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Solid Lipid Nano Particles (SLN's) A Promising Approach in Novel Drug Delivery System

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Abstract

Solid lipid nanoparticles are nanocarriers consisting of a solid lipid core as a matrix required for the incorporation, absorption, or encapsulation of an active pharmaceutical ingredient. The popularity of solid lipid nanoparticles (SLNs) is due to their ability to enhance stability, increase bioavailability, ensure targeted and controlled delivery. In addition, this system allows overcoming the limitation of poor water solubility and, thus, improving therapeutic efficiency. This delivery method can be implemented using various techniques and is applicable to many types of drugs, including anti-inflammatory, antifungal, anticancer, peptide therapeutics.¹⁻³

Keywords: Solid lipid nanoparticles, controlled release, targeted delivery, nanocarriers, lipid matrix.

Introduction

Solid Lipid Nanoparticles (SLNs) are colloidal structures consisting of physiologically acceptable solid lipid stabilized by surfactants, in which the drug molecule is incorporated or dispersed. They were designed as an alternative to conventional drug delivery systems due to some limitations such as the low bioavailability, drug decomposition, and a lack of control over the release of drug. SLNs can provide a stable and biocompatible way of delivering drugs to their target sites thus increasing the drug's efficacy and compliance. Some of the benefits that can be obtained from SLNs include drug release, improved stability of labile drugs, increased bioavailability, the use of biocompatible and biodegradable lipids, and targeted drug delivery. In terms of application, SLNs have been studied for oral, topical, transdermal, ophthalmic, pulmonary, and parenteral drug delivery and thus are relevant in drug delivery of anti-inflammatory, antifungal, anticancer, lipophilic, and peptide/protein molecules.¹⁻⁴

MARKETED DRUGS FOR SLN

DRUG	MAIN THERAPEUTIC USE	REASON FOR SLN FORMULATION
Ibuprofen	Reduce pain, fever and inflammation	Frequent dosing and poor aqueous solubility can make controlled delivery useful
Diclofenac	Reduces pain and inflammation	Useful for prolonged/local delivery, particularly topical delivery
Ketoprofen	Reduces pain & inflammation	Short duration and formulation challenges make prolonged delivery useful
Clotrimazole	Treats fungal infections	Low solubility and need for local skin/vaginal delivery make lipid delivery useful

Table 1: MARKETED DRUGS FOR SLN

ADVANCE APPROACHES

NANOSTRUCTURED LIPID CARRIERS

Nanostructured Lipid Carriers (NLCs) represent one of the leading advanced approaches toward the development of SLN studies, designed to address specific limitations observed for conventional SLNs. Conventional SLNs are characterized by the limited loading capacity and the potential release of the drug due to changes in the crystalline structure of lipid matrix. NLCs consist of solid and liquid lipids, thus forming a more disordered matrix that may contain a larger quantity of the drug and retain it. Moreover, NLCs could offer a controlled release of the drug and facilitate the formulation of poorly water-soluble drugs. Thus, NLCs could be considered a considerable improvement in lipid-based drug delivery, although the benefits of the approach are formulation-dependent and should be experimentally confirmed.^{2,4,5}

TARGETED DRUG DELIVERY

Targeted drug delivery is regarded as one of the most promising advanced approaches because the application of conventional drug delivery systems results in targeting both the desired and undesired tissue, which decreases the drug efficiency and causes additional side effects. In the case of targeted drug delivery, SLN (Solid Lipid Nanoparticles) are designed in order to improve targeting to the specific tissue, organ, or cell. Different targeting molecules such as antibodies, peptides, folic acid, and others can be conjugated to the surface of SLN in order to identify the specific receptor and bind to the target cells. The drug that is incorporated in the SLN then can be released and exert its therapeutic effect. It is especially essential in the case of cancer treatment, because the improved targeting can increase the drug efficiency by reducing undesired exposure of the drug to the healthy cells. For example, paclitaxel, which is an anticancer drug, can be incorporated into the SLN for targeted cancer therapy. Hence, we can suggest that targeted drug delivery is one of the most promising advanced approaches, because it can improve site-specific targeting, thus increasing the potential therapeutic efficiency and decreasing the negative side effects. However, it should be noted that the targeting ability may depend on many factors such as the formulation, target cells, and the route of administration.^{1,2,4}

