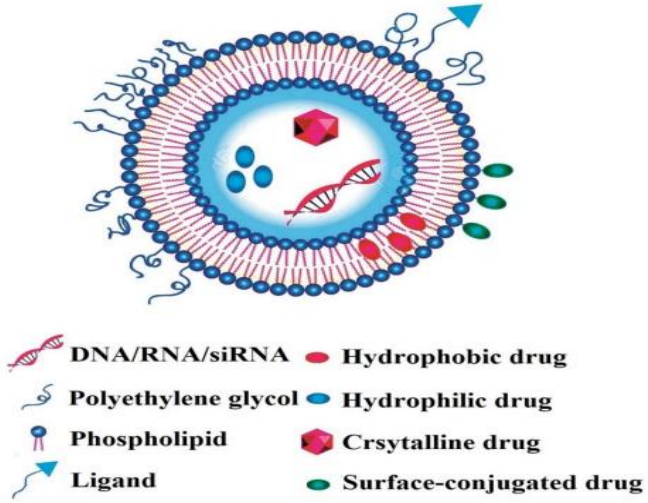

Figure 1 Niosomes as a drug delivery nanocarrier

The drug-loaded nanocarriers have the ability to release the encapsulated drug at a predetermined dose because they remain in the bloodstream for a longer period of time. This characteristic results in less changes in plasma and fewer adverse effects associated with drugs. Additionally, because of their nanosize, they have an easy time penetrating the tissue milieu, which makes it easier and faster for drugs to be absorbed at the intended place. These nanostructures have a far higher cellular absorption than micrometre particles with sizes ranging from 1 to 10 μm. Because of these characteristics, the nanocarrier can interact with the cell directly, improving efficiency and having fewer, even insignificant, adverse effects. [13].

In this instance, section 1 of the article examines the introduction, while section 2 examines the application of niosome. The proposed noisome is explained in Sections 3, and 4 discussed the output of the work. finally, the project is concluded in Section 4.

2. Niosomes in Drug Delivery

Like liposomes, niosomes are bilayer vesicles with an interior hydrophilic core and an exterior lipophilic core [Figures 1 and 2]. Drug distribution that is targeted, regulated, and sustained can be accomplished using them [7]. Although liposomes are employed for vesicular drug administration, their practical usage is hampered by a number of key difficulties. Some of the drawbacks include low stability at varying pH, challenges with surfactant derivatisation, toxicity in vivo, and expensive production costs. Owing to these drawbacks, niosomes—which provide far better control over the aforementioned problems—have become the focus of

research. Nonionic surfactants, cholesterol and its derivatives, and/or charged molecules make up niosomes. In addition to being a lipid used for niosome preparation, cholesterol gives the bilayer membrane stiffness. Niosome stability is maintained by the addition of charged molecules, which stabilise the polar charges. The distinction between niosomes and traditional liposomes is the use of nonionic surfactants.

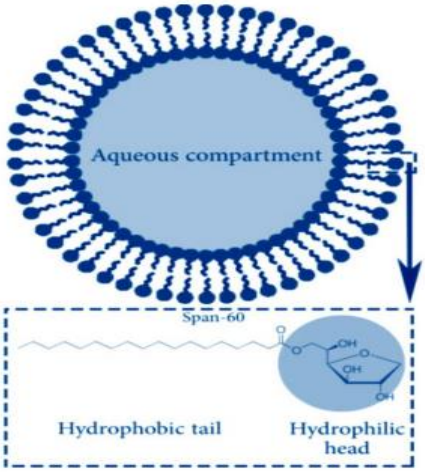

Figure 2 A schematic diagram showing the cross section of a niosome.

Non-ionic surfactants, such as spans and tweens, give the vesicles amphiphilicity and neutrality, which increases their stability and potential for drug administration. Compared to liposomes, niosomes' lipophilic and hydrophilic cores are easier to use for drug entrapment due to their superior control over charge distribution parameters. Drugs are delivered by means of niosomes through several methods of administration. For oral (Cefdinir, Lornoxicam), pulmonary (Glucocorticoids), transdermal (Gallidermin, Clomipramine), ocular (Tacrolimus, Naltrexone HCl) [8], and blood brain barrier (Temozolomide). Niosomes were first used for a variety of purposes by the well-known cosmetics company L'Oréal, and numerous other pharmaceutical companies have since followed suit [14]. In addition to medications, niosomes can also contain various genes, proteins, and vaccinations. Niosomes' clearly defined structure makes this possible. The hydrophilic particles either adsorbe on the bilayer surface or are enclosed in the watery layer. Making a partition between the lipophilic domain of the bilayer allows the lipophilic particle to be encapsulated. The formation of niosomes occurs from the hydration of thin lipid films, which causes subsequent swelling. After then, there is agitation, which causes the hydrated sheets to separate and come together to create a structure resembling a vesicle.

