Chapter 2

Solid Lipid Nanoparticles: An Overview

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Abstract

Solid Lipid Nanoparticles (SLNs) are advanced colloidal drug delivery systems composed of biocompatible and biodegradable lipids, which remain solid at both room and body temperatures. Developed in the early 1990s as an alternative to liposomes and polymeric nanoparticles, SLNs have gained considerable attention due to their potential to improve drug bioavailability, stability, and controlled release. SLNs typically consist of solid lipids (such as glyceryl behenate or stearic acid), emulsifiers (e.g., polysorbates, lecithins), and an aqueous phase. Drugs, particularly lipophilic ones, are incorporated into the solid lipid matrix, which provides protection against enzymatic degradation and environmental factors. Various production methods such as high-pressure homogenization, ultrasonication, microemulsion techniques, and solvent evaporation are used to prepare SLNs. These influence particle size, encapsulation efficiency, and release kinetics. SLNs demonstrate a favorable physicochemical profile, including small particle size (typically 50–1000 nm), high drug-loading potential, and controlled drug release mechanisms. Additionally, their use of Generally Recognized As Safe (GRAS) materials supports their biocompatibility. Applications span across pharmaceuticals, cosmetics, and nutraceuticals, including oral, topical, and parenteral drug delivery. However, limitations such as drug expulsion, polymorphic transitions,

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and relatively low drug loading have prompted the development of second-generation carriers like nanostructured lipid carriers (NLCs). SLNs represent a versatile platform with growing commercial and clinical interest. Future directions involve targeted delivery, stimuli-responsive formulations, and environmentally sustainable production techniques, positioning SLNs as a cornerstone in next-generation drug delivery technologies.

Keywords: Solid lipid nanoparticles, methods of preparations, evaluations, applications.

1. INTRODUCTION

Novel drug delivery methods with enhanced efficacy and safety profiles have been developed as a result of the field of nanotechnology [1,2]. Particulate drug carriers, especially micro particles and Nano scale colloidal systems, have demonstrated significant potential in drug delivery applications [3]. Lipids are a vast class of organic compounds that are essential to life as we know it [4,5]. They are essential to many physiological and biochemical functions, whether they serve as our bodies' energy storage or as the building blocks of cell membranes. Nanoparticles are colloidal systems made of polymers, either naturally occurring or artificially produced, with sizes 10-1000 nm. They work well for improving medication delivery efficiency and decreasing toxicity [5]. With the passage of time, they have become a flexible substitute for liposomes in drug administration. For nanoparticles to work well for drug delivery, they need to be able to get through a number of anatomical barriers, release their contents over time, and stay stable at the nano meter size. Biologics, like proteins, peptides, oligo nucleotides, and SiRNAs, can dissolve in water, but they also have their own problems with how they are made and delivered. Two big concerns are shelf-life stability and enzymatic degradation. The goal of formulation design is to keep the API stable while it's being stored and keep it safe from endogenous enzymes until it reaches its therapeutic target. In advanced formulations, the active pharmaceutical ingredient (API) is incorporated into a targeted delivery system designed to selectively reach specific tissues or cells, thereby enhancing the therapeutic index. In