STIMULI RESPONSIVE SLN

Stimuli-responsive SLNs are deemed to be progressive novel drug delivery vehicles for their ability to alter or modify the drug releasing behaviour they exhibit in response to external or internal environmental conditions. In contrast to conventional SLNs that release drugs depending on the nature of the lipid matrix used, their physicochemical properties and the formulation design, the stimuli sensitive or responsive nanocarriers can be modified to respond and react to specific physiological or environmental conditions such as variations in pH, temperature, and enzymes. For instance, the pH responsive SLNs can be engineered to exhibit enhanced

drug release in an acidic medium while their temperature counterparts can be modified to be sensitive to temperature variations. Similarly, formulations that are responsive to enzymes are designed to specifically respond to the action of certain enzymes that are present in specific organs or tissues. The responsive nature of these formulations is realized by either manipulating the lipid components or by the inclusion of specific responsive elements into the formulation. Such designs are particularly beneficial in cancer therapy and other diseases that require targeted drug action. They can also be utilized to ensure that the rate or the timing of drug release is controlled or modulated. Thus, the stimuli responsive SLNs are regarded as progressive formulations due to their ability to respond to specific stimuli and therefore offer enhanced control over the drug delivery process. There are however certain challenges associated with their application since most of them are still experimental and their performance is dependent on the design criteria adopted and the physiological conditions they are subjected to.^{1,2,4,5}

SURFACE MODIFICATION

Surface modification is regarded as one of the most promising advanced strategies to SLNs because altering the nanoparticle surface makes it stable and changes the interaction mechanism with biological components. This strategy refers to modifying the SLN surface after formation by attaching or coating with polyethylene glycol (PEG), antibodies, peptides, or folic acid. Such modification can improve dispersion stability and reduce rapid recognition and removal from the body by the immune system, thereby increasing circulation time. Meanwhile, antibodies and peptides would improve interaction with the target cell. Additionally, folic acid can facilitate cellular uptake through folate receptors expressed on the surface of certain cells. It is possible to improve the shortcomings of conventional SLNs, such as inadequate circulation time, inappropriate interaction with some biological components, and low cell targeting ability, using this strategy. Surface modification is an advanced strategy that is primarily used in anticancer drug delivery systems or other areas requiring enhanced interaction with specific tissues. Therefore, it is considered an advanced approach because it allows scientists to customize the surface of SLNs according to the desired purpose. However, it should be stated that such improvement depends on the attached material and its overall performance and safety profile.^{1,2,3,5}

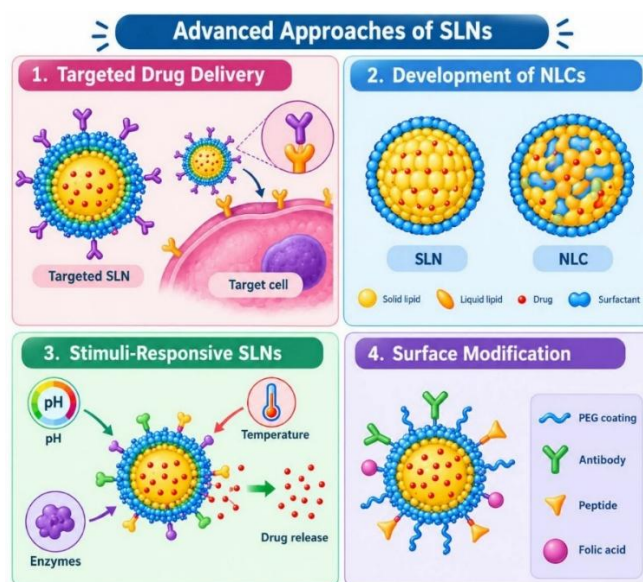


FIGURE 1: Advance approaches of SLN's

Future prospects

In future studies, efforts should be devoted to improving loading efficiency, stability, scalability, and target-specific delivery. The development of smart SLNs with stimuli-sensitive properties in addition to connecting the SLNs with other nanocarriers may help their possible expansion in terms of applications such as 3D printing and personalized medicine to augment the clinical relevance.^{2,4,5}

Conclusion

Solid Lipid Nanoparticles (SLN) is an attractive alternative to conventional emulsifiers that can provide more controlled drug delivery, enhanced targeting and stability. It has a wide range of applicability and can generate numerous innovations in the future. However, there are still difficulties that need to be overcome concerning the loading, stability, and production of these nanoparticles.¹⁻⁵

Declaration of Conflicting Interests

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