3. Formulation of Proposed Niosomes

The factors influencing the creation of niosomal vesicles are among the niosome formulation characteristics. Excipients such as charge inducers, polar lipids, and non-ionic surfactants are included in niosome compositions in different amounts. Critical packing parameters (CPP), transition temperature (Tc), and hydrophilic-lipophilic balance (HLB) are other significant

elements in niosomal vesicle production. [10].

The purpose of this work was to create self-assembled niosomes loaded with two drugs, tamoxifen (TAM) and doxorubicin (DOX), for use in treating breast cancer. The niosomes loaded with two medicines each exhibited a low particle size of 70%. Niosome morphology was proven to be spherical by transmission electron microscopy (TEM). Through FTIR and DSC measurement, a good drug-excipient compatibility was demonstrated. Studies on the in vitro release of drugs at two distinct pH values (5.4 and 7.4) showed a release that lasted for three days. The in-vitro cytotoxicity of TAM + DOX loaded niosomes on the breast cancer cell line (MCF-7 cells) was shown to be 15-fold better (0.01µg/ml) than that of its free drug combination (0.15 µg/ml). Furthermore, research on the uptake of nanocarriers using fluorescence microscopy and flow cytometry revealed that the niosomes were well distributed and absorbed more fully by the cells. Moreover, TAM + DOX loaded niosomes demonstrated remarkable stability in a liquid state at 4–8°C over a 6-month period. [12].

4. Discussion

In particular, the study's findings point to a reasonably priced alternative and a possible update to recent publications on combinative therapy, which combined conjugated antibodies, charge inducers, and peptide alterations to increase the drug-loaded nanocarrier's uptake. On the other hand, the drug-loaded niosomes used in this investigation showed encouraging outcomes and had no modifiers. This study, however, demonstrates a possible advancement in that, in spite of any exterior alterations to the nanocarrier, a fairly considerable internalisation of the cells was accomplished throughout (in both the cytoplasm and nucleus).

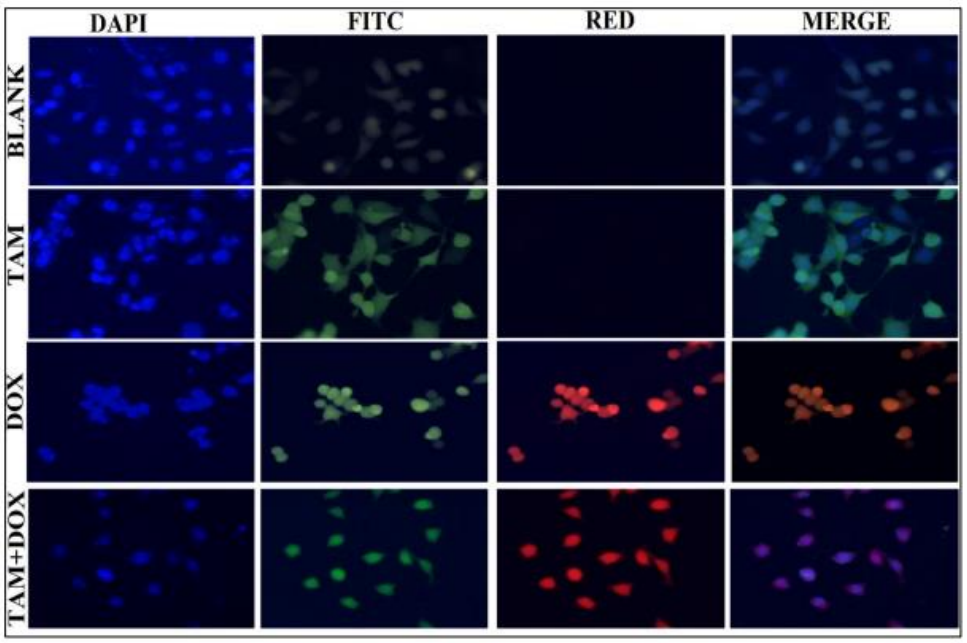

Figure 3: Fluorescence microscopy of niosome samples

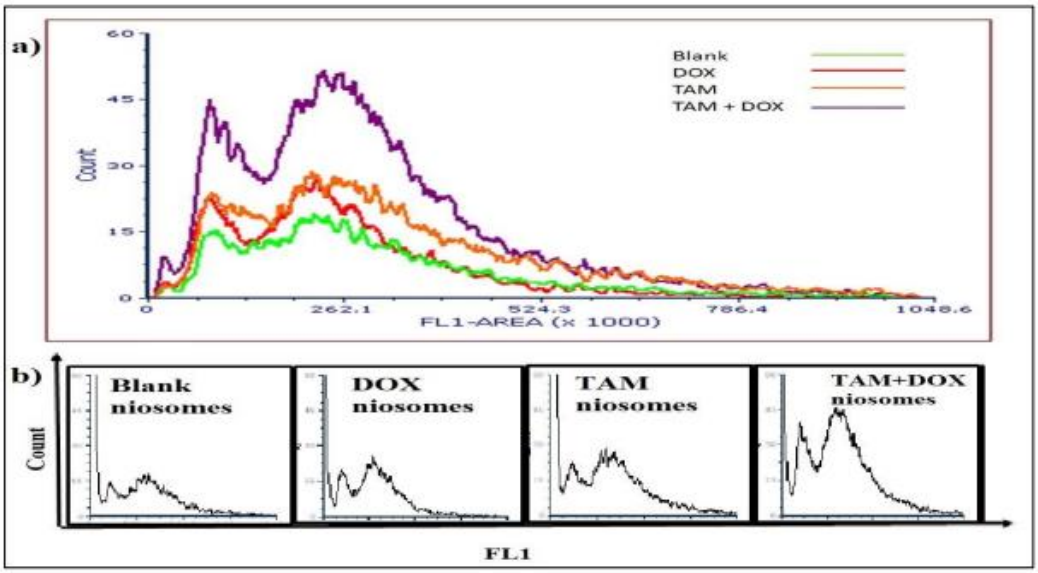

Figure 4: a, b) Cellular uptake of Tamoxifen + Doxorubicin loaded niosomes after 6hr treatment

Flow cytometry analysis was performed to get quantitative data on cellular internalisation. Figure 4 illustrates that the cellular absorption of niosomes loaded with TAM + DOX was notably higher than that of blank niosomes. When compared to blank niosomes, the cells that took up TAM + DOX loaded niosomes had a higher fluorescence intensity. This shows that the medication-loaded niosomes are more effective since it is directly correlated with higher rates of apoptosis and DNA replication inhibition.

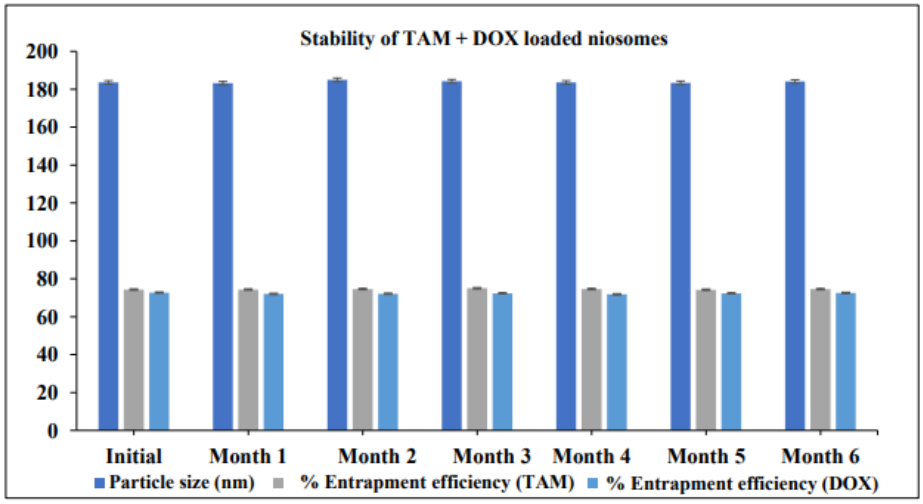

Figure 5: Stability of Tamoxifen + Doxorubicin loaded niosomes at 4-8°C with respect to the particle size (nm) and % entrapment efficiency of Tamoxifen and Doxorubicin plotted on the y-axis (n=3).

This could most likely be due to an enhanced niosome density following dual drug loading. The findings point to the potential application of this niosomal combination as a combinative treatment for breast cancer in the near future. These findings point to the TAM + DOX loaded niosomes' potential for drug delivery as a complementary breast cancer therapeutic strategy.

5. Conclusion

In order to establish a synergistic effect on the MCF-7 cell line, a combinative drug delivery strategy involving TAM + DOX loaded niosomes was investigated in this work. The niosomes demonstrated favourable physicochemical properties, including a low particle size of 70%, continuous drug release for two days, and a strong stability of six months in liquid form when refrigerated. Studies on the niosome absorption and in vitro cytotoxicity revealed higher cellular internalisation and a 15-fold reduction in tumour growth when compared to niosomes loaded with a single medication. In the future, this combination delivery might show promise as a therapeutic alternative for the treatment of breast cancer.

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